



**Supply Chain
for
Sustainability**

The 2nd International Conference
in conjunction with

**The 20th
Asia Pacific
Decision Sciences
Institute
Conference**

**19-24 July
2015**



**Hang Seng Management College
Shatin, Hong Kong**

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Welcome to the Asia Pacific Decision Sciences Institute
&
The 2ndInternational Conference on Supply Chain for Sustainability

Greetings to all,

We would like to take this opportunity and thank you for joining the 20th APDSI Conference, Hong Kong.

We are delighted to report that colleagues from 15 countries and 42 universities and organizations have contributed to the conference in different capacities: track chairs, authors, reviewers, organizers, etc. We had 28 tracks and 47 track chairs from 7 countries. There were 124 submissions by 229 authors. Of the 124 submissions, 117 research papers / panels / workshops will be presented at the conference.

The papers of “Best Paper” awards were reviewed and nominated by at least two reviewers in two categories, “Innovative Education” and “Application of Theory”.

With the diversity of countries, universities, organizations and academic disciplines represented in this conference, we will have a great opportunity to share our knowledge. Thank you for making the conference a success.

We hope this conference will encourage you to participate in future APDSI conferences.

T. S. Lee, Ph.D.
APDSI 2015 Conference Chair
Head and Professor, Department of Supply Chain Management
Department of Decision Science
Hang Seng Management College

Welcome to APDSI



For those of you who are reading about us for the first time, let us explain a little about our group. We are one of several international regions that comprise the Decision Sciences Institute (DSI). Our international region encompasses the Asia Pacific.

Asia Pacific Decision Sciences Institute (APDSI) holds an annual meeting each summer that features presentations of original research papers in different areas of business, such as Accounting, Finance, Marketing, Organizational Behavior, and Supply Chain among others. Awards for "Best Paper" in different categories are given each year.

Our mother organization, the Decision Sciences Institute (DSI), holds annual meetings and publishes the Decision Sciences journal and the newsletter Decision Line. Most members of DSI are academics who teach in colleges and universities, although some practitioners join us from time to time, and they are certainly welcome.

About Hang Seng Management College (HSMC)



Hang Seng Management College (HSMC) was restructured from Hang Seng School of Commerce in 2010 as a non-profit private university-level institution with five Schools (Business, Communication, Decision Sciences, Humanities & Social Science, and Translation). Adopting the unique "Liberal + Professional" education model, HSMC is a modern residential-type college and puts quality teaching and students' all-round development as its highest priorities. Aspiring to be a leading private university in Hong Kong, HSMC features top-quality faculty members, campus facilities, degree programmes, research and graduates, with the aim to nurture young talents with independent thinking, innovative minds, human care, ethical values and social responsibilities.

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Best Paper Awards



**Best Paper Award in Application of Theory
Finance & Financial Management Track**

US Monetary Policy and Global Financial Stability
Eric Tong, University of Auckland

Best Paper Award in Innovative Education

Teaching Concept-Based Sustainable Architectural Design
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CONTEXT EFFECTS ON DECISION STRATEGY SELECTION

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ABSTRACT

How uncertainty information is processed and evaluated in decision making is a topic that has captivated decision research for many decades. Often, monetary gambles are used to mimic the inherent uncertainty in decisions experimentally. However, some researchers raised concerns over this paradigm as research has demonstrated that the context of the decision may come into play when making decisions, while others found the way information pertaining to the decision is presented is crucial as well. In acknowledging these findings, this paper seeks to further understand how decision strategy selection and subsequent outcome might be impacted by these problem elements under uncertainty. Specifically, it investigates the impact of decision context on decision strategy selection.

In this study, 252 participants were presented with an identical decision but in the guise of two different contexts – as a gamble and as a business decision where a choice between two options was to be made. As such, the manipulation is solely on the decision context. Results from this study supported previous studies that demonstrated context effects. In addition, it found that while decision performance (i.e. making a correct choice) improved significantly when the decision is presented in a business context in contrast with a gamble context, participants' choice of strategies was also found to vary depending on the problem's context. Suggesting that context led to participants' using strategies that either focused on the outcomes only, or those that utilised both the probabilities and outcomes in reaching their decision. This was despite the case where both of these decision problems presented essentially have the same underlying information.

KEYWORDS

Context effects, strategy, uncertainty

INTRODUCTION

Decisions, decisions, decisions! We are faced with many decisions every day, with or without realising it. Depending on the type of decisions we make, some require little effort while others require much deliberation. Typically, making a decision involves a cognitive process of choosing among a set of options based on information available. However, our ability to make a rational or an informed choice can be challenging at times due to our 'bounded rationality' (e.g. Simon, 1955; March & Simon, 1958; Thaler, 2000; Gigerenzer & Selten, 2001) and limited information processing capacity (Hogarth, 1987). This often leads to the use of 'satisficing' approaches (Simon, 1955), strategies that are considered suboptimal (Slovic, Fischhoff & Lichtenstein, 1977) or heuristics (e.g. availability, representativeness, anchoring & adjustment) leading to their associated biases (e.g. Kahneman & Tversky, 1973; Tversky & Kahneman, 1974; 1983; Nisbett & Ross, 1980; Dawes, 1988; Ariely, 2008). In addition, 'fast and frugal' heuristics (Gigerenzer & Goldstein, 1996) may also be activated as means to navigate through and overcome our information processing needs.

Past research also demonstrates that our decision making is heavily impacted and even biased by how information is presented, commonly referred to as framing effect (Tversky & Kahneman, 1981). As such, the decision strategies applied on a particular problem in determining the decision choice will largely depend on how we perceive and process the information representing the decision problem (Payne, Bettman & Johnson, 1993). These streams of research emphasise two crucial issues in our continuing quest to understand human decision making behaviour: how decisions are actually made and what elements of the decision problem can potentially influence decisions. Putting these into perspective, it draws our attention to the potential influence presented information may have on the decision making process. Take for example the following decision problems (Figure 1 & Figure 2):

You are in a casino and you've just bet \$62.50 on a new sequential lottery game kind of like "Keno," in which The House draws numbers from a bingo cage. The game involves betting against other players and the house on which numbers will be drawn.

You have lost the first bet. You can quit now and your losses will be \$62.50. Your other choice is to continue playing the game. If you play again the stakes are higher because other players have been betting too. If you continue, then you enter a two-stage lottery. In the first stage, you have a 50% chance of winning. That would leave you with total winnings of \$125 more than when you started and you are finished. However, there is a 50% chance that you will move on to a final lottery. In the final stage there is a 75% chance of losing everything, bringing your total losses to \$300. There is a 25% chance that you will "win" in the final stage. If this happens, then you will have total losses of \$100.

Given the choices above, do you choose to continue to play the game or quit assuming that both choices are equal in terms of fees, taxes and convenience?

Figure 1: Gamble Problem (Rettlinger & Hastie, 2001).

You are given a speeding ticket with a \$62.50 fine. When you pay the fine you include a letter complaining to the traffic judge because you feel you were ticketed "unfairly". You get a letter back from the traffic judge explaining that because of your letter, your case is being given special consideration. In the letter, the judge offers you the opportunity to either plead "guilty" or "not guilty" to the ticket even though you have already paid a fine.

You must decide whether to plead guilty or not guilty. If you plead guilty, then you have already paid your \$62.50 fine, but you must go down to the courthouse and fill out paperwork waiving your right to a hearing. The letter explains that this will take about 2 hours. If you choose to plead not guilty you will get your earlier fine back, then you will have a hearing. You might be found not guilty (50% chance) at your hearing. If you are found not guilty, then you will be able to get \$125 as a settlement for your "false arrest". If you are found guilty (also a 50% chance), you will be fined. There is a 75% chance that your fine will be \$300 and a 25% chance that it will be \$100. The letter says that the hearing will take about 2 hours.

Assuming that the information above is correct, and that both options are otherwise equal in terms of fees, taxes and convenience, do you choose to plead guilty or not guilty?

Figure 2: Traffic Offence Problem (Rettlinger & Hastie, 2001).

Which options will you choose when presented with the above problems? von Neumann and Morgenstern (1944) will assert that your choices between the problems will be normatively consistent (i.e. either quit the game and plead guilty, or continue playing the game and plead not guilty). This is because they are essentially the same; just described under a different context (i.e. gamble vs. traffic offence). However, Rettinger and Hastie (2001) found that the context of the decision problem actually influences how the participants process the information presented which in turn affect their decision outcomes. Their results demonstrate that majority of the participants (i.e. 80%) select the certain (safe) option (i.e. quit the lottery game and accept the initial loss) over the uncertain (risky) option (i.e. continue playing the game where the chance of winning/losing can be higher than the initial loss) when presented with the decision problem under a gamble context (Figure 1). When the same underlying decision is presented under a traffic offence context (Figure 2), 52% of participants select the certain option (i.e. plead guilty to speeding and pay the initial fine) over the uncertain option (i.e. plead not guilty and take the chance of getting a higher settlement or end up with a higher initial fine). They argue that this difference in choice outcomes recorded is due to a change in the problem's context. This change in context shapes the participants' mental representation of the problem, thereby resulting in different strategies being adopted to process the information presented. For example, their results reveal that the avoid-the-worst strategy (41%) dominates the gamble problem whereas the moral strategy (e.g. considering the "right or wrong" of the situation) (37%) dominates the traffic offence problem amongst other numerical (e.g. calculation) and narrative (e.g. regret) strategies recorded. Perhaps, also suggesting a reflection of the multiple attributes involved in the traffic offence problem (e.g. getting a traffic infringement record and having to pay a higher insurance premium in the future) beyond just monetary loss as in the gamble problem.

The decision problem examples highlighted above suggest that context matters. A change in context changes people's decisions by altering how the options are being processed and evaluated. This change in context essentially changes the meaning of the (same) information presented which results in participants using different strategies to address the same decision problem. Their findings appear to suggest that context impacts on people's mental representation of the decision problem resulting in their use of different strategies to process the information presented.

Looking beneath the context, the *framing effect* introduced by Tversky & Kahneman (1981) also contributes to the finding that people exhibit systematic biases when making decisions under uncertainty (e.g. Tversky & Kahneman, 1974; Das & Teng, 1999; Goodwin & Wright, 1994; 2004). For example, the recorded systematic decision biases result from how information pertaining to the options (e.g. the probabilities and outcomes) is framed. That is, people tend to prefer the safe (certainty) option when the options available are framed as gains, while the risky (uncertainty) option is preferred when they are framed as losses. However, when the emphasis is placed on the probabilities instead of the gains and losses frame, the biases disappear (Bless, et al., 1998). These evidences suggest that our ability to make effective decisions under uncertainty is also contingent upon the way and how the uncertainty information is communicated (e.g. Remus & Simkin, 1987; Makridakis, 1988; Kydd, 1989; Payne, Bettman & Johnson, 1993; Weber & Johnson, 2009), and whether the probabilities or outcomes are viewed to be more important (Shavit, Rosenboim & Shani, 2013). After all (as the problem examples cited earlier suggest), making a decision requires the presented information pertaining

to the decision situation and underlying options to be conceptualised and processed, prior to making a decision.

In light of the above, the main objective of this research is to add to previous findings on the impact context have on people's decision strategy selection when making decisions under uncertainty. The following section provides an overview of the literature that drives this line of research.

LITERATURE BACKGROUND

Several theoretical frameworks have emerged from the past decades to understand human decision making. For example, Beach & Mitchell (1978) introduce the Contingency Model of Decision Strategy Selection – asserting that the type of strategies used to derive a decision is contingent upon the characteristics of the task and decision maker, while Image Theory (Beach, 1990) contends that decision makers incorporate their own mental images to guide their decisions. These frameworks suggest that decision outcomes can be influenced by how decision makers relate their individual experiences to the decision task. By examining context effects, it is then possible to investigate and further understand how decision strategy selection is impacted. Crucial to this research is Wagenaar, Keren & Lichtenstein's (1988) problem structure conception. They propose that a decision problem can be characterised by its surface and deep structures. For example, a problem's surface structure reveals the presented story (i.e. its context); while its deep structure contains all the information required that can determine the decision (i.e. probabilities and outcomes). Adopting this distinction enables the investigation of context effects to be conducted in such a way that the probabilistic information does not confound the findings; an approach that is consistent with past decision making studies. The following section considers prior research on factors that influence the selection of decision strategies when making decisions by drawing upon research that emphasises the significance of task and decision maker characteristics.

Factors influencing decision strategies

What influences decision making? How is decision making actually done? For many years, research in judgement and decision making is dominated by normative decision theory (e.g. expected utility theory; founded in the fields of Economics & Decision Theory) entrenching that people make decisions on the basis of information provided (e.g. using probabilities and outcomes) that is independent of its context (von Neumann & Morgenstern, 1944; Savage, 1954). For example, this normative approach involves calculating the expected value of a set of outcomes by probability-weighting all the potential outcomes associated with that option and summing them. When choosing amongst a set of options, this approach posits that decision makers calculate and rationally compare the expected values between the available options leading them to select the option with the highest expected value. Therefore, it is expected that decision makers will arrive at the same consistent decision regardless of the context of the decision (e.g. gambling, financial, or marketing). It should be noted, however, that this normative approach assumes that firstly, information about the potential outcomes and their corresponding probabilities are all known, and secondly, people will always prefer the option that exhibits the highest economic payoff. In practice, not only are these assumptions challenged, other factors have also been identified to explain why such normatively derived understanding of decision behaviour (i.e. what should people do) offer only partial insights to what people actually do.

Task and decision maker characteristics

There has been much debate in decision making research on whether approaches that define what we should do are accurate indicators of what we actually do. For example, Beach and Mitchell (1978) challenge such normative contentions and propose a Contingency Model of decision strategy selection by arguing that other characteristics do come into play when making decisions. These characteristics, involving the task and decision maker are thoroughly tested (e.g. Christensen-Szalanski, 1978; McAllister, Mitchell & Beach, 1979; Waller & Mitchell, 1984) and found to influence the choice of decision strategies that ultimately impacts on the choice outcome.

In other words, contrasting with traditional normative assertions where people are expected to base their decisions purely on economic payoffs, other factors arising from the characteristics of the task and the decision maker's characteristics must be taken into account. Using this framework, they argue that to increase the perceived probability and benefit of making a correct decision, the decision maker will take a more analytical strategy approach; within the limits imposed by the decision maker's characteristics. While the decision problem's characteristics (e.g. unfamiliarity, ambiguity, complexity and instability) may reduce the perceived probability of making a correct decision, the imposition of the environment characteristics (e.g. irreversibility, significance, accountability and accountability) increase the perceived benefit of making a correct decision (McAllister, Mitchell & Beach, 1979).

Beach and Mitchell (1978) conceptually differentiate these closely linked characteristics by defining task characteristics as 'the decision maker's interpretations of the demands and constraints of the specific task at hand' and decision maker characteristics (e.g. knowledge, ability and motivation) as 'enduring aspects of the decision maker that are not task specific', with the surrounding environment playing a crucial role within the task characteristics (p. 444). From their framework, while it is intended to predict the type of strategies individuals actually use to make decisions (e.g. aided/unaided analytic vs. non-analytic) it clearly contends that the selection of decision strategies which ultimately affects the choice outcome is contingent upon both the task characteristics and the decision maker's characteristics. Thus, contesting the assertions made by traditional rational choice theories, and allude to the notion of context influence.

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the ideas expressed by Payne, Bettman and Johnson (1992) and Goldstein and Weber (1995) who also argue that people's decision strategies and their subsequent choices are determined by the elements pertaining to the problem captured through the uncertainties involved (e.g. probabilities and outcomes) and its context (e.g. marketing, financial, medical decisions). While these researches acknowledge the characteristics of the decision maker to have an impact on decision outcomes, there are compelling evidences suggesting that the underlying information of the problem also contribute to differences in decision making behaviour. This is because as information describing the problem provides meaning to the decision maker (e.g. setting its context), there are grounds to then assert that its subsequent decision can also be impacted by how its underlying information (e.g. conveyed through the probabilities and outcomes presented) is perceived and processed by the decision maker (Waller & Mitchell, 1984). Hence, it appears that the literature contributing to this body of work unanimously stresses the significance of information presentation in decision making and its contributions towards decision behaviour.

The decision task

Reinforcing the issues discussed in the preceding section, information lies in the heart of decision making. It provides meaning and knowledge about the decision problem, and identifies the characteristics of the decision. It provides a structure to the decision situation and sets the constraints to which the outcomes of the choices involved are evaluated (Schneider & Barnes, 2003). Although each decision problem is unique in its own right, the format of information presentation can potentially shape how the problem is understood and processed; affecting the outcome of the decision (Payne, Bettman & Johnson, 1993). Previous studies supporting this particular argument found that how decision makers arrive at decisions predominantly lies on how they perceive the problem based on what information is available to them (e.g. Levin, Johnson, Russo & Deldin, 1985; Payne, Bettman, Coupey & Johnson, 1992; Shoorman, Mayer, Douglas & Hetrick, 1994) and the context of the decision problem (e.g. Neale, Huber & Northcraft, 1987; Wagenaar, et al., 1988; Schneider, 1992; Wang, 1996; Bless, et al., 1998; Rettinger & Hastie, 2001; Druckman, 2004; Mercer, 2005; Haerem, Kuvaas, Bakken & Karlsen, 2010).

What seems clear from previous evidences reported is that presented information describing the problem affects our processing and subsequent decision outcome. Furthermore, how people interpret and process the problems' deep structure is impacted by their surface structure (otherwise known as context or cover story); a concept brought into the decision research field by Wagenaar, Keren and Lichtenstein (1988). They suggest that a decision problem can be characterised by its surface structure (i.e. the presented cover story of the problem) and its deep structure which contains 'all information that could determine the decision' in a 'reduced representation' (p. 176). Consistent with Schneider and Barnes (2003) contention, they argue that how the surface structure of the problem as understood by the decision maker will influence how the deep structure is processed and evaluated.

Wagenaar et al. (1988) demonstrate that the participants' preference shifts are brought about by a change in the surface structure through varying its presentation, confounding variables and context; which also changes the role (responsibility) of the decision maker. In addition, they assert that most rational-based theories pay too much attention on the 'evaluation function' (i.e. the reduced representation of the problem; deep structure) but fail to be explicit about 'how a

problem's surface structure is transformed into deep structure that is analysed by the decision maker' (p.187). This surface-deep transformation stage is seen to be crucial in decision making because it amplifies how internal representations (e.g. Maule & Villejoubert, 2007; Simon & Hayes, 1976) of a problem can be constructed through its structures leading to choice behaviour. Changing the context, thus, alters the nature of the decision problem which in turn influences how the information representing the problem (i.e. deep structure) is processed and acted upon.

The case for context effects

Incorporating Wagenaar et al.'s (1988) view by deconstructing the elements of a decision problem, separating a problem into its surface and deep structures, help explain why decision behaviour might differ. Arguably, every decision is made within a particular context that helps to stimulate the decision maker's perception of the decision problem factoring the decision maker's characteristics and subsequent selection of decision strategies in making a choice (Beach & Mitchell, 1978). In other words, the elements pertaining to the decision problem can potentially shape people's preferences by influencing how the choices are understood and evaluated.

Payne (1982) recognises this by describing such context effects as 'factors associated with the particular values of the objects in the decision set under consideration, including similarity and the overall attractiveness of the alternatives' (p. 386) which is inherent in any given decision. Mellers, Schwartz and Cooke (1998) are also of the view that 'preferences are not created in a vacuum' but 'depend on the stimulus context' (p. 457). Collectively, they highlight the significance of context in the decision making process which refers to the environmental variables which can be stimulated by the decision maker's past and present experiences affecting the decision maker's cognitive process. Hence, the elements of the decision problem should be individually recognised as potential contributors to the framing effect. For instance, some researchers found context to play a significant role in influencing decisions and forecasts (e.g. Payne, 1982; Payne et al., 1992; O'Connor, Remus & Griggs, 1993; Bless et al., 1998, Haerem et al., 2010). Reading too much into the context of the decision problem can affect how information is used by the decision maker to arrive at a decision. Findings by O'Connor et al (1993) and Bless et al. (1998) demonstrate this impact context cues can have on decision making. For instance, O'Connor et al. (1993) found that even the simple labelling of a time series can have a significant impact on participants' forecasting performances and can potentially mislead the decision maker if the contextual clues are inappropriate; providing support for Meller, Swartz & Cookes (1998).

Likewise, Rettinger and Hastie (2001) also advocate that people's choices made through their mental representations of the problem are influenced by the decision's context. In their study, they manipulate the context of the problem but kept the probabilities and outcomes of the options presented in each context (legal, grade, stock, and gamble) identical. Of the participants who complete their corresponding task, 80% prefer the safe option in a gamble scenario; while only 35% prefer the safe option in a stock scenario with legal and grade scenarios having about a 50-50 split between the safe versus uncertain options. Through their study, as the choice set is essentially the same, they demonstrate that the context of a problem has an influence over choice behaviour. It is also interesting to note that the gamble and stock context, which show the most difference in decision preferences, are inversely associated in terms of recorded preferences. Despite the assumed association of gambles and stocks due to their nature,

participants in the study still perceive them to be different when making choices. It is also noted that this study, similar to most framing effect studies, requires participants to choose between a certain and uncertain option. This approach, in essence, identifies the participants' attitudes towards risks reflected through their choice preferences under different contexts and suggests that certain contexts promote "safer" preferences than others. As a further note, their study did not examine whether participants actually perform better in one context or another.

In summary, these evidences suggest that the elements of a decision problem have a significant impact on choice behaviour. How a problem is presented can affect the understanding and processing of the decision problem leading to the problem-solving. In addition, decision making process can also be influenced by individual characteristics (e.g. Beach & Mitchell, 1978; Cokely & Kelley, 2009), context (e.g. Wagenaar et al., 1988; Rettinger & Hastie, 2001; Haerem et al., 2010), and even contextual cues (e.g. O'Connor et al., 1993; Bless et al., 1998; Igou & Bless, 2007). Thus, the surface structure of the problem shapes the nature of the decision by characterising the situation, thereby changing the role or circumstance of the decision maker which in turn influences how the information presented (deep structure) is processed.

The above review identifies several main factors and issues that contribute to our understanding of human decision behaviour that has captivated research in decision making. For example, Beach and Mitchell's (1978) Contingency Model of decision strategy selection identify task and decision maker characteristics to collectively influence people's decision strategy selection leading to their decision. Wagenaar et al (1988) propose the breaking down of a problem into its surface and deep components to further understand what influences decision making. Other related studies (e.g. Rettinger & Hastie, 2001) plus others highlighted in the literature review, add compelling evidence for decision behavioural differences that are due to how the decision problem is formulated (or framed).

Taken together, prior literature unanimously asserts the importance of information presentation in decision making; what it represents and how it is presented can influence how the problem is being perceived and processed before reaching a decision. Accordingly, this paper shall empirically examine how context might affect decision strategy selection leading to one's choice, which is in the frame of Beach and Mitchell's (1978) Contingency Model. Thus, this paper contends that under identical uncertainty condition, there will be no difference in strategy selection (H_0) between different contexts.

RESEARCH METHODOLOGY

In line with the surface and deep structure principle, the objective of this study is to investigate how people's decision strategy is impacted through changing the context of an identical decision problem. Three key considerations are made when developing the study tasks to address the research purpose. First, the problem's context used in the study must be realistic to the participants (Wagenaar et al., 1988) in order to limit the abstractness (Haerem et al., 2010) of the decision problem. Second, the underlying information representing the decision options (e.g. using probabilities and outcomes) must be consistent and clear to control for possible issues such as incomplete or vague information leading to ambiguity (Mandel, 2001). Third, the options must be presented in a form that enables an assessment of the decision options e.g. using a rational benchmark to identify if decisions deviate normatively. A business-type context (Figure 7; adapted from Goodwin & Wright, 2004) and a gamble-type context (Figure 8) are considered to be appropriate for this investigation as they are deemed to be realistic to the

participants. The gamble problem also serves as a default (control) decision situation. Furthermore, the decision involving these chosen contexts can be appropriately reduced to probabilistic representations with similar financial goals can be measured (e.g. Garrod & Willis, 1999; Schenider & Barnes, 2003).

<p>Imagine you are the manager of a company specialising in sports merchandise and is planning to market a new product. You have considered a number of possible options but after some preliminary research has narrowed down to two product alternatives. Using information obtained from past internal records, the products' profit potentials were then translated into "earning" probabilities per unit sales (see table below). Which product would you decide to market?</p>	
Product A 90% chance of earning \$96 in profit per unit 5% chance of earning \$14 in profit per unit 5% chance of earning \$12 in profit per unit	Product B 85% chance of earning \$96 in profit per unit 5% chance of earning \$90 in profit per unit 10% chance of earning \$12 in profit per unit
Your Product Choice (please select one): <input type="checkbox"/> Product A <input type="checkbox"/> Product B	

Figure 7: Business-type (M) Task Treatment.

<p>Imagine you have 2 jars (A and B) containing 100 marbles each in 3 different colours. If the colour of marble drawn determines your prize (see table below), from which jar would you rather draw a marble from at random?</p>	
Jar A 90 red marbles to win \$96 5 green marbles to win \$14 5 blue marbles to win \$12	Jar B 85 red marbles to win \$96 5 green marbles to win \$90 10 blue marbles to win \$12
Your Jar Choice (please select one): <input type="checkbox"/> Jar A <input type="checkbox"/> Jar B	

Figure 8: Gamble-type (G) Task Treatment.

When determining the underlying uncertainty information used for this study, it notes that past studies predominantly compare between losses versus gains under conditions of certainty versus uncertainty (e.g. framing effect studies). These manipulations essentially measure people's risk attitudes under those conditions leading to the reported choice preferences (e.g. reversals or shifts in behaviour). It is also crucial that the underlying information clearly and consistently specify the probabilities against their corresponding outcomes to determine the true impact on the decision made. Furthermore, studies following Tversky and Kahneman's (1981) framing paradigm utilise choice sets where the outcomes are logically equivalent (i.e. identical expected outcome). As previously indicated, taking this approach will not allow the correctness of a choice to be established which can be used to also evaluate whether a particular strategy selection leads to a correct decision. In this regard, the decision options presented must exhibit different expected outcomes in order to address the present experiment's aim. The underlying information adopted in this experiment is identical with Birnbaum's (1997) study on stochastic dominance violations. This particular probabilistic condition (as presented within Figures 7 & 8) has been previously tested and found to have caused significant violations in choice

behaviour when compared against normative theories (e.g. Birnbaum & Navarette, 1998; Birnbaum & Martin, 2003; Birnbaum, 2004). Thus, providing an avenue for decision correctness to be evaluated as well.

Design and procedure

This study involves a within-participants treatments design of two groups. The independent (treatment) variable involves the manipulation of the problem's context using a business-type (Figure 7) versus a gamble-type (Figure 8) context. Decision outcome is set as the dependent variable measured by choice outcome correctness (using a normative expected value benchmark). The participants in this study are 252 undergraduate business students recruited from a participant pool. During the semester, they register their interest to participate in this study for course credit. The participants are randomly placed into the two treatments by order categorised as Business (M) and Gambling (G). One-half ($n = 126$) completes the M treatment followed by the G treatment, while the other half ($n = 126$) completes the G treatment followed by the M treatment. For each treatment, on the same page where the participants indicate their choices, they are also asked to describe how their decisions are made in an open space provided. This allows the researcher to identify how their decisions are derived (i.e. strategy used) under each treatment.

RESULTS AND DISCUSSION

Preliminary investigations show that of the total 252 participants, 78.6% (198/252) select the correct choice in the M treatment overall relative to the normative benchmark. In contrast, 67.5% (170/252) select the correct choice in the G treatment. A McNemar's test reveals that the difference in overall decision outcome (performance) between the gamble-type and business-type treatment (i.e. 11.1%) is statistically significant ($p = 0.001$). As each participant complete both tasks, the McNemar's test further reveals that the average difference in decision performance between the first and second treatment exposures (12.7%) is statistically significant ($p = 0.000$).

Decision context effect on strategy selection

Hypothesis 1: There will be no difference in decision strategy selection between the gamble-type and the business-type context.

A content analysis using data from the participants' textual descriptions on how they have derived their decisions in each task treatment will enable their likely adopted strategies to be extracted. The strategies classification for this analysis are adapted from Thorngate (1980) and Payne, Bettman and Johnson (1993). A total of 9 a priori codes are initially identified for the coding process and to allow for intra-coder reliability. This coding system is initially tested using a sample ($n = 10$) of the participants' descriptions and found to be appropriate; identifying 5 different strategy types consistent with the codes (Table 1).

Table 1: Five Strategy Types Identified Through Initial Coding.

Strategies	Process and Prediction	Choice Outcome	Code
Expected Value Analysis	A: $0.90*96 + 0.05*14 + 0.05*12 = 87.7$ B: $0.85*96 + 0.05*90 + 0.10*12 = 87.3$ EV chooses A because A has higher EV than B.	A	EV
Equal-weight	Compare the sum of all outcomes within an option. Select the option with the highest outcome sum. Equal-weight chooses B because B has a higher sum (198) than A (122).	B	EQW
Minimax- <i>p</i> (Modified from Minimax to address non-prediction issue)	Select the option with highest minimum outcome probability. Minimax- <i>p</i> chooses B because B has higher probability (0.10 <i>p</i>) than A (0.05 <i>p</i>) for the same minimum outcome.	B	MINI- <i>p</i>
Most-likely (Addresses non-prediction issue identified in Maximax).	Identify the most likely probability of each option and their respective outcomes. Select the option with the highest, most likely outcome. Most-likely chooses A because A has a more likely probability (0.90) than B (0.85) for the same maximum outcome (96).	A	ML
Least-likely	Identify the worst outcome for each option. Select the option with the lowest probability of the worst outcome. Least-likely chooses A because A has a less likely probability (0.05) than B (0.10) for the same minimum outcome (12).	A	LL

This coding system is then handed to two other coders (for inter-coder reliability; Neuendorf, 2002) independent of this research to evaluate the participants' strategy usage via their textual descriptions, and classify them according to the content codes provided. Analysis of the few differences in coding between the coders and researcher are found to be insignificant, ($\chi^2(8) = 0.870, p > 0.05$) with high inter-coder reliability, ($k = 0.951$; Fleiss, 1971). The initial codes are then refined and revised; reflecting 5 key recurring strategies extracted from the participants' descriptions (Figure 9).

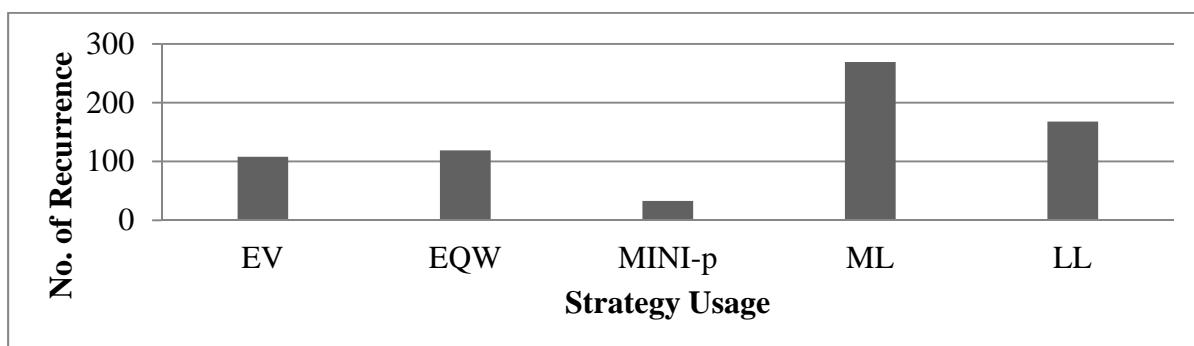


Figure 9: Key Strategies Used By Participants.

A total of 697 strategy recurrences are identified from the 252 participants (excluding 12 recurrences classified as “Other”). As shown in Figure 9, the most popular strategy used is Most-likely (269; 39%) followed by Least-likely (168; 24%). The Equal-weight (119; 17%) and Expected-value (108; 15%) strategies are also commonly cited. A smaller number but substantial strategy cited is the MINI- p (33; 5%) reflecting the risk-averse nature of some participants when making decisions. The higher total number of strategy recurrences than the total number of participants is a reflection of some participants using multiple strategies (resulting in co-occurring codes) in their decision making process.

Figure 10 shows the number of strategies used by participants in each treatment to make their decisions. It reveals that higher number of strategy recurrences are found in the M treatment than in the G treatment overall regardless of whether the M treatment is administered first (M-G order) or second (G-M order).

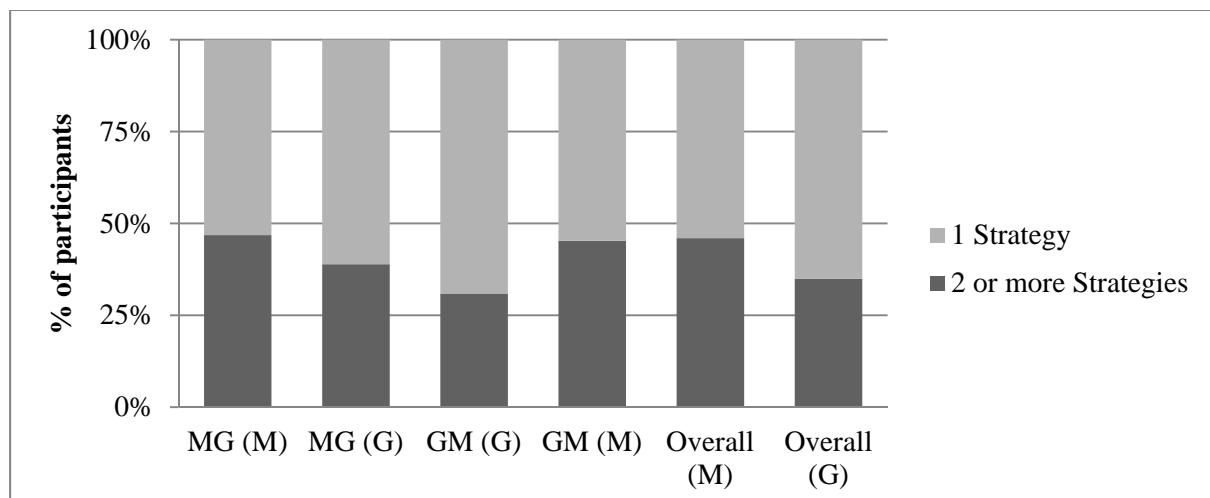


Figure 10: Number of Strategies Used in Each Treatment by Participants.

Overall, a total of 40.5% (204/504) observations are identified to have used more than one strategy in a given treatment. Of these, 46% (116/252) participants use more than one strategy in the M treatment contrasting with 35% (88/252) participants who use more than one strategy in the G treatment. Of the 697 strategies recurrence, 366 recurrences are identified overall in the M treatment contrasting with 331 strategy recurrences recorded in the G treatment. Using the strategy coding from participants’ initial treatments (i.e. M from MG and G from GM) also reveal a similar pattern (measured by number of strategies used) in the M treatment (185) compared to the G treatment (156). These evidences appear to suggest that more elaborate processing (e.g. Rettinger & Hastie, 2001; Cokely & Kelley, 2009) is engaged in the M treatment than in the G treatment.

Strategy type

Participants who use Expected Value analysis to derive their decisions are clearly evident through their descriptions and/or computations incorporating the probabilities and potential outcomes provided under each option by working out their respective expected outcomes. Participants who adopt approaches other than the Expected-value strategy suggest different emphasis and representations used to derive their decisions. Table 2 provides a sample of content analysis revealing other types of strategies used by the participants.

Table 2: Sample of Content Analysis Revealing Other (Non-EV) Type Strategies.

Strategy Type	Content Analysis Sample
Equal-weight (EQW)	<ul style="list-style-type: none"> - Product A has a total chance of earning \$122. Product B has a total chance of earning \$198. Therefore, Product B outweighs A. - The total money involved in each Jar is A has \$122 and B has \$198. So clearly, Jar B is worth more money.
Minimax- p (MINI- p)	<ul style="list-style-type: none"> - Product B is twice more likely to earn \$12 profit than Product A. Product B is more marketable. - The probability of winning \$12 from Jar B is more likely to happen since it has 5 more blue marbles than Jar A.
Most-likely (ML)	<ul style="list-style-type: none"> - If I am the manager, I would launch Product A. Product A has 90% chance to earn the highest profit and it's the goal for every company. - I have 90% probability to get \$96, those are good odds!
Least-likely (LL)	<ul style="list-style-type: none"> - If I were the manager I would choose Product A. This would be because I have only a 5% chance of making \$12 in profit per unit, whereas in B I have a 10% chance. - There is a lower probability (5%) of selecting the marble worth the least (\$12).

While these strategies are distinctive of the Expected Value approach, they show that the correct (Expected-value based) choice can still be achieved through other reflective means (Cokely & Kelley, 2009). For example, those who based their decisions on the Most-likely and/or Least-likely approaches also result in making the correct choice in both M and G treatments. However, participants who use Equal-weight or MINI- p strategies result in making the incorrect choice. The coding results (Figure 11) reveal that strategy types vary between the M and G treatments. Both the Most-likely and Least-likely strategies are the most common (and mostly found to be co-occurring when adopted) although the number of these recurrences recorded are higher in the M treatment.

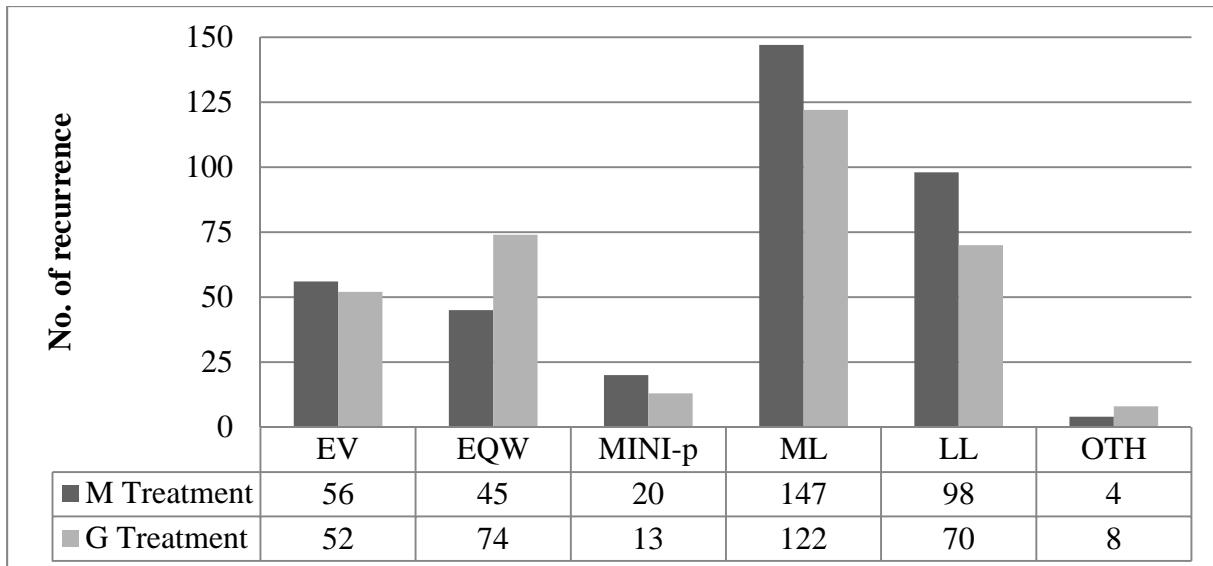


Figure 11: Context (Surface Structure) Effect on Strategy Type (Overall).

to the decision situation and underlying options to be conceptualised and processed, prior to making a decision.

In light of the above, the main objective of this research is to add to previous findings on the impact context have on people's decision strategy selection when making decisions under uncertainty. The following section provides an overview of the literature that drives this line of research.

LITERATURE BACKGROUND

Several theoretical frameworks have emerged from the past decades to understand human decision making. For example, Beach & Mitchell (1978) introduce the Contingency Model of Decision Strategy Selection – asserting that the type of strategies used to derive a decision is contingent upon the characteristics of the task and decision maker, while Image Theory (Beach, 1990) contends that decision makers incorporate their own mental images to guide their decisions. These frameworks suggest that decision outcomes can be influenced by how decision makers relate their individual experiences to the decision task. By examining context effects, it is then possible to investigate and further understand how decision strategy selection is impacted. Crucial to this research is Wagenaar, Keren & Lichtenstein's (1988) problem structure conception. They propose that a decision problem can be characterised by its surface and deep structures. For example, a problem's surface structure reveals the presented story (i.e. its context); while its deep structure contains all the information required that can determine the decision (i.e. probabilities and outcomes). Adopting this distinction enables the investigation of context effects to be conducted in such a way that the probabilistic information does not confound the findings; an approach that is consistent with past decision making studies. The following section considers prior research on factors that influence the selection of decision strategies when making decisions by drawing upon research that emphasises the significance of task and decision maker characteristics.

Factors influencing decision strategies

What influences decision making? How is decision making actually done? For many years, research in judgement and decision making is dominated by normative decision theory (e.g. expected utility theory; founded in the fields of Economics & Decision Theory) entrenching that people make decisions on the basis of information provided (e.g. using probabilities and outcomes) that is independent of its context (von Neumann & Morgenstern, 1944; Savage, 1954). For example, this normative approach involves calculating the expected value of a set of outcomes by probability-weighting all the potential outcomes associated with that option and summing them. When choosing amongst a set of options, this approach posits that decision makers calculate and rationally compare the expected values between the available options leading them to select the option with the highest expected value. Therefore, it is expected that decision makers will arrive at the same consistent decision regardless of the context of the decision (e.g. gambling, financial, or marketing). It should be noted, however, that this normative approach assumes that firstly, information about the potential outcomes and their corresponding probabilities are all known, and secondly, people will always prefer the option that exhibits the highest economic payoff. In practice, not only are these assumptions challenged, other factors have also been identified to explain why such normatively derived understanding of decision behaviour (i.e. what should people do) offer only partial insights to what people actually do.

Task and decision maker characteristics

There has been much debate in decision making research on whether approaches that define what we should do are accurate indicators of what we actually do. For example, Beach and Mitchell (1978) challenge such normative contentions and propose a Contingency Model of decision strategy selection by arguing that other characteristics do come into play when making decisions. These characteristics, involving the task and decision maker are thoroughly tested (e.g. Christensen-Szalanski, 1978; McAllister, Mitchell & Beach, 1979; Waller & Mitchell, 1984) and found to influence the choice of decision strategies that ultimately impacts on the choice outcome.

In other words, contrasting with traditional normative assertions where people are expected to base their decisions purely on economic payoffs, other factors arising from the characteristics of the task and the decision maker's characteristics must be taken into account. Using this framework, they argue that to increase the perceived probability and benefit of making a correct decision, the decision maker will take a more analytical strategy approach; within the limits imposed by the decision maker's characteristics. While the decision problem's characteristics (e.g. unfamiliarity, ambiguity, complexity and instability) may reduce the perceived probability of making a correct decision, the imposition of the environment characteristics (e.g. irreversibility, significance, accountability and accountability) increase the perceived benefit of making a correct decision (McAllister, Mitchell & Beach, 1979).

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CONTEXT EFFECTS ON DECISION STRATEGY SELECTION

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ABSTRACT

How uncertainty information is processed and evaluated in decision making is a topic that has captivated decision research for many decades. Often, monetary gambles are used to mimic the inherent uncertainty in decisions experimentally. However, some researchers raised concerns over this paradigm as research has demonstrated that the context of the decision may come into play when making decisions, while others found the way information pertaining to the decision is presented is crucial as well. In acknowledging these findings, this paper seeks to further understand how decision strategy selection and subsequent outcome might be impacted by these problem elements under uncertainty. Specifically, it investigates the impact of decision context on decision strategy selection.

In this study, 252 participants were presented with an identical decision but in the guise of two different contexts – as a gamble and as a business decision where a choice between two options was to be made. As such, the manipulation is solely on the decision context. Results from this study supported previous studies that demonstrated context effects. In addition, it found that while decision performance (i.e. making a correct choice) improved significantly when the decision is presented in a business context in contrast with a gamble context, participants' choice of strategies was also found to vary depending on the problem's context. Suggesting that context led to participants' using strategies that either focused on the outcomes only, or those that utilised both the probabilities and outcomes in reaching their decision. This was despite the case where both of these decision problems presented essentially have the same underlying information.

KEYWORDS

Context effects, strategy, uncertainty

INTRODUCTION

Decisions, decisions, decisions! We are faced with many decisions every day, with or without realising it. Depending on the type of decisions we make, some require little effort while others require much deliberation. Typically, making a decision involves a cognitive process of choosing among a set of options based on information available. However, our ability to make a rational or an informed choice can be challenging at times due to our 'bounded rationality' (e.g. Simon, 1955; March & Simon, 1958; Thaler, 2000; Gigerenzer & Selten, 2001) and limited information processing capacity (Hogarth, 1987). This often leads to the use of 'satisficing' approaches (Simon, 1955), strategies that are considered suboptimal (Slovic, Fischhoff & Lichtenstein, 1977) or heuristics (e.g. availability, representativeness, anchoring & adjustment) leading to their associated biases (e.g. Kahneman & Tversky, 1973; Tversky & Kahneman, 1974; 1983; Nisbett & Ross, 1980; Dawes, 1988; Ariely, 2008). In addition, 'fast and frugal' heuristics (Gigerenzer & Goldstein, 1996) may also be activated as means to navigate through and overcome our information processing needs.

Past research also demonstrates that our decision making is heavily impacted and even biased by how information is presented, commonly referred to as framing effect (Tversky & Kahneman, 1981). As such, the decision strategies applied on a particular problem in determining the decision choice will largely depend on how we perceive and process the information representing the decision problem (Payne, Bettman & Johnson, 1993). These streams of research emphasise two crucial issues in our continuing quest to understand human decision making behaviour: how decisions are actually made and what elements of the decision problem can potentially influence decisions. Putting these into perspective, it draws our attention to the potential influence presented information may have on the decision making process. Take for example the following decision problems (Figure 1 & Figure 2):

You are in a casino and you've just bet \$62.50 on a new sequential lottery game kind of like "Keno," in which The House draws numbers from a bingo cage. The game involves betting against other players and the house on which numbers will be drawn.

You have lost the first bet. You can quit now and your losses will be \$62.50. Your other choice is to continue playing the game. If you play again the stakes are higher because other players have been betting too. If you continue, then you enter a two-stage lottery. In the first stage, you have a 50% chance of winning. That would leave you with total winnings of \$125 more than when you started and you are finished. However, there is a 50% chance that you will move on to a final lottery. In the final stage there is a 75% chance of losing everything, bringing your total losses to \$300. There is a 25% chance that you will "win" in the final stage. If this happens, then you will have total losses of \$100.

Given the choices above, do you choose to continue to play the game or quit assuming that both choices are equal in terms of fees, taxes and convenience?

Figure 1: Gamble Problem (Rettiger & Hastie, 2001).

You are given a speeding ticket with a \$62.50 fine. When you pay the fine you include a letter complaining to the traffic judge because you feel you were ticketed "unfairly". You get a letter back from the traffic judge explaining that because of your letter, your case is being given special consideration. In the letter, the judge offers you the opportunity to either plead "guilty" or "not guilty" to the ticket even though you have already paid a fine.

You must decide whether to plead guilty or not guilty. If you plead guilty, then you have already paid your \$62.50 fine, but you must go down to the courthouse and fill out paperwork waiving your right to a hearing. The letter explains that this will take about 2 hours. If you choose to plead not guilty you will get your earlier fine back, then you will have a hearing. You might be found not guilty (50% chance) at your hearing. If you are found not guilty, then you will be able to get \$125 as a settlement for your "false arrest". If you are found guilty (also a 50% chance), you will be fined. There is a 75% chance that your fine will be \$300 and a 25% chance that it will be \$100. The letter says that the hearing will take about 2 hours.

Assuming that the information above is correct, and that both options are otherwise equal in terms of fees, taxes and convenience, do you choose to plead guilty or not guilty?

Figure 2: Traffic Offence Problem (Rettiger & Hastie, 2001).

Which options will you choose when presented with the above problems? von Neumann and Morgenstern (1944) will assert that your choices between the problems will be normatively consistent (i.e. either quit the game and plead guilty, or continue playing the game and plead not guilty). This is because they are essentially the same; just described under a different context (i.e. gamble vs. traffic offence). However, Rettinger and Hastie (2001) found that the context of the decision problem actually influences how the participants process the information presented which in turn affect their decision outcomes. Their results demonstrate that majority of the participants (i.e. 80%) select the certain (safe) option (i.e. quit the lottery game and accept the initial loss) over the uncertain (risky) option (i.e. continue playing the game where the chance of winning/losing can be higher than the initial loss) when presented with the decision problem under a gamble context (Figure 1). When the same underlying decision is presented under a traffic offence context (Figure 2), 52% of participants select the certain option (i.e. plead guilty to speeding and pay the initial fine) over the uncertain option (i.e. plead not guilty and take the chance of getting a higher settlement or end up with a higher initial fine). They argue that this difference in choice outcomes recorded is due to a change in the problem's context. This change in context shapes the participants' mental representation of the problem, thereby resulting in different strategies being adopted to process the information presented. For example, their results reveal that the avoid-the-worst strategy (41%) dominates the gamble problem whereas the moral strategy (e.g. considering the "right or wrong" of the situation) (37%) dominates the traffic offence problem amongst other numerical (e.g. calculation) and narrative (e.g. regret) strategies recorded. Perhaps, also suggesting a reflection of the multiple attributes involved in the traffic offence problem (e.g. getting a traffic infringement record and having to pay a higher insurance premium in the future) beyond just monetary loss as in the gamble problem.

The decision problem examples highlighted above suggest that context matters. A change in context changes people's decisions by altering how the options are being processed and evaluated. This change in context essentially changes the meaning of the (same) information presented which results in participants using different strategies to address the same decision problem. Their findings appear to suggest that context impacts on people's mental representation of the decision problem resulting in their use of different strategies to process the information presented.

Looking beneath the context, the *framing effect* introduced by Tversky & Kahneman (1981) also contributes to the finding that people exhibit systematic biases when making decisions under uncertainty (e.g. Tversky & Kahneman, 1974; Das & Teng, 1999; Goodwin & Wright, 1994; 2004). For example, the recorded systematic decision biases result from how information pertaining to the options (e.g. the probabilities and outcomes) is framed. That is, people tend to prefer the safe (certainty) option when the options available are framed as gains, while the risky (uncertainty) option is preferred when they are framed as losses. However, when the emphasis is placed on the probabilities instead of the gains and losses frame, the biases disappear (Bless, et al., 1998). These evidences suggest that our ability to make effective decisions under uncertainty is also contingent upon the way and how the uncertainty information is communicated (e.g. Remus & Simkin, 1987; Makridakis, 1988; Kydd, 1989; Payne, Bettman & Johnson, 1993; Weber & Johnson, 2009), and whether the probabilities or outcomes are viewed to be more important (Shavit, Rosenboim & Shani, 2013). After all (as the problem examples cited earlier suggest), making a decision requires the presented information pertaining

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ECONOMIC ASSESSMENT OF COMPONENTS REUSE FOR REMANUFACTURING

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ABSTRACT

Remanufacturing strategies receive increasing attention as manufacturers are eager to achieve sustainable supply chain management. However, due to the complex cost structure and the demand of increasing product variety, few manufacturers can obtain benefits from re-manufacturing strategies. We propose an integrated approach based on a quantitative decision model to assess the economic aspects of component reuse for remanufacturing management. Our work not only supports manufacturers to evaluate the total cost savings of component reuse but also addresses the issues of securing the return rate of used components and the restoration of the value of components from end-of-life products. We derived the optimal acquisition cost of reusing components from the decision model, which considers a number of cost factors. Then, we identified the component commonality effects to quantify the component reuse rate. Finally, our models and results are illustrated with an industrial case study. Accordingly, the total cost saving opportunities from reusing components could be achieved with 25% of manufacturing cost offered to acquire the used products from customers at a low reverse logistics cost.

Keywords: Remanufacturing; Component reuse; Economics model

1. INTRODUCTION

Sustainability issues in the manufacturing industry have attracted increasing global attention from industry and academia, particularly for the electrical and electronic products, household appliances, automobiles and industrial machinery. In the US alone, 47.4 million computers, 27.2 million televisions and 141 million mobile devices reached the end of their lives in 2009, and the total weight of end-of-life electronics was 2.37 million tons, an increase of more than 120% compared with that in 1999 (EPA 2011). In China alone, about 6 million automobiles reached the end of their useful lives before 2006 (Chen and Zhang 2009). To resolve these environmental challenges, remanufacturing has been widely recognised as a key strategy and defined in the literature (Lund 1984; Sundin 2004; Gray and Charter 2008, Sutherland et al. 2008) with a boarder view on managing various parties in the closed-loop supply chain network (Devika et al. 2014) recently.

Remanufacturing starts with the take-back of end-of-life products from customers as feedstock, which are then disassembled to appropriate component levels and reprocessed by remanufacturers so that the components perform the same function as new components. These reprocessed components with like-new performance are reused in reassembly to produce remanufactured products to satisfy the customer. One of the typical successful cases of remanufacturing is that of the Kodak single-use camera (Wheelwright and Clark, 1992, 1996). Kodak single-use cameras have become the cornerstone in recycling, reuse, and remanufacturing since 1990. By 1994, Kodak captures more than 70% of the U.S. market, with a recycle rate of 70% in US and 60% worldwide. The high recycle rate is due to massive redesign efforts that led to a 77-86% by weight rate of Kodak single-use camera parts being reused or recycled. To summarise, remanufacturing can be defined as an industrial process for an end-of-life part or product to return it to like-new or better performance (United States International Trade Commission 2012).

Our works in this paper are motivated by the emerging industrial issues and challenges in the new product development and remanufacturing sectors. The issues of rapidly evolving technologies, intensive global competition, and more demanding customers have forced manufacturers in a wide range of industries to increase the variety of products, however, causing component reuse in remanufacturing to be inefficient, and difficult to quantify the total remanufacturing costs of reusing components. Firstly, compared with the original manufacturing, there are additional constraints and uncertainties associated with the feedstock in remanufacturing because the return of end-of-life products from individual customers is an independent and stochastic event. Secondly, the volume of remanufacturing is relatively low due to the lack of customer participation, inefficient reverse logistics infrastructure, and competition from second-hand markets. Finally, the ability to customise remanufactured products is required to offer high product variety to increase customer evaluations of remanufacturing. All of these emerging issues involved in remanufacturing can be best dealt with during the product design phase because product design plays the deciding role for various issues in a product's lifecycle such as cost, quality and scheduling. For example, it is argued that as much as 70% of the product life cycle cost can be determined in product design (Barton et al. 2001). Therefore, it is of paramount importance to contemplate remanufacturing, which considers the economic trade-offs among various cost factors and the component commonality effect by a systematic methodology. This

paper presents an integrated approach to assess the economic effect of component reuse in a product family for the better management of remanufacturing.

To enhance the chance of component reuse for remanufacturing, the design for component commonality or component sharing (Thevenot and Simpson 2006) in a product family is regarded as an effective strategy to mitigate the negative effects of product variety while ensuring manufacturers' competitive advantage in the market (Fisher et al. 1999; Desai et al. 2001; Bernstein et al. 2011). Although some new aspects of component commonality in product variety management have been investigated, such as behavioural costs in the manufacturing environment (Brun et al. 2009), to the best of our knowledge, the underlying effect of component commonality on component reuse in remanufacturing management has scarcely been studied. This motivates us to bridge the research gap with this paper by developing an economic decision model.

The remainder of the paper is organised as follows. Section 2 presents a review of the literature concerning remanufacturing, product design and component commonality. Section 3 describes the economic decision model which is used to quantify the potential cost saving from component reuse in remanufacturing. We formulate the total cost of reusing components in the remanufacturing supply chain as a constrained nonlinear optimisation problem. Section 4 provides an industrial case study of bulldozer remanufacturing to demonstrate the applicability of our developed methodology. Section 5 concludes with a brief discussion of the overall results.

2. LITERATURE REVIEW

2.1 Remanufacturing

Remanufacturing has been a consistent focus of research in a variety of disciplines. The environmental benefits associated with remanufacturing, such as savings in resources and energy, are commonly reported (Kerr and Ryan 2001; Giuntini and Gaudette 2003; Smith and Keoleian 2004; Sutherland et al. 2008) with the extended relationship to other operational key performance indicators such as assembly rate, level of inventory and production capacity in the closed-loop supply chain (Asif et al. 2012). Meanwhile, industrial cases have been studied to illustrate the economic profitability of remanufacturing (Ayres et al. 1997; Giuntini and Gaudette 2003; Guide et al. 2003; Lebreton and Tuma 2006). However, to facilitate the understanding of product designers, our literature review of remanufacturing is subdivided into two sequential but interrelated subareas along the remanufacturing supply chain, reverse logistics and remanufacturing production planning and control, respectively.

2.1.1 Reverse Logistics

Reverse logistics was defined in the literature as 'a process by which a manufacturing entity systematically retrieved previously shipped products or parts from the point of consumption for possible recycling, remanufacturing or disposal' (Dowlatabadi 2005). Other similar descriptions were suggested (De Brito and Dekker 2004). In this regard, remanufacturing served as one of the key drivers among many for reverse logistics operations. We focused on two aspects of reverse logistics that particularly pertain to remanufacturing.

The acquisition of end-of-life products as feedstock was studied extensively in remanufacturing management. Through an industrial case study of power tools in Germany, the appropriate budget in reverse logistics, which was allocated through the buy-back of used

products from customers, was analysed to maintain the profitability of remanufacturing (Klausner and Hendrickson 2000). The characteristics of two end-of-life product acquisition systems, waste stream and market-driven, respectively, were compared in terms of profitability in remanufacturing (Guide and Van Wassenhove 2001). Seven types of relationships with customers to take back used products were identified, with discussions regarding both the advantages and disadvantages of each type to achieve better remanufacturing management (Ostlin et al. 2008). Meanwhile, the optimal acquisition quantities of used products were determined by solving trade-offs between acquisition costs, scrapping costs and remanufacturing costs and uncertainty about the condition of returned products together (Galbreth and Blackburn 2010).

Several works focused on formulating mixed integer programming models to address reverse logistics network design problems and to determine the optimal numbers and locations of remanufacturing facilities, simultaneously considered both forward and reverse flows (Jayaraman et al. 1999; Fleischmann et al. 2001; Lu and Bostel 2007; Demirel and Gokcen 2008). Moreover, supply uncertainty in the quantity and quality of returned used products was identified as a major distinction between the reverse logistics network and the traditional forward logistics network (Fleischmann et al. 2000). Some of the recent researches focused on the management of product return among multi-echelons in the closed-loop supply chain network. The decisions of manufacturers, retailers and the third party were analysed in competitive and co-operative situations (Chen et al. 2012; Huang et al. 2013). The optimal strategies of letting the third party firm remanufacture the returned products to the second market were identified.

2.1.2 Remanufacturing Production Planning and Control

A survey in the remanufacturing field focused on an integrated framework in production planning and control including disassembly operations, production planning and scheduling, and inventory control and management (Guide et al. 1999). Inventory control, as a hybrid system of both manufacturing and remanufacturing, was investigated by comparing the long-run average inventory and production costs under push and pull strategies based on numerical studies (van der Laan et al. 1999). Based on another survey, industrial practice and research needs were characterised by seven complicating characteristics of remanufacturing (Guide 2000). An integrated material planning system was developed on material requirements planning logic to manage supply and demand in a remanufacturing facility (Ferrer and Whybark 2001). Since the quality of returned end-of-life products was critical to reprocess operations in remanufacturing management, the value of quality grading of returned end-of-life products was examined in remanufacturing production planning and inventory management by stochastic dynamic programming model, and total profit could be increased by an average of 4% due to a quality grading scheme based on common settings in the remanufacturing industry (Ferguson et al. 2009). Variation and uncertainty in the return of end-of-life products can be mitigated by a hybrid simulation optimisation method to maximise the total remanufacturing profit by deriving an optimal production policy, inventory control policy and resource allocation for remanufacturing (Li et al. 2009). Reassembly and inventory control policy was formulated as a Markov decision process to minimise the average cost related to uncertainty about the timing, quantity and quality of used product returns (Jin et al. 2011). Rather than focused on the entire product, a multi-

component inventory problem in remanufacturing was modelled to determine an optimal mix of remanufacturing and manufacturing to fulfil demand (El Saadany and Jaber 2011). Some of the recent researches also focused on setting dynamic prices (Chen et al. 2013; Xiong et al. 2014) to influence the demands of new and remanufactured products with the considerations of lost-sales, price dependent returns, random demand and uncertain quality.

2.2 Product Design Guidelines for Remanufacturing

As life cycle thinking and environmental concerns gained more attention, researchers had started to consider issues such as disassembly, material recycling and the environment (Boothroyd and Alting 1992; Fiksel and Wapman 1994; Shu and Flower 1999; Kuo et al. 2000; Hauschild et al. 2004). Some researchers (Kwak 2012 et. al., Zhao 2010 et. al., Ramani 2010 et. al.) also tried to integrate product design specifications into the market value evaluation for the whole product life cycle management. The Remanufacturable Product Profile (RPP) was established based on both remanufacturing contexts and remanufactured products properties from 25 products that were remanufactured in industry (Zwolinski et al. 2006). Design guidelines were provided for product designers to improve the internal technical attributes of products from a remanufacturing perspective. Case studies on both the mechanical and electromechanical sectors of the UK manufacturing and remanufacturing areas discussed the incentives of and barriers to remanufacturing (Ijomah et al. 2007). Based on the authors' interviews and observations, profitability was recognised as the primary remanufacturing incentive, whereas barriers to remanufacturing included various issues related to cost, design characteristics, disassembly, materials, access to components, component identification and assembly process. These product design considerations not only affected the management of developing new products, but also the scope of component reuse.

2.3 Component Commonality Effects

Component commonality referred to the use of the same version of a component across multiple products (Fisher et al. 1999). In the literature, component commonality was extensively discussed in different disciplinary domains such as in product family design for mass customisation (Jiao and Tseng 2000), product platform design in custom products (Farrell and Simpson 2003) and the evaluation of design commonality in product families (Kota et al. 2000), among others. However, more traditional research on component commonality started with the economic effects of component commonality, and considered both cost and revenue. Because the component commonality effect on revenue was mainly concentrated on a pricing strategy based on customer preferences for component commonality, it was regarded as being beyond the scope of our research. Therefore, we focused exclusively on the cost effect of component commonality, which could be subdivided into two major streams: the risk pooling effect in inventory management and the economies of scale effect on cost trade-offs in component variety management.

A mathematical model was developed since 1980s to explicitly analyse the relationship between service levels and component safety stocks due to the risk of the pooling effect of

common components in a two-product, two-level, single-period inventory management setting (Baker et al. 1986). Since then, research efforts were directed at extensions of the basic model by incorporating many factors related to demand, such as multiple products, multiple periods, the cost benefits of dual sourcing, product-specific demands and a common component allocation algorithm (Gerchak et al. 1988; Hillier 2000, 2002; Mirchandani and Mishra 2002; Agrawal and Cohen 2001). The other research stream took the perspective of component supply and investigated the effect of component commonality associated with supply uncertainty due to lead times (Mohebbi and Choobineh 2005; Song and Zhao 2009).

According to the literature reviews, it was found that the economic decision models in remanufacturing at the component level were not established, and the variety associated with end-of-life product return had not been addressed yet. This paper aims to bridge these research gaps by integrating all decisions into an economic model with the illustration of a case study.

3. ECONOMIC MODELS OF COMPONENT REUSE IN REMANUFACTURING SUPPLY CHAINS

3.1 Problem Description in the Remanufacturing Supply Chain

Remanufacturing supply chains start with the taking back of used products from customers as feedstock, which can be formulated in a closed-loop product life cycle, as shown in Figure 1. Instead of direct disposal, end-of-life products are taken back via reverse logistics from customers through a series of remanufacturing operations that are integrated into the original value chain to form a closed-loop life cycle.

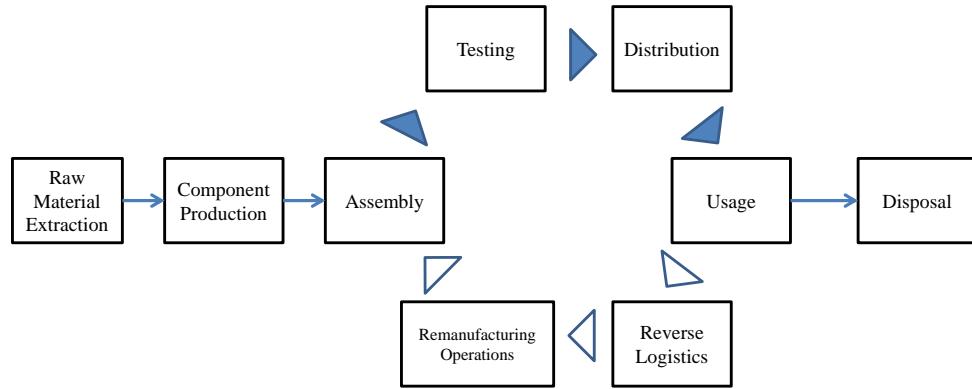


Figure 1. Closed product life cycle with remanufacturing

In this way, component reuse in remanufacturing can alleviate the enormous consumption of raw materials and energy by avoiding new component manufacturing, while simultaneously diminishing the amount of waste generated from end-of-life product disposal. Moreover, the salvage value of used components, which have already gone through a series of value-added activities in the initial manufacturing process, can be sustained, and this makes component reuse more economical than material recycling. To this end, the sufficient and efficient reuse of

components from end-of-life products is the foundation of potential environmental and economic benefits of remanufacturing.

However, in the context of remanufacturing management, securing a higher return rate for sufficient availability of end-of-life products in remanufacturing requires additional acquisition costs which inflate the cost of component reuse. This acquisition cost differs from the cost in marketing programs to acquire customers buying new products, as the cost in the remanufacturing management is generally in the form of a rebate paid to customers for returning the end-of-life products. Therefore, the right amount of end-of-life product return needs to be determined as sufficient feedstock for remanufacturing at the right cost structure within the supply chain. Figure 2 describes the process of reusing components for remanufacturing.

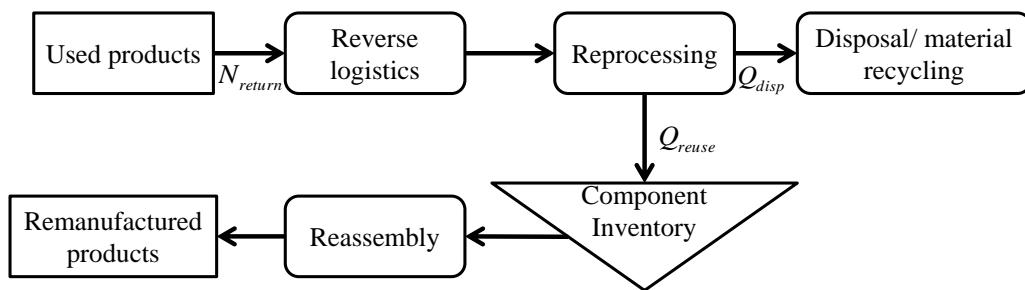


Figure 2. Component flows in remanufacturing supply chain and operations

In the remanufacturing process, products are disassembled into separate components and refurbished to return their functionality to original levels. The refurbished components are then reassembled and placed back on the market. The remanufacturing operations generally include disassembly, cleaning, refurbishing and quality control testing. Used products that cannot be remanufactured are disposed directly. The main problem is the collection and refurbishing processes, from the input volume of the used products' return rates to the output rates for reuse and disposal. Cost factors and various remanufacturing variables must be considered to make appropriate decisions.

3.2 Model Formulation to Achieve Cost Savings from Component Reuse

The objective of our model is to identify the optimal acquisition cost of recalling used products for the purpose of remanufacturing to achieve cost savings. We define the notation of the cost factors and variables as follows.

Cost factors

c_{ac}	: component acquisition cost
c_{disp}	: component disposal cost
c_{rev}	: component reverse logistics cost
c_{rep}	: component reprocessing cost
c_{man}	: component manufacturing cost
$c_{penalty}$: component penalty cost

Parameters

π	: component quantity per product
CI	: customer incentive (salvage value)

Variables

β	: reuse yield rate of component
Q_{reuse}	: reuse rate of component
Q_{disp}	: disposal rate of component
N	: demand rate of product
N_{return}	: return rate of product
N_{rem}	: remanufacturing rate
M	: remanufacturing quantity
R	: return rate of components

We refer to index β as the reuse yield rate of component C , which is jointly determined by the physical characteristics of the components and the reprocessing technologies applied during the remanufacturing process. The relationships between Q_{reuse} , Q_{disp} , N_{return} and π are formulated as follows:

$$\beta = \frac{Q_{reuse}}{Q_{reuse} + Q_{disp}} = \frac{Q_{reuse}}{\pi N_{return}} \quad (1)$$

Because the reuse yield rate is imperfect when components are disassembled from returned products, the total cost incurred by component reuse during the remanufacturing process includes two portions of reusable and non-reusable components as follows:

$$TC_{reuse} = (c_{ac} + c_{rev} + c_{rep})Q_{reuse} + (c_{ac} + c_{rev} + c_{rep} + c_{disp})Q_{disp} \quad (2)$$

The total cost consists of the unit component acquisition, reverse logistics, reprocessing and disposal costs in terms of the component reuse and disposal rates. The cost savings resulting from component reuse are achieved when the total cost of reusing the components is less than the cost of producing the same products using new equivalent components. The cost savings in some countries are enhanced by legislation, e.g., extended producer responsibility (OECD 2001), which penalises manufacturers that do not reuse components in their new products. Hence, the total cost savings (CS) is calculated as follows:

$$CS = Q_{reuse} [c_{man} + c_{penalty} - (c_{ac} + c_{rev} + c_{rep})] - Q_{disp} (c_{ac} + c_{rev} + c_{rep} + c_{disp}) \quad (3)$$

To identify the relationships between the different cost factors and the component manufacturing cost, we convert all of the cost parameters related to the component manufacturing costs by the respective indicators, where all of the indicators are non-negative numbers: $c_{ac} = \alpha c_{man}$; $c_{penalty} = \rho c_{man}$; $c_{rev} = \mu c_{man}$; $c_{rep} = \gamma c_{man}$; $c_{disp} = \sigma c_{man}$. CS can thus be rewritten as follows:

$$CS = Q_{reuse} \left[1 + \rho - \frac{1}{\beta} (\alpha + \mu + \gamma) - \frac{1-\beta}{\beta} \sigma \right] c_{man} \quad (4)$$

Our objective is to maximise the cost savings function by determining the optimal acquisition cost of c_{ac} over the period. The necessary criterion therefore becomes:

$$\left[1 + \rho - \frac{1}{\beta} (\alpha + \mu + \gamma) - \frac{1-\beta}{\beta} \sigma \right] > 0 \quad (5)$$

Without the loss of generality, we consider the case of one component of a single product to identify the optimal component quantity for reuse. Once this case has been solved, a similar approach can be applied to identify the optimal acquisition cost for a case involving multiple components by modifying the corresponding cost parameters. To illustrate the mechanism used to identify the optimal acquisition cost, we consider a problem setting based on the following assumptions. First, we assume that the market demand is sufficient for remanufactured products. Second, we assume that the product demand rate does not vary greatly and is at a stationary level during a planning horizon T . Third, with the considerations of product sales and return and yield rates, we assume that remanufactured products available in the market after a certain time delay τ due to the product usage and reverse logistics lead time. Considering this product return rate and the component quantity per product, denoted by π , the total volume of reused component Q'_{reuse} can be calculated as follows:

$$Q'_{reuse} = \pi N_{rem}(T - \tau) = \pi \beta N_{return}(T - \tau) \quad (6)$$

In practice, the return rate of end-of-life product from customers is closely related to the economic incentives offered by remanufacturers, which is here termed the acquisition cost. In the literature, there are two ways of modelling the relationship between the return rate and acquisition cost. The first approach is to apply a return response function, where a linear relationship is assumed between the return rate and acquisition cost (Minner and Kiesmüller 2011; Kaya 2010; Bakal and Akcali 2006). The second approach is called customer surplus, where each individual customer maintains a reservation incentive for their end-of-life products and only when the acquisition cost is higher than the reservation incentive will the customer be willing to return end-of-life products to remanufacturers (Aras and Aksen 2008; Ray et al. 2005). We consider a customer surplus method because this is a more generalised way of considering end-customer behaviour. In other words, our response function will not be limited by the linear relationship between acquisition cost and the return rate. Instead, we will derive a response function. Given that customers are heterogeneous by nature, we follow a uniform distribution of the reservation incentives of individual customers to capture the randomness. The customer surplus of returning one component C from used products is equal to $c_{ac} - CI$, where CI refers to the reservation incentive for component C in a product returned by an individual customer. For the purposes of illustration, we assume that the customer reservation incentive CI follows a uniform distribution in the interval of $[a, b]$.

The return rate of component C is then equal to the probability that an individual customer will return his or her end-of-life components, which can be represented as follows:

$$R = \Pr(c_{ac} - CI > 0) = \frac{(c_{ac} - a)^+}{b - a} \Rightarrow R = \begin{cases} 0 & \text{for } c_{ac} < a, \\ \frac{c_{ac} - a}{b - a} & \text{for } a \leq c_{ac} \leq b \\ 1 & \text{for } c_{ac} > b \end{cases} \quad (7)$$

In this circumstance, by further considering that the remanufacturing quantity would be less than the return rate over the period $M \leq TN_{return}$, the total cost savings can be formulated as follows.

$$\max_{c_{ac}} CS = \begin{cases} Q'_{reuse} \left[1 + \rho - \frac{1}{\beta}(\alpha + \mu + \gamma) - \frac{1-\beta}{\beta}\sigma \right] & \text{for } a < c_{ac} \leq b, \\ 0 & \text{for } 0 \leq c_{ac} \leq a \end{cases} \quad (8)$$

$$\text{s.t. } Q'_{reuse} \leq \frac{\pi BM(T - \tau)}{T} \cdot \frac{c_{ac} - a}{b - a} \quad (9)$$

Proposition: When $Q'_{reuse} = \frac{\pi BM(T - \tau)}{T} \cdot \frac{c_{ac} - a}{b - a}$, the total cost savings from component reuse in remanufacturing is strictly concave in terms of unit component acquisition cost. As a result, the optimal unit component acquisition cost can be determined as:

$$c_{ac}^* = \begin{cases} \min \left\{ \frac{a + [\beta(1 + \rho - \sigma) - (\mu + \gamma - \sigma)]c_{man}}{2}, b \right\}, & [\beta(1 + \rho - \sigma) - (\mu + \gamma - \sigma)]c_{man} > a; \\ 0, & \text{otherwise.} \end{cases} \quad (10)$$

This proposition indicates that the optimal acquisition cost has a closed-form solution subject to the market demand distribution in maximising the total cost savings from component reuse in remanufacturing. This result will support the identification of optimal return rate in the remanufacturing supply chain as product designers and remanufacturers can jointly apply this proposition to all target components for reuse in remanufacturing during the product design phase.

4. AN INDUSTRIAL CASE STUDY OF BULLDOZER REMANUFACTURING

Our methodology is applied to bulldozer remanufacturing based on a field study of a bulldozer manufacturing group in China.

4.1 Field Study

Bulldozer remanufacturing is one of the key remanufacturing industries in China. We collaborated with a bulldozer manufacturer that plans to enter the remanufacturing business. During the field study, we held comprehensive meetings with their top management and engineering team, including the general manager, vice president, plant managers, product designers and engineers. A site visit to the shop floor of a transmission production line and bulldozer assembly line was also carried out and was followed up by the introduction and application of our methodology.

During the field study, we learned that the company is manufacturing a large product family of bulldozers, including more than 120 types of product variants in the market. Transmissions are the target components for reuse in bulldozer remanufacturing, and the variety of transmissions in the bulldozer family is very high, with as many as 33 variants. The issue of high variety present a critical challenge for the company in terms of remanufacturing management, because they cannot evaluate the return rate of end-of-life products, in addition to the relationship between acquisition cost and reverse logistics cost.

4.2 Determining Optimal Acquisition Cost for Transmissions in Used Bulldozer

For the purpose of illustrating our methodology, we apply our methodology to bulldozer remanufacturing based on our field study with the following steps. According to the company's survey, to get end-of-life transmissions back from the customers, the acquisition cost is needed to pay customers would be between 10%-25% of the manufacturing cost of new transmissions, which corresponds to the lower and upper bounds of the customers' reservation incentive respectively. Another cost-factor concern of the company is the overall reverse logistics cost, which would significantly affect the cost savings potential of transmission reuse in remanufacturing and even the overall remanufacturing strategy of the company. Other factors in the overall cost structure of the bulldozer remanufacturing supply chain related to transmissions are estimated as follows:

- The reprocessing cost of each transmission is 40% of the manufacturing cost.
- The disposal of transmissions as material recycling for those, which cannot be reused, costs 1% of the manufacturing cost.
- The reuse yield rate of transmissions is 80%. If stable demand is assumed, according to our proposition, the optimal acquisition cost of transmissions to maximise total cost savings can be determined from the reverse logistics cost, as illustrated in Figure 3.

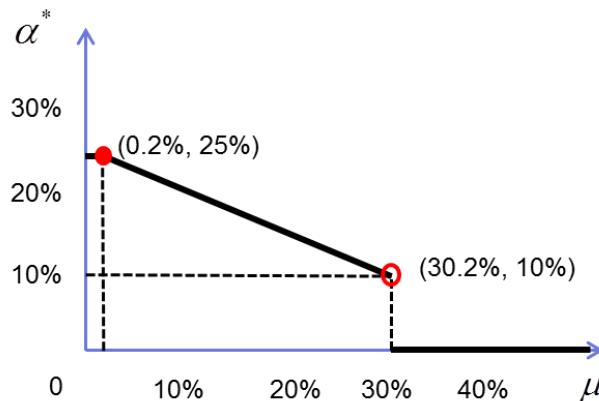


Figure 3. Optimal acquisition cost of transmissions in end-of-life bulldozers

It can be observed from the figure that there is a mapping relationship between the optimal acquisition cost and reverse logistics cost. When the reverse logistics cost is beyond 30.2% of the manufacturing cost of transmissions, it is economically optimal not to reuse transmissions in bulldozer remanufacturing, because the optimal acquisition cost is below the lower bound of the customer reservation incentive (10% of manufacturing cost). However, if the reverse logistics cost can be further lowered to below 0.2% of the manufacturing cost, then all of the transmissions in end-of-life bulldozers should be reacquired from customers by offering the upper bound acquisition cost to customers to achieve maximum cost savings from transmission reuse in bulldozer remanufacturing. In this case, the cost saving opportunity occurs how the acquisition cost is lower than 25% of manufacturing cost.

5. CONCLUSIONS

This paper presents an integrated approach, with the considerations of various key cost factors in the remanufacturing operations and the component commonality effect in the product design, to assess the economic effect of component reuse for more effective remanufacturing management. Formulated all major considerations into the economic decision support model, we derive a closed-form optimal solution for maximising the total cost savings from component reuse compared with equivalent new component, and also quantifying the component reuse and commonality effect in a product family systematically. Illustrated the methodology via an industrial case study, we identify the optimal acquisition cost and the cost relationship with the reverse logistics cost, in which 25% of manufacturing cost offered to acquire the used products from customers will achieve the cost savings from remanufacturing components if the reverse logistics cost is low. Such results in the closed-form solution assisted remanufacturers to decide the acquisition cost given internal operational costs. The case study solution result also suggests that the remanufacturer should invest on the acquisition activities to incur higher return rates when the cost of reverse logistics and reprocessing is potentially low. In other words, the efficiency improvement in reverse logistics and reprocessing operations would indirectly increase the return rate of used products due to the higher affordable cost of acquisition. Apart from the focuses on reverse logistics and reprocessing operations efficiency, the product design which determines the component commonality in a product family would also have critical impacts on the total quantity of component reuse. The relationship between the costs of acquisition, reverse logistics, reprocessing in the optimal status and the quantity of component reuse with the component commonality effect in the product design is established in this paper as a quantitative guideline for industrial practitioners in managing both product design and remanufacturing operations in the closed-loop supply chain.

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The Effects of Location-based Mobile Marketing between Push and Pull on Usage Intentions

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Abstract

Location-based communication has been increasingly applied in marketing. This paper investigates the relations of location-based mobile marketing (LBMM) to usage intentions. Firstly, we carried out a pretest carefully to confirm the representative variable of Push-LBMM. The pretest based on a between- subjects design. Results indicated that the effects of opt-in and opt-out on usage intentions were significantly different, and opt-in led to higher usage intentions. Therefore, we chose opt-in Push-LBMM to represent Push-LBMM in the formal experiment. We find that Pull-LBMM is associated with higher usage intention as compared to Push-LBMM. We also find that technology acceptance plays a mediating role in the relationship between LBMM and usage intentions. Based on experimental results, theoretical and managerial implications are also discussed.

Keywords: Location-based mobile marketing (LBMM), Technology acceptance, Usage intension

Introduction

The recent years have seen a new form of marketing, called Location-based Mobile Marketing (LBMM). This marketing method relies on an integrated use of Global Positioning System (GPS) and Geographic Information System (GIS) technologies to offer marketing information to consumers based on their current locations (Lin, Huang, Chang, and Jheng, 2013). Unlike the traditional retail methods,

LBMM uses mobile phones as the medium of communication to provide location-specific information instantly based on consumer's preferences and needs. Therefore, it has been recognized as an effective marketing approach.

In response to this market tendency, many businesses have developed their own LBMM services. For instance, Jiepang (<http://jiepang.com>) partnered with Starbucks in 2010 to create a win-win situation for both Starbucks and consumers by introducing a program that encourages and rewards togetherness of consumers. Many local companies, such as Chunshuitang and Vieshow Cinemas, are working with Chunghwa Telecom to push promotional text or multimedia messages to consumers and capture consumers' needs as consumers come near their stores. Location detection in this marketing approach is achieved by making use of Chunghwa Telecom's base stations. Despite the promising future of LBMM, it is still at a fledgling stage in Taiwan mainly because consumers' lack of knowledge about LBMM has limited their intentions to use it. Therefore, how to increase consumers' knowledge of the benefits of LBMM and motivate their use of LBMM is a challenge for businesses (Shankar, Venkatesh, Hofacker, and Naik, 2010). The relationship between LBMM and consumers' usage intentions is the main issue of this study.

In LBMM, information is provided in two approaches, namely Push and Pull (Unni and Harmon, 2007; Xu, Oh, and Teo, 2009). The Push approach is to track the location of users of mobile devices and send location-specific information to them without their request for the information. In contrast, the Pull approach is to deliver location-specific information only on user demand. In the present, consumers in Taiwan still have limited knowledge of the benefits of these two marketing approaches, and little domestic research has addressed this issue as well. Hence, the focus of this study is to explore the effects of the two LBMM approaches on usage intentions. Besides, previous research has shown that the Pull approach, as compared to the Push approach, has higher perceived value as it offers higher customization and creates less irritation (Edwards, Li, and Lee, 2002). However, Institute for Information Industry (III) (2010) pointed out that due to cultural differences, Taiwanese consumers do not have the habit to seek information actively, so consumers' intentions to use pull LBMM have been inhibited. This is also a question to clarify in this study.

Despite the fact that information systems are extensively applied to management of time and financial resources, there is usually an enormous gap between expectation and perception of the performance of a new information system (Shani and Sena, 1994; Clegg et al., 1997). As a result, user acceptance has been recognized as a key foundation of most information management programs (Igbaria, Schiffman, and Wieckowski, 1994) and a challenging issue (Paré and Elam, 1995). Davis and his

research fellows (Davis, 1989, 1993; Davis, Bagozzi, and Warshaw, 1989, 1992) found that Technology Acceptance Model (TAM) can be extensively applied to explaining the psychology behind technology adoption (Mathieson, 1991; Taylor and Todd, 1995). They suggested that some exogenous variables (e.g. system experience, education, and age) affect actual use only through perceived usefulness (PU) and perceived ease-of-use (PEOU). Some scholars have also obtained findings that support the influence of PU and PEOU (Hackbarth and Grover, 2003; Burton-Jones and Hubona, 2006). In light of rapid development of mobile technology, we find it necessary to analyze the mediating effects of PU/PEOU on LBMM and answer questions left unaddressed in previous research.

Theoretical Background

Development of mobile marketing

The population of mobile phone users around the world has exceeded 4 billion. Even in Africa, the penetration rate of mobile phones is around 40%. This rate is above 40% in many other nations, including Australia, New Zealand, Denmark, Ireland, Norway, Netherlands, Spain, Sweden, Switzerland, and England. The rate for the market in the USA is greater than 75%. In Hong Kong, Japan, and western Europe, it has even exceeded 100% as many subscribers possess multiple mobile devices (Hu, Balluz, Frankel, and Battaglia, 2010). The high penetrations of mobile phones have made mobile phones an important platform of communication between retailers and consumers. Marketing via this platform is called as “mobile marketing”. According to Mobile Marketing Association, mobile marketing is a set of practices that enable organizations to communicate and interact with their audience through any mobile device or network. Shankar and Balasubramanian (2009) defined mobile marketing as “the two-way or multi-way communication and promotion of an offer between a firm and its customers using a mobile medium, device or technology”. We can infer that interactive mobile marketing models will be increasingly important in the retail environment.

As corporate investment in traditional media such as newspapers, magazines, radio, and television as an advertising platform has drastically decreased by 10~20%, there is an 9.2 and 18.1% increase in Internet and mobile advertising respectively (Wray and Plante, 2011). Previous research of coupon delivery indicates that the redemption rate of print coupons has declined, and that of mobile and Internet coupons is comparatively higher (Wouters and Wetzels, 2006; Wray and Plante, 2011). Driven by the prospect of mobile marketing, many businesses are now using mobile marketing strategies to meet market demands (Scharl, Dickinger, and Murphy, 2005;

Wray and Plante, 2011). Estimates from eMarketer indicate that the advertising budget of advertisers is expected to increase from the current \$1.88 billion to \$3.08 billion by 2017, with a growing ratio of budgets going to mobile advertising (eMarketer, 2013b). In Taiwan, the population of mobile phone users has exceeded 29.45 million, and the penetration rate of mobile phones has also reached 126.2% as of September 2013 (National Communications Commission, 2013). III found in a survey on consumers' buying decisions that about 25% of consumers have reduced their reception of traditional advertising messages, and 33~40% of the respondents have the habit to receive advertising messages via mobile phones and the Internet (Institute for Information Industry, 2012). III also pointed out that the mobile services market is having a steady growth and will reach the maturity stage in five years.

Mobile marketing is not limited to marketing via text and multimedia messages. It also includes mobile application (App) marketing, Quick Response Code (QR Code) marketing, Bluetooth marketing, and location-based mobile marketing (LBMM). LBMM is a form of advertising that uses location positioning technology to provide instant and customized location-specific information to mobile device users (Lin et al., 2013). According to III (2010), LBMM is a form of mobile advertising that delivers messages that most consumers perceive as more positive and useful. Consumers are also more willing to check out more information about messages advertised through this method. Interactive Advertising Bureau (2013) saw an increase in revenue from mobile advertising by 150% compared to the previous year and projected a huge growth of mobile marketing coupled with location-based services. In response to this trend, many businesses in all sectors have been driven to boost their customer flow and sales by using LBMM (Butcher, 2010).

Location-based mobile marketing

LBMM is a form of marketing communication that uses location-tracking technology in mobile networks to target consumers with location-specific advertising on their mobile devices (Unni and Harmon, 2007). It is an application of location-based services (LBS), which is also an important innovative marketing technology. Through LBS, firms can deliver promotional information to consumers' mobile devices in a solicited or unsolicited manner, and consumers can check out or save the information instantly as long as they are within a specific area. As LBMM caters to consumers' individual needs, it can lead to higher sales performance, brand loyalty, and customer lifetime value (Shankar and Balasubramanian, 2009). Business analysts have estimated that the advertising effect of LBMM is at least 20 times greater than that of the Internet (Butcher, 2011). A survey on US consumers shows that 78% respondents use location-based applications on their phone, and 34% would

click on ads in response to location-specific messages (Skeldon, 2011). This result suggests a huge market potential for LBMM. According to Allied Business Intelligence Inc. (2009), the business revenue generated by LBMM would grow from US\$170 million in 2008 to approximately US\$140 billion in 2014.

LBMM advertises messages based on consumers' location and preferences. It can help consumers find the best deals offered by nearby stores, so more and more consumers are willing to share their location information in exchange for the benefits of LBMM (Skeldon, 2011; Wray and Plante, 2011). Applications of LBMM in the retail industry can be divided into two types, namely the push type and the pull type (Unni and Harmon, 2007; Xu et al., 2009). In Push-LBMM, the advertiser works with the mobile phone carriers to detect the location of its users and push messages directly to users. In this push approach, there are two ways that messages can be delivered, namely opt-in and opt-out. Opt-in suggests that users authorize the advertiser to send ads to them, so it is also called permission-based marketing. This marketing approach facilitates development of a better relationship between the advertiser and mobile phone users. Opt-out suggests that the advertiser sends ads to mobile phone users until the users ask not to receive any ads from the advertiser (Bruner and Kumar, 2007). The Pull-LBMM approach, in contrast, is to detect user location and send messages or deliver services only when the user requests for them (Unni and Harmon, 2007). As the push approach gives marketers a greater control over the advertising process, it is considered an effective approach to inducing impulse buying (Unni and Harmon, 2007). However, given a relatively smaller control over push ads, consumers are more likely to have negative evaluations of Push-LBMM (Xia and Sudarshan, 2002). Compared to Push-LBMM, Pull-LBMM allows for more customer participation and usually sets a limitation on the scope of customer consent, so it is considered more reliable and effective (Barwise and Strong, 2002; Shankar and Hollinger, 2007). After acquiring customer consent, retailers can deliver very targeted advertising messages to enhance their business performance (Blum and McClellan, 2006). Schlosser, Shavitt, and Kafer (1999) found that consumers are more influenced by the ads they search for than by unsolicited ads when making a buying decision (Kwak, Fox, and Zinkhan, 2002). It can be inferred that Pull-LBMM is better than Push-LBMM in terms of advertising effectiveness. Previous research has noted that Push-LBMM is more positively related to the perceived risk of information disclosure (Xu, Luo, Carroll, and Rosson, 2011). In Push-LBMM, given lower control over LBMM and fewer interactions with the advertiser, consumers are more likely to receive irritating messages and therefore perceive a lower value in this marketing approach (Xia and Sudarshan, 2002; Edwards et al., 2002). In contrast, LBMM has a higher perceived value. Therefore, we propose H1.

Besides, Technology Acceptance Model (TAM) (Davis, 1989; Davis, Bagozzi, and Warshaw, 1989) proposes that “beliefs, attitudes, intentions, and behaviors” have a causal relationship with potential adopters’ acceptance. In this model, perceived usefulness (PU) and perceived ease-of-use (PEOU) influence attitude toward using, which in turn affects intentions to use. Previous research has documented findings supporting that these two beliefs are the correlates of consumer behavior. For instance, it is found that PU is a key factor affecting adoption of a new technology or information system (Davis, 1989, 1993; Davis, Bagozzi, and Warshaw 1992; Mathieson, 1991) and also has a significant effect on consumers’ attitude toward using and intentions to use an online store (Chen, Gillenson, and Sherrell, 2002; Chen and Tan, 2004; O’Cass and Fenech, 2003; Vijayasarathy, 2004). In addition, PEOU is positively related to attitudes toward using an online store (Chen and Tan, 2004; Chen et al., 2002; Moon and Kim, 2001; O’Cass and Fenech, 2003; Vijayasarathy, 2004). Findings in Gefen and Straub (2002) also suggest that PEOU has a direct effect on intentions to use a new information technology. Since the focus of previous research has been placed mainly on the effect of technology acceptance on usage intentions, we will further examine the effect of PU and PEOU as mediators. We propose H2a and H2b as follows.

H1: Compared to Push-LBMM, Pull-LBMM can create higher intentions to use.

H2a: Compared to Push-LBMM, Pull-LBMM is associated with higher technology acceptance.

H2b: LBMM influences intentions to use through technology acceptance.

Pretest

This study is intended to explore and compare the effects of the two approaches of LBMM, namely Push-LBMM and Pull-LBMM, on intentions to use. Previous research has confirmed the importance of LBMM for today’s businesses. In this study, we attempted to obtain practical implications of LBMM in Taiwan’s retail market, so we conducted the experiment on mobile phone users in the retail market. Through the experiment, we could also analyze whether technology acceptance mediates the relation between this new marketing model and intentions to use. As mentioned earlier, Push-LBMM includes opt-in and opt-out approaches (Bruner and Kumar, 2007). To confirm the representative variable of Push-LBMM, we carried out a pretest carefully as follows:

Method and Procedure

A single-factor (Push-LBMM: opt-in vs. opt-out) between-subjects design was adopted. 44 marketing undergraduate students at a university of science and technology in Southern Taiwan participated in Pretest in exchange for course credit. All the participants were escorted to a store layout and planning laboratory, they had to be randomly assigned to the opt-in and opt-out scenarios. In the opt-in scenario, they were asked to imagine that a popular convenience store on campus is planning to launch the mobile coupon subscription service. It encourages consumers to join the program as follows: "Whenever you come into any area within one kilometer radius of the store, we will send ads of promotional items of the day to your mobile phone. If you agree to subscribe to this service, please provide your name and telephone number. We will sign you up. Enjoy your shopping". Later, we demonstrated the form of approval to receive mobile coupons and a sample of mobile coupons to all the participants. In the opt-out scenario, the participants were also asked to imagine that a popular convenience store on campus is planning to introduce the mobile coupon subscription service. The service is as follows: "Whenever you come into any area within one kilometer radius of the store, we will send promotional messages based on your location to your mobile device. If you dislike the type of messages we send to you, please call our customer center or send a message to us to cancel your subscription". Finally, all the participants were asked to answer the questionnaire and provide their basic data.

According to previous research (Barwise and Strong, 2002; Xu et al., 2011), we designed three questions for opt-in and opt-out Push-LBMM respectively. The dependent variable, that is, usage intentions, was measured using three questions adapted from the usage intention scales introduced by Engel, Blackwell, and Miniard (1995) and Xu et al. (2009). To avoid central tendency of responses, all the questions were designed to be evaluated on a six-point Likert scale (from 1-very disagree to 6-very agree).

Results

The average reliability of the three questions for opt-in and opt-out was first evaluated ($\alpha_{\text{opt-in}} = 0.77$; $\alpha_{\text{opt-out}} = 0.94$). The one-sample t-test showed a value greater than 4 for both scenarios ($M_{\text{opt-in}} = 4.87$ vs. $M_{\text{opt-out}} = 4.00$), suggesting that our manipulation of opt-in Push-LBMM ($t(22) = 9.84, p < .001$) and opt-out Push-LBMM ($t(20) = 2.32, p < 0.05$) was successful. Later, the average reliability of the three questions for usage intentions was assessed ($\alpha = 0.94$), and an independent-sample one-way ANOVA was performed. Results indicated that the effects of opt-in and opt-out on usage intentions were significantly different ($F(1, 42) = 12.63, p < .00$), and opt-in led to higher usage intentions ($M_{\text{opt-in}} = 4.77$ vs. $M_{\text{opt-out}} = 3.81$). These

results suggested that the respondents were more inclined to use opt-in Push-LBMM as compared to opt-out Push-LBMM. Therefore, we chose opt-in Push-LBMM to represent Push-LBMM in the formal experiment.

Formal Experiment

Method and Procedure

The valid sample consisted of 87 participants recruited at the business district around Kaohsiung Arena. 61.2% were female, and the average age was 27.84. All the participants had at least two-year experience of using smartphones. Each participant was given ¹NT\$30 after the experiment. A single-factor (LBMM: Push vs. Pull) between-subjects design was adopted to test H1. The participants were randomly assigned to the Push-LBMM scenario and the Pull-LBMM scenario.

In the Push-LBMM scenario, the participants were asked to imagine that a popular convenience store in the business district is planning to launch the mobile coupon subscription service. The service detail is as follows: “Whenever you come into any area within one kilometer radius of the store, we will send ads of promotional items of the day to your mobile phone. If you agree to subscribe to this service, please provide your name and telephone number. We will sign you up. Enjoy your shopping”. Later, we demonstrated a form of approval to receive mobile coupons and a sample of mobile coupons to all the participants. Finally, we asked them to fill out the questionnaire and provide their basic data.

In the Pull-LBMM scenario, the participants were asked to read the instructions of a mobile application (App) called “hks Good Deals”. The participants were told to imagine the following scenario: They come to an unfamiliar place and want to know about the locations and promotional messages of nearby convenience stores. They launch “hks Good Deals” on their mobile device and then use the GPS positioning function to find their current location. Later, they click on “nearby offers” to view promotional messages of nearby stores. Meanwhile, they were also presented with a sample of mobile coupons. Finally, they had to answer a questionnaire and provide their basic data.

According to previous research (Barwise and Strong, 2002; Xu et al., 2011), we designed three questions for Push-LBMM and Push-LBMM respectively. The dependent variable, that is, usage intentions, was measured using three questions adapted from the usage intention scales introduced by Engel, Blackwell, and Miniard (1995) and Xu et al. (2009). Besides, we also designed six questions to measure

¹New Taiwan dollar.

technology acceptance based on Adams et al. (1992), Straub et al. (1997), Deane, Podd, and Henderson (1998), Moon and Kim (2001), Heijden (2003), and Saade and Bahli (2005). To avoid central tendency of responses, all the questions were designed to be evaluated on a six-point Likert scale (from 1-very disagree to 6-very agree).

Results

Manipulation Check. The average reliability of the three questions for each independent variable was assessed first ($\alpha_{\text{push}} = 0.70$; $\alpha_{\text{pull}} = 0.76$). Later, the one-sample t-test showed a value greater than 4 for each group ($M_{\text{push-LBMM}} = 5.01$ vs. $M_{\text{pull-LBMM}} = 5.30$), indicating successful manipulation of Push-LBMM ($t(40) = 8.51$, $p < .001$) and Pull-LBMM ($t(45) = 13.04$, $p < .001$).

Hypothesis Testing. To validate H1, the average reliability of the three questions for usage intentions was assessed ($\alpha = 0.94$). Later, the one-way ANOVA indicated a significant difference between Push-LBMM and Pull-LBMM in terms of effect on usage intentions ($F(1, 85) = 11.22$, $p < .001$). Compared to Push-LBMM, Pull-LBMM was associated with higher usage intentions ($M_{\text{Push-LBMM}} = 3.98$ vs. $M_{\text{Pull-LBMM}} = 4.81$). Hence, H1 was supported. We further tested H2a and H2b, which propose that LBMM influences usage intentions through technology acceptance beliefs. We first assessed the average reliability of the six questions for technology acceptance ($\alpha = 0.90$) and then performed a one-way ANOVA. Results indicated a significant difference in main effect between the two LBMM approaches ($F(1, 85) = 6.41$, $p < .05$), and Pull-LBMM was associated with higher technology acceptance ($M_{\text{Pull-LBMM}} = 5.03$ vs. $M_{\text{Push-LBMM}} = 4.60$). Hence, H2a was supported. We further carried out a bootstrapping analysis (Hayes, 2013; Preacher, Rucker, and Hayes 2007) to explore the relationship among LBMM, technology acceptance, and usage intentions using 5000 bootstrap samples. The indirect effect was significant ($\beta = 0.32$, 95% CI: 0.09, 0.62) at 95% confidence interval (CI) excluding 0. This result conformed to complementary mediation suggested by Zhao, Lynch, and Chen (2010). H2b was supported.

General Discussion

The results of this study indicate that Pull-LBMM can lead to higher usage intentions. Because Push-LBMM involves tracking of users' locations without any limitation, consumers may perceive higher risk of using Push-LBMM and have reduced intention to use it. Pull-LBMM, in contrast, tracks users' location only on their demand. It allows users to have their information need satisfied instantly. As a result, it is associated with higher perceived value and usage intentions. According to

III (2010), Taiwanese consumers do not have the information-seeking habit, and the absence of such habit may hinder their use of Pull-LBMM. However, the participants in our experiment gained a deeper understanding of the characteristics of LBMM through our scenario simulation. They showed significantly higher intentions to use Pull-LBMM than to use Push-LBMM. Therefore, we infer Taiwanese consumers' intentions to use LBMM are mainly inhibited by a lack of knowledge about mobile marketing than by the absence of an information-seeking habit. Moreover, the empirical evidence in this study confirms that technology acceptance plays a mediator role in consumers' use of LBMM. Technology acceptance mediates intentions to use LBMM among consumers.

Theoretical Contributions and Managerial Implications

Previous research has shown that mobile marketing affects consumer evaluations (Xia and Sudarshan, 2002), and consumers have a stronger preference for Pull-LBMM (Shankar and Hollinger, 2007). However, little research has explored the effects of different LBMM types on consumer behaviors, and there is limited evidence that can be generalized to the entire Asian society. In this paper, we conducted a comparative analysis of two major types of LBMM and empirically confirmed that Pull-LBMM is associated with higher usage intentions. This finding contributes to existing literature and also responds to the call for verifying the generalizability of existing findings to consumer behaviors in Taiwan.

This finding fills the gap in literature about the effectiveness of mobile marketing for physical stores. In addition, previous research of PU and PEOU is mainly focused on consumers' attitude and intentions toward using virtual stores (Chen, Gillenson and Sherrell, 2002; O'Cass and Fenech, 2003; Chen and Tan, 2004; Vijayasarathy, 2004). In this paper, we provide empirical evidence of the mediating role of these two beliefs in consumers' intentions to use LBMM in a physical store context.

To better understand consumers' intentions to use LBMM, we conducted the experiments at a convenience store located in a business district. Our empirical results can be a reference for the retail industry in Taiwan. On the other hand, despite the prevalence of IT applications in Taiwan, application of LBMM in the retail industry can increase consumers' attention to the perceived value of this technology. As to technology acceptance, our evidence confirms its mediating effect. This implies that the perceived value of LBMM should be considered in marketing strategies that involve application of LBMM.

Limitations and Future Research

The experimental scenarios involve a convenience store that offers the mobile coupon subscription service. As the benefits for consumers vary across industries, the effectiveness of LBMM may also differ. Hence, the experimental results may not be generalizable to other sectors. Further researchers can compare the effectiveness of LBMM for different store types or consider multiple types of promotional messages in the research to obtain more insights into the effectiveness of LBMM. Besides, we considered only the opt-in Pull-LBMM and Push-LBMM. Future researchers can perform a comparative analysis of all the three approaches of LBMM.

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**WHEN EAST MEETS THE WEST: COMPARE THE EFFECTS OF GIVING
GIFT AND RELATIONAL INVESTMENT ON RECIPROCITY LIKELIHOOD
IN B2B CONTEXT IN TAIWAN**

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ABSTRACT

Many researchers have inquired about the antecedents and consequences of buyer-supplier relationship investment in Western society. While rooting on Western management theories to conduct business, Taiwanese business managers in their daily works are affected by Chinese cultural values at the same time. In oriental society, it is a common practice to give gift to cultivate business relationship with business partners. Hence, it is interesting to know and compare the effects of giving gift and relational investment on business partners' reciprocity likelihood (RL). A proposed structural model was tested with 125 valid questionnaires collected from an online survey. The results show that both relational investment and gifting behavior have positive impacts on reciprocity likelihood; yet, giving gift, through the mediation of mianzi (face), exert a stronger affection on RL than relational investment.

Gift, Manipulative Intent, Relational Investment, Mianzi, Value

1. INTRODUCTION

Business can hardly survive without external relationships. External connections and relationships with suppliers or partners are required for successfully doing business. Hence, firms must understand how to create successful relationships with their partners; this issue has become critical for gaining success. The research stream of relationship marketing has contributed significantly to the development of theories regarding

enhancing sales performance by improved buyer-supplier relationships [25]. Among which, many researchers focused on how to effectively invest in relationship to increase the possibility of reciprocity likelihood in the future [7; 17].

In oriental society, it is a common business practice to improve the reciprocity likelihood by giving gift to business partners; for example, a sale representative from supplier's company might offer some gifts to the procurement decision makers in buyer organizations to improve their impressions. Yet, in western society, giving gift is often considered as bribery. Hence, the effects of giving gift, or gifting, on reciprocity likelihood was rarely being examined, or examined solely from Chinese cultural perspective [e.g., see 32].

This study intends to mitigate the above gap, and compare the effects of relational investment and gifting on reciprocity likelihood, in a context of small and medium enterprises in Taiwan. Taiwan is known for its significant role in the worldwide supply chain in many industries; for some decades, Taiwan's economic and business systems are deeply influenced by and rooted on Western mind thoughts to make decisions rationally. Western management theories are widely deployed by Taiwanese business managers in their daily works. Yet, Taiwan is also famous of well-preserving traditional Chinese culture. Their initiatives, hence, is also impacted by Chinese cultural values at the same time.

Specifically, this study will focus on role of the cultural variable of Mianzi or face, the perception of one's social status, prestige, or pride [20; 32] played in gifting behavior. In social interaction, it is important for Chinese people to conduct face work, like giving someone expensive gifts, to maintain one's own, or other's Mianzi. There is an old saying, similar to the slang in English: "hat and no cattle," portraying the behavior that people in Chinese society would somewhat irrationally make sacrifices to not suffer from losing their faces [31]. For example, business owners of small and medium enterprises would buy luxury goods that they can't afford just because such stuffs become indications of success in Chinese society; such impression of success may help open the gate of initial contacts and future cooperation with other companies [54].

Therefore, it is interesting to know whether gifting behavior has any effect at all in Taiwan. The objective of this study, hence, is to generate some academic implications for the development of theories in regard to relational investment and reciprocity likelihood; in particular, whether or not the eastern cultural factors like gifting and

Mianzi should be incorporated into the traditional theoretical paradigm to extend the applicability of these theories in Taiwan.

2. LITERATURE REVIEW

2.1 The Antecedents and Consequences of Relational Investment

The concept of relationship investment has been explored by scholars for a long time. Blau [6] defined relationship investment as "an investment of time, effort, and other irrecoverable resources in a relationship creates psychological ties that motivate parties to continue the relationship and sets an expectation of reciprocation." Hence, for the purpose of this study, relationship investment is defined as the investment of time, efforts, and other irrecoverable resources in a relationship by the sale representative to create psychological ties that motivate sales representative and customers to maintain their relationship and sets an expectation of reciprocation [15; 45].

In recent years, several studies have revealed the effects of relationship investment can have on consumers' general cognition of the company. Generally, customers may highly likely be favorably impressed, once a seller makes a relationship investment using bonding tactics of any kind [22]. Baker, Simpson, and Siguaw [3] reported that consumers were more satisfied with sellers who provide extra services to them; Moreover, Bagozzi [2] found that customers illustrated loyalty to certain sales representatives in reciprocation of these sales representatives' investments in the relationship.

As Kang and Ridgway [27] contend, the recipients may feel a need to reward the marketer's or seller's "friendliness." By devoting resources and efforts to relationship investment sellers, hence, can have strong connections with their customers, which in turn can improve sellers' performance such as increased sales growth, market share and profitability [13; 37]. Therefore, in line with the concept of social exchange and reciprocity, a positive relation between relationship investment and reciprocity likelihood can be expected.

De Wulf et al. [15] identified four relationship marketing efforts, including direct mail, preferential treatment, interpersonal communication, and tangible rewards, as determinants of perceived relationship investment. Among those efforts, direct mail

and tangible rewards are not deemed appropriate acts in the business-to-business context in which enterprise procurement is different with personal shopping. Although a few slight modifications to the conceptualization of the remaining two efforts must be done to suit the context of this study, they are considered to be appropriate as the antecedents of relationship investment in the business-to-business context.

Preferential treatment is defined as a buyer's perception of the extent that a sales representative provides favorable treatments to him/ her better than other sales representatives [16]. Previous research found that distinctive treatments enables a sales representative to satisfy customers' basic human requirements of feeling important [42]. Moreover, Hennig-Thurau and Klee [23] also found that a company's efforts to care for customers may result to an increase in consumer retention rate.

Interpersonal communication is defined as "a buyer's perception of the extent to which a sales representative interacts with him in a warm and personal way" [15]. Social interaction and personal exchanges between a customer and a sales representative have been shown to influence relationship outcomes [16]. The personal touch from inter-personal communication between a seller and customers therefore is expected to influence the outcome of relational investment.

The effects of the above two variables can be explained by the concept of reciprocity in social exchange behavior. The commonly held definition of reciprocity is "an individual evokes obligation toward others on the basis of their past behavior [21]". Although equivalent exchange of favors between the two parties of a business transaction was stressed in social exchange context, the returns are not necessarily happened immediately or in kind, but over time a balance of exchange may be finally achieved [41].

Normally, people feel an ingrained psychological pressure to reciprocate after they received a benefit; Once people fail to repay obligations, it can lead to a feeling of guilt [18; 40]. People should repay good for good, in proportion to what they receive to create stable exchange relationship [2]. The need for reciprocity becomes a norm guiding behavior in a social exchange context. For the same reasons, in business-to-business context, while procurement employees within an organization received a benefit from a sales representative, they may feel guilty if they don't reciprocate to the sales representative.

However, people measure the kindness of action not only by its consequences but also

by the intention underlying this action [18]." While giving gifts to customers, businesses may express their intent to be reciprocated from customers, either explicitly or implicitly [7]. Customers may perceive different degree of manipulative intent from the businesses. While perceiving stronger manipulative intent, people may feel they were enforced to reciprocate, and the choice of reciprocation is limited to the ways preferred by the businesses, which may cause feelings of reactance [7]. For the same reasons, in business-to-business context, perceived manipulative intent behind the act of giving gift may cause adverse effects on the perception of the investment of relationship by the givers, or even hurt buyers' intent to reciprocate [7].

2.2 Giving Gift and Giving Mianzi

2.2.1 Gifting Behavior

A gift can be tangible or intangible goods or services, which convey and deliver symbolic meanings, such as social rank, status, or prestige, to the receivers in a social interaction context [44]. Through the act of gift-giving, people show their respects and apologies to other people. For example, it is a custom in Taiwan that seniority give an expensive fountain pen to a descendant who pass the university entrance exam to congratulate his/ her achievement. Gift-giving, or gifting behavior is taking place in all societies.

Yet, people in oriental society, Chinese people in particular, influenced by cultural factors, normally give business gifts when they visit their business partners or customers to cultivate relationship with their partners. It is a common way to reinforce mutual trust, caring and commitment between the parties [14]. Business gifts are a form of non-verbal and symbolic communication during personal interactions to deliver a variety of messages; and gift-giving between companies has become usual to a large extent [8].

In this study, business gift refers to the gift that a sales representative gives to people in buyers' organizations who own decision power at business visits, or some certain holidays or festivals. Business gifts are given in the hopes of creating a positive first impression that might help to create an initial business relationship; sometimes business gifts are given expecting a favor in return [1].

When people get paid, they will expect to pay back in the future [29; 38]. In Joy [26]'s view, gifting behavior is interpreted as an social exchange initiative. Since social exchange is concerned about the building and maintenance of long-term relationships,

rather than one-off exchange relationship [36], reciprocity become the core of gift-giving. The recipient may feel obligated to reciprocate in the future [8]. Wolfinbarger and Yale [52] also suggested that people may be motivated to give gift due to a sense of obligation derived from reciprocation purpose or requirements of social norms. In Business-to-business (B2B) context, therefore, gift giving by the buyers may allow the opportunity to ask a favor in business deals with their suppliers in the future; but suppliers can also, through mutual reciprocity, establish and enhance long-term relationships with their customers.

2.2.2 Values of Gift

Gifts are mostly also ordinary products or services that can be consumed. Hence, a perception of gift value will be derived after its consumption. The concept of gift value is similar with the consumer value in marketing literature. Consumer value, or consumption value, is defined as an “overall assessment of the utility of a product based on the perceptions of what is received and what is given” [54, p.14]. It is a tradeoff between the sacrifice one paid to get, and the benefits or utility received from the consumption of the products. Some authors defined the “get” component as the quality of the product.

Price is the primary monetary sacrifice that people paid to get the utility of a product. Hence, price is an external cue of product quality [39]; a higher price therefore indicates a higher level of value. In most occasions, gift with higher monetary value are, hence, evaluated more favorably [30; 7]. In this study, gift value is accordingly defined as the economic value of a gift [7]. Economic value is most familiar to ordinary people, who evaluate gift value by its market value or monetary value, and expect to receive an equivalent feedback from the consumption of gift in the future [4; 7].

Underlying the above definition of gift value is the assumption of rational consumer who always compares and makes a trade-off between the give and the get component [11]. Yet, Holbrook & Hirschman [24] argued that rational view may neglect subjective experiences gained from product consumption. Since gift is a medium conveying symbolic meanings, how will the recipient interpret the implications of a gift may have significant influences on the subjective experiences derived from gift consumption. For example, sending a clock or watch may be interpreted as a curse of death and is deemed as inappropriate as a gift.

Hence, recipients may subjectively evaluate the value of gift other than its economic

and objective value. Gift evaluation here is defined as a recipient's subjective perception of the gift's significance and appeal [7]. A gift of relatively low monetary value can be evaluated advantageously if it is ideal to the recipient, or if it conveys a positive symbol.

2.2.3 Mianzi

Due to the different cultural contexts, the conducts for the progresses and accumulations of relationship investments such as gifting are performed differently in Western and Chinese societies. Western enterprises mostly follow the social exchange rules to establish partnership to fit the business purposes. In opposition, Chinese enterprises, while building partnerships, deeply concerned about and are influenced by traditional cultural variables, which may exert significant influences on buyers' reactions to sales' investment in the relationships.

Miazi is one of the traditional Chinese cultural variables tied tightly with gift. Mianzi, or face, refers to "an individual's prestige in society, a reputation achieved through getting on in life, through achieving success, and through ostentation [32]." In ethnic Chinese society, mianzi is an individual's possession of the respect, pride, and dignity [20], which is somewhat similar with the Western concept of reputation or dignity [10]. Mianzi can also be defined as one's position in a social network, as well as the ample and proper implementation of appropriate behaviors to get this respect status as determined by others in the social network.

A social skill named face work was used frequently in Chinese society for people to maintain or improve others' mianzi [28]. Maintaining the mianzi can be described as a protection of one's image in a relational situation, and practice of face work has strong impacts on business decisions [9; 48]. It is found that the concern of mianzi will lead to the consumption of luxury goods without necessity [54]. For instance, many entrepreneurs in Taiwan, or owners of SMEs, will purchase limousine not in accordance with their wealth, just to show the difference between the general class and them, and present an impression of success to the public.

Maintaining others' mianzi is considered as an appropriate behavior with close and intimate people to protect their dignity, and making each other feeling proud. A gift which doesn't correspond to the recipients' social status will make him/ her losing mianzi. "Face work" is important for Eastern society, as it is commonly practiced in social interactions to emphasize interpersonal harmony [10]. For example, the amount of cash put in a red envelop giving to a new couple while attending their wedding

ceremony must reflect the cost of the wedding ceremony, and more importantly, the relation between the giver and the couple. Through these skills, giving one's mianzi can be accumulated and exchange for proper interest or favor in the future [32].

Mianzi is important not only for Chinese people's personal life, but also for their business life. Hong Kong businessmen claim that mianzi is consistently a key factor during professional interactions [43]. Most of ethnic Chinese people are fear of losing face, which forms the informal system of contracts or agreements in ethnic Chinese business. Furthermore, Redeling and Ng [43] found that for middle level business executives in Hong Kong, mianzi has an important influence during business negotiations. Giving mianzi to someone in a business negotiation is considered highly desirable, whereas to harm or challenge other's mianzi is perceived as highly undesirable [34].

To not lost one's face, an individual's possession of mianzi needs visible social success in matching well-established expectations from people inside his/ her social network. In ethnic Chinese context, people hence would rather make sacrifices to maintain their faces [31]. Wang [50] found that caring about mianzi will affect the amount of money, normally greater amount, spent in buying, as well as the choice of brand of a gift. Since gift can also convey important symbolic meanings such as highlighting the recipients' social status, prestige, or achievements, one may improve others' mianzi by giving an expensive gift loaded with appropriate social implications. Hence, Leung et al. [32] suggested that people can create friendship (relationship) effectively with one who just met by improving his/ her face through giving appropriate gifts.

3. Research method

3.1 Model and Hypotheses

A theoretical model and a set of hypotheses were developed according the literature reviewed (see fig. 1). The model was composed of two subsets of hypotheses. The first one depicts the role and the antecedents of relational investment (H1-H4); and the second one describes the role of gift and Mianzi (H5- H7).

Consumers were more satisfied with a seller who made extra efforts to serve them [3]. A seller investing time, effort, and other irrecoverable resources in a relationship is trying to create psychological bonds with buyers to encourage buyers to stay in the

relationship and sets an expectation of reciprocity [45]. Therefore, the following hypothesis is offered:

H1: A higher perceived relationship investment leads to a higher degree of reciprocity likelihood.

Interpersonal communication refers to the personal contacts, social interactions, or personal exchanges between a sales representative and his buyers. Through interpersonal communication, a sales representative can familiarize with the buyers' relevant information such as their preferences. The similarities between sellers and buyers become a basis to adapt the exchange between them from a purely transactional orientation to a relational [16; 40]. Under such context, interpersonal communication will be viewed as a willingness to invest in each other's relationship for long-term purposes [46]. Since interpersonal communication has been shown to influence relationship outcomes [16], the following hypothesis is offered:

H2: Perceived interpersonal communication is positively related with perceived relationship investment.

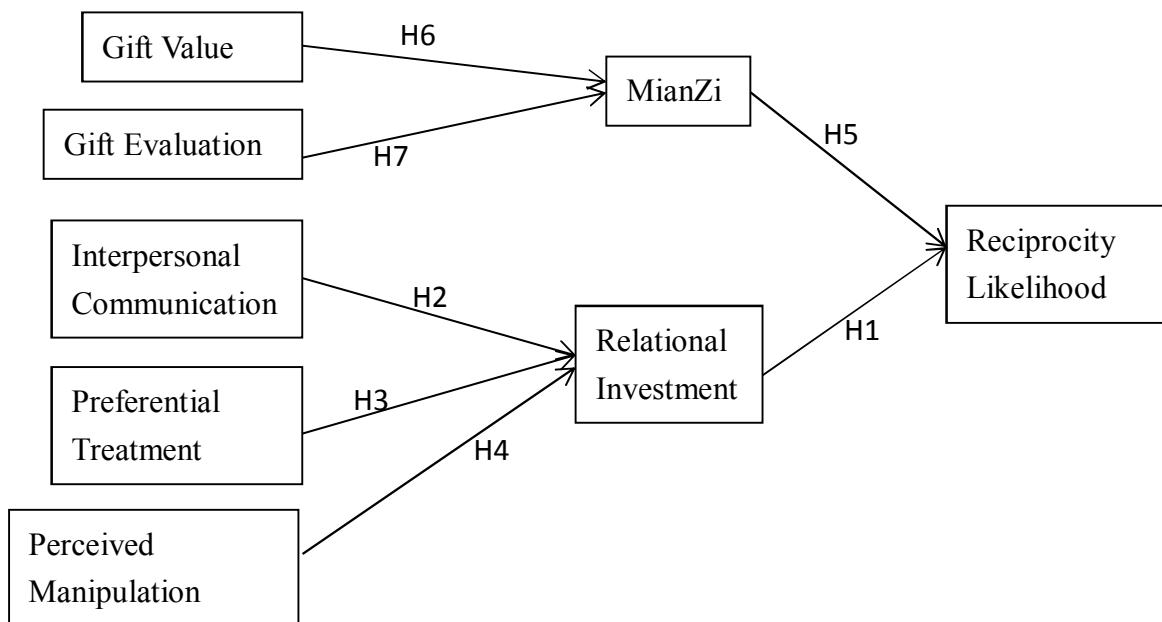


Figure 1 the theoretical model of this research

Preferential treatment is defined as a buyer's perception of the extent that a sales representative provides better treatments to him/ her [16]. Peterson [42] found that providing distinctive treatments enables a sales representative to satisfy buyers' basic human requirements such as feeling important, which may become an indication that the sales representative cares and is cultivating their relationship. Therefore, the

following hypothesis is offered:

H3: Perceived level of preferential treatment is positively related with perceived level of relationship investment.

The gifting behavior should not be interpreted as having deliberate intention specifically targeted for the gift receiver. Beltramini [5] pointed out business gifting should reduce customers' perceptions of being tactfully induced to continue doing business with the gift giver. Customers may respond to the gift positively if they perceived a lower level of manipulative intent behind the gift [7]. A perception of manipulative intent behind the gifting behavior might become a signal for asking for a favor, rather than improving the relationship between both parties. Therefore, the following hypothesis is offered:

H4: A higher level of perceived gift manipulation leads to a lower level of perceived relationship investment.

Mianzi is a social asset which can be banked and exchanged for favors in the future [32]. Mianzi is built based on the rule of reciprocity. Hence, in social interactions, one should practice face work to not only maintain his/ her, but also enhancing other's mianzi. To do so, one should emphasize on the reciprocity of obligations and dependence, and the protection of the esteem of those participants [20]. Therefore, if a purchasing executive perceived that his/ her face was improved by a representative, s/he may feel owe the sales representative a favor that is obliged to pay back in the future. The buyer must consciously consider to reciprocate to avoid the feeling of guilt, as well as any damage to his own social prestige [47]; therefore, the following hypothesis is offered:

H5: Mianzi is positively associated with perceived reciprocation likelihood.

A higher gift value may be an external cue of high quality and luxury product. Receiving such gift will make recipients feeling more honorable, getting a sense of higher social status, and having more respect from givers. Showing respect to someone may cause them to gain mianzi; moreover, giving others mianzi is beneficial to the advancement of reciprocal social relationship [55]. By giving expensive gifts, one may enhance the recipients' social positions to improve their mianzi [33]. Therefore, the following hypothesis is offered:

H6: A higher gift economic value leads to a higher level of mianzi

Mano and Oliver [35] found that product-evoked evaluations and emotions are significant and concurrent factors in the formation of satisfaction responses. In other

words, if a gift recipient subjectively perceive that the gift is valuable, even though the gift is cheap or not too expensive, the gift recipient may still feel having mianzi. Therefore, the following hypothesis is offered:

H7: A higher gift evaluation leads to a higher level of mianzi

3.2 Questionnaire Development

This study conducted a questionnaire survey to collect data for hypotheses testing. In order to ensure the content and face validity, all questionnaire items were adapted from existing questionnaire with good reliability, and validity to fit into the research context. Table 1 summarizes the operational definition of each variable, the sources of measurement scale, and the number of original items.

Table 1 Operational definition and measurement

Variable	Operational definition	Measurement	Items
Interpersonal communication (IC)	A customer's perception of the extent to which a sales representative interacts with him in a warm and personal way.	De Wulf et al. [15]	3
Preferential treatment (PT)	A customer's perception of the extent that a sales representative provides treatments to him better than other sales representatives did.	De Wulf et al. [15]	3
Perceived relationship investment (RI)	The investment of time, efforts, and other irrecoverable resources in a relationship by the sale representative to create psychological ties that motivate sales representative and customers to maintain the relationship and set an expectation of reciprocity.	De Wulf et al. [15]	3
Perceived gift manipulation (PM)	The extent to which the purchasing executive perceived that the vendor attempted to influence his or her behavior in an unfair way.	Bodur and Grohmann [7]	5
Gift economic value (GV)	The economic value of a gift.	Tsai [49]	4
Gift evaluation (GE)	The recipient's perception of the gift's significance and appeal.	Mano and Oliver [35]	4
Mianzi (MZ)	An individual's prestige in society: a reputation achieved through getting on in life, through achieving success, and through ostentation.	Developed by this study	7
Reciprocation likelihood (RL)	The probability that an individual reciprocates after having received a benefit.	Bodur and Grohmann [7]	3

Eight volunteer subjects who have frequent contacts with sale representatives were invited to participate in the pretest. The questionnaire items were being revised according to the subjects' advices. A pilot test was conducted to evaluate the quality of the measurement model. This study asked an instructor working at ITI (International Trade Institute) Taiwan, to share the member list of his discussion forum built on the Facebook. These members, his personal prior students who are working in companies with related experiences, were required to fill out the online questionnaire. In total, 131 questionnaires were retrieved. After excluding a total of 30 invalid questionnaires, the number of valid questionnaires left was 103.

Exploratory factor analysis was used to evaluate and improve the quality of the measurement model. Since the KMO value is 0.811, and the Bartlett's test of Sphericity is significant, a principal components analysis with orthogonal rotation by varimax method was conducted. Seven factors with eigenvalues value larger than one were extracted (Table 2).

According to the results of EFA (table 2), PT1 and RL1 were dropped, because they either: (1) have a factor loading less than 0.5, or (2) are loaded into incorrect factors. Though items of IC and RI were all loaded into the same factor, they were still kept for further analysis, since they are highly correlated with each other ($\alpha=0.651$, $p<0.001$). Their discriminant validity will be re-examined while formal data is collected.

3.3 Subjects and Data Collection

The suitable subjects of this study are employees in business organizations who had experiences of interaction and contact with sale representatives, and experiences of receiving any gift from them. Purposive and snow-ball rolling sampling methods were used to collect data. A free online survey platform, My Survey online, was deployed to collect data; a hyperlink to the online questionnaire was sent to the informants recruited. Prior students, friends of the authors, and the informants of pilot test were told about the qualification of suitable subjects, and required to introduce their known people with related experiences to fill the questionnaire. A screening question, asking the potential subjects to reply their experiences in receiving gifts from their sale representatives, was used to ensure the qualification of the respondents.

Table 2. Results of Exploratory Factor Analysis
Factor

	1	2	3	4	5	6	7
PT1 ^b	.688						
PT2							.639
PT3							.621
IC1	.732						
IC2	.674						
IC3	.514						
GE1				.790			
GE2				.577			
GE3				.701			
GE4				.799			
GV1					.837		
GV2					.669		
GV3					-.545		
GV4					.721		
PM1		.746					
PM2		.802					
PM3		.763					
PM4		.764					
PM5		.814					
MZ1			.662				
MZ2		.409	.688				
MZ3			.651				
MZ4			.677				
MZ5			.643				
MZ6			.505				
MZ7			.546				
RI1	.683						
RI2	.768						
RI3	.629						
RL1 ^a					.458		
RL2					.816		
RL3					.800		

Note: Suppress absolute values < 0.4.

^aitem deleted because of factor loading < 0.5

^bitem deleted because it is loaded into wrong factor

Abbreviation: PT- preferential treatment; IC- interpersonal communication; GE- gift evaluation; GV- gift value; PM- perceived manipulative intent; MZ-Mianzi; RI-relational investment; RL-reciprocity likelihood

4. DATA ANALYSIS

A total of 152 samples were collected. Among which, 11 samples have no experiences of receiving gifts (about 91% of our sample are qualified), hence they are dropped for further analysis. Sixteen of the remaining samples are judged as invalid samples, hence, they are eliminated. In total, 125 valid samples are left for hypotheses testing. The most of the respondents are female (56.62%), under 40 years old (83.52%), and working at companies with number of employees between 101 and 500 (40.44%). The

rest valid samples, hence, were suitable for further analysis because most of them could relate to the questionnaire items.

Data will be analyzed by Partial Least Square (PLS), and SmartPLS 2.0 will be employed as the primary tool for data analysis¹. The R-square for the dependent variable and the size, along with the t-statistics and significance level of the structural path coefficients were chosen as criteria of quality evaluation [51]. PLS can be utilized to confirm theory as well as explain very complex relationship among latent variables [12]. PLS is also able to evaluate both formative and reflective construct simultaneously [19]. More importantly, it is most suitable for small sample size situation to test a set of hypotheses.

The analysis using standard PLS procedure is composed of analyzing the data in two stages, and the results will be presented below. First, the measurement model is assessed for validity and reliability; then, the structural model is evaluated to test the hypotheses.

4.1 Measurement Model

Exploratory factor analysis and Cronbach's α were first used to evaluate and improve the reliability and validity of our measurement model. Since the KMO value is 0.81, and the Bartlett's test of Sphericity is significant, a principal components analysis with orthogonal rotation by varimax method was conducted. Seven factors with eigenvalues value larger than one were extracted, and the results are summarized in table 3.

According to the results of EFA, only one item, MZ3, was dropped, because it has a factor loading less than 0.5. Though items of IC and RI are again loaded into one factor, their discriminant validity will be analyzed and re-examined below. The variables' Cronbach's α values are all greater than 0.7, with a highest value of 0.942 (RL- reciprocity likelihood), and a lowest value of 0.818 (IC- interpersonal communication).

¹ Ringle, C.M., Wende, S., and Will, S., SmartPLS 2.0 [M3] Beta, Hamburg 2005,
<http://www.smartpls.de>.

Table 3. Results of Exploratory Factor Analysis
Factor

	1	2	3	4	5	6	7	Cronbach's α^a
PT2							.808	0.826
PT3	.451						.581	
IC1	.770							0.818
IC2	.715							
IC3	.558							
RI1	.781							0.869
RI2	.868							
RI3	.689							
GE1					.739			0.863
GE2					.721			
GE3					.790			
GE4					.678			
GV1				.776				0.870
GV2				.640				
GV3				.729				
GV4				.825				
PM1			.712					0.851
PM2			.644					
PM3			.705					
PM4			.672					
PM5			.795					
MZ1		.804						0.906
MZ2		.734						
MZ3 ^b		.473						
MZ4		.705						
MZ5		.765						
MZ6		.714						
RL2					.858			0.942
RL3						.799		

Note: Suppress absolute values < 0.4.

^aThe Cronbach's alpha of the measures composed of the selected items for the corresponding constructs

^bitem deleted because of factor loading < 0.5

Abbreviation: PT- preferential treatment; IC- interpersonal communication; GE- gift evaluation;

GV- gift value; PM- perceived manipulative intent; MZ-Mianzi; RI-relational investment;

RL-reciprocity likelihood

The convergent validity was again evaluated by average variance extracted (AVE), composite reliability (CR), and the significance level of each measure item. The results, shown in table 4 indicate that the item loadings are all significant and larger than 0.5; the average variance extracted (AVE) of the variables are all larger than 0.5; the composite reliability of the variables are all greater than 0.7, indicating a satisfactory level of convergent validity. Finally, all the square roots of AVEs were larger than the correlations between variables, providing evidence of discriminant validity for the measurements (table 5).

Table 4. Summary of the Results of Convergent Validity Analysis

variables	items	loading	t	AVE	CR	Cronbach's α^a
PT	PT2	0.910	37.123	0.851	0.915	0.826
	PT3	0.935	89.909			
IC	IC1	0.879	80.215	0.726	0.888	0.817
	IC2	0.899	62.916			
	IC3	0.773	21.026			
RI	RI1	0.869	45.281	0.796	0.921	0.871
	RI2	0.930	94.797			
	RI3	0.876	48.562			
GE	GE1	0.859	31.878	0.712	0.908	0.871
	GE2	0.777	14.371			
	GE3	0.896	58.498			
	GE4	0.838	33.110			
GV	GV1	0.906	56.933	0.720	.911	0.871
	GV2	0.825	33.921			
	GV3	0.822	32.688			
	GV4	0.837	32.565			
PM	PM1	0.868	42.352	0.623	0.892	0.851
	PM2	0.690	8.809			
	PM3	0.780	22.283			
	PM4	0.777	13.413			
	PM5	0.821	29.657			
MZ	MZ1	0.891	62.283	0.728	0.930	0.906
	MZ2	0.863	44.915			
	MZ4	0.834	37.065			
	MZ5	0.854	40.729			
	MZ6	0.821	32.900			
RL	RL2	0.970	164.693	0.945	0.972	0.942
	RL3	0.974	237.867			

Abbreviation: PT- preferential treatment; IC- interpersonal communication; GE- gift evaluation; GV- gift value; PM- perceived manipulative intent; MZ-Mianzi; RI-relational investment; RL-reciprocity likelihood

Table 5. Summary of the Results of Discriminant Validity Analysis

	GE	GV	IC	MZ	PM	PT	RI	RL
GE	0.844							
GV	0.400	0.848						
IC	0.180	0.131	0.852					
MZ	0.511	0.395	0.369	0.853				
PM	0.257	0.385	0.067	0.339	0.789			
PT	0.251	0.341	0.497	0.368	0.184	0.922		
RI	0.083	0.193	0.688	0.225	0.270	0.480	0.892	
RL	0.244	0.209	0.453	0.488	0.173	0.386	0.357	0.972

Abbreviation: PT- preferential treatment; IC- interpersonal communication; GE- gift evaluation; GV- gift value; PM- perceived manipulative intent; MZ-Mianzi; RI-relational investment; RL-reciprocity likelihood

4.2 Hypotheses Testing

Results of the hypotheses testing, shown in figure 2, show that the independent variables explain 30.2% of the variance in the reciprocity likelihood construct, and 53.9% of the variance in the relational investment construct, and 30.4% of the

variance in the Mianzi construct, indicating a satisfactory explanation power of the theoretical model. All the t-statistics of every path are significant. However, the direction of coefficients of the path between PM (perceived manipulation) and RI (relational investment) is contradictory to the predictions of H3. Therefore, this hypothesis is rejected. The results of data analysis tend to support the remaining 6 hypotheses.

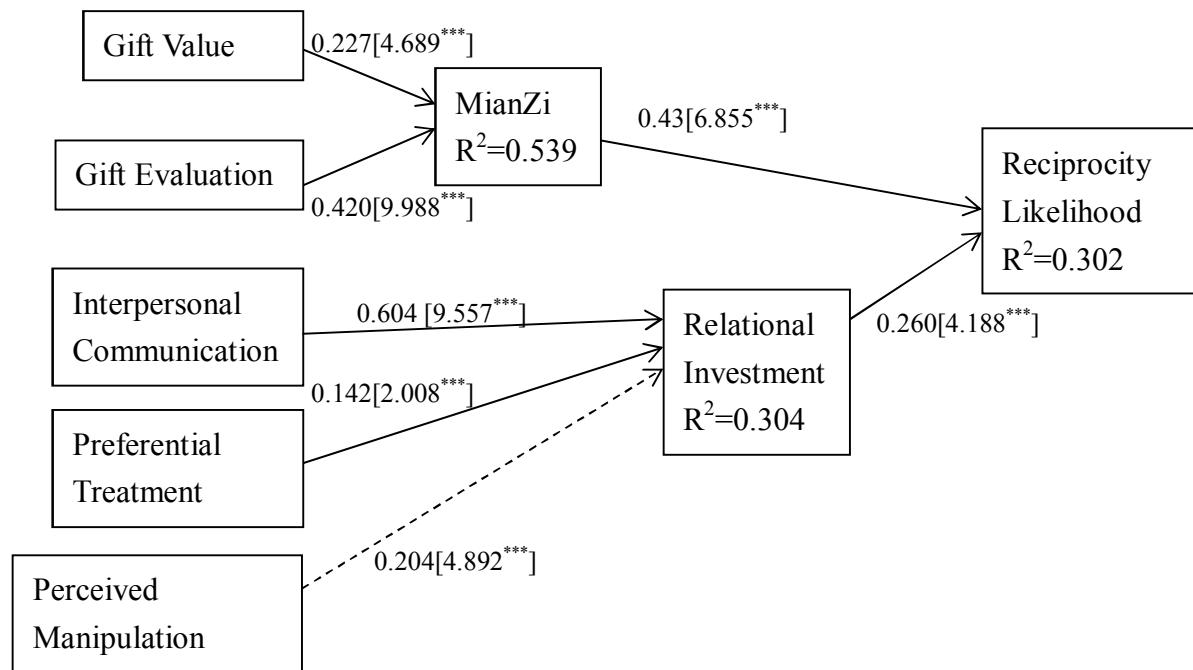


Figure 2 Results of hypotheses testing

***p < 0.005

Note: -----> rejected hypotheses

5. CONCLUSION

The business managers in Taiwan are trained about and deeply immersed in Western management theories; they rely heavily on Western disciplines to run their business. Yet, their decisions are also influenced by Chinese cultural factors. This study, specifically focused on the role played by gifting and Mianzi, build a model to integrate the effects of cultivation of relationship on reciprocity likelihood from the two different perspectives. This model was tested in a context of buyer-supplier relation in small-medium size enterprises in Taiwan, with 125 valid samples collected.

The results show that the reciprocity likelihood is influenced positively and concurrently by both relational investment and Mianzi. The subset of hypotheses of Western perspective (H1, H2, H3), and subset of hypotheses of Chinese cultural

perspective (H5, H7, H8) are mostly supported. It is worthy and interesting to note that Mianzi exerts a stronger impact than relational investment does, indicating that the decisions of Taiwanese managers are still being bound by traditional cultural factors. It is advised and suggested by the finding that future studies regarding the theories of relational investment should incorporate the concepts of gift and Mianzi to extend its scope of domain into Eastern society.

Yet, our guess that perceived manipulative intent will decrease the perception of relational investment is not true. Hence, H4 is rejected. Ordinary consumers may have the freedoms of, and abundant choices. The actions of restricting consumers' spaces of choices by sending a gift may be viewed as urging more for a favor in the short term, rather than concentrating on building relationships in the long run. Conversely, mutual benefits can be gained from the tightened cooperative relations between business partners. A strong and obvious manipulative intent could be interpreted as having an attitude towards building such relationships.

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**EFFECTS OF ETHICAL LEADERSHIP AND MORAL EFFICACY ON
EMPLOYEES' INTENTION TO ENGAGE IN ETHICAL BEHAVIORS: THE
SOCIAL COMPARISON PERSPECTIVE**

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ABSTRACT

The literature of behavioral ethics has so far focused on investigating the contextual factors that determine employees' ethical behaviors. Integrating social comparison theory with research on ethics, we propose that both ethical leadership (as a contextual factor) and an employee's moral efficacy (as an individual factor) may influence the employee's intent to engage in ethical behavior in the workplace. Specifically, we argue that the social comparison process serves as a dynamic mediating mechanism accounting for the main effects of ethical leadership and moral efficacy on employees' intention to engage in moral acts. Theoretical contributions, methodological issues, and directions for future research are discussed.

KEYWORDS

Ethical leadership, moral efficacy, social comparison

INTRODUCTION

Corporate scandals of giant companies such as Enron and WorldCom have drenched the globe in recent decades. These undesirable corporate scandals have not only driven a surge of attention regarding the importance of fostering an ethical climate in organizations and encouraging moral behaviors among employees, but have also increasing drawn societal and scholarly interests in research on behavioral ethics in organizations. Behavioral ethics researchers widely acknowledge ethical decision-making as a social process that involves interpersonal interactions (Albert et al., 2014; Brass et al., 1998; Jones, 1991). For example, Jones (1991) defined unethical behavior as an action with a harmful effect upon others and is “either illegal, or morally unacceptable to other larger community (p. 367). Hence, by definition, unethical behavior is a social phenomenon in nature that can be influenced by social relationships (Beu & Buckley, 2001). Other researchers (e.g., Brass, Butterfield, & Skagg, 1998; Zey-Ferrell & Ferrell, 1982) argue that unethical behavior could be a learnt action through interpersonal interactions with those who accept immorality or could be deterred by mutual surveillance by others in a social network. A recent study conducted by Albert, Reynolds, and Turan (2014) adopted an interpersonal approach to investigate individuals’ ethical decision-making and found that social consensus plays an important role in affecting one’s orientation of ethical behaviors.

Despite the recent scholarly attempt to integrate interpersonal dynamics with research on behavioral ethics, few studies have considered social comparison theory as a perspective for examining behavioral ethics in organizations. Accordingly, we propose a social comparison model of ethical intent, taking both contextual variables and individual factors into consideration. Specifically, we propose that both ethical leadership and an individual’s moral efficacy shape the process of social comparison, which, in turn, ultimately impact one’s intention to engage in ethical behaviors in the workplace.

Our theoretical paper offers an integrated approach involving both contextual and personal factors for explaining the interpersonal process in relation to employees’ ethical intent. In particular, we intend to make a few contributions to both the literature and practice. First, integrating multiple theories with the ethics literature, we propose a comprehensive theoretical perspective for understanding the determinants of individuals’ intent to enact ethical behaviors. Second, we advance research on social comparison by delineating the dynamic influence of individuals’ self-concept on the direction of social comparison. Third, by concurrently examining the effect of ethical leadership and moral efficacy on individuals’ ethical intent, we provide a more comprehensive picture of the cognitive, psychological, and interpersonal dimensions of ethical intent.

LITERATURE REVIEW AND PROPOSITIONS

Social comparison theory

Social comparison can be either a conscious or an automatic process of self-evaluation driven by the primary goal of acquiring information about the self (Festinger, 1954; Gibbons & Buunk, 1999; Suls et al., 2002). As a conscious process, social comparison can be driven by the motive of self-enhancement (a desire to protect one's attitude and to maintain one's positive view on the self) and/or the motive of self-improvement (the desire to improve the self; Bunnk et al., 2001; Gibbons et al., 2002; Pyszczynski et al., 1985; Wills, 1982; Wilson & Benner, 1971). In addition to the associated motive, the process of social comparison may also be classified by its direction – upward social comparison and downward social comparison (Wood, 1989). Upward social comparison refers to one's comparison with a superior other whose possesses something that is better than the individual, whereas downward comparison occurs when an individual compares oneself with an inferior target (Buunk & Gibbons, 2007). And the direction of social comparison is linked to an individual's motive (Taylor et al., 1996; Yip & Kelly, 2013). Engaging in social comparison with the motive of self-enhancement, individuals tend to engage in downward comparison in order to boost their subjective well-being (Gibbons & Boney, 1991). In contrast, individuals with the motive of self-improvement often engage in upward comparison in the interest of improving the self (Gibbons et al., 2000; Martin & Wheeler, 2002).

One of the underlying premises of social comparison theory is that individuals tend to make comparison on objects or possessions that are central to their self-evaluation (Wood, 1989). In the literature, researchers generally found that the process of social comparison encompasses a wide range of content, including achievement, personal qualities, beliefs and opinions (Suls et al., 2002), possessions such as the quality of relationship with others (Duffy et al., 2012; Liao, Liu, & Loi, 2010), and treatment received (Vidyarthi et al., 2010). While past studies have amassed abundant empirical evidences demonstrating the significant impact of social comparison on employees' behavioral and performance outcomes (e.g., Cohen-Charash & Mueller, 2007; Lam et al., 2011; Thau et al., 2007; Wayne et al., 2002), individuals' comparison of their behaviors with others have not been fully explored. Building on the existing body of knowledge about social comparison, we propose that employees may also compare their positive and ethical behaviors with others in the workplace with a motive of self-enhancement or self-improvement, particularly if those behaviors are advocated by their leaders.

Prior studies show that the process of social comparison is a function of both contextual factors and personal factors (e.g., Brown et al., 2007; Steil & Hay, 1997). For example,

differentiation in leaders' treatment to subordinates has been found to generally trigger upward social comparison among employees in the team (Lam et al., 2011; Vidyarthi et al., 2010). Gibbons and Buunk (1999) developed the Social Comparison Orientation Scale, which captures individual difference in their uncertainty about the self and their tendency to compare themselves with others (cf. Thau et al., 2007).

Ethical leadership and employee social comparison

Ethical leadership is an essential indicator of the organizational social contexts (Wang & Sung, 2014). Avail et al. (2004) argued that ethical leadership can remarkably shape the attitudes and behaviors of subordinates. Whereas majority of past studies rely on social learning theory (Bandura, 1977), social exchange theory (Blau, 1964), and social identity theory (reference) for examining the effect of ethical leadership on followers' behaviors, in this paper, we propose a novel integration between ethical leadership and the social comparison research.

Recent studies assert that social comparison may influence subordinates' propensity to engage in citizenship behaviors if they want to be recognized by their leaders (e.g., Spence et al., 2011). Such motivation is particularly salient if a leader exhibits a strong ethical leadership style (Brown & Trevino, 2006; Resick et al., 2013). Based on the conceptualization of ethical leadership (Brown et al., 2005; Brown & Trevino, 2006), an ethical leader does not only uphold a high level of ethical standard as a moral person, but also proactively leverages on rewards and punishment to hold employee accountable for their moral conduct as a moral manager. Under the influence of ethical leadership, employees may become more motivated to speak the same language and to conform to the ethical standards set by their leaders. Based on these premises, we argue that ethical leadership may foster a social comparison climate under which subordinates are more likely to compare their ethical behaviors either with inferior others to confirm that "they are not the worst" (motive of self-enhancement), or with superior others to achieve their desired moral-self and to be recognized by their ethical leaders (motive of self-improvement; cf. Collins, 1996; Suls et al., 2002).

Proposition 1: Ethical leadership is positively related to both upward and downward social comparison among employees.

Moral efficacy and employee social comparison

Stemmed from theory of self-efficacy beliefs (Bandura, 1997), moral efficacy is a recently emerged construct with a high level of predictive power on individuals' behaviors (Hannah & Avolio, 2010; Hannah et al., 2011). In his seminal work, Bandura (1997) postulates that self-efficacy reflects one's ability to self-regulate one's behaviors. Being investigated its implications on individuals' behaviors, self-efficacy should be tailored to the specific domain of psychological functioning being explored (Bandura, 1986). Therefore,

self-efficacy has been operationalized in different forms in the literature, such as academic efficacy, athletic efficacy, academic efficacy, interpersonal efficacy and managerial self-efficacy (Bandura, 1997). Such concept has recently evolved to be linked to the domain of ethics. In Hannah et al.'s (2011) recent study, they proposed the concept of "moral efficacy" which refers to "an individual's belief in his or her capabilities to organize and mobilize the motivation, cognitive resources, means, and courses of action needed to attain moral performance, within a given moral domain, while persisting in the face of moral adversity" (p. 15). In the present paper, we adopt Hannah and Avolio's (2010) conceptualization of moral efficacy that construed it as a trait-based variable guiding people through moral dilemmas. Specifically, we posit that individual employees' moral efficacy may serve as an essential personal factor influencing their tendency and the direction of social comparison.

Individuals high in moral efficacy tend to espouse a greater sense of perceived behavioral control (Hannah & Avolio, 2010). With greater confidence in one's capability to behave ethically, one may perceive himself/herself having higher accessibility and capabilities to attain a higher level of functioning or to avoid a downfall, which in turn be inspired to engage in upward comparison (cf. Buunk et al., 1990). Supplementing such argument, Major and colleagues concluded from their studies that individuals who perceived higher control of their behaviors were more likely to engage in upward comparison (Major et al., 1991; Testa & Major, 1988). Translating former research on self-efficacy in the context of behavioral ethics, we argue that employees high in moral efficacy will believe that they are more capable to mobilize their cognitive resources to behave ethically. Such belief, in turn, motivates employees to compare their behaviors and moral conduct with that of ethically superior others for self-improvement (cf. Wheeler, 1966; Wood, 1989). Put it differently, upward comparison may be a strategy for employees high in moral efficacy to transmit their self-improvement goals into ethical behaviors (Lockwood & Kunda, 1997).

For individuals low in moral efficacy, on the other hand, they believe themselves being less able to persist in face of moral adversity (Hannah & Avolio, 2010). As a means of self-enhancement and maintaining their psychologically well-being, they may be more likely to engage in downward comparison with ethically inferior others (Pyszczynski et al., 1985; Wills, 1981). According to Wood et al. (1985), downward social comparison is regarded as a tactic for people to self-enhance their deficient efficacy. Summarizing the above arguments, we propose that:

Proposition 2: Employees with a higher level of moral efficacy will engage in upward social comparison to a larger extent.

Proposition 3: Employees with a lower level of moral efficacy will engage in downward social comparison to a larger extent.

Social comparison and moral intent

Drawing on social learning theory (Bandura, 1977), we argue that the process of social comparison is essential for fostering higher moral intent among employees. Mayer et al. (2012) suggested that ethical behaviors could be trained and be assimilated through the social learning process (cf. Brown & Trevino, 2006). Engaging in upward social comparison with the motive of self-improvement, employees may acquire inspirations from the morally superior referents and be more motivated to improve themselves for higher achievement (cf. Brown & Trevino, 2006). Past empirical evidences demonstrate support for the positive linkage between upward social comparison and desirable outcomes among individuals (e.g., Collins, 1996; Johnson & Stapel, 2007). Thus, upward social comparison is expected to be positively linked to employees' intention to enact more ethical behaviors.

Researchers generally recognize downward social comparison as a means of self-enhancement (Wood, 1989). Witnessing someone being in a worse situation or an inferior position, one may experience an uplift of positive feeling and replenishment in one's efficacy (Wills, 1981). Along this line of reasoning, we argue that subsequent to downward social comparison, employees low in moral efficacy confirm that they are not the worst moral transgressor in the team. Such feeling of malicious joy (Brandstatter, 2000) and pseudo satisfaction (Buunk et al., 2001; other reference?) may reduce employees' motivation to enact more in ethical behaviors to become a better self. Prior studies demonstrate strong empirical support for such argument. For instance, Jordan and Monin (2008) conducted experimental studies, which revealed that individuals who witnessed ethically inferior behaviors exhibited by their peers tend to moralize their own behaviors and elevate their belief about themselves being a morally superior person. Findings of their study imply a meaningful message: individuals may not see themselves as an ethical person simply because they comply strictly to rules and regulations; in fact, their self-evaluation of their moral status may also be inflated when they engage in downward social comparison with inferior others.

Summarizing our reasoning, we predict that:

Proposition 4: Upward social comparison is positively related to employees' intent to enact ethical behaviors.

Proposition 5: Downward social comparison is negatively related to employees' intent to enact ethical behaviors.

Our theoretical model is illustrated in Figure 1.

GENERAL DISCUSSION

In accordance to our theoretical model, we begin by addressing the essential role of ethical leadership in fostering the frequency of social comparison among subordinates. We then proceed by proposing subordinates' individual difference in level of moral efficacy as a parallel predictor of their direction of social comparison (i.e., upward versus downward). Further, we posit that both the frequency and the direction of social comparison regarding ethical behaviors will influence subordinates' intent to enact ethical behaviors in the workplace. By exploring these relationships, our paper makes several noteworthy contributions to multiple literatures and lays some promising avenue for future research.

Theoretical contributions and avenue for future research

First and foremost, majority of past research on ethical leadership mainly anchors on social learning theory (Bandura, 1977), social exchange theory (Blau, 1964), or social identity theory (Tajfel, 2010). Our article advances the ethical leadership literature by linking it to the process of social comparison. Their potential relationship provides a novel explanation for the effect of ethical leadership on subordinates' behavioral outcomes. More specifically, according to our postulations, an ethical leader promotes the importance of moral conduct as a role model and manager, and therefore fosters a norm that facilitating subordinates' social comparison of their ethical behaviors with others. When employees engage in upward comparison, they will have a proclivity to mimic the role models' (the superior others') behavior. On the other hand, when they engage in downward comparison, they maintain a consistent and positive view on their moral status. All in all, this paper takes ethical leader, focal employees and comparison targets all into account to explain the social comparison dynamics embedded in an ethical leadership process.

To further extend our paper, future research may attempt to integrate other related theoretical perspective with the ethical leadership literature to obtain a more comprehensive understanding about how the ethical leadership process affects subordinates' behaviors. In particular, recent studies have shown that ethical leadership is related to the allocation of employee multiple resources (Kalshoven & Boon, 2012; Zheng et al., 2015). Gleaning ideas from the resource perspective (Bakker et al., 2007; Hobfoll, 2002), employees possess different types of social and psychological resources that are essential for them to fulfill their valued needs and job requirements. Ethical leadership is a crucial factor in affecting the accessibility and amount of resources for employees to foster effectiveness at work (Judge, Colbert, & Ilies, 2004; Tierney, Farmer, & Graen, 1999). Cognitive resources such as cognitive trust in leaders' morality and professionalism (McAllister, 1995; Murphy, Blyth, & Fiedler, 1992) and motivational resources such as moral self-efficacy (Hannah & Avolio, 2010; Hannah, Avolio, & May, 2011) may be particularly susceptible to the influence of

ethical leadership, which ultimately augment employees' behavioral and performance outcomes. Future research, therefore, may seek to determine the role that the deployment of employee multiple resources, including both cognitive and motivational resources, play in this ethical leadership-social comparison dynamics.

Second, social comparison is an omnipresent social phenomenon in organizations. It has been characterized as a frequent and everyday psychological process (Summerville & Roese, 2008). As Buunk and Gibbons (2007) mentioned in their review paper, despite the alleged ubiquity, social comparison process was a "more or less peripheral topic" in the literature two decades ago (p. 16). Until recently, researchers radically expand the realm of social comparison and the interest of studying social comparison process has been rekindled in organization studies (e.g., Jensen et al., 2014; Tse et al., 2013; Quratulain & Khan, 2014). However, limited attention and effort has been given to examine how environmental cues (e.g., Wood, 1989) and individual factors may jointly influence the underlying social comparison dynamics in organizations. As a response to this plea, this theoretical paper sought to understand whether individuals may engage in social comparison of (un)ethical behaviors with coworkers, given that they feel competent to enact ethical behaviors and that those ethical behaviors are advocated by their leaders. Thus, this article highlights the possibility that the content of social comparison may also cover behaviors, as long as those behaviors are valued in the social context.

According to Hannah et al.'s (2011) conceptualization and discussion on moral efficacy, this construct may be analyzed from two dimensions: magnitude (i.e., the level of difficulty one expects to successfully perform in a given moral situation) and strength (the extent of certainty one has in one's ability). They argued that these two dimensions are associated with different implications on various contexts. Therefore, we strongly encourage researchers to empirically examine how these two dimensions may respectively influence the effect of moral efficacy on individuals' behaviors across multiple contexts.

Another contribution of our paper is that we promote the concept of moral efficacy, which has been largely neglected in the past studies. Moral efficacy differs from other moral-related constructs such as moral clarity (high certainty in judging certain behaviors being right or wrong; Wiltermuth & Flynn, 2012) and moral courage (the capacity to overcome threat and fear of being in dangerous conditions for the sake of morals and virtue; Osswald et al., 2009). Specifically, moral efficacy is important for transforming an individuals' moral clarity and moral courage into actions to combat or report unethical behaviors and to act ethically (cf. Hannah et al., 2011). Such concept is essential for addressing the gap in whether individuals will actually act ethically (Hannah et al., 2005, 2011; May et al., 2003). In this paper, we pioneer an attempt to link moral efficacy with

individuals' intention to enact behaviors, which expands the applicability of self-identity theory to literature of organizational ethics.

Future research may further examine and compare employees' intention to enact ethical behaviors and their actual ethic-related behavioral outcomes. Simultaneously investigating employees' behavioral intentions and actual behaviors may address a limitation regarding common method bias in our theoretical model. Specifically, all the variables in our theoretical framework capture employees' perceptions, intentions, and their views on self-concept that are mostly available from self-reported data, which may be vulnerable to common method bias (Podsakoff et al., 2003). Addressing such potential shortcoming, future studies may capture both employees' self-reported intention to engage in ethical behaviors and other-reported actual ethical behaviors of employees to examine if there is any discrepancy between employees' behavioral intention and actual behaviors. In addition, Jones and Kavanagh (1996) conducted an experimental study which revealed that employees' intention to engage in unethical behaviors might equally subjected to the interactive influence of both individual factors such as locus of control and Machiavellianism and situational factors such as managers' ethicality. Hence, researchers may extend to assess the joint impact of ethical leadership and moral efficacy on an individuals' relative intention to behave ethically versus unethically. This stream of future studies may uncover if employees adopt a proactive approach or a reactive approach to ethical behaviors.

AVENUES FOR FUTURE RESEARCH

Conclusion

We introduced a theoretical model to guide researchers' investigation of the effects of both ethical leadership and moral efficacy on the social comparison process and individuals' intent to enact ethical behaviors. We suggest that whereas ethical leadership generally fosters subordinates' tendency to engage in social comparison of their ethical behaviors with others, their (subordinates') moral efficacy affects the direction of their social comparison. Our paper serves to deepen scholarly understanding about the potential implications of distal variables such as leadership style and proximal factors such as self-concept on ethical intent.

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Supply Chain Integration and Firm Performance: Ownership Concentration or Restriction?

---Empirical Study on Chinese Listed Companies

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Abstract: Competition is no longer between firms, but extends to supply chains. The integration degree in operations for managing the supply chain becomes a major factor affecting firm performance. Using the data collected from listed manufacturing enterprises in China, the study analyzes the impact of supply chain integration on firm performance and the moderating role of ownership structure on the performance structure. The study shows that (1) supply chain integration has a positive effect on firm performance; (2) Ownership concentration significantly weakens the effect; (3) ownership restriction significantly strengthens the performance effect. This study provides managerial implications that improving current ownership structure is beneficial for firm performance.

Keywords: supply chain integration, firm performance, ownership structure

1. INTRODUCTION

The view that supply chain integration benefits firm performance has received support in many studies (Prajogo and Olhager, 2012). To extend research on the links between supply chain integration and firm performance, it's desirable to model some contingency factors (Wong, Boon-Itt, and Wong, 2011), for example, the moderating role of corporate governance mechanisms (Wagner, 2011). Scholars hold the idea that corporate governance directly affects firms' operating decisions, which impacts firm performance in turn (Kang and Shivdasani, 1995). Furthermore, ownership structure plays a fundamental role in corporate governance (Michel, Oded, and Shaked, 2014).

The observation that one shareholder holds too much shares is common in Chinese listed companies (Xu and Jiang, 2014). The paper mainly focuses on the moderating role of ownership structure in supply chain integration and firm performance.

2. LITERATURE REVIEW

2.1 Supply chain

From the existing research, Jay Barney brings forward the notion of supply chain when discussing industrial downstream and upstream relationships (Forrester, 1961). The concept of value chain, a chain showing value-adding activities in all aspects from sourcing to sale discussed in Michael Porter's *Competitive Advantage* (Porter, 2008) can also be regarded as some kind of supply chain.

For the theoretical and practical needs, supply chain has attracted more and more researchers' attention since the mid-1990s. However, there is no uniform definition on supply chain management. Researchers give different definitions from different perspective. Supply chain is a process of planning, coordination, control of materials, components and products in all the activities from suppliers to consumers (Stevens, 1989). Supply chain should include material producers, product distributors, wholesalers, transporters, retailers and other related members (La Londe and Masters, 1994). In addition, they hold that supply chain is a value chain in which producers and other enterprises deliver products to end-consumers. Some others think supply chain is composed of many processes. Supply chain is a network, in which producers may acquire raw materials, half-products, and also sale channels (Lee and Billington, 1992). Supply chain comprises four basic exercises: plan, source, make and deliver. The four processes include all activities from produce to delivery, while linking supplier, supplier's supplier, end-customer and other members together (Cao, Vonderembse, Zhang, and Ragu-Nathan, 2010).

From the above discussion, though different researchers examine supply chain from different angles, but their definitions share common emphases. They all think that supply chain should include all sections from making products to satisfying customers. In the process, through the control of materials flow, knowledge flows, information flows and capital flows, manufacturers, distributors, suppliers, retailers and consumers are forming a network for collaborative operations.

2.2 Supply chain integration

Due to constant changes of market environment, competition among firms has been extended to broader supply chain context. Therefore, supply chain integration has been promoted as a viable way to enhance supply chain operation efficiency by many researchers and practitioners (Leuschner, Rogers, and Charvet, 2013).

Supply chain integration has different meanings to different researchers. The concept of integration can be drawn from their definitions of supply chain management. Supply chain integration is a higher-level cooperation behavior with the aim to provide more value to their customers and increase their own competitive advantage (Maloni and Benton, 1997), which links suppliers and consumers and realizes better firm performance by vertical integration (Frohlich and Westbrook, 2001). Supply chain integration can be divided into three categories: process integration within organizations, coordination integration across organizations and operation integration (Morash and Clinton, 1998). Increasingly, researchers categorize it into internal integration and external integration, while the latter can be further divided into supplier integration and customer integration (Huo, Qi, Wang, and Zhao, 2014). From these definitions, it can be drawn that integration emphasizes both internal and external integration.

Supply chain management as integration of all activities involves management of goods from raw materials through to the end user for competitive advantage (Gibson, Mentzer, and Cook, 2005). On the other hand, it integrates and coordinates all activities involved for delivery of a product from raw materials to the customers, including sourcing raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels. (Lummus and Vokurka, 1999) These

definitions focus on the activities involved in supply chain integration.

2.3 Supply chain integration and firm performance

Recent years, researchers pay attention on the links between supply chain integration and firm performance. Some researchers consider integration as a popular topic in supply chain management area (Flynn, Huo, and Zhao, 2010; David J Ketchen and G Tomas M Hult, 2007; Zhao, Flynn, and Roth, 2006).

There are totally two kinds of research methodologies in the field. One is to make analysis and conclusion theoretically from practical observations (Lee, Padmanabhan, and Whang, 2004; Zailani and Rajagopal, 2005), and the other is to do empirical studies based on a theoretical framework and research hypotheses (Das, Narasimhan, and Talluri, 2006; Frohlich and Westbrook, 2001). The performance they discuss varies greatly, covering operations performance, customer service performance, financial performance, competitive advantage, technical innovation performance, and new product introduction performance.

Many researches show that supply chain integration has a positive effect on firm performance, however, a small proportion of empirical studies get different results (Gimenez and Ventura, 2005; Swink, Narasimhan, and Wang, 2007).

Based on transaction cost theory, many researchers discover the relationship between supply chain integration and firm performance from ways in information sharing, process integration, mutual production. Cooperation within and across supply chains has a positive effect on logistical service performance (Stank, Keller, and Daugherty, 2001). Five different

strategies firms may adopt: inward-facing, periphery-facing, supplier-facing, customer-facing and outward facing (Frohlich and Westbrook, 2001). By their sample, compared to the firms adopting other strategies, firms with outward facing strategy have the best performance.

2.4 Ownership structure

Ownership structure is an important component in corporate governance mechanisms. It originates from the separation of ownership and control in modern stock companies. When discussing ownership structure in a quantitative way, we usually consider proportions of shares in different shareholders, and power restrictions caused by different amount of shares. Ownership concentration refers to the share's concentration or dispersion degree, while ownership restriction refers to the difference of all shareholders' proportions (Thomsen and Pedersen, 2000).

There are lots of literatures discussing the relationship between ownership concentration/restriction on firm performance. Totally, two confronting idea exists in the past research. When investigating American capital market, minority stockholders have no incentive to supervise the top managers due to dispersed ownership (Berle and Means, 1932). When company manager is the only owner, then there occurs no agency cost (Jensen and Meckling, 1976). Thus, dispersed ownership will increase agency cost, and therefore decrease company's value. However, if a comparatively high amount proportions is owned by a sole shareholder, he/she would seek his/her own interest at the expense of sacrificing firms' benefits, which would harm minority stockholders' interests. That's the so-called "tunnel

effects"(Chen, Li, and Lin, 2015).

From the above literature analysis, there are abundant literature on the relationship between supply chain integration and firm performance. However, most use survey technologies lacking in contingency analysis, especially from corporate governance angle (Alfalla-Luque, Medina-Lopez, and Dey, 2013). Therefore, the study targets to discuss supply chain integration problem from a perspective of corporate governance mechanism, specifically ownership structure using objective data from Chinese listed companies.

The study aims to answer the following questions: How will supply chain integration influence firm performance? Considering ownership structure, which ownership structure will be more effective when adopting supply chain integration strategies, ownership concentration or ownership restriction?

3. RESEARCH FRAMEWORK AND HYPOTHESES

3.1 Supply chain integration and firm performance

Integration is a process which combines two or more elements or sub-systems into a whole. By function, structure and process re-engineering, integration may realize a higher performance which cannot be accomplished without integration. Supply chain integration is to plan, control and coordinate the commodity flow, logistic flow, information flow and cash flow over the entire supply chain. It enhances the efficiency and effectiveness of the supply chain system at a higher level.

Transaction cost economics (TCE) points out that transaction cost comes from the bounded rationality, transaction uncertainties and opportunism (Williamson, 1979, 1985). The reason that firms exist to minimize the sum of the transaction cost between and within firms (D. J. Ketchen and G. T. M. Hult, 2007). Supply chain integration is helpful to restrain from opportunism, decreasing the expenditure in information-seeking, negotiation and monitoring (Kalwani and Narayandas, 1995). Therefore, by integration, transaction cost undertaken is decreasing, thus, firm performance is improved.

From resource-based view or organizational capability perspective(Cao et al., 2010; Huo, 2012), working in close relationships and sharing knowledge with partners cultivate unique and distinctive capabilities, which allow enterprises to acquire long-term competitive advantage over their competitors. From knowledge-based view (Swink, Narasimhan, and Wang, 2007), integration includes knowledge dissemination and sharing activities that create new knowledge, which enhances organizational capabilities.

Information processing theory also interprets the positive effect of SCI (Swink et al., 2007). Process integration on information sharing across the supply network drastically reduces the uncertainty in planning, operational and logistics activities by increasing companies' information processing capabilities, which in turn reduces inefficiencies (high stocks or rush deliveries), while at the same time allows to increase flexibility and punctuality, to anticipate demand changes and new market/technological opportunities.

From the above theories, it can be shown that SCI improves firm performance. However,

there are abundant indices measuring firm performance. Adopting the view of value chain, activities can be classified into basic activity and support activity(Porter, 2008). Basic activities create value directly, while support activities complement basic activities in value creation. These activities create value and have some indices to measure their performance. By Dehning, Richardson, and Zmud (2007), we selected some of the indices in this study.. Figure 1 shows activities in manufacturing enterprises and the corresponding performance measures.

inbound	operations	outbound	overall
raw materials inventory turnover	work-in-process inventory turnover	market share operating margin ratio	net profit margin ratio
support			total asset turnover
selling, general and administrative expenses (or period expense)			

Figure 1 Simplified value chain model of performance measures

It's not necessary to choose too much indices in the study, and the indices chosen should cover important activities. To survive in market competition, it's vital to get revenue for enterprises. The index “operating margin ratio” in outbound process is chosen. Support activities appear in all basic activities, thus, “period expense” is chosen. To make better comparison, similar index “net profit margin ratio” is chosen in the overall performance measurement. Therefore, three indices are chosen in all.

SCI fully integrates firms' all logistics activities, and optimizes them in two aspects: SCI enhances the logistics activities efficiency by removing non value-added activities such as invalid inventory, repetitive transportation; by using integration mode such as logistics outsourcing, logistics equipment utilization efficiency is increased, thus decreasing logistics cost per product.

Information integration across firms in a supply chain makes information in fields like demand, production, inventory and transportation flows smoothly across supply chain partners. Therefore, it enhances their forecast accuracy and response speed, decrease the coordinating cost and loss caused by lacking of related information.

Cash flow integration is beneficial to decrease firms' debt collection cost and enlarge firms' credit scale. It is also good to cultivate firms' financing capacity by supply chain finance.

Therefore, SCI realizes effective coordination among the nodes in the supply chain, promoting seamless connection in information flow, logistics flow and cash flow in supply chain. SCI decreases logistics cost, information cost, and cash cost in supply chain. According to the existing Accounting Accountability System, those cost are not directly recorded, however, most of which can be found in "period expense". Hence,

Hypothesis 1: SCI is helpful to decrease firms' period expense.

From the concept of operating margin ratio, we conduct following derivation: operating margin ratio = operating profit/operating income = (operating income – operating cost – period expense) / operating income = gross profit ratio – period expense ratio. From the

formula, it can be seen that the factors affecting operating margin ratio are gross profit ratio and period expense ratio. From Hypothesis 1, we need to check how gross profit ratio changes in the process of supply chain integration.

From the cooperation with major suppliers, firms may get more price discount in raw materials purchasing. Business integration with suppliers and logistics providers will further decrease firms' purchasing cost. Those factors are good to decrease operating cost. If supply chain relationship doesn't have effect on selling price, we may have sales gross margin increased.

However, the above premise that "supply chain relationship doesn't have effect on selling price" may not hold. Supply chain management is different from vertical integration. Firms in the chain are cooperative on the basis of competition. Competitive mechanism makes the benefited firm to share its profit with supply chain partners both downstream and upstream (Spekman, Kamauff Jr, and Myhr, 1998). Otherwise, supply chain cooperation cannot be maintained. Firms in a chain are independent economic entities with buying-selling price as the way to connect with each other. In this way, the benefited firm will transfer part of its profit to upstream partners by "purchasing with a higher price" and downstream partners by "discounted price". Compared to other firms in the industry, a higher degree of SCI may cause more cooperative benefits, thus the main benefited firm may transfer more profit to its upstream and downstream partners. In this way, the increasing degree of the gross margin will be shortened. Furthermore, the benefits transferred by a firm in supply chain will be restricted into a certain amount in the process of supply chain integration. Otherwise, the firm will be

better-off without supply chain integration. Therefore, we may have:

Hypothesis 2: SCI is helpful to increase firms' operating margin ratio.

According to the computing formula of net profit margin ratio: net profit margin ratio = operating margin ratio \times (1 - income tax rate). It is assumed that supply chain integration will increase firm's operating margin ratio in hypothesis 2. In China, the subject of corporate income tax payment is the companies, not the whole supply chain. Supply chain is only a cooperation union in firms, while the firms are not forming a single entity. Therefore, the income tax rate of the firms in the supply chain is stable. Thus, we may have

Hypothesis 3: SCI will increase firms' net profit margin ratio.

3.2 Moderation role of ownership structure

Ownership structure is an attracting issue in corporate governance research. Abundant researches are addressing to the problem how ownership structure impacts firm performance. Ownership structure will affect any decision making processes, and hence the effect of such decisions. Supply chain integration is an important decision in enterprises. The study will focus the moderating effect of ownership structure on firm performance from two aspects: ownership concentration and ownership restriction.

(1) Ownership concentration

Ownership concentration denotes the shares of dominant shareholders. It will decrease firm's defense capability. Defense capability refers to the ability to make resistance to competitors' attacks in market competition. Ownership concentration will cause a majority

shareholder control a firm, who will make all decisions in the firm. Such decision method is deficiency in knowledge capacity, information acquisition. When dealing the risks occurred in supply chain integration, higher ownership concentration will cause weaker defense capability. By agency theory, high ownership concentration makes majority shareholders pursuing their private benefits, regardless of the firm's long-term profit(Berle and Means, 1932). When majority shareholders participate in corporate governance, they are focusing on more profit, thus causing low management efficiency (Shleifer and Wolfenzon, 2002).

When firms have very strong close relationships, opportunism will appear (Villena, Revilla, and Choi, 2011). Other firms will get to know the business secrets, and probably use them in some areas causing harmful consequences to the firms. Therefore, in the case of ownership concentration, low defense capability will weaken the effect of supply chain integration.

Furthermore, ownership concentration will increase the financing difficulties. In the case of ownership concentration, the “tunnel effect” will appear (Chen et al., 2015). To grab private profit, firm's majority shareholders will engage in some affairs hurting minority shareholders' benefits. In such circumstances, information asymmetry between major and minor shareholders will become serious. Thus, majority of shareholders are unwilling to publicize the unknown secrets. Therefore, outside investors are unwilling to make more investments. Specifically, suppose the firm need a fixed amount of capital, since the supply of capital market is decreased, then the financing cost will be increasing, and the firm is facing a serious financing problem.

In the course of supply chain integration, firms need to do much investment. It is necessary to establish new information system in supplier and customer integration to make better communication channel (Fabbe-Costes and Jahre, 2008). If firms have difficulty in financing, it would weaken the effect of supply chain integration. Therefore, in the case of ownership concentration, the effect of supply chain integration would be worse.

Moreover, ownership concentration will cause insider control. Professor Masahiko Aoki brought forward insider control theory in 1990(Aoki, 1994; Aoki and Kim, 1995). Shareholders control the firms in modern governance structure. Board members are elected in shareholders' meeting, and the board nominates top managers. In such way, firms are controlled in top managers. In ownership concentration situation, majority shareholders will occupy seats in the board, and usually, the chairman of the board. Moreover, they will also take the positions in top management teams. Therefore, the phenomenon called insider control appears.

In supply chain relationship management, it is necessary to pay attention to the problem of protection of partners. High ownership concentration degree will make the majority shareholders supervise managers' performance better; however, it will also cause the problem of "insider control"(Gomes and Novaes, 2005). In order to control the company, the majority shareholders will limit the width of information disclosure, which in turn will make the partners unfamiliar to the development of the firm, thus decrease the effect of supply chain integration.

Hence, we may get the following hypotheses:

Hypothesis 4: Ownership concentration weakens the relationship between supply chain integration and firm performance.

Hypothesis 4a: Ownership concentration weakens the relationship between supply chain integration and period expense. More period expense decreases by firms characterized with low ownership concentration by supply chain integration.

Hypothesis 4b: Ownership concentration weakens the relationship between supply chain integration and operating margin ratio. More operating margin ratio increases by firms characterized with low ownership concentration by supply chain integration.

Hypothesis 4c: Ownership concentration weakens the relationship between supply chain integration and net profit margin ratio. More net profit margin ratio increases by firms characterized with low ownership concentration by supply chain integration.

(2) Ownership restriction

Ownership restriction means the differences of all shareholders' proportions, which can be explained as the controlling power over the majority shareholder. Many researchers discover the relationship between ownership restriction and firm performance (Pagano and Roell, 1998). Ownership restriction may improve firms' internal governance. When there exist multiple majority shareholders, they can restrict each other; therefore it weakens the majority shareholders' occupying of firm assets. In similar way, the moderating role of ownership restriction is discussed.

First, ownership restriction will increase firm's defense capability. Ownership restriction will form an effective internal governance environment. Collective decision process can overcome the deficiencies of individual decision. High ownership restriction makes firms have strong defense capability when facing risks in supply chain integration. Therefore, in case of ownership restriction, the effect of supply chain integration would be better.

Second, ownership restriction will promote the corporate financing. In case of ownership restriction, majority shareholders can no longer take some behaviors harmful to the firm. Information asymmetry will be disappearing, and firms are willing to disclose their financial problems (Shleifer and Vishny, 1997). Outside investors can get the related information on firms' development, which motivate them to invest more. Suppose the firm need a fixed amount of capital, since the supply of capital market is increasing, then the financing cost will be decreasing, which provides necessary financial support to supply chain integration.

Third, ownership restriction will hamper insider control. China is a developing country, with incomplete law systems. Law isn't entire enough to protect all entities' benefits. The supervision among shareholders is a good to overcome the deficiency of law. Ownership restriction makes fewer activities like insiders tunneling firms and shareholders have the incentives to supervise the managers' behaviors. In such situation, shareholders and managers in each level will aim to improve firms' performance in case of implementing supply chain integration strategies. Therefore, in ownership restriction, supply chain integration may improve firm performance better.

Hence, we may get the following hypotheses:

Hypothesis 5: Ownership restriction strengthens the relationship between supply chain integration and firm performance.

Hypothesis 5a: Ownership restriction strengthens the relationship between supply chain integration and period expense. Less period expense decreases by firms characterized with low ownership restriction by supply chain integration.

Hypothesis 5b: Ownership restriction strengthens the relationship between supply chain integration and operating margin ratio. Less operating margin ratio increases by firms characterized with low ownership restriction by supply chain integration.

Hypothesis 5c: Ownership restriction moderates the relationship between supply chain integration and net profit margin ratio. Less net profit margin ratio increases by firms characterized with low ownership restriction by supply chain integration.

The following figure shows the research model of the study:

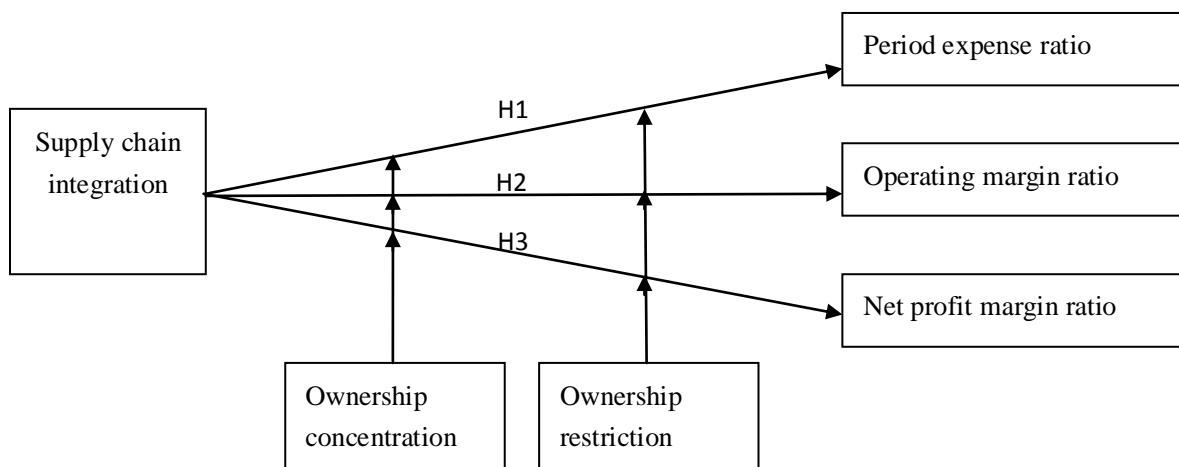


Figure 2 Research Model

4. METHODOLOGY

4.1 Sample

The study chooses “manufacturing industry” in Shanghai and Shenzhen stock markets in China as the research object. China is an emerging market, with its economy developing very fast these years. Comparing to other industries, manufacturing industry can be most characterized by supply chain. The industry is quite dependent on its suppliers and buyers. Since Chinese accounting policies has changed in 2007, the starting year of the research data will be 2007 in order to avoid the influence caused by the changes. The time frame of the study will be 2007-2013. All data come from WIND and CSMAR datasets. Finally we get a sample of 5831 observations with 833 companies.

4.2 Variables

The study includes variables like: dependent variables, independent variables, moderating variables and control variables.

(1) Dependent variables: firm performance

To measure firm performance, the study use indices like period expense rate, operating margin ratio and net profit margin ratio. The exact way of calculating the indices have been explained above.

(2) Independent variables: supply chain integration

Since there're no requirements that listed companies should report anything related to their

supply chain in China, it is difficult to measure supply chain integration. Currently, many researches use survey methodology to check how supply chain integration progresses in the firms. However, it's controversial on what should be included in the survey. In China, according to the regulations, it is mandatory to report "sum of rate of the first five largest suppliers' buying amount" and "sum of rate of the first five largest customers' sale amount". These two figures are the closest to the concept of supply chain integration. Integration degree with customers and suppliers is related to their business scale. Firms are incentive to integrate only if their scale is relatively high and stable. Integration includes supplier integration and customer integration. Therefore, we believe the two figures are related to integration. We multiple the two figures to construct supply chain integration index.

(3) Moderating variables: ownership structure

One of the research questions is to discuss the impact of supply chain integration on firm performance under different ownership structure. Therefore, we introduce ownership concentration and ownership restriction to measure the ownership structure. We use the sum of first five largest shareholders' share to measure ownership concentration, and use the ratio of the first largest shareholder's share to the sum of the second to the fifth largest shareholders' share to measure ownership restriction.

(4) Control variables

In addition, we need to control the following variables: asset liability ratio, firm size, investment opportunity, firm age, board size, board independence, TMT turnover. These

variables are usually considered in literature(Michel, Oded, and Shaked, 2014). In addition, we add year dummies. Detail information about the variables is shown in table 1.

All data can be publicly accessible from the firms' yearly financial statements in the datasets.

Table 1 Variables

Variables	abbreviation	Calculation
period expense rate	<i>Peri</i>	(management expense + sale expense + financial expense)/ operating income
operating margin ratio	<i>Oper</i>	(operating income – operating cost – period expense) / operating income
net profit margin ratio	<i>Npro</i>	operating margin ratio \times (1 - income tax rate)
Supply chain integration	<i>SCI</i>	Top 5 supplier buying rate \times Top 5 customer sale rate
Ownership concentration	<i>Conc</i>	Sum of top 5 stockholders' share
Ownership restriction	<i>Rest</i>	Top stockholder's share / sum of 2 to 5 stockholders' share
Asset liability ratio	<i>Alr</i>	Liability / asset
Firm size	<i>Fsize</i>	logarithmic of total asset
Investment opportunity	<i>Oppo</i>	(total asset – total asset in last year) / total asset
Board size	<i>Bsize</i>	The total number of the director of the board
Board independence	<i>Bind</i>	The percentage of independent directors in the board
TMT turnover	<i>Turn</i>	Dummy: if CEO or board chair changes, it equals to 1

4.3 Models

Data collected is a strongly balanced panel data. We use Stata to perform regression with fixed effect model. Considering that it would take some time before supply chain integration becomes effective, firm performance variables are taken in a two-year-lagged way.

Model One:

$$\begin{aligned} Performance_{i,t+2} = & \beta_0 + \beta_1 SCI_{i,t} + \beta_2 Conc_{i,t} + \beta_3 Rest_{i,t} + \beta_4 Alr_{i,t} + \beta_5 Fsize_{i,t} + \beta_6 Oppo_{i,t} \\ & + \beta_7 Bsize_{i,t} + \beta_8 Bind_{i,t} + \beta_9 Turn_{i,t} + \beta_{10-15} (year dummies) + \varepsilon_{i,t} \end{aligned}$$

Model Two:

$$\begin{aligned} Performance_{i,t+2} = & \beta_0 + \beta_1 SCI_{i,t} + \beta_2 Conc_{i,t} + \beta_3 Rest_{i,t} + \beta_4 Alr_{i,t} + \beta_5 Fsize_{i,t} + \beta_6 Oppo_{i,t} \\ & + \beta_7 Bsize_{i,t} + \beta_8 Bind_{i,t} + \beta_9 Turn_{i,t} + \beta_{10-15} (year dummies) + \beta_{16} SCI \times Conc_{i,t} + \varepsilon_{i,t} \end{aligned}$$

Model Three:

$$\begin{aligned} Performance_{i,t+2} = & \beta_0 + \beta_1 SCI_{i,t} + \beta_2 Conc_{i,t} + \beta_3 Rest_{i,t} + \beta_4 Alr_{i,t} + \beta_5 Fsize_{i,t} + \beta_6 Oppo_{i,t} \\ & + \beta_7 Bsize_{i,t} + \beta_8 Bind_{i,t} + \beta_9 Turn_{i,t} + \beta_{10-15} (year dummies) + \beta_{16} SCI \times Rest_{i,t} + \varepsilon_{i,t} \end{aligned}$$

Model One is used to check the main effect, while the other two models are used to check the moderating effect, which is to see whether the interaction term is statistically significant.

5. REGRESSION RESULTS

5.1 Descriptive statistics

Table 2 shows the descriptive statistics of the variables. The result shows that dependent variables, independent variable and moderating variables all vary greatly. Performance indices vary greatly across different companies, and some are even in severe debt. Mean and standard deviation of supply chain integration index is 0.1125 and 0.1280, the numbers of minimum and maximum values suggests that a huge difference exists in firms' supply chain integration. Ownership concentration indices show one shareholder owns all shares in some companies.

But the figure is only 5.73% in the most dispersed company. Ownership restriction is quite similar to ownership concentration, with a maximum of 2.029 and minimum of 0.003.

From the descriptive analysis, we can discover other interesting phenomena in Chinese listed companies. The average asset liability ratio is 58.32%, with a standard deviation of 1.717. The standard deviation of logarithmic of total asset is also not quite large. For the board structure of Chinese listed companies, the smallest scale of the board is only 3, which is the lowest requirement by the law, while some large firms have a board achieving 18. On average, the figure is 9. Considering the independency of the board, the most independent one has two thirds independent directors in the board; the average number is only 36%. Almost 30% firms have CEO or board chair changes in these years.

Table 2 Descriptive statistics

Variables	Observations	Mean	St. Deviation	Minimum	Maximum
1.Peri	5824	0.3229249	2.974145	-.004092	129.0431
2. Oper	5824	-0.1894774	5.214336	-230.7599	38.1315
3. Npro	5824	2.25396	175.2514	-326.951	13357.55
4. SCI	4706	0.112509	0.1280575	0.0001225	1
5. Conc	5823	0.4900574	0.1532018	0.0573	1
6. Rest	5823	0.06792	0.1171892	0.0025505	2.029286
7. Alr	5829	0.5832064	1.716642	0.0071	96.9593
8. Fsize	5825	21.64727	1.247656	16.70218	26.64752
9. Oppo	5826	0.4088949	8.681991	-0.915126	529.944
10. Bsize	5757	9.080945	1.758938	3	18
11. Bind	5757	0.3639127	0.0509672	0.0909091	0.6666667
12. Turn	5831	0.274224	0.4461606	0	1

Table 3 reports the correlations of the variables. It is interesting to discover that the

correlation between supply chain integration index and period expense rate is significantly positive, and operating margin ratio is significantly negative. These figures tell us that since the expense is high and profit is low at the moment, the firm has more incentive to adopt supply chain integration strategy. Such strategy will take into effect years later. The correlations among all variables are below 0.5, which suggests that multi-collinearity should not be a problem in this study.

Table 3 Pearson Correlation Matrix

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1. Peri	1.000											
2. Oper	-0.496***	1.000										
3. Npro	0.275***	-0.024*	1.000									
4. SCI	0.130***	-0.058***	0.022	1.000								
5. Conc	-0.043***	0.040***	-0.003	-0.029**	1.000							
6. Rest	-0.021	0.014	-0.006	-0.010	0.115***	1.000						
7. Alr	0.167***	-0.119***	-0.005	0.130***	0.000	0.006	1.000					
8. Fsize	-0.121***	0.089***	-0.037***	-0.297***	0.210***	0.149***	-0.108***	1.000				
9. Oppo	-0.003	-0.014	-0.001	0.042***	0.055***	-0.013	0.000	0.038***	1.000			
10. Bsize	-0.036***	0.025*	-0.015	-0.077***	0.092***	-0.025*	-0.015	0.289***	-0.000	1.000		
11. Bind	0.007	-0.010	0.017	0.052***	0.025*	0.050***	0.031**	-0.005	0.010	-0.283***	1.000	
12. Turn	0.031**	-0.033**	-0.008	0.039***	-0.038***	0.017	0.033**	-0.038***	0.036***	-0.018	0.026*	1.000

5.2 Hierarchical regression

Table 4 reports the regress results of the models. Totally nine models are shown. Models 1(a) to 1 (c) are to show the main effect, models 2(a) to 2(c) are to show the moderating effect by ownership concentration, and the last three models are showing the moderating effect by

ownership restriction.

Table 4 Hierarchical Regression Result

Models	1(a)	1(b)	1(c)	2(a)	2(b)	2(c)	3(a)	3(b)	3(c)
	Peri	Oper	Npro	Peri	Oper	Npro	Peri	Oper	Npro
SCI	-2.099*** (0.605)	7.033*** (1.331)	7.021*** (1.324)	-6.114*** (1.780)	27.791*** (3.897)	27.245*** (3.875)	-0.967 (0.674)	4.500*** (1.483)	4.358*** (1.474)
SCI*Co nc				8.904** (3.713)	-46.038*** (8.130)	-44.855*** (8.084)			
SCI*Re st							-17.001*** (4.501)	38.023*** (9.905)	39.973*** (9.843)
Conc	0.592 (0.782)	-0.955 (1.721)	-0.561 (1.711)	-0.473 (0.899)	4.555** (1.968)	4.807** (1.957)	0.516 (0.780)	-0.783 (1.717)	-0.381 (1.707)
Rest	-0.442 (0.690)	1.239 (1.518)	1.266 (1.509)	-0.425 (0.689)	1.150 (1.509)	1.179 (1.501)	1.101 (0.800)	-2.212 (1.761)	-2.363 (1.750)
Alr	-0.026 (0.120)	0.217 (0.264)	0.162 (0.262)	-0.053 (0.120)	0.358 (0.264)	0.299 (1.14)	-0.014 (0.120)	0.191 (0.263)	0.134 (0.262)
Fsize	-0.169 (0.134)	0.256 (0.296)	0.331 (0.294)	-0.182 (0.134)	0.326 (0.294)	39.956 (1.36)	-0.157 (0.134)	0.230 (0.295)	0.304 (0.293)
Oppo	0.0005 (0.009)	0.004 (0.020)	0.003 (0.020)	0.0005 (0.009)	0.004 (0.020)	0.003 (0.020)	0.0003 (0.009)	0.0048 (0.0198)	0.0036 (0.0197)
Bsize	-0.015 (0.055)	0.052 (0.120)	0.086 (0.120)	-0.020 (0.055)	0.079 (0.120)	0.113 (0.119)	-0.0136 (0.055)	0.049 (0.120)	0.083 (0.119)
Bind	0.196 (1.244)	-0.756 (2.737)	-0.536 (2.721)	0.274 (1.243)	-1.156 (2.722)	-0.925 (2.706)	0.213 (1.240)	-0.794 (2.730)	-0.575 (2.712)
Turn	-0.048 (0.088)	0.216 (0.193)	0.229 (0.192)	-0.047 (0.088)	0.213 (0.192)	0.226 (0.191)	-0.046 (0.087)	0.217 (0.192)	0.225 (0.191)
N	3388	3389	3388	3388	3389	3388	3388	3389	3388

F	1.45*	2.70***	2.66***	1.76**	4.82***	4.70***	2.37***	3.57***	3.66***
R ²	0.0072	0.0134	0.0132	0.0095	0.0255	0.0249	0.0127	0.019	0.0195

Year dummies are omitted. The numbers in brackets are Standard Error. * p<0.05; ** p<0.01; *** p<0.001

(1) Main effect. Model 1(a) shows supply chain integration index is statistically significantly negatively related to period expense rate (p=0.001). The more integration a listed company does, the lower period expense rate will be. Hypothesis 1 is supported. Model 1(b) shows supply chain integration index is significantly positively related to operating margin ratio (p=0.000). The more integration a listed company does, the higher operating margin ratio will be. Hypothesis 2 is supported. Model 1(c) shows supply chain integration index is positively related to net profit margin ratio (p=0.000). The more integration a listed company does, the higher net profit margin ratio will be. Hypothesis 3 is supported.

(2) Moderating effect. On the basis of Models 1(a) to 1(c), Models 2 and 3 add an interaction term to check the moderating effect. Interaction terms in Models 2(a) to 2(c) are significant. In Model 2(a), the coefficient is positive, which shows ownership concentration will make period expense rate decrease slowly. Hypothesis 2(a) is supported. In Model 2(b) and 2(c), their coefficients are both negative, indicating that ownership concentration will make profit a short increase. Hence, hypotheses 2(b) and 2(c) are supported.

Similarly, the signs of coefficients in the interaction terms in Models 3(a) to 3(c) are different from what is in Models 2(a) to 2(c), and they're all significant with p-value<0.001. It shows ownership restriction' moderating effect is opposite to what ownership concentration

does. Therefore, hypotheses 3(a) to 3(c) are supported.

6. DISCUSSION

6.1 Conclusion

Using the data in manufacturing industry from Chinese listed companies, the study analyze the impact of supply chain integration on firm performance. At the same time, it considers the moderating role of ownership structure.

From transaction cost and information processing theory, supply chain integration reduces transactions cost, information cost, and has a positively effect on firm performance.

By agency theory and insider control theory, ownership structure significantly moderates the above effect. High ownership concentration makes majority shareholders weaken firm long-term benefit and pursuing their private interests. Ownership concentration weakens the above effect and ownership restriction strengthens the effect. Therefore, firms should take some steps in promoting ownership restriction to get higher performance.

6.2 Research significance

The research is of theoretical significance. The research establishes an index to measure supply chain integration, and it incorporates corporate governance theory into supply chain. Furthermore, the contingency factors of supply chain integration are examined.

The research is of managerial implications. China is a transforming economy, and decision makers are facing many peculiar environment. Decision makers need to think how to activate

the firms and enhance their competitive advantage. First, supply chain integration improves firm performance. Managers should strengthen their collaboration with supply chain partners. Second, Ownership structure moderates the impact of supply chain integration on firm performance --- ownership concentration weakens and ownership restriction strengthens the effect. Decision makers should think how to improve ownership structure. It is advisable to introduce restriction system among majority shareholders.

6.3 Limitation and directions

The sample is limited only to Chinese manufacturing enterprises listed on stock exchange. The research result can't be generalizable to other enterprises and in other national context. It would be better to collect data in other industries and other countries.

The current study only uses ownership governance as a moderator. In the future, we may try some other contingency factors, for example, board structure or even some external governance mechanisms.

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PRODUCT RECOVERY PLANNING AND LOGISTICS NETWORK DESIGN IN CLOSED-LOOP SUPPLY CHAIN ENVIRONMENTS

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ABSTRACT

Recovery of used products and their remanufacturing into new ones has gained justifiable popularity among environmentally friendly companies in recent years. For a remanufacturing operation to function effectively the existing logistics network of facilities must be redesigned in the form of a closed-loop system to handle the arising forward flows of goods to the customer and return flows of cores from end users. At the same time the organization must plan the quantities to collect, disassemble, store and remanufacture in such a way to meet demand at the minimum cost. This paper presents a multi-period cost minimization mixed integer programming model that simultaneously solves for the location of the remanufacturing/distribution and disassembly facilities, the transshipment, production, stocking, and disposition of the optimal quantities of remanufactured products and cores.

KEYWORDS

Closed-Loop Supply Chain, Remanufacturing, Mixed-Integer Programming

INTRODUCTION

Because of environmental, legal, social, and economic factors, product recovery and remanufacturing is gaining increasing popularity among society, government, and industry worldwide. A number of governmental legislations are forcing producers to take care of their End of Life (EOL) products. For instance, the Waste Electrical and Electronic Equipment (WEEE) directive (directive 2002/96/EC), which contains mandatory requirements on collection, recycling, and recovery for all types of electrical goods with a minimum rate of 4 kilograms per head of population per annum became European law in 2003 (Georgiadis and Besiou, 2010).

WEEE-like legislation was also introduced in Canada, Japan, China, and many states in the U.S. (Quariguasi Frota Neto et al., 2007). A Boston University study (Lund, 1996) concluded that the remanufacturing industry is a \$53 billion industry in the U.S. alone, on par with the steel industry. The growth of remanufacturing is recognized as a prevalent manufacturing trend in the 21st century (Coates, 2000). Until recently much of the remanufacturing was driven by cost cutting considerations and limited to low-volume high-value items. For example, the reuse of parts and materials obtained from high-value, end-of-lease copiers, reportedly saves the Xerox Corporation 40% to 65 % in manufacturing cost (Ginsburg, 2001). However many companies, attempting to combine good business sense with environmental sustainability, are now increasingly remanufacturing high-volume low-value items such as single-use cameras, mobile phones, ink-jet printers, and cartridges (Guide et al., 2003). For instance, Eastman Kodak Company reuses on average 76% of the weight of a disposed camera in the production of a new one (Savaskan et al., 2004).

Remanufactured products are generally upgraded to the quality standards of new products so that they can be sold as new products. The production and distribution systems which combine product recovery and remanufacturing are referred to as closed-loop supply chains. Closed-loop supply chains differ from traditional supply chains in many aspects. In a traditional supply chain the product is moved forward, and the customer is typically at the end of the chain. However, a closed-loop supply chain includes not only the forward processes, but also the reverse activities of product return and recovery. These activities include: acquisition of used products from end-users and their transportation to disassembly sites, recovery and storage of reusable units, disposition of non-reusable units, and remanufacturing of reusable units.

Closed-loop networks link together two distinct markets, namely a “disposer market” from which used products are collected, and a “reuse market” in which demand for remanufactured product exists. The intercession role that closed-loop networks play between these two heterogeneous markets gives rise to the issue of coordination between supply and demand in a recovery operation. Availability of used products for recovery is less predictable than supply of new input materials in a traditional supply chain. Therefore, mismatch between supply and demand with respect to quantity and timing is more prevalent in closed-loop than in traditional supply chains (Fleischmann et al., 2001).

Another major characteristic of recovery networks is the level of uncertainty about the quality of used products. In general, used product quality is not known beforehand and can, depending on the condition of the individual product, be subject to considerable variability. As a result, disassembly inspection and testing activities play an important role in transitioning the product from the disposer to the reuse market. The quantity of used products that may be reused, and the quantity to be disposed of, and hence the magnitude and destination of the various reverse flows can only be determined after disassembly and testing.

Moreover, even if technically feasible, a recovery operation may not be economically attractive. Since total recovery costs (collection, disassembly, processing, and transportation) depend to a large extent on the structure of the logistics network (the relative location and size of disassembly centers to plants, collection points and disposal sites, and on the relative location and size of plants to markets), then optimal design of the closed-loop network becomes critical to the economic viability of the recovery operation. For a recovery operation to function effectively, the issues of: (1) mismatches between supply and demand, (2) quality uncertainty, and (3) network structure need to be taken into account when formulating closed-loop logistics models.

A growing amount of supply chain management research addresses reverse logistics issues. A comprehensive literature review can be found in (Govindan et al., 2015), (Guide et al., 2000), and (Fleischmann et al., 1997). Reverse logistics research may be classified into three main areas: (1) reverse distribution planning (Pohlen and Harris II, 1992), and (Jahre, 1995); (2) inventory control of return flows (Schrady, 1967), (Mabini and Gelders, 199), and Barros et al., 1998); and (3) production planning with reuse of parts and materials (Johnson and Wang, 1995), and (Van der Laan and Salomon, 1997). It is noteworthy that this literature appears to be focused mainly on optimization and inventory control of return flows. Studies

addressing recovery planning and logistics network redesign in closed-loop environments are rare.

Remanufacturing can be carried out by a local manufacturer or an original equipment manufacturer (Pranab and Harry, 2001). In this paper we consider the latter case wherein the manufacturer remanufactures products from returned cores and other major components in parallel with the manufacturing of new products in the same facilities. In this environment, recovery networks are not commonly established from scratch but are designed using the existing set of plants and other logistics facilities. To this end, it is important to know which plants and disassembly centers to open and operate, and the number of units to process, store, and distribute out of them. Also, since capacity and recovery cost are facility-dependent, there is interest in determining whether it is economical to collect all returns and, by virtue of consequence, service all customer zone demands; and if not determining the appropriate level of collection remanufacturing and distribution of the recovery operation. Hence, facility and transportation decisions have to be integrated with recovery planning decisions so that material requirements, inventory levels, demand, and capacity constraints over the various stages of collection, disassembly, recovery, and disposition can be coordinated in the most economical way.

The objective of the paper is to formulate a multi-period cost-minimization integrated network design and recovery planning model that provides unambiguous answers to such questions as:

1. Which plants and which disassembly centers should be opened and operated during the planning horizon?
2. Which plants should service which market's product demand, in what quantity, and in which period?
3. How many units of used products are to be collected from each customer zone and shipped to each disassembly center in every period?
5. How many reusable units should each disassembly center ship to each plant in every time period?
6. How many reusable units should be held in inventory at each disassembly center in every period?
7. In which disposal site and in what quantity should non-reusable units be disposed of in every time period?

MODEL DEVELOPMENT

The proposed integrated network design and recovery planning model follows the closed loop network structure shown in Fig. 1. We consider four types of facilities, namely plants where remanufacturing of the reusable units takes place, disassembly centers where the inspection and disassembly function of the used units is carried out, disposal sites where non-reusable inputs are disposed of, and customer zones in which remanufactured units are sold and from which used units are collected. Moreover, two outcomes are possible for the used units: recovery and disposal. Only a given fraction of the used units processed in the disassembly centers is deemed recoverable and therefore reusable during remanufacturing, the remaining units are considered non-reusable and thus disposable. We also consider two types of flows: forward and reverse flows. Forward flows represent shipments of remanufactured units from plants to customer zones. The reverse flows represent: (1) transportation of used units from

customer zones to disassembly centers, (2) shipments of reusable units from disassembly centers to plants, and (3) transportation of non-reusable units from disassembly centers to disposal sites.

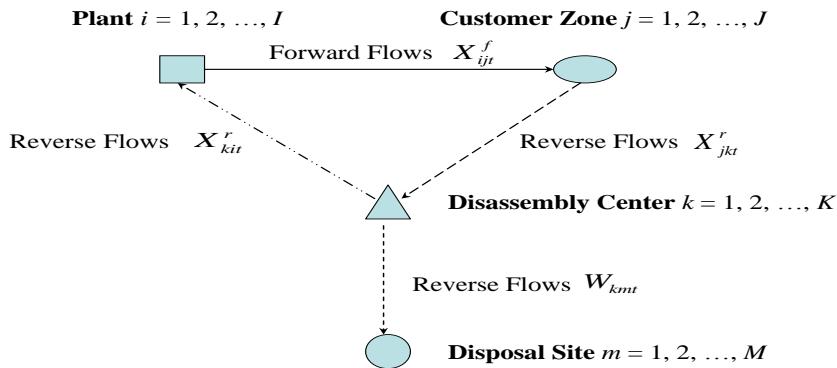


Fig. 1 Closed-Loop Network

Assumptions

The following assumptions are postulated:

1. The supply chain facilities (plants, customer zones, disassembly centers, and disposal sites), already exist.
2. Demand for remanufactured products and supply of used products at customer zones are known and constant throughout the time period.
3. Plant production capacities, customer zone collection capacities, and disassembly center capacities are known.
4. A given product recovery ratio determines the number of reusable units resulting from the disassembly and inspection of a certain number of used units. This ratio is common to all used units regardless of the disassembly center they are processed in and the customer zone they are collected from.
5. Inventory of reusable units is held at the disassembly centers.
6. A minimum proportion of the reusable units recovered within a given disassembly center in a time period must be shipped out of that center in that period. This minimum quantity is a management policy designed to achieve an adequate inventory turnover at each center and thereby to reduce obsolescence of the reusable unit inventory in the supply chain.
7. Disposal sites have unlimited capacities.

Notation

We use the following notation to formulate the model.

Primary Sets and indices

I = Set of potential plants for product remanufacturing, $i \in I$;

K = Set of potential centers for used product disassembly, $k \in K$;

J = Set of customer zones or demand points, $j \in J$;

M = Set of disposal sites, $m \in M$;

T = Set of time periods, $t \in T$;

Supply/Demand Data

D_{jt} = Product demand at customer zone j during period t ;

S_i = Plant i production capacity per period;

S_j = Customer zone j used product collection capacity per period;

S_k = Center k disassembly capacity per period;

θ_k = Center k inventory storage capacity per period;

A = Policy factor specifying the minimum proportion of reusable units to be shipped out of each disassembly center to plants in every period, $0 \leq A \leq 1$;

d_{jt} = Used product return forecast at customer zone j during period t ;

λ = Product recovery ratio, $0 \leq \lambda \leq 1$;

Cost Data

F_i = Fixed cost of opening and operating plant i ;

F_k = Fixed cost of opening and operating disassembly center k ;

C_{ki} = Per unit remanufacturing cost at plant i using a reusable unit sourced from center k .

This cost includes production cost at plant i , transportation cost from center k to plant i and the cost of material sourced from center k ;

C_{jk} = Per unit disassembly cost at center k of a used product collected in customer zone j .

This cost includes collection cost at zone j , transportation cost from j to k , and disassembly cost at k ;

C_{km} = Per unit disposal cost at site m of a non-reusable unit processed at center k . This

cost includes disposal cost at site m and transportation cost from k to m ;

H_k = Per unit per period inventory holding cost of a reusable unit in inventory at center k ;

P_j = Unit penalty cost for not collecting a used product from customer zone j ;

G_j = Unit penalty cost of not serving demand of customer zone j . Observe that G_j could be quantified by taking into account the relative importance of the different customer zones j 's; alternatively it could be related to the cost of meeting demand of zone j by resorting to external suppliers.

T_{ij} = Unit transportation cost of a product from plant i to customer zone j ;

Variables

X_{ijt}^f = Forward flow: units shipped from plant i to customer zone j in period t ;

X_{jkt}^r = Reverse flow: units of used product shipped from customer zone j and to center k in period t ;

X_{kit}^r = Reverse flow: reusable units shipped from center k to plant i in period t . Observe that since no inventory of remanufactured units is held at the plants, this quantity also reflects the number of units produced in plant i out of cores sourced from center k in period t ;

W_{kmt} = Non-reusable units shipped from disassembly center k to site m for disposal in period t ;

B_{jt} = Units of unsatisfied demand from customer zone j in period t ;

I_{kt} = Disassembled units held in inventory at center k at the end of period t ;

U_{jt} = Uncollected units of used product from customer zone j at the end of period t ;

$Z_i = \begin{cases} 1, & \text{if product is produced in plant } i; \\ 0, & \text{otherwise.} \end{cases}$

$Y_k = \begin{cases} 1, & \text{if used product is disassembled in center } k; \\ 0, & \text{otherwise.} \end{cases}$

Constraints

$$\sum_{j \in J} X_{ijt}^f \leq S_i Z_i, \quad i \in I, t \in T; \quad (2)$$

Constraints (2) specify that the total flow out of plant i , and thereby the total number of units produced at plant i , during period t must be less than or equal to that plant production capacity if the product is produced in such a plant; and must be equal to zero otherwise.

$$\sum_{i \in I} X_{ijt}^f + B_{jt} = D_{jt}, \quad j \in J, t \in T; \quad (3)$$

Constraints (3) ensure product flow balance between forward product flows into customer zone j , and demand requirement for that zone at time period t , and account for the possibility of unsatisfied demand at that zone. Unsatisfied demand occurs when not enough used units are collected or when product demand is greater than production and/or disassembly capacities.

$$\sum_{k \in K} X_{kit}^r = \sum_{j \in J} X_{ijt}^f, \quad i \in I, t \in T; \quad (4)$$

Equation (4) is a material balance constraint ensuring that the total number of reusable units going into a plant i (or reverse flow) equals the total number of remanufactured units coming out of that plant (or forward flow) in every time period. Input into plant i can be sourced from any open disassembly center k and the output of such a plant can be shipped to any customer zone j .

$$I_{k,t-1} + \lambda \sum_{j \in J} X_{jkt}^r = \sum_{i \in I} X_{kit}^r + I_{kt}, \quad k \in K, t \in T; \quad (5)$$

Constraints (5) ensure product flow balance between inventory of reusable units, processing of used units, and shipment of reusable units at disassembly center k in time period t . Used units are assumed to yield λ reusable units. Inventory at center k may be carried to provide better customer service or to satisfy forecasted demand that exceed production capacities in future time periods.

$$I_{kt} \leq \theta_k Y_k, \quad k \in K, t \in T; \quad (6)$$

Constraints (6) specifies that the total number of reusable units stored in inventory at center k in period t cannot be larger than the inventory storage capacity of that center.

$$\sum_{k \in K} X_{jkt}^r + U_{jt} = d_{jt}, \quad j \in J, t \in T; \quad (7)$$

Constraints (7) ensure product flow balance between collection of used units, forecasted return of used units and uncollected units of used product at customer zone j in time period t . Observe that the number of used units collected at zone j determines the total reverse flow from zone j to all open disassembly centers.

$$\sum_{k \in K} X_{jkt}^r \leq S_j, \quad j \in J, t \in T; \quad (8)$$

Constraints (8) require that the total number of used units collected at customer zone j in time period t to be less than the collection capacity of that zone.

$$\sum_{j \in J} X_{jkt}^r \leq S_k Y_k, \quad k \in K, t \in T; \quad (9)$$

Equation (9) requires the total flow into center k , and thereby the total number of units processed at such a center, during period t to be less than or equal to that center processing capacity if returns are disassembled in such a center; and must be equal to zero otherwise.

$$\sum_{i \in I} X_{kit}^r \geq A \lambda \sum_{j \in J} X_{jkt}^r, \quad k \in K, t \in T; \quad (10)$$

Constraints (10) require that the total flow out of any open center k in period t meets the minimum output requirement A for that center. Management may specify A in such a way to ensure a minimum outflow activity for center k thereby preventing such a center from becoming just an inventory storage location of reusable units.

$$\sum_{m \in M} W_{kmt} = (1 - \lambda) \sum_{j \in J} X_{jkt}^r, \quad k \in K, t \in T; \quad (11)$$

Constraints (11) specify the number of non-reusable units transported from disassembly center k to site m for disposal. Observe that a proportion $(1 - \lambda)$ of the used units collected from all customer zones and processed in center k are non-reusable and must therefore be disposed of.

Objective Function

$$\begin{aligned} \text{Min } & \sum_{i \in I} F_i Z_i + \sum_{k \in K} F_k Y_k + \sum_{t \in T} \left[\sum_{j \in J} (P_j U_{jt} + G_j B_{jt}) + \sum_{k \in K} H_k I_{kt} + \right. \\ & \left. \sum_{i \in I} \sum_{k \in K} C_{ki} X_{kit}^r + \sum_{j \in J} \sum_{k \in K} C_{jk} X_{jkt}^r + \sum_{k \in K} \sum_{m \in M} C_{km} W_{kmt} + \sum_{i \in I} \sum_{j \in J} T_{ij} X_{ijt}^f \right] \end{aligned} \quad (1)$$

Objective function (1) minimizes the total multi-period cost of remanufacturing, collection, disassembly, disposal, inventory, and transportation of the recovery operation. The components of the objective function may be described as follows:

Fixed cost at plants and disassembly centers over the entire planning horizon

$$= \sum_{i \in I} F_i Z_i + \sum_{k \in K} F_k Y_k.$$

$$\text{Multi-period variable production cost at the plants} = \sum_{t \in T} \sum_{i \in I} \sum_{k \in K} C_{ki} X_{kit}^r.$$

$$\text{Inventory costs at processing centers} = \sum_{t \in T} \sum_{k \in K} H_k I_{kt}.$$

$$\text{Penalty cost of unsatisfied demand at customer zones} = \sum_{t \in T} \sum_{j \in J} G_j B_{jt}.$$

$$\text{Penalty cost of uncollected returns at customer zones} = \sum_{t \in T} \sum_{j \in J} P_j U_{jt}.$$

$$\text{Collection, transportation, and processing costs of used units} = \sum_{t \in T} \sum_{j \in J} \sum_{k \in K} C_{jk} X_{jkt}^r.$$

$$\text{Disposal and transportation costs of non-reusable units} = \sum_{t \in T} \sum_{k \in K} \sum_{m \in M} C_{km} W_{kmt}.$$

$$\text{Transportation cost of new units from plants to retailers} = \sum_{t \in T} \sum_{i \in I} \sum_{j \in J} T_{ij} X_{ijt}^f.$$

The mixed integer programming model, described above, can now be rewritten as:

$$\begin{aligned} \text{Min } & \sum_{i \in I} F_i Z_i + \sum_{k \in K} F_k Y_k + \sum_{t \in T} \left[\sum_{j \in J} (P_j U_{jt} + G_j B_{jt}) + \sum_{k \in K} H_k I_{kt} + \right. \\ & \left. \sum_{i \in I} \sum_{k \in K} C_{ki} X_{kit}^r + \sum_{j \in J} \sum_{k \in K} C_{jk} X_{jkt}^r + \sum_{k \in K} \sum_{m \in M} C_{km} W_{kmt} + \sum_{i \in I} \sum_{j \in J} T_{ij} X_{ijt}^f \right] \end{aligned} \quad (1)$$

Subject to:

$$\sum_{j \in J} X_{ijt}^f \leq S_i Z_i, \quad i \in I, t \in T; \quad (2)$$

$$\sum_{i \in I} X_{ijt}^f + B_{jt} = D_{jt}, \quad j \in J, t \in T; \quad (3)$$

$$\sum_{k \in K} X_{kit}^r = \sum_{j \in J} X_{ijt}^f, \quad i \in I, t \in T; \quad (4)$$

$$I_{k,t-1} + \lambda \sum_{j \in J} X_{jkt}^r = \sum_{i \in I} X_{kit}^r + I_{kt}, \quad k \in K, t \in T; \quad (5)$$

$$I_{kt} \leq \theta_k Y_k, \quad k \in K, t \in T; \quad (6)$$

$$\sum_{k \in K} X_{jkt}^r + U_{jt} = d_{jt}, \quad j \in J, t \in T; \quad (7)$$

$$\sum_{k \in K} X_{jkt}^r \leq S_j, \quad j \in J, t \in T; \quad (8)$$

$$\sum_{j \in J} X_{jkt}^r \leq S_k Y_k, \quad k \in K, t \in T; \quad (9)$$

$$\sum_{i \in I} X_{kit}^r \geq A \lambda \sum_{j \in J} X_{jkt}^r, \quad k \in K, t \in T; \quad (10)$$

$$\sum_{m \in M} W_{kmt} = (1 - \lambda) \sum_{j \in J} X_{jkt}^r, \quad k \in K, t \in T; \quad (11)$$

$$Y_k, Z_i = \{0, 1\}, \quad i \in I, k \in K; \quad (12)$$

$$X_{ijt}^f, X_{jkt}^r, X_{kit}^r, W_{kmt}, I_{kt}, B_{jt}, U_{jt} \geq 0, \quad i \in I, j \in J, k \in K, m \in M, t \in T. \quad (13)$$

Observe that optional constraints representing logical conditions between the decision variables may be added to tighten the above formulation.

$$X_{ijt}^f \leq \min\{D_{jt}, S_i\} Z_i, \quad i \in I, j \in J, t \in T; \quad (14)$$

$$X_{jkt}^r \leq \min\{d_{jt}, S_j, S_k\} Y_k, \quad j \in J, k \in K, t \in T; \quad (15)$$

$$X_{kit}^r \leq \min\{Z_i, Y_k\} S_i, \quad k \in K, i \in I, t \in T; \quad (16)$$

$$W_{kmt} \leq (1 - \lambda) S_k Y_k, \quad k \in K, m \in M, t \in T; \quad (17)$$

Constraints (14) state that the flow between plant i and customer zone j in period t can never exceed the minimum of zone j 's demand and the capacity at plant i if plant i is open; and must be zero otherwise. Likewise, constraints (15) indicates that the flow between customer zone j and disassembly center k in period t can never exceed the minimum of zone j 's product

return, the collection capacity of zone j , and the capacity of center k if center k is open; and must be zero otherwise. Constraints (16) state that the flow between center k and plant i in period t can never exceed the capacity of plant i if both plant i and center k are open, and must be zero otherwise. Observe that in (16) plant i capacity, S_i , is used in lieu of center k capacity, S_k , to account for the possibility that the flow from center k to plant i can be larger than the center's capacity because of the presence of inventory at that center. Finally, constraint (17) states that the flow between center k and disposal site m in period t can never exceed the capacity of center k multiplied by the product non-reusable ratio, $(1-\lambda)$, if that center is open, and must be zero otherwise.

The above formulation is general enough to reflect many practical product recovery scenarios. In particular different market structures, closed-loop and open-loop, can be modeled by selecting the D_{jt} and d_{jt} parameters accordingly. If $D_{jt} \times d_{jt} > 0$, then customer zone j belongs to both the disposer and reuse market, and therefore a closed-loop logistics structure applies. Conversely, when $D_{jt} \times d_{jt} = 0$ customer zone j belongs to either one of these two markets and thus an open-loop logistics structure is implied. Furthermore, both push and pull collection strategies can be modeled. Large penalty costs P_j reduce the values of U_{jt} and, by virtue of constraint (7), result in a collection obligation (push strategy). Conversely, an economically driven (pull) collection strategy can be captured by setting $P_j = 0$ for all customer zone j 's. Likewise, by varying the value of G_j both a push strategy to market for remanufactured products and a demand pull strategy can be modeled.

CONCLUSION

From these results it is apparent that collection, recovery, remanufacturing, transportation and distribution are complicated decisions subject to structural constraints of the logistics network as well as environmental factors concerning supply and quality uncertainty of the used products. The proposed model is able to effectively capture these constraints and determine the optimal design of the recovery network, and specify the optimal flows from customer zones to disassembly centers, from centers to plants, from plants to customer zones, and from centers to disposal sites, along with the optimal levels of unsatisfied demand and non-collection of used units over a multi-period planning horizon in such a way to minimize the total cost of the recovery operation. The next stage of this research effort is to conduct a computational experiment to test this model and report the results in a later paper.

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IMPACT OF SUPPLY CHAIN COLLABORATION ON ORGANISATIONS' SUSTAINABILITY PERFORMANCE

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ABSTRACT

While supply chain collaboration has sometimes proven difficult to implement, once implemented, it has the potential to offer significant improved performance for the organisations involved. This study aims to examine the impact of collaboration on all the dimensions of the triple bottom line performance (environmental, social and economic). The data used for this study was obtained from the fifth round of the Global Manufacturing Research Study (GMRG). Multi-level regression analysis results show that collaboration had a positive impact on all three components of the triple bottom line. The results further show that country level factors such as economic outlook and social sustainability can also influence overall performance. We discuss the implications of the findings for practice and future research.

KEYWORDS

Supply chain, collaboration, triple bottom line

INTRODUCTION

Over the last few years, the field of supply chain management (SCM) has received considerable interest and attention from practitioners and scholars. Much of this has been attributed to trade globalisation, increasing competition globally and more recently issues pertaining to increasing costs of energy and resulting regulations (Chaabane et al., 2012, Ageron et al., 2012, Zhu and Sarkis, 2004). These pressures have resulted in companies engaging in various partnerships and collaborations to achieve higher sustainability performance.

Collaboration is a broad and encompassing term in the context of supply chain (Barratt, 2004). Collaboration is commonly described as two or more organisations working and operating together to resolve common problems and to achieve the desired goals (Barratt, 2004, Corbett et al., 2012, Wagner et al., 2002). Members in the supply chain work together to create a competitive advantage through practices such as sharing of information, processes, technologies and resources, making joint decisions, and sharing benefits as a result of working together. Furthermore, collaboration provides a way for organisations to protect the value of their resources by implementing various financial and organisational safeguards against opportunistic behaviour (Jorde and Teece, 1990).

The concept of sustainability was originally proposed by the World Commission on Environment and Development (Burton, 1987) as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." In a supply chain, sustainability considers the entire life cycle of the product using the triple bottom line (TBL) approach as a measure of success (Elkington, 1997, Linton et al., 2007, Pagell et al., 2010). By encouraging TBL, a firm signals to shareholders, stakeholders, and supply chain partners that the company's focus is not only restricted to economic targets, but also includes

environmental and social concerns (Markley and Davis, 2007).

The environmental dimension involves factors relating to climate change, global warming, air, land and water pollution (or preservation) and ozone layer depletion. The social aspect involves health and safety issues, community well-being, employment opportunities, charities, cultural sensitivities and requirements and organisational behaviour (Gopalakrishnan et al., 2012). The economic aspect of the TBL refers to profit making and attaining and sustaining competitive advantage through sustainability. With the recent climate changes and depletion of resources together with the need for improved efficiency and competitiveness, it has become necessary for organisations to acknowledge the importance of TBL.

The purpose of this study is to examine the impact of collaboration on sustainability performance using a large-scale survey conducted among manufacturers around the globe. Unlike other studies that only explore one or two dimensions of the TBL (Lee and Klassen, 2008, Schliephake et al., 2009, Vachon and Klassen, 2008, Borchardt et al., 2011, Rao, 2002, Zhu et al., 2007, Large and Gimenez Thomsen, 2011), this study will examine all three dimensions performance (environmental, social and economic). In addition, our study is a multi-level study that looks at both plant and country-level effects. The results of this study will be useful to managers and practitioners in understanding the significant benefits associated with having close collaborations to achieve sustainable performance. The structure of the paper is as follows: Firstly, we review the literature around collaboration and TBL which leads to our research hypotheses. We then present the methodology section followed by results. The final parts of the paper present our discussions, implications and conclusions.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Collaboration and sustainable performance

Collaboration among supply chain partners is a common global practice and has been practiced for a long time. Inter-organisational collaboration is known to be an important ingredient to improve supply chain performance and integrate partners as a network (Kache and Seuring, 2014, Winter and Knemeyer, 2013). Potential forms of supply chain collaboration can be divided as vertical and horizontal. Vertical form includes collaboration with customers, internally across functions and with suppliers. Horizontal form includes collaboration with competitors, internally and with non-competitors (Simatupang and Sridharan, 2002, Barratt, 2004). There are several benefits discussed in the extant studies for collaboration with partners, especially with suppliers. Being a reservoir of knowledge and expertise, collaborative relationships with suppliers can provide competitive advantages to buyers (Theissen et al., 2014). Opportunities on the downstream side of the supply chain include improved customer relationship management, demand planning and forecasting, demand replenishment and shared distribution. On the upstream side of the supply chain opportunities include improved supplier planning and production scheduling, collaborative design and transportation (Barratt, 2004).

Sustainable performance incorporates environmental, social and economic responsibilities. Sometimes also referred to as people, planet and profit, these are the three important dimensions under the triple bottom line. Environmental or ecological performance requires organisations to re-examine their use of resources in order to account for energy and reduce their carbon footprint. In the supply chain, this means that specific environmental

performance criteria have to be applied by all partners (Awasthi et al., 2010). Some examples of environmental performance include reductions in waste and pollution, decrease in the consumption of harmful materials and environmental accidents (Zhu et al., 2008). Social performance requires organisations to operate in a sensible manner and work towards improved employee health and safety and the general quality of life. Therefore, organisations need to promote equal opportunities, diversity in the workplace, increased democratic and accountable practices and structures (Elkington, 1997, Pullman et al., 2009). Economic performance is generally well understood and is often operationalised as costs associated with purchased materials, energy consumption, waste discharge and financial gains that can be made consequently (Carter, 2005, Zhu et al., 2008).

Collaboration and its impact on TBL

Increased pressures from stakeholders, proliferation of laws, growing customer awareness and competitive pressure persuade firms to address social and environmental concerns. To achieve this goal, firms need to collaborate along the lines of long term views, mutual investment for green projects and buyers' support (Vachon and Klassen, 2006, Vachon and Klassen, 2008, Lintukangas et al., 2013). The focus of supply chain collaboration efforts is therefore on adding value for each other (and other stakeholders) by reaping the cost benefits without lowering environmental benefits (Reuter et al., 2010). By collaborating buyers look to growing the pie and facilitate suppliers, especially small and medium sized suppliers, to understand the impact of their actions on the environment for both forward and reverse supply chains (Kocabasoglu et al., 2007). Buyers should allow suppliers to experiment with environmental-friendly innovative solutions and motivate them to take ownership of environmental related problems (Tachizawa and Wong, 2014).

There are various studies that have found that environmental investments can in fact increase associated costs such as costs of development/implementation of environmental friendly options, suppliers training and monitoring. Studies that found negative relationships between sustainable performance and financial performance argue that environmental challenges are always costly to meet with little financial payback (Ortas et al., 2014). For instance, the time window policy formed by many municipalities to restrict large vehicles' entry into the city centre during peak times although improved social and sustainable performance by reducing noise and improving pedestrian safety resulted in retailers' financial performance to decline (Quak and de Koster, 2007).

Likewise, building an environmental-friendly factory in place of an old one could be a good green policy but is a costly option and may not be financially viable. Technological development in palm oil milling is important to reduce discharge of environment pollutants, however, the Malaysian Palm Oil Board agreed that it is a very expensive process and they need collaboration between supply chain partners to pool resources together to develop the required technology (Chong Tan and Oly Ndubisi, 2014).

It is logical to acknowledge that no firms can invest in environmental friendly options by sacrificing their financial benefits. Consequently, the challenge today is how to run a business profitably without compromising the natural environment in which it is embedded in (Wu and Pagell, 2011). To maintain long term viability of sustainability strategies, it is important that organisations have a positive viewpoint on financial performance. 'Sustainability cannot exist if a firm is not profitable' (Stefan and Paul, 2008: 583), there is often a debate between how much one wants to be green and one affords to

be. This is especially true for small and medium sized suppliers that are located overseas and struggle to run businesses amidst high competition and poor local regulatory frameworks (Lee, 2008, Lee and Klassen, 2008). The decision related to sustainability has to be a pragmatic and cost-neutral one that can satisfy both shareholders and other stakeholders.

There are various empirical studies that have found improvement in financial aspects of the organisations as a result of engaging in social and environmental practices. By satisfying stakeholders, firms can raise share price, raise demand for products/services and are able to spend less on fines and penalties (Ortas et al., 2014). Some studies indicate that the relationships between these constructs depend on situational or contextual factors such as the global financial situation, industry and country-specific factors (Simpson et al., 2007, Pivato et al., 2008). Finally, a bidirectional relationships between sustainability and financial performance is proposed in the literature (Ortas et al., 2014). The tricky relationship between sustainable performance and financial performance could be because of information uncertainty, evolving decision parameters and changing decision boundaries. Mostly, firms and their suppliers do not know how to implement suitable and cost-effective green solutions and cannot see when the benefits will be realised.

In addition, the presence of multiple stakeholders and their different priorities can make the situation confronting (Wu and Pagell, 2011). The situation becomes critical also because the initial investments for environmentally friendly solutions are often costly to justify to shareholders. Therefore, decisions about the trade-off between short-term profitability and long term environmental sustainability involve uncertainties and risks. With the help of life cycle analysis, Adhitya et al. (2011) argue that maximum economic benefits can be achieved with minimum environmental impact. By using mathematical optimisation model, they developed optimal selection tools for appropriate raw materials, suppliers, technologies and transportation route to improve customer satisfaction and profitability via a diaper case study. Walmart through collaboration with NGOs helped suppliers reduce running costs of factories and were able to save up to 60 percent with a shorter payback period (Plambeck and Denend, 2011).

With sustainable investments, firms have the opportunity to increase revenue by having better access to markets, differentiating products from their competitors and selling any pollution control technologies developed (Stefan and Paul, 2008). However, studies also mentioned that relationship is generally positive when basic environmental management jobs, that are incremental in nature, are performed. When firms focus on radical changes, initial economic burden can force them to stop pursuing environmental friendly strategies. However, in the long run, the relationship between sustainable and financial performance is found to be a positive one.

Matthews (2004) illustrates analytically that a proper green reverse supply chain can reduce energy consumption and emission of greenhouse gases by 40 percent and costs by 80 percent with a \$2 million savings in cardboard production, although the cost savings can take several years to be materialised. Likewise, Toyota in the USA developed an on-line calculator for their suppliers to calculate the environmental impact of packaging materials and their use. Moreover, this calculator provides information about costs associated with all types of packaging materials and assists suppliers to decide on environmental-friendly and low-cost solutions (Early et al., 2009). Kimberley-Clark has increased net sales from green products from 13 percent to 22 percent between 2011 and 2012, similarly DuPont's green product-related revenue increased from \$100million to

\$2 billion between the years 2007 to 2012 (Lubin and Esty, 2014).

Another study by Halldórsson et al. (2010) show that environmental initiatives can increase efficiency and productivity, reduce risks and costs, thereby increasing profits for businesses. Environmental initiatives include reduced packaging, carbon emissions accounting for energy efficiency and use of renewable sources and social programmes like increased employee involvement, workplace benefits, diversity and equality for workers and contribution to communities around the organisations (Holmes et al., 1996). Integrating the dimensions of TBL increases reputation among customers, suppliers, employees and shareholders, hence favouring economic benefits (Capaldi, 2005, Ellen et al., 2006).

Up until now, only a handful of studies have examined the impact of collaboration on all the dimensions of the triple bottom line (environmental, social and economic). Authors Lee and Klassen (2008), Schliephake et al. (2009), Borchardt et al. (2011) and Vachon and Klassen (2008) in their study found that organisations that implemented collaborative initiatives with their suppliers saw an improvement in their environmental performance. The findings from Rao (2002) and Zhu et al. (2007) suggest that economic benefits only arise once a threshold of environmental performance has been attained and ample time has passed to allow improvements to reduce costs and increase sales. In a study by Large and Gimenez Thomsen (2011), collaboration tended to have a direct influence on environmental performance. A more recent study by Gimenez et al. (2012) showed only partial support for the impact of collaboration on all three dimensions.

Therefore, based on these arguments and in light of the studies done to date, we hypothesize:

H1: Supply chain collaboration among buyers and suppliers will have a positive impact on a firm's triple bottom line (TBL).

H1a. Supply chain collaboration has a positive impact on a firm's environmental performance

H1b. Supply chain collaboration has a positive impact on a firm's social performance

H1c. Supply chain collaboration has a positive impact on a firm's financial performance

Country specific differences

Country comparisons may be of value if the countries are truly different. In this study, the data used came from the 5th round of the GMRG survey. Data was collected from 13 countries. Collaboration motivations towards achieving TBL goals may be different for the plants involved depending on various country based factors. There is a possibility that reasons to collaborate may vary for different industries and the country in which it operates. This is in line with the earlier arguments made by Simpson et al. (2007) and Pivato et al. (2008) on industry and country specific factors.

Under the theory of the firm, it is generally agreed that firms may engage in collaborative activities to enhance their economic performance. From a financial standpoint, GDP figures may provide valuable information on the general health of the economy. This can be a useful signal for businesses in terms of the expected profits and arising opportunities. For plant managers, a healthy and growing economy may assist them in making informed decisions on the levels of collaboration needed and the areas of focus for performance. That is, plant managers in a smaller country like Hungary and Croatia may

likely face different decision making scenarios compared to larger countries like USA and Australia. Similarly, there may be differences between developed and less developing countries. However, this attitude is changing more and more as countries have started to introduce stricter regulatory requirements on environmental and social practices. In addition, stakeholder demands are also changing (demand for socially responsible goods) which may influence firms and their collaboration goals.

Hence, in light of the arguments presented above, it may be useful to understand whether country differences such as the wellbeing of a country measured through its GDP, regulatory frameworks on environmental and social sustainability influence collaboration practices and decisions on environmental, social and economic performance. Based on this argument, we hypothesise that:

H2: The relationship between collaboration and TBL can vary depending on country based factors.

H2a: The relationship between collaboration and environmental performance can vary depending on country based factors (GDP, social and environment-based factors).

H2b: The relationship between collaboration and social performance can vary depending on country based factors (GDP, social and environment-based factors).

H2c: The relationship between collaboration and financial performance can vary depending on country based factors (GDP, social and environment-based factors).

RESEARCH DESIGN

To address the above hypotheses, we utilized survey data collected through the latest round (i.e., in 2013) by the Global Manufacturing Research Group (GMRG). The GMRG is an international research group consisting of scholars who aim to explore issues and concepts related to global operations and manufacturing (Wacker and Sheu, 2006). The manufacturing plant was the level of analysis where the plant manager was the person who provided the data in most cases. Most of the data was collected electronically, through email or online survey, however, respondents were also contacted via telephone or mail. In some cases, face-to-face interviews were conducted to complete the questionnaire. The data was collected from 13 countries. The effort was centrally coordinated, but the collection was organized by GMRG country representatives. Subsequently, the consolidated database consisting of all country- level data was distributed throughout the GMRG membership. With regards to the country- level data, these are publicly available from the Global Competitiveness Index (GCI) data obtained from the World Economic Forum and the World Bank. For the purposes of this study, a sub-section of the questions in the GMRG questionnaire has been used. Those countries with very low sample sizes were also excluded from the analysis.

Measurement of variables

The key variables of this study are collaboration factors which involve a composite score of items such as green vendor certification, direct investment and joint green improvement work sessions. To measure the dimensions of the TBL, items measuring environmental performance, social performance (OHS) and economic performance (plant financials) were utilized. These were all obtained from the GMRG dataset (see

Appendix 1). Country specific variables were also considered. In order to account for country specific differences affecting TBL performance, we included environmental sustainability and social sustainability scores along with GDP figures (2013 GDP US \$billions). Country specific variables were sourced from the recent Global Competitiveness Report 2014-15. The environmental sustainability score is composed of various indicators representing three main areas, these being environmental policy, use of renewable resources and degradation of the environment. The social sustainability score is also composed of various indicators representing areas such as access to basic necessities, vulnerability to economic exclusion and social cohesion. The use of multiple indicators makes the scores comprehensive and usable for the purposes of this study. We have also included controls for the industry. In this study, we considered industry affiliation and size of the plant measured through the number of employees. Table 1 presents the summary statistics and correlations coefficients among the key variables.

Table 1: Summary statistics and correlations

Variable/construct	Mean	Std. dev.	1.	2.	3.	4.	5.	6.	7.	8.
1. GDP (US\$billions)	2366.5	4476.84	1							
2. Social sustainability	4.93	1.02	0.373	1						
3. Environmental sustainability	4.70	0.83	0.207	0.941 **	1					
4. Collaboration	2.84	1.56	-0.338	-0.312	-0.358	1				
5. Financial Performance	4.23	1.24	0.191	0.062	-0.057	0.110 **	1			
6. Social Performance	4.98	1.58	0.358	0.073	0.056	0.211 **	0.046	1		
7. Environmental Performance	4.50	1.54	-0.233	-0.671 *	-0.621	0.348 **	0.121 **	0.668 **	1	
8. Plant size	1020.6	7077.84	-0.108	-0.394	-0.392	0.128 **	0.057	0.091 *	0.112 **	1

**. Correlation is significant at the 0.01 level (2-tailed), *. Correlation is significant at the 0.05 level (2-tailed).

DATA ANALYSIS

We employed the multi-level modelling technique to capture the variations that country-level data brings in. Regression analysis is not appropriate in these circumstances since the unexplained variability in country-level study could exist at the levels of plant and the country where it is operating. Thus, we conceptualize a nested structure with “COUNTRY” as a level 2 variable and “PLANT” constituting the level 1 variable. We tested the model with random intercept only with the model that considers random coefficients for the country effect. This null model with Environment Performance as a dependent variable generates Intraclass correlation of 6.5%, with Social Performance as a dependent variable generates Intraclass correlation of 3% and Economic Performance as a dependent variable generates Intraclass correlation of 16%. This shows that quite a large variance in dependent variables is due to country based differences. Hence, it is evident that a multilevel model is needed.

Hence, we consider the following model for a mixed-effects REML (Restricted Maximum Likelihood) regression:

$$\begin{aligned} Y_{ij} &= \beta_0 o_{ij} + \beta_1 X_{ij} + b_i Z_{ij} \\ \beta_0 j &= \beta_0 + v_0 \end{aligned}$$

In the above model, i is level 1 (PLANT) and j is level 2 (COUNTRY). The variable β_0 is the average intercept and v_0 is the random effect at the COUNTRY level. The parameter β represents the fixed-effects coefficients and b_{ij} represents random-effects coefficients. We estimated the fixed-effects coefficients for the main effects (Collaboration) and country and control variables (Environmental sustainability, social sustainability, GDP, industry affiliation and plant size).

RESULTS

The results of the multi-level regression analysis is presented in Table 2. The hypothesized positive relationship between collaboration and environmental performance (H1a), collaboration and social performance (H1b) and collaboration and financial performance (H1c) was supported. As shown in Table 2, higher levels of collaboration improve environmental performance ($B = 0.380$, $p= 0.000$), social performance ($B = 0.231$, $p= 0.000$) and economic performance ($B = 0.077$, $p=0.058$).

Different country specific factors were found to have a significant impact on different triple bottom line performance. GDP, which was used to measure economic aspects of countries, influenced social performance negatively ($B = -0.205$, $p=0.049$) and people factors that were used to measure social aspects of countries influenced financial performance positively ($B = 1.091$, $p= 0.099$). Country specific factors had no influence on environmental performance. Plant level factors were also found to be significant. Plant size (measured by employee number) had a positive influence on environmental performance ($B = 0.125$, $p=0.036$) and different industry types had different influences on triple bottom line performance. Specifically, automobile industry had a negative influence on environmental performance ($B = -1.10$, $p=0.031$), tobacco industry had a negative influence on social performance ($B = - 4.713$, $p=0.002$) but positive influence on financial performance ($B = 2.023$, $p=0.082$), apparel industry had a negative influence on social performance ($B = -0.724$, $p=0.092$) and finally construction industry had a negative influence on financial

performance ($B = -0.721$, $p=0.033$). The results are presented in Table 2.

Table 2: Mixed-effects REML regression results Triple Bottom Line (TBL)

	EnvPerf	SocialPerf	EconomicPerf
Fixed effects parameters			
Collaboration	Model 1 0.380**	Model 2 0.231**	Model 3 0.077*
Log_Profit (GDP)	-0.020	-0.205*	-0.125
People	-0.656	0.332	1.091†
Planet	0.577	-0.290	-0.921
Plant size (Log_employee_number)	0.125*	0.048	0.056
Industry: automobile - 1.10*	tobacco:-4.713*, apparel: - 0.724*	tobacco-2.023*, construction: - 0.721*	
Intercept	3.412	5.273	3.521*
Random effects parameters			
Country intercept	0.084	-	0.172
Residual	1.944**	2.276**	1.29**
Log restricted-likelihood	1507.362	1568.262	1616.377
Wald Z	0.868	-	1.257

**p < 0.01; *p < 0.05; p < 0.1

DISCUSSION AND IMPLICATIONS

The aim of our study was to first analyse the impact of collaboration on each dimension of the triple bottom line. Our results show that collaboration activities have a positive impact on each dimension of the triple bottom line (environmental, social and economic performance). This means that firms engaging in collaborative efforts such as green vendor certification, direct investments in green activities and joint green improvement sessions can expect improvements in their environmental, social and economic performance. Our results are in line with that of Vachon and Klassen (2008) and Gimenez et al. (2012) who also found that collaboration had a positive impact on various dimensions of the triple bottom line. The impact of collaboration can also be explained from the resource-based view perspective. Specifically, when buyers and suppliers work together to improve their environmental and social performance they are more likely to develop valuable, rare and inimitable resources (Barney et al., 2001).

Next, unlike other studies that examine collaboration and its impact of the dimensions of the triple bottom line, we also investigated the effect of country based factors. Three country factors in line with the notions of the triple bottom line were included (environmental and social sustainability figures for the environmental and social measure and GDP figures for the economic measure). What is interesting is that countries that promoted high levels of social sustainability (in this study comprising access to basic necessities, vulnerability to economic exclusion and social cohesion) had a positive influence on their economic performance. Plant size also impacted the environmental performance of firms. Given that the dataset is made up of plants operating in various industry sectors, the results revealed that automobile and tobacco industry had a negative influence on environmental and social performance respectively and positive influence on financial performance. The apparel industry had a negative influence on social performance and the construction industry had a negative impact on financial performance. The results especially for the automobile, tobacco and apparel industry do not come as a surprise given that historically industries of this nature have always been driven by profits and mass production practices with little attention and investment on general employee well-being and environment.

This paper has increased our understanding on supply chain collaborations. Through the flexibility and scope of our dataset, we were further able to see the impact of collaborations on all three pillars of the triple bottom line. Papers in the past have mainly examined the impact on one or two dimensions. Furthermore, we have extended this research by examining the impact of country based factors. This was enabled through the availability of country factors sourced from the Global Competitiveness Report which were then included in the GMRG dataset.

By reflecting on the theory of the firm, we have come to a better understanding as to the reasons as to why firms choose to collaborate and the impact it has on performance overall. The theory of the firm implies that firms collaborate to realize financial gains, i.e., profit. In our study, the results show that in fact collaboration is having a positive impact on all three dimensions of the triple bottom line (environmental, social and economic). This shows that a collaborator or value facilitator approach is more suited to the nature of competitive environment today. For practitioners, our results show that such investment although costly and time consuming does pay off and therefore is worthwhile. Hence, companies need to collaborate and starting sooner is perhaps the best way to reap early benefits.

CONCLUSION

The results of our study show that collaboration does have a positive impact on all the dimensions of the triple bottom line. This suggests that engaging in these sorts of activities can result in quicker returns than what one anticipates and it is indeed worthwhile in thinking beyond financial gains. Furthermore, the results indicate that country-level differences such as economic and social status were also influencing TBL practices. The research makes a valuable contribution in being able to explore country-level effects something that has not been explored before. For researchers, our study shows that exploring country-level differences using indicators along environmental, social and financial areas enhance knowledge on collaboration practices. Our research contributes to existing discussions on collaboration and its impact on all the dimensions of the

TBL by furthering the understanding through inclusion of country-level factors.

For managers and policy makers, the results show how country-level factors related to sustainability can influence organizations performance in general. It also assists managers of plants make that critical decision on the sort of collaboration to be undertaken for goals beyond just profit. Our results in general suggest that in order for firms to be competitive it is essential for them to think beyond financial gains and to take a broader perspective that encompasses society and environment. The pay-off is much greater through the efforts of collaboration and lasting.

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**ASSESSMENT OF NEED FOR LEAN THINKING AT EMERGENCY
DEPARTMENT IN OMAN THROUGH EXPLORATION OF FACTORS
AFFECTING THE EFFICIENCY OF SERVICES FROM PATIENTS'
PERSPECTIVE**

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ABSTRACT

Healthcare services provided by Emergency departments (ED) worldwide are required to function with maximum efficiency. Application of Lean Thinking principles in ED context was found to improve the efficiency in delivering services. Developing countries, including Oman, suffer from a dearth of information in exploration of this area.

The aim of this study was to assess the need for Lean Thinking in Oman through exploration of the attitudes, perceptions, and experiences of patients towards services provided in the ED in Oman. A qualitative study was conducted that covered aspects relating to efficiency of healthcare services and in relation to Lean Thinking principles. Participants identified several factors affecting efficiency of services provided by the ED that are linked to Lean Thinking principles. The main themes highlighted were the untimely provision of services and communication barriers with healthcare providers.

Lean Healthcare, Emergency Department Efficiency, Lean Thinking, Patient Focus Group, Lean Emergency Medicine

INTRODUCTION

Emergency departments (EDs) globally face problems with increased demand (overcrowding), limited capacity (staffing and education levels as well as available facilities and equipment), cost-containment, and higher patient expectations regarding quality, safety and timeliness of care (1, 2, 3, 4).

Interviews conducted in the preliminary phase of this study evidenced these same global factors impacting healthcare reforms in Oman's public health care sector (5). It was shown that improvements can be made to the healthcare sector in the Sultanate of Oman by applying "*Lean thinking*" to deliver higher-quality healthcare to all citizens (6). '*Lean thinking*' for the healthcare setting is defined as: '*A process improvement strategy consisting of a set of tools at the operational level, and a set of strategic guiding principles, which provide some standards for processes, serving the creation of flow, and decreasing interruptions and potential for errors'* (5).

The Sultanate of Oman is a Middle Eastern country that stretches across approximately 309,500 sq km. According to Oman's 2010 census (7), its population is estimated to be 3.3 million. The country is classified by the World Bank as a 'middle-income economy' among the emerging economies (8). Over the past four decades, Oman has benefitted from positive social changes and a significantly increased standard of living, to the extent that it has been rated as the most-improved nation by the United Nations Development Program (9). The improved standard of living over the last four decades has led to a 'demography in transition' (10); a transition that occurs when traditional societies experience rapid modernization and acculturation (11). These socio-demographic changes are likely to bring enormous assets as well as some challenges that national planners will need address so that evidence-based policy and resource allocation can be responsibly implemented. Among anticipated challenges that caught attention are services provided by emergency departments (1). The aim of this study was to assess the need for Lean Thinking in EDs in Oman through exploration of the attitudes, perceptions, and experiences of patients towards services provided in the ED in Oman.

Methods

The study was carried out in the Emergency Department (ED) at Sultan Qaboos University Hospital (SQUH), a tertiary teaching hospital in Muscat, Oman. The study was nested in the ongoing strategic research grant "An Assessment of the Application of Lean Thinking in the Omani Health Care Sector that was scientifically and ethically approved by Sultan Qaboos University.

The target group for this study were patients attending the Emergency Department (ED) at SQUH. A total of 10 patients were purposefully selected and interviewed. Potential participants were pre-selected to reflect the general spectrum of patients attending the ED at SQUH. All participants consented to participate. The total number of participants was based on reaching data saturation.

A qualitative study was conducted to assess the need for Lean Thinking in the ED in Oman through exploration of the attitudes, perceptions, and experiences of patients towards services provided at the ED. The qualitative enquiry helps in exploring areas where there is likely to be complexity and diversity of experiences and perspectives of participants (12). Therefore, a topic guide for individual interviews was developed using some of the available literature and local experience. The topic guide was piloted in the first two interviews to assess the comprehensibility of the language, the relevance and logical progression of the questions.

Participants were selected based on convenient sampling. Potential rich-informant participants were identified based on their educational background and experience with Oman's healthcare system. They, then, were invited by the research team to participate in the study. The total number of participants in the qualitative study was decided based on the saturation of the data. Patients were interviewed in their hospital rooms after transfer from the ED, or awaiting discharge from the ED. Each interview was conducted for 30 to 45 minutes. The interviews were carried out by two researchers, one of whom was questioning the participant and the other was observing as well as helping with logistical issues such as recording and taking notes. All the interviews were recorded and transcribed verbatim. Using the interview guide, participants were asked and probed about their experiences and views of different aspects of services at ED.

The framework approach, widely used for qualitative analysis, was employed to analyze data (13). As the framework highlights the associations between participants' attitudes, perceptions and experiences, it is expected to fit well with the aims of this study. Data analysis was conducted by the research team, and findings emerging from the analysis were thoroughly discussed and refined as part of an ongoing interactive process. The final analysis and findings were based on mutual agreement by members of the research team. Significant findings from patients' quotes were highlighted.

Results

As mentioned earlier, ten participants were interviewed in the study. Two main themes emerged from data analysis of the factors affecting the quality of services at ED from the participants' perspective. The first was timely provision of services; the second was poor communication.

Theme One: Timely provision of services

1. Participants expressed their disappointment towards that they were sometimes turned away by the ED.
2. Participants expressed their concern towards the long waiting time spent at the ED.
3. Some participants were unhappy about the delay of their laboratory results report.
4. Some participants commented on the entry to the ED and the waiting area. They felt that the entry position is not convenient and the waiting area is noisy. They also commented that the waiting area is small in size and sometimes becomes over-crowded.

Theme Two: Communication with healthcare providers

1. Due to the fact that significant proportion of healthcare providers in Oman are non-Arab expatriates, some participants stated that they often face problems in communicating their medical problems well with doctors and other healthcare professionals in the ED.
2. Participants commented that there was lack of detailed explanation about the importance of life-style modification and other culturally-related factors when consulting their medics at the ED.
3. Other participants felt unhappy because the attending medics did not explain in full the results of their current investigations, and in relation to previous investigations, what actions the patient should then consider.
4. Although participants appreciated the existence of all specialties at SQUH, some of them felt they were not referred to the specialties that they had expected.
5. Participants highlighted the importance of efficiency of work at the ED and the importance of avoiding unnecessary waste of time or efforts.

Discussion

This study explored the need for application of Lean Thinking principles at ED in Oman through studying the factors that might affect the efficiency of healthcare services at ED from patients' perspective.

Several factors were identified which could affect the efficiency of services provided at ED, which included: long waiting time, inefficient utilization of the waiting area, language barriers

with non-Arabic-speaking staff at ED, difficulties in timely referral to appropriate medical and surgical specialties, insufficient clarification of disease-related issues, delays in obtaining results of investigations, inadequate supplies of medications at the ED's internal pharmacy.

Some participants reported difficulty in communicating with expatriate staff who could not speak Arabic. Research in other countries has also provided supportive evidence that language barriers can be a risk factor for adverse outcomes and might affect the quality of healthcare service (14). Nurses, on the other hand, have perceived language barriers with their patients as an impediment to quality care delivery and a source of workplace stress (15). The language barrier was also reported in another study which explored the quality of healthcare services at diabetic clinics at primary healthcare centers in Oman (16).

In the case of Oman, large number of expatriate nurses and other health care professionals contribute to healthcare workforce. Nonetheless, the overall Omanization rate (replacement of expatriate professionals by Oman nationals) in Ministry of Health and other healthcare institutions in Oman has grown over the years. As a matter of fact, the percentage of Omani nurses in 2007 was 64% of total nurses compared to only 12% in the year 1990 (17). This Omanization of the healthcare workforce could help to overcome the language barriers in the future.

Participants have emphasized the importance of efficiency of work and avoidance of waste as much as possible. This note is very much related to the principles of Lean Thinking, the cornerstone of which is to eliminate waste in all processes that take place in a healthcare setup. Application of Lean Thinking principles was found to be associated with better clinical outcomes and significant improvement in efficiency of healthcare delivery, for example, by reducing unnecessary morbidity and mortality (18). Indeed, Lean Thinking was highly valued by hospital management due to its impact in reducing unnecessary waste (19). It has been found that applying Lean principles improves the quality of care at ED and enhances the clinical management of cases by improving outcomes and decreasing complications.

Previous research has assessed the readiness of the healthcare system in Oman for application of Lean, and the results were supportive that the system is ready (5). Efforts are therefore needed to apply the Lean principles in the country on a limited scale initially in order to provide imperative evidence of the applicability of Lean Thinking in Oman.

Participants also emphasized that the quality of their care could have been affected by long waiting time throughout the whole process of receiving care at ED. This finding is not uncommon as long waiting times have been shown to seriously affect the evaluation and management of cases at ED, and has led to serious complications and adverse prognosis of diseases (20). Providing a sufficient number of staff at the ED was found to improve the process of care.

Participants highlighted the importance of efficient utilization of the waiting room. Studies have shown that best utilization of space has a direct impact on the efficiency of healthcare delivery, and would lead to saving of resources. In addition, research has shown that the waiting areas at

the ED can be used for educational purposes, and were found to effective for patient education (21).

Although the emerging findings from the analysis were discussed and refined by the research team which increased the credibility of the study, we believe similar studies should be repeated. Furthermore, the sample of participants was selected by convenient sampling methodology, thus, they might not represent all shareholders in Oman.

Conclusion

In conclusion, this study attempted to explore the potential for applying Lean Thinking principles in the ED in Oman through exploring the attitudes, perceptions, and experiences of patients attending the emergency services setting in Oman. It was found that the need for Lean Thinking was substantial in order to minimize waste and improve efficiency of services. The main themes highlighted by participants were several recommendations emerged from this study were timely provision of services and communication barriers with healthcare providers. These domains and other related issues can be tackled through application of Lean Thinking principles.

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SUPPLY CHAIN COORDINATION WITH PRICE- AND STOCK-DEPENDENT SELLING RATE AND CREDIT OPTION

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ABSTRACT

In this paper, a single-manufacturer and single-retailer supply chain is considered and the demand rate at the retailer's end is dependent on the selling price and the instantaneous stock level. Without coordination, the retailer can use inventory policy to determine its replenishment cycle time or order quantity then maximizes its own profit, which is usually less than the manufacturer's production cycle time or production quantity. Two coordination policies are presented to coordinate the supply chain decisions. We give analytic formulations of the coordination policies and present numerical example to illustrate the proposed policies. It is indicated that the centralized supply chain can always get higher channel profit than credit period and non-coordination.

Key words: Supply chain coordination; Stock-dependent selling rate; Credit period; Pricing

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1. INTRODUCTION

It has been observed in supermarkets that the demand is usually influenced by the amount of stock displayed on the shelves, i.e., the demand rate may go up or down if the on-hand stock level increases or decreases. Such a situation generally arises from a consumer-goods type of inventory. As reported by Levin et al. (1972) and Silver and Peterson (1985), sales at

the retail level tend to be proportional to inventory displayed and a large pile of goods displayed in a supermarket will lead the customers to buy more. In practice, retail stores, like Costco, Spencer, Wall-Mark stock large piles of goods on their shelf to magnetize customers. These observations have attracted many marketing researchers and practitioners to investigate the modelling aspects of this phenomenon. For example, Gupta and Vrat (1986) first developed models for consumption environment to minimize the cost with the assumption that stock-dependent consumption rate is a function of the initial stock level. Datta and Paul (2001) analyzed an inventory system where the demand rate is influenced by both displayed stock level and selling price. Chang et al. (2006) have also mentioned that an increase in shelf space for an item always induces more customers to buy it. Other related analysis on inventory systems with stock-dependent demand have been performed by Urban(1995), Padmanabhan and Vrat(1995), Hou (2006), Hou and Lin (2006), Abbott and Palekar (2008), Panda et al. (2008,2009), Goyal and Chang (2009), Chang et al. (2010), Teng et al. (2011), Soni (2013), Tsao et al. (2014), Wu et al. (2014), Yang (2014). On the other hand, incorporating the effects of deteriorating items and stock-dependent demand to develop the order-level lot size inventory models were discussed by Pal et al. (1993), Giri et al. (1996), Sarker et al. (1997), and Giri and Chaudhuri (1998). Other issues relating to deterioration or batch sizing problem were also addressed by Ghare and Schrader (1963), Shah (1977), Heng et al. (1991), Wee (1995), Chang and Dye (1999), Goyal and Giri (2001), Teng et al. (2002) and Sarker and Yao (2003). Although several researchers have explored characteristics of stock-dependent demand models, few of them have discussed coordination issues of the supply chain with price- and stock-dependent demand. This paper will consider coordination issues of a two-echelon supply chain composed of a single manufacturer and a single retailer. The manufacturer offers a single product to the retailer and the demand for the product at the retailer's end is price and stock dependent. In the following, we briefly review the relevant literature.

To achieve coordination, the replenishment policy characterized by the unit selling price and the order quantity is often coordinated through the mechanism of quantity discounts. That is, the supplier often induces the buyer to accept the coordination by quantity discounts. Therefore, the research of quantity discounts becomes an important field in supply chain management. Many researchers have considered coordination issues such as replenishment policy and quantity discount schedule between manufacturers and retailers in supply chain management. First, Goyal (1977) considered an integrated inventory model with a single supplier and a single retailer. Rosenblatt and Lee (1985) determined the retailer's order quantity and the supplier's lot size when the supplier offers a linear quantity discount schedule. Weng (1995) considered the case when the demand is the function of the selling price and

established the model to illustrate that quantity discounts can increase the amount of demand. Viswanathan and Wang (2003) considered quantity discounts and volume discounts as coordination mechanisms in distribution channels with a price-sensitive deterministic demand. Li and Liu (2006) developed a model for illustrating how to use quantity discount policy to achieve supply chain coordination. In reality, another important means for achieving supply chain coordination is the credit option, where the supplier allows a certain fixed credit period to settle the account for stimulating retailer's demand. Thus, from the supplier's perspective, the resulting potential increase in sales may compensate for the loss from issuing credit. Other benefits of the credit option are mentioned in Shinn and Hwang (2003) and Sarmah et al. (2007). For instance, a credit policy can serve as a useful mean for enhancing the supplier's competitive position and can facilitate the development of a stable, long term buyer-supplier relationship, which can yield benefits for both the parties. Later on, many researchers have considered the coordination issues of credit payment option and pricing policies, such as Munson and Rosenblatt (2001), Chen and Simchi-Levi (2006), Ouyang et al. (2009), Chen and Kang (2010), Arkan and Hejazi (2012), Du et al. (2013).

All the above works on supply chain coordination concerned the assumption that the demand rate is constant or price-sensitive. As mentioned earlier, the demand rate may depend on not only the selling price per unit, but also the stock level. Zhou and Yang (2003) determined the optimal lot-size for the items with a stock-dependent demand rate and a fixed lifetime. Hou (2006) incorporated the effects of deterioration rate, inflation and time value of money to develop an inventory model with stock-dependent consumption rate. Hou and Lin (2006) further extended the work in Hou (2006) to consider selling rate as a function of stock level and selling price. So, a finite planning horizon inventory model for deterioration items with price- and stock-dependent selling rates is developed. Zhou et al. (2008) considered quantity discount as the coordination mechanism with stock-dependent demand and showed that the quantity discount policy may also achieve full channel coordination. Recently, Yang et al. (2014) considered the effects of credit period and quantity discount to coordinate a two-echelon supply chain under stock-dependent demand rate. Saha and Goyal (2015) considered the effects of rebate, price discount, and cost sharing contracts for a two-echelon supply chain coordination under stock and price dependent demand. However, no papers considered trade credit and quantity discount to coordinate a two-echelon supply chain for deteriorating items with price- and stock-dependent selling rates.

In this paper, a single-manufacturer and single-retailer supply chain is considered and the demand rate at the retailer's end is dependent on the selling price and the instantaneous stock level. The trade credit and quantity discount policies are used as incentives to coordinate the manufacturer's and retailer's activities. The comparisons between trade credit and quantity

discount policies are made for the manufacturer to choose. We show that the centralized supply chain can always achieve equal or higher channel profit than between trade credit and quantity discount policies. Finally, the results are illustrated with some numerical examples.

2. NOTATIONS AND ASSUMPTIONS

The following notations and assumptions are used throughout this paper. Additional notations and assumptions will be listed when needed.

2.1 Notations

c	manufacturer's production cost per unit
S	unit selling price of the product
w	unit wholesale price of the product
M	credit period that the supplier offers to the retailer
A_r	retailer's ordering cost
A_m	manufacturer's setup cost
h_r	holding cost per unit per unit time for the retailer
h_m	holding cost per unit per unit time for the manufacturer
$I(t)$	retailer's inventory level at time t
R	manufacturer's production rate
Q	order quantity (decision variable)
T	replenishment cycle length (decision variable)
T_m	manufacturer's production length per cycle
I_r	interest which can be earned per \$ per year by the retailer
I_m	interest which can be earned per \$ per year by the manufacturer
π_c	channel's average profit
π_r	retailer's average profit
π_m	manufacturer's average profit

2.2 Assumptions

- (1). The demand rate $D(t,S)$ is a function of current inventory level $I(t)$ and the constant selling price S . We assumed that $D(t,S) = \alpha(S) + \beta I(t)$ for inventory level $I(t) > 0$, where β is the stock-dependent selling rate parameter and $0 \leq \beta \leq 1$, $\alpha(S)$ is a positive decreasing function of S with $\alpha'(S) = d\alpha(S)/dS < 0$. It should be noted that the selling rate function is a special type and not a general function of time t and selling price S .
- (2). The supply chain structure considered in this study involves a single manufacturer and a single retailer dealing with a single product.
- (3). Single item with a constant rate of deterioration is considered and only applied to on-hand inventory for the retailer.
- (4). The manufacturer follows the lot-for-lot policy, which is a common assumption in

literature on channel coordination.

- (5). The replenishment of the retailer is instantaneous.
- (6). The lead time is zero.
- (7). Shortages are not allowed.

3. MODEL FORMULATION

Consider a supply chain which consists of a single manufacturer and a single retailer. Within each replenishment cycle, the manufacturer produces items at a constant production rate R for T_m , $T_m < T$, and dispatches them to the retailer at the end of each cycle. The retailer's inventory is depleted due to the price-and stock-dependent selling rate and deterioration until the inventory becomes zero at time $t = T$. Hence, the instantaneous inventory level of the retailer is governed by the following differential equation:

$$\frac{dI(t)}{dt} + \theta I(t) = -[\alpha(S) + \beta I(t)] \quad 0 \leq t \leq T \quad (1)$$

With the boundary condition $I(T) = 0$, the solution of (1) can be represented by

$$I(t) = \frac{\alpha(S)}{\beta + \theta} [e^{(\beta+\theta)(T-t)} - 1] \quad 0 \leq t \leq T \quad (2)$$

and $I(0) = Q$

$$= \frac{\alpha(S)}{\beta + \theta} [e^{(\beta+\theta)T} - 1] \quad (3)$$

3.1 Non-coordinated supply chain

Without coordination, the retailer determines the replenishment cycle length T to maximize its own average profit. The profit of the retailer per cycle consists of sales revenue, purchase cost, ordering cost, and holding cost. First, the associated elements of the retailer's profit per cycle are as follows.

- (1) Sales revenue per cycle

$$\begin{aligned} S_a &= S \int_0^T [\alpha(S) + \beta I(t)] dt \\ &= S\alpha(S)T + \frac{S\beta\alpha(S)}{(\beta + \theta)^2} [e^{(\beta+\theta)T} - 1 - T(\beta + \theta)] \end{aligned} \quad (4)$$

- (2) purchase cost per cycle

$$\begin{aligned} C_p &= wI(0) \\ &= \frac{w\alpha(S)}{\beta + \theta} [e^{(\beta+\theta)T} - 1] \end{aligned} \quad (5)$$

- (3) Order cost per cycle

$$C_r = A \quad (6)$$

(4) holding cost per cycle

$$\begin{aligned} C_h &= h_r \int_0^T I(t) dt \\ &= \frac{h_r \alpha(S)}{(\beta + \theta)^2} [e^{(\beta+\theta)T} - 1 - T(\beta + \theta)] \end{aligned} \quad (7)$$

Consequently, the retailer's profit per unit time can be formulated as

$$\pi_r(T) = \frac{1}{T} [S_a - C_p - C_r - C_h] \quad (8)$$

So, the retailer's profit per unit time is

$$\begin{aligned} \pi_r(T) &= \frac{1}{T} \left\{ S\alpha(S)T + \frac{S\beta\alpha(S)}{(\beta + \theta)^2} [e^{(\beta+\theta)T} - 1 - T(\beta + \theta)] - A_r \right. \\ &\quad \left. - \frac{w\alpha(S)}{(\beta + \theta)} [e^{(\beta+\theta)T} - 1] - \frac{h_r\alpha(S)}{(\beta + \theta)^2} [e^{(\beta+\theta)T} - 1 - T(\beta + \theta)] \right\} \end{aligned} \quad (9)$$

Taking the second derivative of $\pi_r(T)$ with respect to T ,

$$\begin{aligned} &\frac{d^2\pi_r(T)}{dT^2} \\ &= \frac{-2A_r}{T^3} + \frac{\alpha(S)[S\beta - (h_r + w\beta + w\theta)]}{(\beta + \theta)^2 T^3} \{e^{(\beta+\theta)T} [(\beta + \theta)^2 T^2 - 2(\beta + \theta)T + 2] - 2\} \end{aligned} \quad (10)$$

Note that if $S\beta - (h_r + w\beta + w\theta) \leq 0$, Eq. (10) yields $d^2\pi_r(T)/dT^2 < 0$ (since last term in Eq. (9) $e^{(\beta+\theta)T} [(\beta + \theta)^2 T^2 - 2(\beta + \theta)T + 2] - 2 > 0$). Hence $\pi_r(T)$ is concave with respect to $T > 0$. The optimal value of T , T^* , can be obtained when the first derivative of $\pi_r(T)$ equals zero.

$$\begin{aligned} &\frac{d\pi_r(T)}{dT} \\ &= \frac{1}{T^2} \left\{ A_r + \frac{\alpha(S)[S\beta - (h_r + c\beta + c\theta)]}{(\beta + \theta)^2} [T(\beta + \theta)e^{(\beta+\theta)T} - e^{(\beta+\theta)T} + 1] \right\} = 0 \end{aligned} \quad (11)$$

Note that a search technique such as Newton-Raphson's method can be employed to solve Eq. (11) though a closed-form solution of Eq. (11) cannot be obtained. From this the optimal order quantity for retailer is

$$Q^* = \frac{\alpha(S)}{\beta + \theta} [e^{(\beta+\theta)T^*} - 1] \quad (12)$$

Substituting T^* into Eq. (9), we can get the retailer's optimal average profit, π_r^* .

On the other hand, without coordination, the manufacturer has to follow the retailer's decision. The manufacturer's profit per unit time is the sum of sales revenue, production cost, setup cost, transportation cost and holding cost, and is given by

$$\pi_m(T) = \frac{1}{T} \left[(w - c)I(0) - A_m - (f + gI(0)) - \frac{1}{2} h_m I(0) T_m \right] \quad (13)$$

where $T_m = I(0)/R$.

Substituting Eq. (3) into Eq. (13) gives

$$\pi_m(T) = \frac{1}{T} \left\{ \frac{\alpha(S)}{\beta + \theta} \left(e^{(\beta+\theta)T} - 1 \right) \left[(w - c) - g - \frac{h_m}{2R} \frac{\alpha(S)}{\beta + \theta} \left(e^{(\beta+\theta)T} - 1 \right) \right] - f - A_m \right\} \quad (14)$$

If $\pi_m(T)$ is concave with respect to T , we can get the manufacturer's optimal cycle time at $d\pi_m(T)/dT = 0$.

$$d\pi_m(T)/dT$$

$$\begin{aligned} &= \frac{1}{T^2} \left\{ \left[T \alpha(S) e^{(\beta+\theta)T} - \frac{\alpha(S)}{\beta + \theta} \left(e^{(\beta+\theta)T} - 1 \right) \right] [w - c - g] \right. \\ &\quad \left. - \frac{h_m}{2R} \frac{\alpha(S)}{\beta + \theta} \left(e^{(\beta+\theta)T} - 1 \right) \left[2T \alpha(S) e^{(\beta+\theta)T} - \frac{\alpha(S)}{\beta + \theta} \left(e^{(\beta+\theta)T} - 1 \right) \right] + f + A_m \right\} = 0 \end{aligned} \quad (15)$$

Note that, the optimal value of T in Eq. (11) is usually different from that in (15), so the retailer's optimal order quantity should be different from the manufacturer's economic production quantity. If the manufacturer's economic production quantity is larger than the retailer's order quantity, the manufacturer can get higher profit when the retailer orders more.

3.2 Coordinated supply chain

In this section, two coordination policies are presented which are credit period policy and centralized supply chain policy to coordinate the manufacturer's and the retailer's business activities.

3.2.1 Credit period policy

The manufacturer requires the retailer to increase its order quantity which can result in lower setup cost and lower transportation cost, so that the manufacturer can get higher profit. However, the retailer may not be able to change its current order quantity because it is already optimal. Therefore, the manufacturer should compensate the retailer for its lost profit and probably provide extra savings. Under coordination, the manufacturer will offer the retailer an order quantity dependent credit period M , in which retailer can save interest.

The manufacturer's objective function with offering credit period is

$$\pi_m^{cp}(T) = \frac{1}{T} \left[(w - c)I(0) - A_m - (f + gI(0)) - \frac{1}{2R} h_m I(0)^2 - wI(0)M I_m \right]$$

s.t.

$$\pi_r^{cp}(T) - \pi_r^* = \frac{1}{T} \left[(S - w)I(0) - A_r - h_r \int_0^T I(t)dt + wI(0)MI_r \right] - \pi_r^* \geq 0 \quad (16)$$

From Eq. (16), the constraint condition makes sure the retailer have no less profit than without coordination case.

Obviously, $\pi_r^{cp}(T) - \pi_r^* = 0$ is the lowest level that the manufacturer makes the retailer accepts this credit policy. Hence, based on $\pi_r^{cp}(T) - \pi_r^* = 0$, we can obtain M which is a function of T as follows:

$$M(T) = \frac{1}{wI_r I(0)} \left\{ T\pi_r(T)^* + A_r + \frac{h_r \alpha(s)}{(\beta + \theta)^2} [e^{(\beta+\theta)T} - 1 - T(\beta + \theta)] \right\} - \frac{p - w}{wI_r} \quad (17)$$

Substituting Eq. (17) into $\pi_m^{cp}(T)$, we have

$$\begin{aligned} \pi_m^{cp}(T) &= \frac{1}{T} \left[(w - c)I(0) - A_m - (f + gI(0)) - \frac{1}{2R} h_m I(0)^2 - \frac{I_m}{I_r} A_r \right. \\ &\quad \left. + \frac{h_r \alpha(S) I_m}{(\beta + \theta)^2 I_r} (e^{(\beta+\theta)T} - 1 - T(\beta + \theta)) + \frac{(p - w)I(0)I_m}{I_r} \right] - \frac{I_m}{I_r} \pi_r^* \end{aligned} \quad (18)$$

If $\pi_m^{cp}(T)$ is concave in T , we can get the optimal cycle time T^* by $\frac{d\pi_m^{cp}(T)}{dT} = 0$, and is given as:

$$\begin{aligned} d\pi_m^{cp}(T)/dT &= \frac{1}{T^2} \left\{ \left[T\alpha(S)e^{(\beta+\theta)T} - \frac{\alpha(S)}{\beta + \theta} (e^{(\beta+\theta)T} - 1) \right] \left[w - c - g + \frac{(p - w)I_m}{I_r} \right] \right. \\ &\quad \left. - \frac{h_m}{2R} \frac{\alpha(S)}{\beta + \theta} (e^{(\beta+\theta)T} - 1) \left[2T\alpha(S)e^{(\beta+\theta)T} - \frac{\alpha(S)}{\beta + \theta} (e^{(\beta+\theta)T} - 1) \right] \right. \\ &\quad \left. - \frac{h_r \alpha(S) I_m}{(\beta + \theta)^2 I_r} [e^{(\beta+\theta)T} - (\beta + \theta)T e^{(\beta+\theta)T} - 1] + A_m + f + \frac{I_m}{I_r} A_r + \frac{I_m}{I_r} \pi_r^* \right\} = 0 \end{aligned} \quad (19)$$

Hence, substituting T^* into $\pi_m^{cp}(T)$, we can obtain the manufacturing optimal profit with credit period policy π_m^{cp*} .

3.2.2 Centralized supply chain

In this section, we assume the manufacturer and the retailer are willing to behave as an integrated firm and share all relevant information. They determine the optimal cycle time to maximize the channel profit together. So, the objective function of the whole supply chain is

$$\begin{aligned}\pi_c(T) = & \frac{1}{T} \left[(S - c)I(0) - A_m - (f + gI(0)) - \frac{1}{2R} h_m I(0)^2 - A_r \right. \\ & \left. - \frac{h_r \alpha(S)}{(\beta + \theta)^2} [e^{(\beta+\theta)T} - 1 - T(\beta + \theta)] + wI(0)M(I_r - I_m) \right] \quad (20)\end{aligned}$$

If $\pi_c(T)$ is concave in T , the optimal cycle time can be obtained by equating the first derivative of $\pi_c(T)$ with respect to T to zero at $T=T^*$ as follows:

$$\begin{aligned}\frac{d\pi_c}{dT} = & \frac{1}{T^2} \left\{ \left[T\alpha(S)e^{(\beta+\theta)T} - \frac{\alpha(S)}{\beta + \theta} (e^{(\beta+\theta)T} - 1) \right] [S - c - g + wM(I_r - I_m)] \right. \\ & - \frac{h_m \alpha(S)^2}{2R(\beta + \theta)^2} [e^{2(\beta+\theta)T} (2(\beta + \theta)T - 1) - e^{(\beta+\theta)T} (2(\beta + \theta)T - 2) - 1] \\ & \left. - \frac{h_r \alpha(S)}{(\beta + \theta)^2} [(\beta + \theta)Te^{(\beta+\theta)T} - e^{(\beta+\theta)T} + 1] + A_m + f + A_r \right\} = 0 \quad (21)\end{aligned}$$

4. NUMMERICAL EXAMPLE

Example 1. To illustrate the results we assumed that $D(t, S) = \alpha(S) + \beta I(t)$, where $\alpha(S)$ is a linear decreasing function of selling price S and $\alpha(S) = a - bS$. β is the stock-dependent selling rate parameter and $0 \leq \beta \leq 1$. In addition, to compare the non-coordinated supply chain and credit period policy we consider a case with the following data.

$a = 600$, $b = 2$, $\beta = 0.10$, $\theta = 0.30$, $S = 30$, $w = 22$, $c = 10$, $A_r = 50$, $A_m = 100$, $h_r = 2.4$, $h_m = 10.2$, $R = 2000$, $I_r = 0.3$, $I_m = 0.1$, $M = 0.1$, $f = 30$, $g = 2$. Using the solution procedure described above, the related results for non-coordination, credit period policy, and centralized supply chain cases are shown in table 1 and the second order optimality conditions are satisfied for all case. For non-coordination case, the retailer's optimal cycle time and total profit are $T^* = 0.226$ and $\pi_r = 3647.934$, respectively. Similarly, the manufacturer's optimal cycle time and total profit are $T^* = 0.946$ and $\pi_m = 5387.024$, respectively. For credit period policy, the retailer's optimal cycle time and total profit are $T^* = 0.399$ and $\pi_r^{cp} = 3647.934$, respectively. In this case, the manufacturer's optimal cycle time and total profit are $T^* = 1.619$ and $\pi_m^{cp} = 6959.142$, respectively. For centralized supply chain case, the

optimal cycle time $T^* = 1.317$ and the channel profit $\pi_c^{cs} = 10249.541$, respectively. From results, it is indicated that the centralized supply chain can always get higher channel profit

than credit period and non-coordination.

Table 1. Optimal solutions under credit period, centralized supply chain and non- coordination

coordinated cases	the retailer		the manufacturer		the channel	
	T^*	π_r^*	T^*	π_m^*	T^*	π_c^*
Non-coordination	0.147	3647.934	0.946	5387.024	---	---
Credit period policy	0.399	3647.934	1.619	6959.142	---	---
Centralized supply chain	---	---	---	---	1.317	10249.541

5. CONCLUSIONS

In this paper, the credit period and centralized supply chain policies are used to coordinate a two-echelon supply chain for deteriorating items with price- and stock-dependent selling rates. Without coordination, the retailer makes inventory policy to maximize its own profit. In general, the retailer's replenishment cycle time or economic order quantity is less than the manufacturer's optimal production cycle time or optimal production quantity. Therefore, the manufacturer could offer a credit period or quantity discount as an incentive to make the retailer increase its current order quantity and then increase profit each other. We have given analytic formulations of the coordination policies and have presented numerical example to achieve illustrated the results as our expected. It is indicated that the centralized supply chain can always get higher channel profit than credit period and non- coordination. This paper can be extended in several ways. For example, we could apply more coordination policies, such as quantity discount, cash discount, and buy-back could be considered in the future.

Acknowledgments

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THE IMPACT OF SUPPLY RELATIONSHIP DYNAMICS AND NETWORK STRUCTURE ON OPERATING PERFORMANCE

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ABSTRACT

Our study tests for empirical evidence that customer-supplier relationship dependency and supply network structure act as catalysts significantly influencing firm performance. We use cost and revenue supply chain relationship data for manufacturing firms in the electronics industry to estimate the effects of customer-supplier relationship dependence on a firm's operating performance. Specifically, we analyze supply chain relationship data for such firms using the proportion of the firm's business that each of its partners is responsible for – in terms of customer cost and supplier revenue – as a proxy for relationship dependence. We also examine the extent to which structural characteristics of the firm's supply network facilitate the effect of relationship dependence on performance. We complement the growing stream of supply chain management research by investigating relationship dependence and supply network structure in tandem for insight into how to manage supply network relationships for improved performance. Further, this study adds an additional layer to prior literature by examining relationship dependence from the perspective of the focal firm, both as a customer and a supplier. Our study sheds light on the tradeoffs in profitability and efficiency gains when managing supply relationship dynamics across a supply network to drive performance. Our results suggest that while firm performance is influenced by how it concentrates its cost and revenue both upstream (as a customer) and downstream (as a supplier), this effect can be attenuated or enhanced by the way that its supply network is structured.

Keywords: supply networks, supply chain management, operating performance

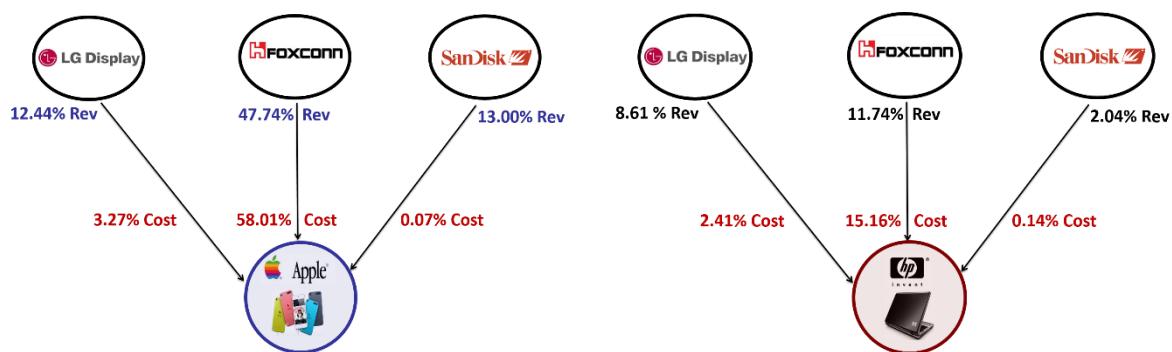
INTRODUCTION

A growing stream of research has identified supply chains as a key source of competitive advantage and superior performance for firms (Ketchen and Hult 2007). The continual rise in globalization and pressure to keep up with technological and environmental changes is an

ongoing issue that leaves firms in a constant flux to find better strategies to manage their supply chains and outperform competition (Cheung et al. 2010). The ongoing pressure to sustain such changes in the competitive environment have led firms to rely on their supply chain partners for more external capabilities that were once handled internally. Researchers have since contributed to conceptual studies advocating a firm strategy that leverages its portfolio of customer and supplier relationships as an important strategic asset to improve performance (Johnson 1999; Tang and Rai 2012), elevating competition based on a battle of firm strategies to a battle of supply chain strategies (Ketchen Jr and Giunipero 2004; Boyer et al. 2005).

Contemporary supply chain management involves leveraging the capabilities of a multitude of partners both upstream and downstream in the supply chain. One challenge, however, is that effective management of a network of interdependent customer and supplier relationships is extremely complex (Bozarth et al. 2009), warranting an examination of supply relationship dynamics that account for such interdependencies as strategic assets that impact performance (Choi et al. 2001). Research studies have accordingly evolved in their examination of this issue, from earlier work on transactional make-buy considerations (e.g., Walker and Weber 1987) to more recent work on collaboration mechanisms (e.g., Cachon and Fisher 2000; Cachon and Lariviere 2005; Paulraj et al. 2008; Cheung et al. 2010; Nyaga et al. 2010; Cao and Zhang 2011) and multi-tier sourcing decisions (Majumder and Srinivasan 2008; Agrawal et al. 2013) to improve performance. While much insight has been gleaned as a result of these studies, it is still not clear how the vast number of interdependences prevalent in the supply chain may in fact be swaying a firm's performance benefits. Prior literature has made traction in identifying two key supply relationship dynamics impacting a firm's performance: customer-supplier relationship dependency and supply network structure (Dyer 1996; Dyer and Singh 1998; Choi and Kim 2008).

The first supply relationship dynamic, customer-supplier relationship dependency has been examined primarily from the perspective of resource dependence theory (Pfeffer and Salancik 1978) and social capital theory (Tsai and Ghoshal 1998), and has been linked to level of trust, power, and influence (Handfield and Bechtel 2002; Benton and Maloni 2005; Ireland and Webb 2007; Krause et al. 2007; Terpend et al. 2008; Terpend et al. 2011). Many firms in a supply chain operate in a dual role as customer and a supplier. As customers, these firms concentrate their total annual cost among each relationship to a different degree and for a different purpose. For example, though Hewlett Packard (HP) and Apple Inc. shared several of the same suppliers, their proportion of total cost tied in each supplier relationship varied substantially, as illustrated in Figure 1. Apple and HP had over 50 percent and 15 percent of their total cost, respectively, concentrated in Foxconn Technology Group, the world's biggest contract manufacturer of electronics and maker of Apple's iPhones and iPads as well as a major assembler of PCs for HP. Conversely, both firms had less than four percent of their total costs concentrated in LG Display Co., a core producer of LCD panels, and less than one percent in Sandisk, a supplier of flash memory chips to both firms (Bloomberg 2012). This same observation can be made viewing both HP and Apple in their role as suppliers, as depicted in Figure 2.



Apple's cost concentration among LG, HP's cost concentration among LG, Foxconn, and Sandisk
Foxconn, and Sandisk

Figure 1. Sample of cost and revenue concentrations for Apple and HP in role as customers.

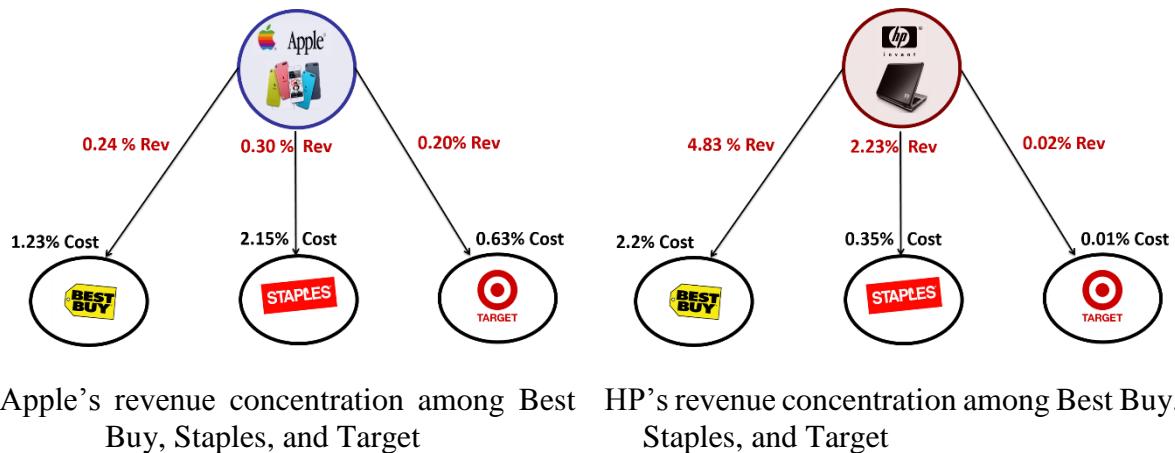


Figure 2. Sample of cost and revenue concentrations for Apple and HP in role as suppliers.

The proportion of the firm's business that the partner is responsible for serves as a proxy for relationship dependency and has been linked to the trust and commitment fostered between a firm and its partners (Flight et al. 2008; Autry and Golicic 2010; Handley and Benton Jr 2013). At the same time, literature has also identified potential negative effects from a firm being over-reliant or vulnerable to its partner, leading to a lag in ensuing performance (Forker 1997; Handfield and Bechtel 2002; Villena et al. 2011). Thus, insight into how a firm's cost and revenue are concentrated across its supply network both upstream and downstream offers a potentially clearer portrayal of performance implications. One limitation of previous studies is that they have considered performance implications of relationship dependency predominantly only at the dyad level (e.g., customer-supplier), thus not factoring in the wider performance effect arising from the variance in the way a firm's relationship dependency is concentrated across its supply chain. This study differs from prior related empirical work in the following ways. First, it factors for the dual role that several firms occupy, that operate as a customer to certain partners and as a supplier to others. Second, it goes beyond effects at the dyad level by examining the degree to which a focal firm concentrates its cost upstream (as a customer) and revenue downstream (as a supplier).

The second supply relationship dynamic, supply network structure, factors in structural characteristics of the supply network as drivers and facilitators of firm performance. A network analytic approach to investigate supply relationship dynamics helps account for the embedded nature of supply networks and of the various interactions taking place between customers and suppliers within the supply network (Kim et al. 2011). A firm's customers and suppliers share several business processes with each other as well as other members along each supply chain tier, causing them to be embedded in a larger supply network (Rowley et al. 2000; Choi et al. 2001; Choi and Kim 2008). Thus, the supply network structure derived from the embeddedness of a firm's supply network partners can influence that firm's ability to lower costs, integrate and coordinate its supply chain activities, and increase knowledge spillovers from its partners (Camuffo et al. 2001; Choi and Krause 2006). Prior literature points to the way that a supply network is structured as an important factor driving firm performance (Kim et al. 2011), and we show empirical support for its facilitating role to moderate the effect of relationship dependency on performance. To account for supply network structure in our study, we examine four related characteristics: the level of shared relationships between a firm's suppliers upstream and customers downstream—defined in this study as supplier and customer interconnectedness—and the speed at which a firm can reach suppliers upstream and customers downstream in the supply network—defined in this study as upstream and downstream closeness.

In sum, we build on prior research by investigating the effect of supply network partner cost concentration, revenue concentration, and the way that a supply network is structured on firm performance. Alongside any direct effect from the way that the supply network is structured, we emphasize the moderating role of network structure on a firm's concentration levels. Specifically, we aim to address the following research questions: How does the way that a firm

concentrates its cost and revenue across its supply network impact its performance? How is firm performance directly influenced and also facilitated by the way that its supply network is structured?

We develop our theoretical framework by drawing on prior research on buyer-supplier relationships, supply chain management, and dependency theory. We then empirically validate our model by analyzing supply chain relationship and financial data from the Bloomberg database for firms in the electronics industry. Our study makes use of a unique set secondary data that reveals the cost and revenue concentration between a focal firm and its corresponding customers and suppliers. Also, instead of potentially averaging out the effects of the way that a firm's cost and revenue are concentrated among customers and suppliers in our analysis, we make use of this richer model to factor in the wider effects of the variance in its concentration.

Through our empirical study, we offer contributions to both theory and practice in operations management. First, by shedding light on the intricacies and performance implications from dependency and structural aspects of supply relationship dynamics, we offer a richer understanding of the joint effects of supply chain management decisions and contextual factors on a firm's ability to operate profitably and efficiently. Second, our study's joint focus on relationship dependency, through the use of a multilevel mixed-effects model, and supply network structure, through the use of network analytic assessments, helps address the call for future research that advances existing theories on supply networks and firm performance (e.g., Chen and Paulraj 2004; Kim et al. 2011). We use a multilevel mixed-effects model that allows us to combine firm level and customer-supplier dyad level effects into our analysis. We also use network analytics to capture structural characteristics, which help proxy for a firm's influence accrued from relationships within the supply network as a whole. Thus, consideration

of supply relationship dynamics at multiple levels of analysis in a common framework allow for richer insight into the underlying mechanisms of supply networks.

The remainder of this paper proceeds as follows. In Section 2, we discuss the related literature on buyer-supplier relationships, supply chain management, and dependency theory. In Section 3, we describe our data collection and research methodology. We present our empirical model, analysis, and results in Section 4. We conclude in Section 5 with a discussion of our findings, their implications, and suggested directions for future research.

THEORETICAL FRAMEWORK AND HYPOTHESES

Next, we discuss our hypothesized effects of supply network cost concentration, sales concentration, structure, and relationship type on a firm's operating performance.

Relationship dependency

Assessment of relationship dependency has been documented by scholars studying buyer-supplier relationships, some with emphasis on performance implications (e.g. Cousins and Menguc 2006; Golicic and Mentzer 2006; Krause et al. 2007; Autry and Golicic 2010). Research in this area highlights the importance of content and relative intensity of each relationship in affecting supply chain outcomes. Relationship dependency is rooted in the notion of relational embeddedness, where strength relates to the extent to which the relationship between two network entities is strong, weak, or absent (Granovetter 1985). Relational dependency has since been identified as a key dimension of social capital that refers to the degree of mutual respect, trust, and close interaction that exists between a firm and its partners (Granovetter 1992; Kale et al. 2000). Two facets identified to help embody relationship dependency are the proportion of a firm's cost going to each of its suppliers and revenue coming from each of the firm's customers.

Cost concentration and revenue concentration as indicators of relationship dependency

Supply network cost and revenue concentration can be viewed as one form of relationship dependency, represented by the proportion of a firm's business activities that a particular partner is responsible for (Barry et al. 2008; Autry and Golicic 2010). Taking this perspective, relationship dependency can manifest itself in two ways: as supplier dependence and customer leverage. Supplier dependence in this context is based on the proportion of the supplier's sales revenue that comes directly from a focal customer. From the other perspective, a firm as a customer who contributes more to proportion of the supplier's sales can be in a better position to achieve more leverage over its supplier. Prior research has shown that contributing to a larger proportion of a partner's revenue is likely to lead to a greater commitment and long-term orientation with the partner (e.g. Sheu et al. 2006). Customer dependence is based on the proportion of the customer's cost that is tied directly to its relationship with a particular supplier. Supply chain concentration, involving a heavier concentration of spend among suppliers and its customers, implies more extensive utilization of modern supply chain management practices, which should decrease transaction costs and increase the diffusion of knowledge throughout the supply network (Lanier Jr et al. 2010). On the other hand, a more highly integrated relationship is expected between a customer and supplier if that customer purchases a high percentage of its resources from the supplier (Uzzi 1996; Flight et al. 2008) and as a result, may lead to diminishing returns on the performance benefits accrued by the focal firm.

Summarizing, prior research suggests that relatively higher relationship dependency, through customer dependence, can lead to more efficient supply network benefits and better operating performance for firms. However, greater customer dependence may actually make the firm more vulnerable and start to experience minimal improvements in its performance. Along similar lines to prior literature, we conjecture that a firm being over-reliant or dependent,

through heavily concentrated supplier dependence of revenue from fewer customers, may actually lead to a lag in ensuing performance (Forker 1997; Handfield and Bechtel 2002; Villena et al. 2011). Overall, we expect the following:

Hypothesis 1. *Supply network partner cost concentration has a positive curvilinear relationship with firm operating performance.*

Hypothesis 2. *Supply network partner revenue concentration has a negative curvilinear relationship with firm operating performance.*

Hypothesis 3. *Supply network partner cost concentration positively moderates the relationship between revenue concentration and firm operating performance.*

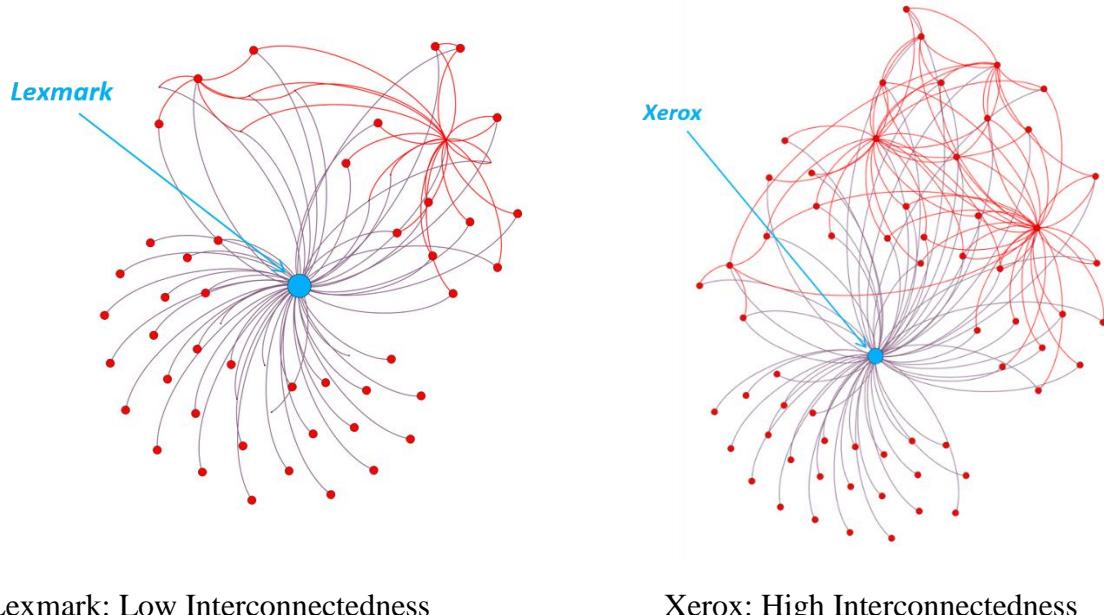
Supply network structure

Several streams of literature on supply chain management are benefitting from a focus on supply chains as a system or network as opposed to sole analysis of fragmented subsystems and dyads. Some such examples are research on supply relationship governance (Detoni and Nassimbeni 1995), supply chain integration (Vickery et al. 2003), supply chain risk (Nair and Vidal 2010; Basole and Bellamy 2014), and knowledge sharing (Dyer and Nobeoka 2000; Dyer and Hatch 2004).

Supply network interconnectedness

Also emerging from supply network research are the collaborative benefits a firm can accrue by having a more interconnected supply network (e.g. Dyer 1996; Skjoett-Larsen et al. 2003). The rationale advocating such benefits of supply network interconnectedness is as follows. Greater supply network interconnectedness translates to more ties connecting any two firms, where the increase in even one tie also increases the frequency of exchange among the same set of supply network partners. In Figure 3, we provide supply networks of two representative

firms from our sample, Lexmark and Xerox, to help illustrate the differences in supply network portfolios according to both their level of supply network interconnectedness.



Lexmark: Low Interconnectedness

Xerox: High Interconnectedness

Figure 3. Representative firm (ego) supply networks.

Viewing Figure 3, supply network interconnectedness is depicted by all links between that go from partner to partner. Research has cited several benefits from having more interconnected supply networks. First, information flow traversing a set of densely connected partners—such as forecasted demand or a new manufacturing technology— increases the chances to reach other firms in the supply network quicker than that same information residing in among a set of sparsely connected partners. Even if the information received is redundant, the multiple pathways can serve as fidelity checks of such information (Schilling and Phelps 2007). Second, greater supply network interconnectedness has been shown to strengthen efforts such as joint collaborative planning forecasting and replenishment (CPFR) technology integration, and standardization efforts between a firm and its partners, where these efforts become more effective as all the firms become increasingly involved in the relationship (Skjoett-Larsen et al.

2003; Defee and Stank 2005). The efficiency gains from improved planning and forecasting can lower total inventory held and better align inventory levels to match actual demand. Third, interconnected supply networks can improve coordination, communication, and reciprocity in knowledge sharing between supply network partners (Dyer and Nobeoka 2000).

Supply network partner interconnectedness and cost (revenue) concentration

Aside from benefits of both supply network interconnectedness and relationship dependency on their own, we also expect that an interaction of the two factors to have an influence on firm performance. Increased coordination, communication, and information flow from having a densely connected supply network should be reinforced by the presence of several strong ties (i.e., high concentration of supply network revenue) between each supply network partner dyad. Researchers in organizational research have used a linear combination of relational and structural components, in particular, tie strength and network density (Sosa 2013) to reflect the quantity of time and energy that dyads invest in their relationship with each other as well as with common partners, and how scoring high in this composite measure can lead to improved outcomes benefiting both parties. Similarly, for our context, we postulate that higher supply network revenue concentration in a firm's supply network will strengthen the positive influence of supply network interconnectedness on firm performance, both in terms of efficiency gains and financial gains.

Hypothesis 4. *Highly interconnected suppliers accentuate the positive effect of supply network partner cost concentration operating performance.*

Hypothesis 5. *Highly interconnected customers mitigate the negative effect of supply network partner revenue concentration operating performance.*

Upstream and downstream closeness

Upstream and downstream closeness relates to how quickly a firm can reach partners of the supply network. In this sense, a focal firm can reach each partner either (i) directly if it has a direct relationship with that partner (i.e., it is a direct customer or supplier to the firm), or (ii) indirectly through the use of its intermediate partner relationships. Previous studies have found a strong linkage between closeness and firm performance, suggesting that firms in central positions in a network have far more pathways than their counterparts to access knowledge, information, and resources from other members in the network (Burt 1992; Dyer and Singh 1998; Koka and Prescott 2008). Higher centrality gives the firm the ability to navigate the network with greater autonomy (Kim et al. 2011), offering multiple ports to retrieve reliable information about demand shifts, lean approaches used by other customers or suppliers that have yet to have been established as best practices, and richer insight into potentially new, complementary resources from other members in the supply network. Greater closeness and thus ability to collect information from multiple sources can help reduce the risk that key information used by the firm has somehow been distorted in the transmission process (Schilling and Phelps 2007). We expect that greater closeness both upstream and downstream to impact a firm's ability to efficiently manage its inventory well, maintain improved margins from the flexibility in being able to access resources quicker than its less central counterparts, and thus better utilizing its resources.

Hypothesis 6. *A firm's upstream closeness within the supply network accentuates the positive effect of supply network partner cost concentration operating performance.*

Hypothesis 7. *A firm's downstream closeness within the supply network mitigates the negative effect of supply network partner revenue concentration operating performance.*

DATA AND MODEL DEVELOPMENT

Sampling and data collection

The primary source of data used for testing our empirical model is the Bloomberg database. Bloomberg maintains a vast historical database of company financials covering both international and domestic markets. This database has been used in numerous studies for financial data (e.g. Jaillet et al. 2004; Longstaff et al. 2005; Longstaff 2010). All of the financial data for the firms in our sample were obtained from the Bloomberg database.

As an additional check on the reliability of the Bloomberg data, we cross-validated our financial measures with Standard & Poor's COMPUSTAT database. To check for similarity in finances from the two databases, we first developed some custom coding that matched firms according to their 9-digit Committee on Uniform Security Identification Procedures (CUSIP) number, which consists of a 6-digit issuer number, a 2-digit security number, and a check digit as the 9th character. We then ran a series of paired t-tests on net income, total assets, inventory, cost of goods sold (COGS) and sales. In total, we used 498 firm paired observations. The dependent-sample or paired t-test is used when the observations are not independent of one another. It tests to see whether the difference in means from two variables of interest, on the same set of subjects, is equal to zero. Our results indicated that the mean difference between each pair was not significantly different from zero, providing more assurance of the similarity in financials used from the two data sources.

In addition to the rich historical financial data, Bloomberg also began capturing supply chain relationship data on more than 35,000 companies globally in more than a dozen languages, making use of an algorithmic design for deriving proprietary data. We used the Bloomberg database to build our network of customers and suppliers. First, we had to identify and map each lead firm to its customers and suppliers. Next, we took each of the supply chain members who were not a part of the initial lead firm list, and retrieved data on all of each new member's customer and supplier relationships listed in the Bloomberg database.

In order to get a broader understanding of the industries represented in our supply network dataset, we used Global Industry Classification Standard (GICS) codes, a classification standard developed by Morgan Stanley Capital International (MSCI) and Standard & Poor's (S&P). It is intended to be a more universal score that allows for classification firms across the globe. It comprises 10 two-digit sectors, 24 four-digit industry groups, 68 six-digit industries, and 154 eight-digit sub-industries.

Dependent variables: firm performance

Consistent with prior research, we rely on more than one measure of performance for our hypothesized effects (Modi and Mabert 2010; Modi and Mishra 2011). We use two measures of performance at the firm level: return on assets (ROA) and return on sales (ROS). These measures have been linked to higher firm financial performance (e.g. Hendricks and Singhal 2009) and have been deemed as appropriate measures for operations management contexts (Chen et al. 2005). Measures for firm performance were obtained from the Bloomberg database.

Independent variables

Supply network partner cost and revenue concentration

We operationalize relationship dependency in two ways. First, we capture the proportion of supplier sales revenue and customer cost that comes through each customer-supplier dyad relationship in the sample. For each pair of supply network dyads, *supplier dependence* is calculated using the concentration of a supplier's sales revenue that comes directly from its direct customers and *customer dependence* is calculated using the concentration of a customer's costs that are incurred from its direct suppliers. Other studies have adopted a similar measure to proxy for relationship dependency and to reflect high-quality interactions (Sheu et al. 2006; Flight et al. 2008; Autry and Golicic 2010; Handley and Benton Jr 2013).

Supplier and customer interconnectedness as well as upstream and downstream closeness

For supplier and customer interconnectedness, we use the measure of network density to reflect the extent to which partners of a focal firm are also partners of each other into a single measure as follows (Wasserman and Faust 1994):

$$\text{NetDensity}_i = \frac{L_i}{g_i(g_i-1)/2} \quad [1]$$

where L_i represents the number of existing ties among all g_i direct partners of focal firm i . We operationalize a firm's closeness in the network by closeness centrality, calculated using the following equation (Wasserman and Faust 1994):

$$CC_i = (g_i - 1) / [\sum_{j=1}^{g_i} d(n_i, n_j)] \quad [2]$$

where $d(n_i, n_j)$ represents the number of edges in the shortest path(s) linking n_i and n_j (also referred to as the geodesic distance(s) from n_i to n_j), g_i corresponds to the number of direct partners of focal firm i , and $(g_i - 1)$ reflects the minimum possible total distance. This measure has been cited as a guide to capture the extent to which a firm has freedom from the controlling actions of others in terms of accessing information in the supply network (Kim et al. 2011). We

calculate our measures through the use of the social network analysis software package, UCINET 6.365 (Borgatti et al. 2002).

Control variables

We also controlled for various measures related to firm performance. We included firm size, operationalized as average annual sales, to control both for the effect of size on supply network interconnectedness and firm performance. Larger firms naturally have greater availability of resources, which may also explain why they are performing well (Tsai 2001). We also include the measure of capital intensity calculated as total capital expenditures over total sales. A description of all variables and their data source is summarized in Table 1.

We also include dummy variables accounting for industry and geographical differences in our sample. Descriptive statistics by industry can be found in Table 2 and by region in Table 3. Our final sample of firms represents a wide range of industries with seven distinct two-digit GICS sectors. In terms of the highest industry sector representation, more than 78% of firms in the sample do business related to information technology (IT), 10.42% related to industrials, and nearly 6% related to consumer discretionary. Conversely, the lowest concentration is in financials (0.06% of firms), healthcare (0.06% of firms), and consumer staples (0.56% of firms).

ANALYSIS AND RESULTS

Model specification

The descriptive statistics for the overall sample can be found in Table 4. To mitigate issues with multicollinearity, we grand-mean centered all continuous variables used in interactions (Kreft et al. 1995). Further, we calculated the variance inflation factors (VIFs) and found all of our

Table 1. Variable descriptions and sources.

Variable	Type	Variable Name	Description	Calculation	Sources
Dependent	Financial Performance	Return On Assets (ROA) as measure of efficiency of resource utilization		$\frac{(Net\ Inc)_i}{Avg\ Total\ Assets_i}$	Bloomberg, Compustat
		Return On Sales (ROS)		$\frac{(Net\ Inc)_i}{Sales_i}$	Bloomberg, Compustat
Independent	Cost Concentration	Proportion of customer's costs involved in each relationship		$RelInt_i \in [0,1]$	Bloomberg
	Revenue Concentration	Proportion of supplier's sales involved in each relationship		$RelInt_i \in [0,1]$	Bloomberg
	Supplier (Customer) Interconnectedness	Proportion of shared relationships between partners		$\frac{L_i}{g_i(g_i - 1)/2}$	Bloomberg, UCINET
	Firm Closeness Centrality	How quickly a firm can reach partners in the supply network		$(g_i - 1) / \left[\sum_{i=1}^{g_i} d(n_i, n_j) \right]$	Bloomberg, UCINET
	Firm Size	Proxy for size based on sales volume		$Ln(Sales_i)$	Bloomberg, Compustat
	Capital Intensity	Capital expenditures relative to sales		$\frac{Capital_i}{Sales_i}$	Bloomberg, Compustat
Control	Regional Effects	accounting for geographic differences		$Reg_i \in \{0,1\}$	Bloomberg
	Industry Effects	accounting for industry differences		$Industry_i \in \{0,1\}$	Bloomberg

variables to be below the common threshold of 10 (Neter et al. 1996), with the mean VIF scores of 1.98. This finding, along with the grand-mean centered approach, helped ensure that any traces of multicollinearity in our data were well-mitigated.

We modeled our study using a two-stage least squares (2SLS) approach to account for the potentially endogenous nature of the supply network closeness measures. Specifically, we first predict upstream and downstream closeness as a function of exogenous instruments and other variables not posing endogeneity concerns. Next, these predicted scores are used to estimate the regression parameters for operating performance as the dependent variable. The 2SLS procedure helps to mitigate any bias in estimates from a conventional OLS procedure with endogenous variables not properly accounted for. We used several alternative models to determine which model best reflected the data appropriately. As a base model, we employed a basic ordinary least squares (OLS) to test whether our 2SLS model performed better. In general, each model had structurally similar results in terms of the key variables of interest, though the 2SLS model was deemed a better fit over the OLS.

Table 2. Descriptive statistics by industry – defined at the 2-digit global industry classification standard (GICS) level.^a

GICS Sector	Sector Name	Percent	ROA	Firm Size	Cost (avg)	Rev (avg)	Cost Conc	Revenue Conc	Sup Interc	Cus Interc	Up Close	Down Close
20	Industrials	10.42	0.03	80224.73	0.01	0.02	0.12	0.10	0.02	0.02	51272.21	64181.20
25	Consumer Discretion.	5.93	-0.07	52707.93	0.01	0.01	0.18	0.12	0.03	0.01	50481.38	58251.11
30	Consumer Staples	0.56	0.04	3979.01	0.00	0.03	0.26	0.32	0.00	0.01	43763.73	59286.59
35	Health Care	0.06	-0.13	29.42	0.01	0.02	0.86	0.57	0.50	0.17	45475.00	62861.00
40	Financials	0.06	-0.01	23807.02	0.00	0.01	0.52	0.51	0.00	0.00	44536.00	54252.00
45	Info. Technology	78.14	0.04	24202.36	0.01	0.02	0.29	0.17	0.05	0.06	49351.66	65181.01
50	Telecom. Services	0.8	0.07	28946.94	0.01	0.10	0.42	0.67	0.02	0.05	49026.77	24206.00
U	Unspecified	4.03	0.02	45923.34	0.01	0.02	0.27	0.07	0.05	0.03	50604.71	63395.18
Total (Avg.)		100	0.03	32515.73	0.01	0.02	0.27	0.16	0.05	0.05	49630.30	64224.62

^a N = 8724 observations.

Table 3. Descriptive statistics by region.^a

Country	Freq.	Percent	ROA	Firm Size	Cost (avg)	Rev (avg)	Cost Conc	Revenue Conc	Sup Interc	Cus Interc	Up Close	Down Close
Bermuda	78	0.89	0.06	2708.84	0.01	0.02	0.24	0.16	0.02	0.09	47373.26	54571.15
Britain	12	0.14	-0.05	1225.37	0.02	0.06	0.75	0.31	0.50	0.25	46741.00	65823.00
Canada	125	1.43	-0.03	12470.68	0.01	0.01	0.21	0.15	0.11	0.03	51146.36	60319.76
China	71	0.81	-0.03	499.26	0.02	0.02	0.51	0.78	0.06	0.12	44364.80	55547.03
Finland	369	4.23	-0.02	56135.96	0.01	0.01	0.06	0.03	0.01	0.01	52550.00	65884.00
France	174	1.99	-0.10	18755.91	0.00	0.01	0.24	0.33	0.01	0.00	50629.54	60991.81
Ireland	101	1.16	0.19	11963.60	0.01	0.02	0.16	0.10	0.03	0.09	51253.00	66603.00
Israel	42	0.48	-0.03	227.69	0.01	0.01	0.47	0.15	0.05	0.13	47295.00	67127.00
Japan	923	10.58	-0.03	56858.16	0.02	0.02	0.12	0.15	0.04	0.02	51521.17	62557.35
Netherlands	152	1.74	0.05	15305.31	0.01	0.01	0.23	0.12	0.03	0.04	48712.99	65498.24
Singapore	98	1.12	0.18	1995.20	0.01	0.01	0.13	0.10	0.03	0.06	47614.00	67535.00
South Korea	42	0.48	0.07	59.55	0.01	0.04	0.38	0.45	0.01	0.11	42420.95	58860.57
Spain	6	0.07	0.01	4260.93	0.00	0.01	0.43	1.00	0.00	0.00	44926.00	49510.00
Switzerland	76	0.87	0.07	12751.80	0.01	0.01	0.23	0.03	0.00	0.04	43526.00	66554.00
Taiwan	92	1.05	0.03	10931.02	0.03	0.05	0.34	0.36	0.05	0.10	48547.86	64097.71
United States	6,363	72.94	0.04	31376.16	0.01	0.02	0.30	0.16	0.05	0.06	49404.67	64632.48
Total (Avg.)	8,724	100	0.03	32515.73	0.01	0.02	0.27	0.16	0.05	0.05	49630.30	64224.62

^a N = 8724 observations.

Table 4. Descriptive statistics and correlations.^a

Variable	Mean	Std. Dev.	1	2	3	4	5	6	7	8	9	10
1 ROA	-0.03	0.21	1.00									
2 ROS	-0.08	0.63	0.69	1.00								
3 Firm Size	4050.85	12552.97	0.16	0.10	1.00							
4 Capital Intensity	4.79	4.86	-0.05	-0.17	0.02	1.00						
5 Cost Concentration	0.02	0.04	0.12	0.11	0.24	-0.10	1.00					
6 Revenue Concentration	0.05	0.09	-0.31	-0.29	-0.12	0.01	0.21	1.00				
7 Supplier Interc	8.85	14.14	-0.28	0.00	-0.12	-0.19	0.04	0.09	1.00			
8 Customer Interc	10.70	11.73	-0.22	-0.02	-0.20	0.12	-0.02	0.16	0.16	1.00		
9 Upstream Closeness	212.65	406.33	0.15	0.12	0.84	-0.05	0.36	-0.08	0.04	-0.15	1.00	
10 Downstream Closeness	713.79	854.31	0.21	0.13	0.19	0.16	0.12	0.03	-0.06	-0.04	0.17	1.00

^a N = 8724 observations. All correlation coefficients above |0.02| are significant at p < 0.05 level.

Results

Results for the 2SLS and OLS regression models are presented in Tables 5 and 6. We postulated in that increases supply network partner cost and revenue concentration lead to a positive and negative curvilinear effect in firm performance, respectively. While the signs of the regression coefficients seen in Table 5 agree with our first two hypotheses, the significance levels indicate support for our second assertion of the negative curvilinear effect from supply network partner revenue concentration (Hypothesis 2). The positive and significant interaction between supply network partner cost and revenue concentration and performance indicates support for Hypothesis 3. As far as the accentuating or mitigating effects of interconnectedness (Hypotheses 4-5), there is not clear support in either direction. As a note, the interaction terms for interconnectedness were left out of the table to alleviate noise, though the results shown still hold with them in the analysis. Lastly, we find evidence that a firm's downstream closeness within the supply network positively facilitates the effect of supply network partner revenue concentration on its operating performance (Hypothesis 7). The results remained consistent with both OLS and 2SLS models.

Table 5. 2SLS Regression results on firm performance.
2SLS Regression results on firm performance.

VARIABLES	(US Only)				(US Only)			
	1 st Stage Down_C	1 st Stage Up_C	1 st Stage Hyp 5	2 nd Stage ROA	1 st Stage Down_C	1 st Stage Up_C	1 st Stage Hyp 5	2 nd Stage ROS
Controls								
Firm Size	0.03 (0.09)	- (0.11)	0.21*** (0.06)	-0.03 (0.03)	0.03 (0.09)	- (0.11)	0.21*** (0.06)	-0.07 (0.11)
Capital Intensity	-0.02 (0.04)	0.03 (0.05)	-0.01 (0.03)	-0.02 (0.02)	-0.02 (0.04)	0.03 (0.05)	-0.01 (0.03)	-0.14* (0.06)
Direct effects								
Cost Concentration	0.13*** (0.04)	-0.07+ (0.04)	0.00 (0.02)	0.01 (0.02)	0.13*** (0.04)	-0.07+ (0.04)	0.00 (0.02)	0.02 (0.06)
Revenue Concentration	-0.06 (0.10)	0.25* (0.11)	-0.17** (0.06)	- (0.03)	-0.06 (0.10)	0.25* (0.11)	-0.17** (0.06)	- (0.10)
Supplier Interconnectedness	0.07* (0.03)	0.04 (0.04)	0.00 (0.02)	- (0.01)	0.07* (0.03)	0.04 (0.04)	0.00 (0.02)	-0.02 (0.05)
Customer Interconnectedness	0.02 (0.04)	0.05 (0.04)	0.02 (0.02)	-0.01 (0.01)	0.03 (0.03)	0.05 (0.04)	0.02 (0.02)	0.08+ (0.05)
Upstream Closeness				0.05 (0.04)				0.13 (0.14)
Downstream Closeness				0.07*** (0.02)				0.17*** (0.05)
Exogenous variables								
Out ARD Centrality	0.19*** (0.05)	-0.06 (0.06)	-0.03 (0.03)		0.19*** (0.05)	-0.06 (0.06)	-0.03 (0.03)	
In ARD Centrality	-0.13+ (0.07)	0.32*** (0.09)	0.16** (0.05)		-0.13+ (0.07)	0.32*** (0.09)	0.16** (0.05)	
No. Suppliers	0.79*** (0.12)	0.17 (0.15)	-0.11 (0.08)		0.79*** (0.12)	0.17 (0.15)	-0.11 (0.08)	
No. Customers	0.04 (0.06)	1.06*** (0.08)	0.01 (0.04)		0.04 (0.06)	1.06*** (0.08)	0.01 (0.04)	
Interaction effects								
Cost Conc*Rev Conc	-0.06* (0.03)	0.01 (0.03)	0.02 (0.02)	0.03* (0.01)	-0.06* (0.03)	0.01 (0.03)	0.02 (0.02)	0.10** (0.04)
(Rev Conc) ²	0.00 (0.02)	-0.02 (0.02)	0.00 (0.01)	0.02** (0.01)	0.00 (0.02)	-0.02 (0.02)	0.00 (0.01)	0.06* (0.03)
Rev Conc *Down Close				0.09*** (0.03)				0.19* (0.09)
Industry Dummies	Y (0.38)	Y (0.45)	Y (0.25)	Y (0.17)	Y (0.37)	Y (0.45)	Y (0.25)	Y (0.55)
Constant	-0.11 (0.38)	-0.33 (0.45)	0.06 (0.25)	-0.01 (0.17)	-0.12 (0.37)	-0.33 (0.45)	0.06 (0.25)	-0.02 (0.55)
Observations	172	172	172	172	173	173	172	173
R-squared	0.876	0.841	0.820	0.349	0.876	0.841	0.820	0.226

Variables in interactions were grand mean-centered; Interaction variables were also made for the first stage regression to account for the interaction of potentially endogenous downstream closeness with revenue concentration, were excluded from the table to preserve space; Standard errors in parentheses.

*** p<0.001, ** p<0.01, * p<0.05, + p<0.10.

Table 6. Regression results on firm performance.

VARIABLES	ROA (US Only)			ROS (US Only)		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Controls						
Firm Size	0.03*	-0.03	-0.02	0.06	-0.03	-0.01
	(0.02)	(0.03)	(0.03)	(0.05)	(0.09)	(0.09)
Capital Intensity	-0.01	-0.02	-0.02	-0.11*	-0.15*	-0.14*
	(0.02)	(0.02)	(0.02)	(0.05)	(0.06)	(0.06)
Direct effects						
Cost Concentration	0.03+	0.02		0.08+	0.03	
	(0.01)	(0.02)		(0.05)	(0.06)	
Revenue Concentration	-0.07***	-0.13***		-0.21***	-0.39***	
	(0.02)	(0.03)		(0.05)	(0.10)	
Supplier Interconnectedness	-0.06***	-0.05***		-0.01	-0.01	
	(0.02)	(0.01)		(0.05)	(0.05)	
Customer Interconnectedness	-0.02	-0.01		0.04	0.07	
	(0.02)	(0.02)		(0.05)	(0.05)	
Upstream Closeness	0.03	0.03		0.04	0.05	
	(0.03)	(0.03)		(0.10)	(0.10)	
Downstream Closeness	0.04**	0.06***		0.10*	0.14**	
	(0.01)	(0.01)		(0.05)	(0.05)	
Interaction effects						
Cost Conc*Rev Conc		0.03*			0.10*	
		(0.01)			(0.04)	
(Rev Conc) ²		0.02**			0.06*	
		(0.01)			(0.03)	
Rev Conc *Down Close		0.10***			0.19*	
		(0.03)			(0.09)	
Industry Dummies	Y	Y	Y	Y	Y	Y
Constant	0.05	0.05	-0.01	-0.01	0.01	-0.03
	(0.21)	(0.19)	(0.18)	(0.61)	(0.60)	(0.58)
Observations	182	172	172	183	173	173
R-squared	0.032	0.260	0.351	0.037	0.161	0.230

Variables in interactions were grand mean-centered; Standard errors in parentheses.

*** p<0.001, ** p<0.01, * p<0.05, + p<0.10.

DISCUSSION AND CONCLUSION

This study was motivated in part by the recognition in the operations management community that more research is needed that explains the linkage between network structure and supply chain performance (Chen and Paulraj 2004) and the call for more research incorporating relationship dependency and supply network structure into a single framework (e.g. Kim et al. 2011). Our study complements earlier research efforts characterizing supply relationship dynamics (e.g. Dyer 1996; Dyer and Nobeoka 2000; Choi et al. 2001; Harland and Knight 2001; Chen and Paulraj 2004; Choi and Krause 2006; Choi and Wu 2009) by using a unique customer and supplier dataset to account for supply network characteristics at the firm, dyad, and network level, and ultimately to enrich our understanding of the joint effect of these characteristics on a firm's performance.

Our results provide an initial indication that supply network cost and revenue concentration, supply network interconnectedness, closeness centrality and the interaction bear significant influence on firm performance. These findings are line with prior studies suggesting the benefits of relationship dependency and supply network structure on their own. These studies have conceptually argued or empirically demonstrated certain knowledge gains that are contingent in part on the relationship dependencies between dyads in a network (Yli-Renko et al. 2001). Our contribution comes by jointly considering the interaction of supply network cost and revenue concentration – a form of relational capital and a proxy for relationship dependency – and supply network structure –a form of structural capital –, as a clear benefit aside from each of these factors in isolation. Taking these findings collectively, our study corroborates past scholarly premonition calling for future studies to factor in advantages and constraints derived from the structural positions held by customers and suppliers embedded in a larger supply

network, which ultimately impact the dependency of social capital derived from these customer and supplier relationships (Villena et al. 2011).

Limitations and future research

We extend existing research on supply networks and performance by exploring several underlying factors that have not been jointly accounted for in prior supply chain empirical studies. Though we believe our study to provides important implications for supply chain and operations management research, we acknowledge certain limitations which we hope that future research can help resolve.

First, our current dataset is cross-sectional. The static nature of our supply network data make it difficult to study how supply networks evolve and impact performance over time. As other researchers are well aware of, it is difficult to retrieve extensive historical data on proprietary elements such as customer and supplier relationships. Some researchers have made good strides to try and resolve this issue, looking to annual 10K filings and segment data on the Compustat database to build partial supply networks, which comprise almost exclusively of only major customers and suppliers. Nonetheless, future research would benefit tremendously from a longitudinal study, but with more of a comprehensive supply network such as that used in our study. This would help capture the dynamic nature of supply networks to test the sensitivity of performance implications in the long run.

Second, other performance measures should be considered to ensure that our results are robust to different considerations. Lastly, we analyzed supply chain relationship and financial data for focal firms classified as operating primarily in the electronics industry. Further insight can be drawn from investigating how the magnitude of the supply relationship dynamics differs across other industries as well.

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Will you change your mind? The Effect of Product Attribute Carryover Effect on Consumer Choice

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ABSTRACT

The study investigates how consumer choice lunch boxes when the first option is unavailable (out of stock), the preference is for a property with consistency, validate consumers make decisions without rational choice. Studies in experimental method to select two decisions, the results found that consumers face the first option in the selection process unavailable (out of stock), because of the effect of Carryover affected by product attributes, would give preference to the second option, and select the “carryover effect” option. Finally, the study presents recommendations for consumers to choose the interpretation process for benefit of consumer behavior theory and practice.

Key words: Attribute Carryover Effect, Consumer Choice

RESEARCH BACKGROUND AND MOTIVE

"When Andy walked into a convenience store to buy his today's dinner, he looked at pictures of delicious fast food in the shop, and thought: shall I have 'fried chicken leg' or 'crispy spare ribs' for dinner? At this time, the store assistant asked him: "excuse me, sir; what would you like?" Then he answered: "fried chicken leg, please." And then the assistant checked food preparation and said to him that: "Sir, fried chicken leg has been sold out, would you like something else?" So Andy thought over and answered that "Japanese style

grilled chicken leg" instead of his second favorite "crispy spare ribs" So think about it, do you have similar decision making behavior like Andy? "

Andy in the story has formed a multiple sequential choice phenomenon during his buying the fast food which is also a situation for common people facing choice decision in daily life. Bettman, Luce, and Payne (1998) believe that consumers make decision analysis through product attributes and results advantage comparison, while the "attribute" represents obtained different results, relatively favorable or unfavorable conditions of products, and some attributes exchange (for example, "high price" for "with the production certification to ensure food quality"). However, is it able to predict consumer choice as long as the decision attribute preference is made? The answer seems not so rational. Boland, Brucks, and Nielsen (2012) explain this phenomenon as attribute carryover effect on products that when consumers may have multiple choices in the selection process, they decide the option combinations by "filter attribute" and in accordance with the preference rank the options as "first option", "runner-up option", but when the first option is not available (for example, out-of-stock), in theory he/she shall select the runner-up option, but due to enlarging effect on "attributes differences" between choices, some consumers may refuse the runner-up option while choose the one with same "attributes differences" with the first option instead.

For food and beverage industry, the disclosure of product attributes information is a very important element in consumer choice process. Ortega et al. (2011) found that under food safety risk perception, consumer preference focuses on attributes with health and safety certification information, i.e. consumers would prefer using "the health and safety certification" as the filter attribute for their food choice decision, and then they would remove the products without such attribute to help to make effective decisions. In order to explore the above issue, the purpose of this study is to understand food and beverage products attribute carryover effect on the consumers' choice process. Moreover, during two choices process when a consumer learns his/her favorite first option is not available (out-of-stock), whether he/she would pick up the runner-up based on sequential choice or rejects it for another alternative due to the attribute carryover effect? So the question of this study is that if there is change in preferences on options with attribute carryover effect.

LITERATURE REVIEW

Do product attributes have influence on consumer choice and decision? Goyal, Rahman, Kumar and Kumar (2011) conducted a research on green product attributes and illustrated that consumer awareness would become mature with environment and hence product' green

attribute has relationship with consumer attitudes and behavior which leads their decision toward the green products, and interestingly, such attributes purchase decision will eventually form a habit and then change consumers' whole life pattern. Also, Kotler, Brown and Armstrong (2003) pointed out that, product or service is regarded as a set/group of attributes or characteristics, and the attributes of this product or service will have impact on consumer choice. While Tseng and Lii (2011) research shows that the perceived and processed quantity of product attribute information have effect on the consumers' multi-attribute preference decision, and therefore, characteristics of product attributes and perceived information quantity have indeed influence on consumer choice and decision.

Also there is same perception in the food and beverage industry that the disclosure of product attributes information is the important factor in consumer choice process. It will cause consumers' expect gap to the suppliers due to nondisclosure or information asymmetry on product attributes so that errors may occur in consumers' choice decision. Ortega et al. (2011) conducted an experimental research after multiple food safety incidents outbreak within Chinese food market, they found out that consumers began to pay attention to the effect of product attributes on choice process, and they preferred the product with food safety and quality certification attributes and formed food safety awareness when they selected pork products, so the empirical evidence illustrated that consumers prefer the product attributes in their choice process.

Lagerkvist (2013) pointed out that the attribute information on food labels is able to represent relative product and manufacturing process quality and is also a reference for consumers' decision-making. Moreover, his study made a comparison on different attribute of beef food and ranked them based on importance and consumers' preference which indicates that consumers put weight on product attributes. In addition, Zander and Hamm (2010) argue that most of consumers are willing to pay a higher price for their valued attributes and discussed consumer preferences for additional ethical attributes (whether it is really organic manufacturing) of organic food. Although the organic food manufacturers have to increase the cost by losing market price competitiveness, the findings indicate that consumers were willing to pay higher prices for organic product and additional ethical attributes which once again demonstrate that the "attributes" of products are essential to consumers' choice and decision. Therefore, this study believes that consumers will be affected by product attributes in their choice process and will make different final decisions, and hence, it will discuss how product attributes have impact on consumer choice process.

Attribute Carryover Effect on Consumer Choice

Attribute Carryover Effect

Unfortunately, the product you selected is out of stock? This study discusses how to select the first option rather than the runner-up option in the decision making process. In daily life, consumers are likely to learn that their first favorite product choice is out of stock (unavailable) when they make a purchase decision, at this time, consumers will select their runner-up option, or pick up another alternative which is not their original options. So such choice preferences shift phenomenon has potential impact on consumer choice.

By reviewing the study of Boland et al. (2012), the definition of attribute carryover effect refers that in the choice process of distinguishing the first option and the runner-up option, when the first option is not available (out-of-stock), consumers could theoretically select the runner-up option, however, due to the amplified difference attributes by the consumers, they would abandon the runner-up option and instead to choose the option with common attribute difference which indicates that the first choice decision making transfers the consumer preference, resulting in the potential possibility of reversing the preference on the runner-up option which is as attribute carryover effect. For example, by way of illustration the authors describe a customer who is shopping for a new pen with black ink. However, at the checkout line the consumer learns that the black ink pen out-of-stock. And, instead of selecting other ink color pen, most consumers may choose black ink ballpoint pen as the final decision. In that situation, black ink is the attribute difference as the most important attribute which is called as "the carryover effect."

Consumer Sequence Decision Process Model

Trouble with the choice? No matter when consumers select a house, car, or even a simple pen, with a large number of potential options for choice, all options have its attributes and the benefits. So this study will explore when consumers learn that the first option is not available (out-of-stock), how they will make their decisions. Therefore, referring to the research of Boland et al. (2012), it will investigate consumer decision-making process model which is divided into two stages and applied to the experimental design as two-stage choice design is easy manipulation for experimental purpose, specifically, the objective of the first stage to screen a combination of large amount options to a combination of small amount options, and the objective of the second stage to distinguish the options of screening combination and make the final decision (Bettman & Park, 1980).

The "attributes" can help consumers select, people expect that consumers will use the most important attribute to narrowing down the choice combination (i.e. the use of edit mode). In the application of decision-making process, consumers will use attributes to reduce the combination of options, and there is a narrow down selection function in the first stage, while there is a choice evaluation function in the second stage, so this attribute is called "filter

attribute". Moreover, when the options are narrowed to a high homogeneity combination, the filter attribute will appear relatively not so important, decision-makers will focus on the heterogeneity attribute in narrowing down the combination, and such attribute is called "attribute differences" (Diehl et al., 2003).

Attribute Carryover Effect on Consumer Choice Process

Discussion on the two decision consistency: the first option is available

Boland et al. (2012) pointed out that the first option is available when consumers making a sequent two decisions, they will remain the same choice in their subsequent decision. The findings of their empirical experiment have verified that 100% of the participants had selected the same option in the sequent decision-making when the first choice was available. Also, assuming under the condition that the choice combination is the same, consumers will not be affected on their liking degree on first option because of reconsidering the decision options. Therefore, the following hypotheses are proposed:

Hypothesis 1: Comparing two decisions, when the first option is available, consumers will remain their first preferred choice. (H1)

Hypothesis 2: Comparing two decisions, when the first option available, consumers will maintain the same liking degree on their first choice. (H2)

Discussion on the two decision consistency: the first option is not available (out of stock)

Muthukrishnan and Kardes (2001) believe that when the first option is not available to consumers, it will generate a new selection process, and the attributes preference may lead consumers to abandon the runner-up option and select the carryover option. In addition, Boland et al. (2012) also overturned their previous research results that when the first option is not available (out-of-stock), consumers would select runner-up option in theory. But in their recent research, the results showed that nearly 50% of the subjects chose option with attributes carryover effect which further verify that it is not because they forget the first decision options but to choose the alternative option. When the first option is available, 100% of participants would select their first preferred option in two sequent decisions which reverses the carryover option, and this is because of the increased weight "attribute difference" effect. Furthermore, Fitzsimons (2000) pointed out that when the option is constrained, the consumers will increase the liking degree on the carryover effect option over the time. Therefore, the following hypotheses are proposed:

Hypothesis 3: Comparing two decisions, when the first option is not available, consumers will abandon the preferred runner-up option and reversely select the option with attribute carryover effect. (H3)

Hypothesis 4: Comparing two decisions, when the first option is not available, consumers will increase the degree of preference for carryover effect option. (H4)

METHOD

In this study, four experiments were conducted to explore the influence of product attributes carryover effect on consumer choice, in order to testify the irrational behavior of consumer decision making. The design process and the scenario description of the four experiments of this study are illustrated in Figure 3-1.

Experiment Start**First Desicion****Experiment 1-4****The Same****First Decision Scenario:**

Experiment 1-4
The Same
Scenario Description:
 Research staffs inform the subjects that they will obtain “a fast food lunchbox” as a thanks gift after the completion of “mobile phone usage”

Before filling in the survey, the subjects will select the lunchbox first in a separate research room. By watching six pictures of fast food lunchboxes, the subjects will rank these six lunchbox in liked scale of 1-9 point and make their first decision.

Ask the subjects to select two favorite lunchboxes and choose the first preferred and

Conduct an irrelevant questionnaire (“mobile phone usage”) to the objective of this study.

First Desicion (Different Scenario)**Experiment 1 (when the first option is available/remake a choice)**

Scenario 1: Sorry, our staff accidentally lost the chosen lunchbox note, please select again, what are your two favorite lunchboxes?

Experiment 2 (when the first option is available/remake a choice after evaluation)

Scenario 2 : We offer you a second selection chance in case you regret your last order, please watch all the pictures again, rewrite your preference degree on the six lunchbox, and choose two favorite lunchboxes.

Experiment 3 (when the first option is not available/remake a choice)

Scenario 3: The lunchbox you selected is out of stock, please select another one from the rest five lunchboxes.

Experiment 4 (when the first option is not available/remake a choice after evaluation)

Scenario 4: The lunchbox you selected is out of stock, please rewrite your preference degree on the rest five lunchboxes, and select another one.

Final Decision**Experiment 1-4**
The Same

Make final decision

Time Shaft Start

Time Shaft End

Figure 3-1 Two Decision Making Experiments Process And The Scenario Description Of This Study

Pretest - Product Attribute Selection

The stimuli in this study are fast food lunchbox. From the results of the pretest, two key attributes to the fast food lunchbox design are identified, as well as a relatively unimportant attribute, which are as the basis for stimuli design.

The attributes for fast food lunchbox design are listed as the following twelve attributes: main dish meat type, main dish cooking type, side dish choice, overall side dish color, staple food choice, with health certification label, lunchbox material, lunchbox shape, lunchbox packaging picture, meal drink, meal soup, and convenience store brand. A pilot questionnaire was conducted and 73 valid respondents were received and showed that the “with health certification label” ($M=6.03$) and “main dish meat type” ($M=5.77$) are relatively important attributes, while “lunchbox packaging picture” is relatively less important attribute ($M=3.95$). T-test confirmed that the importance of “lunchbox packaging picture” is significantly lower than “with health certification label” ($t=9.881$, $p<.01$) and “main dish meat type” ($t=11.664$, $p<.01$). Therefore, this study adopts “with health certification label”, “main dish meat type” and “lunchbox packaging picture” as stimuli design attributes and designed a total of 6 fast food lunchbox.

Experimental Process

From the experiment process description in Figure 3-1, experiment 1-4 have the same process flow before the first decision making. First of all, the subjects were individually arranged in a separate room for experiment. The staffs first informed the subjects that they would obtain a fast food lunchbox as a thanks gift after the experiment, then the subjects were given six pictures of fast food lunchboxes (5 x 7 inch color photos) on which each photo has shown three attributes (meat type, HACCP certification and fast food lunchbox cover) and hence gave the evaluation of liking degree. Secondly, the subjects selected their favorite two lunchboxes and ranked them in preference order and gave the reason why they selected the first lunchbox option.

After made the first decision, the participants would write an irrelevant questionnaire to the objective of this study in order to make the participants believe the experiment was real. And after the completion of the questionnaire (in about 15 minutes), the staffs once again walked into the room and conducted the four scenarios for the second decision making (Experiment 1 to Experiment 4) and completed the final option. Finally, after the completion of the experiment, staffs informed the participants the purpose of this study and gave them a small gift, and asked them to sign a confidentiality agreement.

RESULTS

Experiment 1: This experiment received a total of 58 valid questionnaires from university students.

There are two main findings: 1) when the first option is available, 84.5% of participants maintained consistency in their first option in two decision making process which verifies that the majority of the participants are willing to maintain their first option with time factor added (two decision investigation), and hence it supports H1 that comparing two decisions, when the first option is available, consumers will remain their first preferred choice. 2) When the first option is available, 72.4% of participants maintained consistency on their second option. So comparing the two results, the consistency in the first option is relative higher.

Experiment 2: This experiment received a total of 62 valid questionnaires from university students.

There are three main findings: 1)as the same as the Experiment 1, when the first option is available, the majority of the participants are willing to remain their first decision in the second decision making process which indicates the consistency in two decisions (87.1%; N = 49). 2) When the two decisions on the first option remain the same, there was no significant difference between the degree of the participants' preference. 3) This experiment has conduct the scenario of "re-evaluate and then make a choice" which results showed that the judgment task would not affect the result of liking degree on the first option in two decision-making process, which supports H2 that comparing two decisions, when the first option is available, consumers will maintain the same liking degree on their first choice.

Experiment 3: This experiment received a total of 60 valid questionnaires from university students.

There are two main findings: 1) it supports H3 that when the first option is not available (out-of-stock), the participants may not fully select the runner-up option due to the attribute carryover effect, and may abandon the preferred runner-up option and select the option with attribute carryover effect because of the attributes preference (36.7%; N = 22). 2) When the first option is not available (out-of-stock), the participants selected the option with attribute carryover effect, not because they forgot the runner-up option but because of preference shift caused by attributes differences (95%; N = 57).

Experiment 4: This experiment received a total of 56 valid questionnaires from university students.

The results of this experiment are same as that of Experiment 3. When the first option is not available (out-of-stock), 50% participants would abandon the preferred runner-up option but select the carryover option. Interestingly, the participants may increase their liking degree on the carryover option in the two decision making process. Therefore, the findings of this experiment support H4 that comparing two decisions, when the first option is not available, consumers will increase the degree of liking for carryover effect option.

CONCLUSION AND DISCUSSION

Research Conclusion

Under the scenario of first option available, consumers would make consist decision on their first preferred option in the sequence decisions and there was no change in liking degree. However, when “the first option is not available (out-of-stock)”, consumers” had to make second decision. 37% participants would transfer their preference due to the attribute carryover effect. While the participants were taken reconsideration on the liking degree and the results found that 50% participants would select the carryover effect option and the preference for carryover effect option has increased from 37% - 50%.

The Findings of “How to Select?” Attribute Carryover Effect on the Consumer Choice Process in Food and Beverage Industry

The important contribution of this study is to apply the subject of attribute carryover effect in the food and beverage industry, the lunchbox as stimuli verifies the consumer lunchbox choice process as the following:

Under the scenario when the first option is available, consumers will select the first preferred option in two sequence decisions and maintain the same liking degree.

When the first option is not available (out of stock), not all consumers select the runner-up option, but instead to select the option with carryover effect which the liking degree has increased.

Managerial Implication

For managers, product or service attributes design should consider consumer preferences, and use the after-sale questionnaire to understand what factors affect the consumer choice on products. Furthermore, by establishing customer relationship and consumer buying behavior analysis, it can predict consumers' future purchase behavior through the historical data before the purchase and meet consumer requirements in advance to achieve marketing efficiency,

such as, ultra-popular lunchbox recommendation, and seasonal limited cuisine appointments, etc., all are designed with consumer preference attribute and it is also helpful to the inventory management expectation.

In practice, there are common management issues that the product is out of stock or imbalance of supply and demand of human resources, which may lead that consumers would often purchase the product or service from the alternative vendors. So in order to solve such phenomenon, supplier will choose to provide more merchandise combination with related attributes which is intended to allow consumers to have multiple choices to achieve the transaction. For example, the menu of convenience store is design with 20 kinds of combinations, so when the first preferred option is out of stock, the store assistant will immediately promote the alternative product with similar attributes to consumers in order to help transfer the consumer preference to complete the transaction.

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Lean in Healthcare for the Gulf Cooperation Council (GCC) Countries: Improving Emergency Department Patient Flow through Triage Redesign in Oman, a Case-Study

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ABSTRACT

A pilot study of Lean improvement projects was carried out in Emergency Department in one public-sector tertiary-care teaching hospital located in the Sultanate of Oman. One purpose of the pilot study was to improve triage wait and admission times through redesign of patient flow in the ED. This was done through introduction and application of lean tools such as value-stream mapping and conducting value-quotient calculations which resulted in a structured redesign process of the existing triage system to compare with pre-lean improvements.

As a result, the triage waiting time was significantly reduced and patients expressed higher satisfaction with wait times, and quality of care regarding communication and access to treatment. Value-driven focus upon the patient for the design of operations is essential to enhance patient satisfaction, and the efficiency and quality of care in emergency medicine.

Triage Redesign in Emergency Department, Lean Emergency Medicine, Lean Health, Lean Service, Lean Patient Flow

INTRODUCTION

In general healthcare it has been well documented that provision of care is expensive and that patient expectation of quality of care is increasing (1, 2, 3, 4, 5). For many hospitals, along with their Emergency Departments (ED), traditional increases in resources and capacity are either unavailable or not working (6). EDs globally face problems with increased demand (overcrowding), limited capacity (staffing and education levels as well as available facilities and equipment), cost-containment, and higher patient expectations regarding quality, safety and timeliness of care (7, 8, 9, 10).

Interviews conducted in the preliminary phase of this study evidenced these same global factors impacting healthcare reforms in Oman's public health care sector, and in the ED of the hospital selected for our pilot study. These factors clearly impact the principal management goals of EDs, which are universally safe and effective patient flow (11). The literature supports evidence that high demand levels with unmatched capacity levels in EDs affect safety and quality of care levels (12, 13, 14, 15). Patient satisfaction has been documented to be negatively impacted by

long wait times (16, 17, 18, 19, 20) and there is evidence to suggest that patients leaving without treatment or against medical advice, and return for the same complaint, are often the influence of negative patient experience based on overly long wait times (7, 21, 22, 23).

Global factors impacting healthcare reforms have led health care executives in both the private and public sector to engage in process improvement strategies which aid adherence to patient requirements, while delivering better performance using the available resources (24, 25). Of these process improvement strategies commonly applied to the health care setting, a 51 percent majority of publications focus on lean (26). Such focus in recent research marks lean for the healthcare setting as one possible solution for reducing cost of care and meeting patient requirements for service quality and safety.

Markedly, public healthcare settings in the UK have adopted or have released statements that they are planning to adopt lean in order to decrease costs and to improve quality, efficiency and safety of patient care (27). A 53 percent of (majorly private sector) US hospitals surveyed in 2009 reported applying lean to some degree, and of those hospitals that reported implementing lean, 60% reported applying lean in the ED (28). The percentage of publications covering lean applications in the ED is growing annually, which suggests a trend of increasing awareness from the healthcare sector itself towards the plausible success and derived benefits lean may offer healthcare providers and patients, even in environments with uncontrolled or unpredictable demand levels such as EDs (29, 30, 31, 32, 33).

However, findings documenting operational and strategic lean implementations in the context of the healthcare setting originate mainly from records of delivery outcomes in regards to quality and cost in hospitals in the US, UK, Australia, and a few other European examples. Therefore, any methodological contribution is based upon these previous contexts of Western or what may be defined as developed countries. Lean publications pertaining to the GCC and Middle East and North Africa (MENA) regions are thus far restricted to the context of manufacturing, and what general lean examples were provided held no practical or theoretical framework for designing a consolidated methodology for the implementation of lean in either manufacturing or services, such as healthcare. No consideration of any cultural context which could affect lean sustainability and success within the MENA region and Oman could be found despite the comprehensive literature review undertaken before commencing this study ((34, 35, 36, 37) .

This case study presents a new cultural context (the GCC and MENA region) for lean implementation, along with practical implications within a given hospital's ED given special regard to patient flow with preliminary findings from our results on triage redesign. The case study is part of a larger pilot being carried out in the ED and another medical ward related to the ED through referrals/patient transfers. The aim of the pilot is to understand any unique cultural factors that may impact the implementation of lean in healthcare in Oman, and to design the best methodology for suggesting lean as a means to improve quality of care using the available resources in Oman's public healthcare sector. The focus of this paper is in specific regards to increasing efficiency of patient flow and decreasing admission wait times in an example ED triage in a tertiary-care training hospital from Oman.

Before giving an overview of this paper, a brief overview of lean in health care is necessary.

While also referred to as ‘the ‘Toyota Production System’ (TPS), ‘Lean Production’, ‘Lean Thinking’, ‘Lean Management’, or ‘Lean Healthcare’ (38, 39, 40, 41, 42, 43) we have used the term ‘Lean’ to describe general lean applied to healthcare. *‘Lean’ for the healthcare setting is defined for the purposes of this paper as: ‘A process improvement strategy consisting of a set of tools at the operational level, and a set of strategic guiding principles, which provide some standards for processes, serving the creation of flow, and decreasing interruptions and potential for errors’* (44, 45).

Key concepts for Lean in healthcare are the provision of tools for, and the empowerment and involvement of front-line hospital staff to continually improve their work (46, 47, 31, 48, 42). Through their overview of 4 ED 4 case-studies, authors Dickson, Anguelov, Vetterick, Eller & Singh propose that this means that all care “providers have 2 jobs: taking care of patients and finding better ways to take care of patients by constantly improving quality and flow” (49, p. 505).

The basis of continual improvement for lean in the healthcare setting is the lean principle of value production (33, 43). The concept of lean is that all value is the result of a process (50, 51). With lean in the healthcare setting, value is defined from the perspective of the patient as to what parts of a process add value (24, 52). In order to be valuable work must transform or enhance the service or result in some way, it must be done correctly the first time, and the patient must require it (53, 42). If the work is not of value then it is defined as a waste and must be removed from the process (54, 43). Traditional hospital management generally focuses on the utilization of an ED’s assets (equipment, clinicians, etc.), whereas lean requires inspection, analysis, and often re-design, of the ED’s value-creating processes (38, 55). We inspect patient flow through entering to exiting (through admission/transfer or discharge) the ED in order to undertake an end-to-end process view of the complex and interconnected, inter-dependent processes, that compose patient experience of a hospital stay/visit. This paper will limit those observations to triage and admission processes.

Previous research exhibits findings that lean principles applied to triage redesign in EDs significantly shortens the time of first contact with a physician or senior clinician, may lead to a shorter stay in the ED, and may positively impact the overall patient experience of a given hospital (56, 57, 58, 59).

The primary objective of a wider study of lean healthcare in Oman, whose implications are yet ongoing, was to run pilot lean improvement projects in a public sector hospital. This was proposed in order to derive a context-based best-methodology, including recommended measurements, for the design of a national strategy for lean in Oman’s healthcare system.

This paper examines one aspect of an on-going pilot study of lean improvement projects being carried out in one public-sector tertiary-care teaching hospital located in the capital region of the Sultanate of Oman. Before a hospital-wide application of lean could begin (with the aim of improving not only patient flow, but also efficiency of the flow of information, intellect, materials, and equipment of other aspects of the hospital, from wards to administrative, technical and support units) cultural context and readiness factors had to be assessed in advance. This paper concerns the part of the study conducted in the hospital’s ED, and a completed aspect of

the pilot project, which was to improve triage wait and admission times through redesign of patient flow in the ED, and discusses the processes of triage and patient admission in lean terms, and from an operations management perspective.

The hospital selected for the pilot is tertiary care hospital. It has a 679 inpatient and ambulatory bed capacity, having had an occupancy rate of 74.9% in 2013. It is managed by 2, 775 employees: 440 doctors, 1196 nurses, 512 technical staff, 347 administrative staff, and 280 support staff.

Organizational structure of the selected hospital is divided between clinical services and teaching resources through shared and integrated joint Executive Committees between the University Institution and the Hospital itself. The Hospital Board, the Medical Advisory Committee, and the Administrative Coordinating Committees are responsible for developing and ensuring implementation of various policies and procedures for Hospital. However, the hospital provides all types of patient care, which include primary, secondary, tertiary, and in a few specialties, quaternary clinical care. Patients present to various OPD clinics and the ED at the selected hospital for both primary and tertiary care. Statistics taken over a five year period reveal an increase in patient demand on the hospital clinical services classified per department or clinic, and in year 2012 the hospital's ED presents a 24% increase from 2007, which suggest a heavy load of patient activities in the ED in particular.

Methods

This section of the paper documents our rationale for studying patient flow through the ED and study-type, study design, length of the study, the type of data collection, and methods for analysis of data.

The rationale for studying patient flow in the ED was to derive concrete cultural context and develop the best methodology for lean success and sustainability within the context of Oman, with data that could be comparable to previous studies. As 60 percent of hospitals documented using lean in the US reported doing so in their EDs, conducting the pilot study in an Omani hospital's ED was considered necessary in order to provide comparative cultural context.

Towards a practical significance, findings would also help to determine the best performance measures to assess progress in the context of Oman's healthcare sector.

It is a qualitative, pre- and post- lean design study, employing mixed methods for both data collection and analysis of the derived data provided for in the results section of this paper.

During the study of the ED triage process and structure redesign, lean was the single paradigm for improvement.

Pre-lean introduction to the hospital selected to run the pilot and its ED staff, semi-structured interviews composed a qualitative study designed to elicit interview subjects' understandings and opinions regarding lean readiness factors across Oman's healthcare sector (34), and specific to this study, patient satisfaction regarding the EDs flow efficiency and quality of care. The interview questions were semi-structured, and designed to gauge existing readiness factors in

place, and any gaps that might exist. The interviews were recorded and then transcribed. Ten patients admitted and undergoing care in the EMW were interviewed, and the ED staff included its department head, its head of nursing, one senior physician, one junior physician, and two nurses, along with the department head of the *Patient Services Department* (which supplies many surveys about patient satisfaction and clinical statistics regarding the ED), the head of the *Quality Department*, and the senior executive management team of the hospital itself, including the hospital director.

During the interview process, pre-site visits were carried out by the research team, data collection began, and key stakeholders from the ED were identified and invited to attend a two day workshop to introduce them to lean principles and train them how to use lean tools, such as current and ideal-state process and value-stream mapping (52, 60). Pre-site visits provided examples and material references of lean concepts that related exactly to the front-line work of the ED. The workshop was designed based on the literature on lean, lean health, and health change management to train integral persons in lean tools and lean project design for healthcare, and had the objective of the workshop attendees themselves providing direction for the pilot based on their own knowledge of their work.

Pre-lean data collection consisted of 30 cases observed from entering the ED doors, until exiting the department, either through transfer, referral, discharge, without receiving treatment (WRT) or left against medical advice (LAMA). This data was collected randomly during the month of December 2014, from 8 am until 2pm Saturday through Thursday, and Friday to Saturday at 7pm-1am.

The following efficiency indicators were documented: total length of stay, time from entering the ED until registration completed, time from registration to vitals being taken, time from vitals to treatment commencement or patient being seen by physician, time from seen by physician to being admitted or treated and discharged/transferred/referred, time for running tests (such as radiology, and blood work), time consultation request made until consultation occurs, and time of disposition decision until transfer or discharge. Gender, age, and triage category of the patient were noted.

According to lean principles the current-state patient flow process was physically mapped from the above data using the following categorizations: total patient flow, by triage category, and by similar process-flow (such as internal medicine cases, or cardiac cases grouped together, or treatment-and-discharge-but-not-admitted cases grouped together, regardless of triage category). From the current-state process maps, value-quotients could be made. Clinically it was determined that the most useful current-state maps were those categorized by similar process flow, although triage categories could indicate overall performance and help design ideal-state maps, and total patient flow was of use to senior executives towards understanding the ED's output and demand and capacity levels (throughput).

Value-quotient calculations required every minute of the observed patient's stay in the ED to be accounted for and were categorized and calculated by classifying the recorded efficiency indicators by the following: waste, value, or required (thus of value).

After compilation of the initial data and completion of the first value-stream maps of the current-state patient flow, the ED initiated a trial redesign of their triage-team and structure based on lean principles.

Previously the triage in ED consisted of the registration process, and then the patient moving or waiting for one of two exam rooms for a nurse first/junior physician triage model. The triage model was changed to a predominately nurse first/emergency physician second model, with the occasional physician-led team triage whenever available, and a senior emergency nurse to direct patients to the triage team after registration.

Post-lean data collection consisted of 49 cases observed from entering the ED doors, until exiting the department, either through transfer, referral, discharge, left without receiving treatment (LWRT) or left against medical advice (LAMA). This data was collected randomly during the month of July 2014, from 8 am until 5pm Saturday through Thursday.

The same efficiency indicators were documented: total length of stay, time from entering the ED until registration completed, time from registration to vitals being taken, time from vitals to treatment commencement or patient being seen by physician, time from seen by physician to being admitted or treated and discharged/transferred/referred, time for running tests (such as radiology, and blood work), time consultation request made until consultation occurs, and time of disposition decision until transfer or discharge.

Gender, age, and triage category of the patient were noted, along with the computerized data entered by ED clinicians on the hospital's information system (which was found to differ somewhat from physical observations).

Again, the current-state patient flow process was physically mapped from the post-lean triage redesign data using the categorizations of total patient flow, by triage category, and by similar process-flow. Value-quotient calculations were likewise made. Pre and post lean data was collected and merged into a database using excel, and value quotient calculations along with efficiency indicators were compared.

FINDINGS/RESULTS

Our interviews with ED staff showed willingness to change as well as awareness of key lean principles such as waste, value, and customer group identification. Patients receiving treatment in the ED of the pilot hospital interviewed provided confirmation of gaps and possible inhibitors to lean readiness described by hospital staff in Oman's public healthcare sector interviewed.

During the workshop conducted to introduce key stakeholders from the pilot group ED to lean principles and train them in the use of lean tools, our objective of having the workshop attendees themselves provide direction for the pilot based on their own knowledge of their work was achieved. Lean improvement projects were suggested and designed by the ED staff trained during the aforementioned workshop. These projects include the following which were monitored during our data collections in the ED: patient flow from ED to wards (accompanying patients by nurses), interruption of doctors and nurses work (a patient safety concern), time of waiting for the decision of patient admission to a medical ward, cutting down on high referrals

related to basic care, better management of follow-up for chest pain patients, streamline consultation/entry/registration/triage/time seen by a doctor/treatment/discharge/cure, communication: getting a hold of responsible radiologists/confusion ultra-sound requisition, minimizing repeat or unscheduled visits, monitor and reduce the number of patients that leave without being seen or against medical advice, discharge plan (even policy) for outliers, locating staff and patients, and stocking of equipment and medications to be more efficient.

While the typical ED registration-triage-admission process might have seven typical flows in healthcare (patients, patients' family or attendants, care providers/hospital staff consisting of doctors and nurses as well as orderlies, security personnel and registrars, medications, supplies, equipment, and information) from the analysis of our interviews with ED hospital staff and ED patients and their attendants, the processes they decided to target in the ED triage for lean improvement projects of their own design were patient flow and inventory flow. These processes still maintained typical healthcare flows such as patients, patients' attendants, care providers, medications, supplies, equipment, and information, however pre-lean improvement data collection mainly recorded efficiency indicators relating to patient flow. However, the categorizations required for conducting value-quotient calculations did provide waste identification and measurements (in minutes) for other flows, such as information, medicines, equipment, supplies, patients, and care providers. These wastes were compared with research on patient safety indicators in emergency medicine by ED staff and were found to negatively impact the quality of care provided during the triage process of the given ED.

When value-stream mapping exercises were conducted using the current state data provided by the pre-lean portion of the study, ED staff were able to identify waste in the triage process, and recommendations for redesign were developed to cut (if possible), or minimize waste in the patient flow process through registration and triage. This was the initiation by ED staff of a trial redesign of their triage-team and structure based on lean principles.

Pre-lean triage team and structure re-design, from the time the patient walked in through the ED doors, until the time their vitals were taken, was an average of 6.0 minutes, and time to physician consult from patient entering the ED, an average of 69.5 minutes (if at all, some cases were seen solely by a senior nurse if they were not categorized as urgent or emergent upon arrival). The lowest time from entering ED until being seen by physician in our pre-lean data set was 6 minutes (emergent case of amputated trauma). The high in our pre-lean data set, from entering the ED until seen by physician was 269.0 minutes. Again, some cases, not classified by the senior triage nurse as emergent or urgent, were never seen by the physician, in the pre-lean data set. This understandably led to some level of patient dissatisfaction, and increased chances of verbal and physical violence in the workplace for the medical staff.

Post-lean triage team and structure re-design, from the time the patient walked in through the ED doors, until the time their vitals were taken (and life-saving measures began, only relevant in emergent cases), was an average of 2 minutes, and total time from entering the ED to physician consult was an average of 16.9 minutes for urgent, less-urgent, and non-urgent cases, who form the majority of the patients visiting the ED. Thus there was an increase in patient satisfaction, and a decrease in patient and patient attendant hostility towards medical staff. The average time from entering the ED until seen by physician for emergent category and resuscitation-required

category cases remained constant between pre and post lean data, which is reassuring, that the new triage redesign has not affected emergency responsiveness, and yet is flexible enough to accommodate greater variety in a shorter amount of time. The high in our post-lean data set for urgent, less urgent, and non-urgent cases was 167.0 minutes, which is still 102.0 minutes faster than any case in our pre-lean data set, and in this data set, no case, no matter the category, was not seen by a physician. The lows from our urgent, less-urgent, and non-urgent category post-lean data set also indicate a decrease in time from the pre-lean data set, from pre-lean 6.0 minutes, to post-lean 1.5 minutes, a decrease of 4.5 minutes.

ED staff expressed the intention and desire to use the statistically efficient physician-led team triage model, with two nurses and one physician serving each patient in triage regardless of category, and emergent cases being seen inside the department

Further, although it was not the objective of triage re-design, overall reductions of triage categorization and time-to-physician consult wait times impacted the time of patient admission/commencement of treatment in the EMW by reducing wait times for emergent and urgent category patients by an average of 48 percent (this especially impacted simple treatment procedures such as the setting of broken bones, the wrapping of wound dressings, and some sickle cell patients that would otherwise occupy beds). Patients in less-urgent categories, who, in the pre-lean data set, were seen by the senior triage nurse rather than a physician, were reduced in terms of the percentage of referrals related to basic care given by physicians in the post-lean data set, which could be explored in future studies, as to how that affects overall patient flow efficiency in the entire hospital, although that goes beyond the scope of this paper.

Patients interviewed and efficiency indicators (clinician interruption and standardized patient flow through required work in the triage process) monitored suggest that patient confusion is less regarding the introduction of a main desk triage nurse to direct care during the registration/triage process. While patient safety indicators were not monitored during the course of this study, hospital staff interviewed expressed their opinion that lack of interruption during clinical examination and treatment reduced potential for error and seemed to impact patient satisfaction (which was assessed by clinicians' verbalized opinion of patients' and their attendants demeanor during the triage process).

Based on the initial positive findings reported of the triage team and structure redesign based on lean principles, ED staff have expressed further plans to improve patient flow during the registration and admission process in the ED through redesign of the flow of information for patients, their attendants, and clinicians by improving the current hospital IT software according to lean A3 problem-solving outcomes. Examples would be providing triage wait times and patient test completion information for categories to patients and their attendants on a digital board to reduce nurse and physician interruption, and lab result notifications for physicians and nurses, along with ongoing collaboration with medical equipment stores support personal, to decrease dependency upon clinical nurses for re-stocking and re-ordering inventory. While supplies, medicines, equipment, and information flows are not the primary focus of the patient flow through registration and triage, they do impact the EDs capacity to provide a high level of care to the patient during this process.

Conclusion

This study indicates firstly that high times for patient flows (in both triage categorization and start of treatment and admission times) are reduced to the greatest extent through the use of physician-led team triage. Significant reduction in wait times for triage and treatment, as well as admissions, also occurred through use of a nurse first/emergency physician second triage model over the previous nurse first/junior physician model. This comparatively reflects previous research findings (11,31) that suggest EDs using lean principles to guide triage team designs will perform best in value quotient calculations and performance indicators using a physician-led team triage model over a nurse first/emergency physician second triage model, and better when through using a nurse first/emergency physician second triage model over the a nurse first/junior physician triage model. Our conclusion is that a physician-led team triage is the best structure for creating value from the patient perspective.

Secondly, it may be surmised from comments made by patients themselves and their observing attendants, that patient satisfaction is improved through the result of having a senior Triage nurse direct the flow of care during the registration and triage categorization process. Patient confusion was reduced, thus interruptions of clinicians were reduced, and efficiency and quality of care increased from a patient, and arguably, a clinical perspective.

From our preliminary findings on triage redesign, the application of lean can improve patient flow efficiency, along with patient satisfaction levels, in a hospital ED, and this can be backed by solid performance indicators and patient satisfaction surveys. Emergency medicine requires that value-creating processes be defined, enhanced, and standardized to best practices continually, rather than capacity and organizational assets being the focus of hospital operations' management in order to improve patient satisfaction and safety in the ED, and the efficiency and quality of care in emergency medicine in general.

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A CONTINGENCY KNOWLEDGE-BASED PERSPECTIVE OF INNOVATION STRATEGY: THE DIFFERENTIAL EFFECT OF KNOWLEDGE SOURCES

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ABSTRACT

Using a contingent resource-based view (RBV) of the firm and the strategy typology by Miles and Snow (1978), this study attempts to examine how firms' innovation strategy determines the choice of different knowledge sources (own-generated, bought-in and co-developed) and their impacts on innovation performance. This study uses data from the Community Innovation Survey (CIS2008), covering 9,054 sample firms from 14 European countries. The results derived from multiple-method empirical analysis provide strong support that investments into acquiring different knowledge sources will generate different values, depending on key contextual factors. In particular, we find that, for effectiveness-oriented firms, investments in own-generated and bought-in knowledge will improve innovation performance while for efficiency-oriented firms, only investments in bought-in knowledge will create a significant impact on innovation performance. Additionally, firms that simultaneously pursue effectiveness and efficiency through a balanced portfolio of knowledge sources, including own-generated, bought-in and co-developed knowledge, will create the maximal innovation performance. Therefore, an effective distribution of investments into knowledge resources requires careful consideration of a firm's innovation strategy.

KEY WORDS

Innovation Strategy, Knowledge Source, R&D Portfolio, Empirical Study

INTRODUCTION

Ever-increasing product complexity, coupled with interconnectivity among multiple technologies, is forcing even the largest innovation-active organizations to access knowledge from beyond their boundaries to foster innovation and build and maintain high performance (Brusoni et al., 2001; Cassiman and Veugelers, 2006; Cui et al., 2012; Revilla and Rodriguez, 2011; Rigby and Zook, 2002). Indeed, firms are experimenting in their innovation process, combining internal knowledge (which we refer to as *own-generated*); external knowledge of licensing, outsourcing, company acquisition or the hiring of qualified researchers with relevant expertise (referred to as *bought-in*); and collaborative knowledge created with other organizations (referred to as *co-developed*) (Arora and Gambardella, 1990; Cockburn and Henderson, 1998; Granstrand et al., 1992; Parmigiani, 2007). While own-generated knowledge is fully internalized, the other two sources have different degrees of externalization. With bought-in knowledge, there is often a full arm's-length relationship between a firm and its external resources. In the case of co-developed knowledge, a research agreement with other organizations allows the parties to exchange knowledge and jointly work to stimulate learning. This study considers these three types of knowledge sources and examines how they interact with firms' innovation strategy.

Firms increasingly build innovation capacity by tapping into external knowledge sources (Chesbrough, 2003; Laursen and Salter, 2006). However, critical knowledge is not always easily available through external sources (Argote, 1999), creating a need to

build knowledge internally (Nonaka, 1994). Previous literature suggests that the success of innovation requires a tight integration of internal and external knowledge within a firm's innovation process such that the positive effects each knowledge source has on the marginal return of the other can be fully captured (Cassiman and Veugelers, 2006). The relation between internal and external sources of knowledge can be found in the notion of absorptive capacity introduced by Cohen and Levinthal (1989), which stresses the importance of owning internal knowledge to recognize the value of "new, external information, assimilate it, and apply it to commercial ends" (p. 128).

Besides an interest in unraveling the complex links among different sources of knowledge, few results can be found in the existing literature that provide a contingent perspective of innovation to understand the effectiveness of different knowledge sources in different contexts. This study attempts to fill this gap in the literature by examining how firms' innovation strategy determines the choice of knowledge sources and their impact on innovation performance. Drawing on the strategy typology by Miles and Snow (1978), we argue that a firm's innovation strategy can adopt either an exploitative or efficiency-oriented perspective (e.g., focused on cost saving or return on assets) or an explorative or effectiveness-oriented perspective (e.g., focused on market share growth or sales growth) (Hambrick, 1983; Miles and Snow, 1978). Accordingly, firms could possibly excel in both dimensions, in only one, or neither. Thus, we categorize firms' innovation strategy into four types: Prospects, Defenders, Analyzers, and Reactors. Such a configuration perspective of innovation strategy establishes patterns or profiles that could capture the complexities of organizational reality (Ketchen and Shook, 1996; Miller, 1986), facilitating a holistic analysis of the phenomenon under investigation (Flynn et al., 2010; Ward et al., 1996).

The contingent resource-based view (RBV) of the firm suggests that depending on certain conditions, organizations may achieve competitive advantage and create capabilities through the bundling of knowledge (Barney, 1991). In the area of innovation management, the existing studies argued that creating the right context is crucial for success in innovation (Cassiman and Veugelers, 2006). Along the same line of arguments, we believe that firms' innovation strategy should moderate the impact of different knowledge sources on innovation performance. In particular, we found that firms following an exploitative or efficiency-oriented innovation strategy mainly rely on bought-in knowledge to create innovations, while firms following an explorative or effectiveness-oriented innovation strategy rely on own-generated knowledge. Co-developed knowledge will see maximum returns when a firm's innovation strategy balances efficiency (exploitation) and effectiveness (exploration).

This study provides three main contributions. First, we extend the RBV analysis of innovation management by adding the contingent effect of innovation strategy. This helps specifically address the challenges of designing and managing knowledge portfolios in innovation management. In addition, this elicits future research of other factors that help explain the co-existence of multiple knowledge sources (Cassiman and Veugelers, 2006; Hagedoorn, 2002; Parmigiani, 2007) and their effects on innovation performance. Second, by empirically validating Miles and Snow's (1978) strategy typology, we answer calls for more applications of theory in the field of innovation management (Cassiman and Veugelers, 2006). Typologies have been applied widely in the extant literature to describe underlying phenomena. Despite their strong descriptive and prescriptive orientation, typologies often lack explanatory and predictive abilities. This study provides solid empirical evidence linking a taxonomy of innovation strategies with different knowledge sources. Third, our study covers 9,054 sample firms from 14 countries while most of existing studies using Community Innovation Survey

only cover sample firms from a single country (e.g., Frenz and Ietto-Gillies, 2009; Laursen and Salter, 2006; Leiponen and Helfat, 2010; Mol and Birkinshaw, 2009). The empirical findings from this study hence provide a high level of generalizability.

The paper is structured as follows: In Section 2, we briefly review the existing literature on innovation strategies and sources of knowledge, as well as their impact on innovation performance. This provides a theoretical backdrop to our hypotheses. In Section 3, we introduce research methodology, followed by the presentations of main results. We conclude by discussing theoretical and managerial implications and providing suggestions for future research.

THEORY AND HYPOTHESES

Our investigation focuses on the knowledge resource, the most critical competitive resource that a firm can possess (Grant, 1996; Helfat, 1994). Taking the perspectives of both a RBV of the firm and capability-building, we echo the work of Teece et al. (1997) to define innovation as a dynamic capability that represents “the firm’s ability to make changes to product, process, and services that results in new value creation to the organization by leveraging internal and external knowledge”. This definition of innovation emphasizes value creation: the “integrating, building, and reconfiguring of internal and external competences to address rapidly changing environments” (p. 516). Innovation is crucial for the continual prosperity of a firm, as it creates new knowledge or recombines existing knowledge to develop new products, processes or services, thereby providing a competitive advantage to the firm (Czarnitzki and Kraft, 2004; Geroski et al., 1993; Hall, 2000). Clearly, innovation is a challenge in integration and by no means static. As noted by Iansiti and Clark (1994), “Dynamic capability links capacity for action to the evolution of the associated knowledge base through the effective execution of problem-solving processes” (p. 563).

Our definition of innovation is typology-neutral since the efforts of value creation can be achieved through both efficiency- and effectiveness-oriented strategies. It is also consistent with the open innovation concept, since firms might use knowledge from a diverse set of sources and organizations—customers, suppliers, competitors or research institutions—during the development of innovation. Internal innovation activities are not incompatible (and can even be synergetic) with bought-in knowledge or research agreements with other organizations (Arora and Gambardella, 1990; Cassiman and Veugelers, 2006; Hagedoorn and van Kranenburg, 2003). Therefore, internal and external sources of knowledge can be viewed as complements.

Resources and capabilities have been examined together in a limited number of studies (e.g., Brandon-Jones et al., 2014). Organizational capabilities are a higher-order construct required to exploit existing resources. Knowledge may not provide value on its own but instead need to be processed or utilized in bundles in order to drive performance (Newbert, 2007). In our specific context, the process of bundling refers to “the integration of knowledge to allow innovation capability to solve problems” (Sirmon et al., 2008). This bundling process could potentially provide a competitive advantage to firms for several reasons: (1) it is socially complex since it is built upon both continua of cooperative relationship forms and sociological strength-of-ties; (2) it resides in processes rather than resources themselves, making observation difficult until processes are put into use; (3) it is tailored to a firm’s specific needs, impeding its transfer to other relationships; and (4) given the cumulative nature of knowledge, it is guided by path-dependent learning processes and therefore takes time to develop.

Although prior research has found that innovation has a significant impact on a firm’s financial performance, there is a dearth of complex theoretical models to explain

how to deploy knowledge-based capabilities to foster innovation and build and maintain high performance (Priem and Swink, 2012). Additionally, few empirical studies have identified the managerial actions that promote a firm's integrative capability (Mishra and Shah, 2009). As a result, it becomes especially important for firms to understand the conditions in which resources or capabilities may become most valuable (Ling-yeo, 2007). Contingency theory argues that organizational actions should be adapted according to the contexts in which they are applied. Specifically, organizations should adjust their actions, structures, or processes to their context with the main purpose of maximizing performance (Donaldson, 2001; Lawrence and Lorsch, 1967; Thompson, 1967). Neither ad-hoc problem solving nor unsystematic knowledge gathering is sufficient to provide the performance required in each situation (Gardner et al., 2012). Decision makers must recognize the factors motivating the choice of a particular source of knowledge for a given situation, then reconsider their actions in order to achieve a good "fit" between an organization's needs and the changing environment (Shenhar, 2001). Without such fit, firms may lose opportunities, incur increased costs and sacrifice their sustainability (Child & Kieser, 1979).

A contingent RBV has been suggested by scholars as it addresses the somewhat static nature of the RBV (Brandon-Jones et al., 2014). This theoretical angle analyzes the value of different organizational resources or capabilities (Aragon-Correa and Sharma, 2003), further enhances the usefulness of the theory (Brush and Artz, 1999) and identifies conditions that affect the utility of different resources or capabilities. When applying contingency theory to the arena of innovation management (Galbraith, 1973; Lawrence and Lorsch, 1967), researchers suggest that organizations should match their management practices to innovation strategy in order to improve performance (Cassiman and Veugelers, 2006; Shenhar, 2001). Taking a similar approach, our study explicitly examines how innovation strategy, as a contingent variable, affects the selection of a particular source of knowledge and its relationship with innovation performance. The theoretical model postulated is shown in Fig. 1.

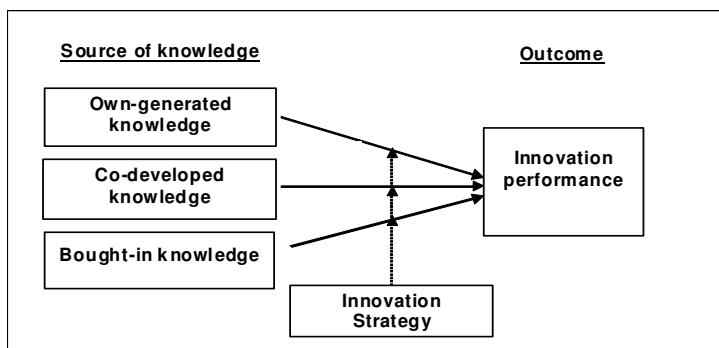


Figure 1. Conceptual Framework

Innovation strategy

Organizational researchers have explored multiple dimensions of organizational performance such as efficiency and effectiveness (Mahoney, 1988; Pennings and Goodman, 1977). In the context of innovation management, efficiency can often be linked with knowledge exploitation and effectiveness can be linked with exploration (Auh and Menguc, 2005; Hambrick, 1983; Miles and Snow, 1978).

Knowledge exploitation occurs when firms use existing knowledge to solve innovative problems. Repeatedly using the same knowledge reduces the likelihood of errors and facilitates the development of familiar routines (Levinthal and March, 1993)

that allow the decomposition of sequenced activities in an efficient order where unnecessary steps can be eliminated (Eisenhardt and Tabrizi, 1995). It also leads to a deeper understanding of concepts, boosting a firm's ability to identify valuable knowledge, develop connections and combine knowledge in many different ways (Katila and Ahuja, 2002). By contrast, knowledge exploration occurs when firms do not own sufficient existing knowledge to solve the problem identified. Exploration often refers to constructing and acquiring new knowledge, moving away from current organizational routines and knowledge bases (March, 1991). Knowledge exploration introduces the variations needed to provide a sufficient number of choices for problem solving, improves the possibility of engendering new ideas or creating new knowledge combinations and allows the substitution of obsolete knowledge (March, 1991).

Investments into exploitative vs. explorative innovation activities reflect a firm's attitudes that manifest its innovation strategy. They are strategic choices that shape the innovation process and determine how a firm's knowledge resources and capabilities are aligned to the environment and organizational performance. The most crucial element of a firm's innovation strategy is resource allocation, more specifically, the degree to which the firm focuses its resources on incrementally enhancing existing knowledge or generating radically new knowledge (Chiesa, 2001; Revilla and Rodriguez, 2011).

Adopting Miles and Snow's (1978) strategy typology, our study develops a taxonomy of innovation strategies in configuring firms' innovation activities along the dimensions of exploitation (efficiency) and exploration (effectiveness). Different from the pairwise relationships used in conventional econometric research (e.g., Auh and Menguc, 2005), a configuration approach focuses on relations as simultaneous combinations of multiple dimensions (Cannon and Perreault, 1999). It establishes patterns or profiles to capture the complexities of organizational reality (Ketchen and Shook, 1996) and facilitates a holistic analysis of the phenomenon under investigation (Flynn et al., 2010; Miller 1986; Ward et al., 1996). As such, this configuration approach helps us classify firms into mutually exclusive and completely exhaustive groups (Doty and Glick 1994; Miller and Roth, 1994), by considering each group as a particular combination of attributes. Because firms may place different emphases on innovation activities (either exploitation or exploration), various configurations of innovation strategy can exist.

		Effectiveness perspective	
		Low exploration	High exploration
Efficiency perspective	High exploitation	Defenders	Analyzers
	Low exploitation	Reactors	Prospectors

Figure 2. Taxonomy of Innovation Strategies

Figure 2 highlights how the two innovation perspectives result in four extreme configurations of innovation strategy. With the same spirit of the typology by Miles and Snow (1978), we address firms' innovation strategies via four distinct roles: Prospector, Defender, Analyzer and Reactor.

Prospectors develop innovation strategies that explore environmental changes and search for new opportunities for growth and expansion into untested markets (Auh and Menguc, 2005). Their main interest is to explore new products and/or markets. In addressing the tradeoffs of using this strategy, March (1991) argues that focusing only on exploration may slow down the development of skills and processes associated with a firm's existing competencies. In balance, following a Prospector strategy may expose firms to higher costs and increased risks but also may create more opportunities to maintain a sustainable competitive advantage (Bierly and Daly, 2007).

By contrast, the innovation strategy of *Defender* focuses on the efficiency of existing operations and products (exploitation) (Auh and Menguc, 2005). By refining existing knowledge, firms may gain expertise in areas that have been neglected or become obsolete (Bierly and Daly, 2007). The main risk of using Defender strategy is that firms may become less agile in responding to a dramatic shift in the market (Miles and Snow, 1978).

When firms pursue both high levels of exploitative and explorative activities, they take on the role of *Analyzer*. Firms in this configuration present a more balanced profile of innovation activities than Prospectors and Defenders. However, it is not a trivial task to become an Analyzer, and many firms experience significant difficulties in managing trade-offs between opposing logics underlying exploitation and exploration (Kristal et al., 2010; Lavie and Rosenkopf, 2010).

The last category, *Reactor*, presents the lowest level of both exploitation and exploration. Firms driven by Reactor strategy lack a proactive response to an inconsistent and unstable environment (Miles and Snow, 1978). As a result, the Reactor exhibits a state of almost continual instability, responding to environmental change in an inappropriate manner repeatedly (Miles and Snow, 1978).

Sources of knowledge

In this study, we consider three main sources of knowledge in the development of innovation: own-generated knowledge, bought-in knowledge carried out by external organizations and co-developed knowledge with external organizations.

In practice, firms concurrently get knowledge from all three sources, suggesting that these activities are complementary and relevant in explaining innovation performance (Cassiman and Veugelers, 2006; Frenz and Ietto-Gillies, 2009; Parmigiani, 2007). Each knowledge source has its structural strengths and weaknesses, as well as areas of relevance for innovation. We briefly discuss the main characteristics of these three sources of knowledge, before developing the relevant hypotheses.

The first distinction arises from compatibility with a firm's existing knowledge systems. Own-generated knowledge often comes from a firm's "local" search for its specific needs (Helfat, 1994), within the boundary of its existing knowledge (Mihm et al., 2003). It usually can be adapted easily into a firm's existing knowledge system as it is generated internally (Nonaka, 1994). Bought-in knowledge acquired to fulfill a firm's specific needs has lower compatibility than own-generated knowledge, yet has a higher compatibility potential than co-developed knowledge, which considers the needs of all involved parties.

A second difference concerns the potential of transferability, which generally depends on the nature of knowledge (tacit vs. codifiable) (Polanyi, 1967) and the suitability of the knowledge (Foss and Pedersen, 2002). Own-generated knowledge is developed in-house to tackle a firm's specific needs. Therefore, among all three knowledge sources, own-generated knowledge has the strongest transferability (Frenz and Ietto-Gillies, 2009). By contrast, despite its high suitability to a firm's needs,

bought-in knowledge may have transferability issues because it often takes the form of codifiable knowledge. Some tacit aspects of knowledge may be lost during the transfer of ownership. Co-developed knowledge can be both tacit and codifiable. If managed properly, it can be smoothly transferred to the entire organization.

A third area of difference involves different scopes of appropriability. Both own-generated and bought-in knowledge ensure that the focal firm has ownership of innovation outcomes, enabling full appropriation of innovations. By contrast, firms usually do not completely own co-developed knowledge, so the scope of appropriability for this knowledge source is partial (Frenz and Ietto-Gillies, 2009).

Another distinction between different knowledge sources stems from the likelihood of creating breakthrough innovations. Own-generated or bought-in knowledge comes from the “local search” of a firm’s existing knowledge (Mihm et al., 2003) or the portfolio of existing knowledge providers (Cui et al., 2012). These are rooted in a backward-looking experiential learning process based on previous experience, reducing the range of options explored. As a result, own-generated and bought-in knowledge often carry the risk of being trapped in local optimal choices, weakening a firm’s likelihood of making breakthrough innovations. By contrast, co-developed knowledge comes from a “global search” for solutions on the landscapes of both the focal firm and the collaborative partners (Mihm et al., 2003). By co-developing knowledge together, firms could gain access to a larger variety of knowledge sources, have an increased likelihood of accessing novel and unique knowledge (Grimpe and Kaiser, 2010) and become more likely to create breakthrough innovations (Rosenkopf and Nerkar, 2001).

Lastly, the time horizon required to launch a product to the market differs across the three sources of knowledge. In particular, building own-generated knowledge can take a long time when firms lack sufficient expertise. Bought-in knowledge has the shortest time horizon among all three knowledge sources because it does not need to be developed “from scratch”. Instead, it may offer a market-ready solution satisfying the focal firm’s well-defined needs. Co-developed knowledge built with external partners has an uncertain time frame. It can be quite time consuming due to a broader scope of “search space” (Duysters and Lokshin, 2011) and the complexity of coordinating multiple parties.

Linking innovation strategy, source of knowledge and performance

According to the RBV of the firm and the results of prior research, we expect a positive relationship between own-generated knowledge, bought-in knowledge, co-developed knowledge and innovation performance (Duysters and Lokshin, 2011; Frenz and Ietto-Gillies, 2009; Leiponen and Helfat, 2010; Rothaermel and Alexandre, 2009). Recent literature, however, argues that this viewpoint may be incomplete because it overlooks the potential contingencies regarding a firm’s specific situation (Kraaijenbrink et al., 2010). The theoretical framework connecting a firm’s strategy and structure (Donaldson, 2001; Lawrence and Lorsch, 1967; Thompson, 1967) indicates that effective decision-making in pursuit of organizational objectives requires a “fit” between a strategy and its structure and processes. It implies that a firm’s innovation strategy involves managerial choices between knowledge exploitation and exploration, together with choices among own-generated, bought-in and co-developed knowledge. Similarly, our study aims to examine the contingent effect of innovation strategy on the relationship between the different sources of knowledge and innovation performance. Given that a *portfolio* of innovation strategies is available to firms, including the roles of Prospector, Analyzer, Defender and Reactor, it is critical to

understand the conditions under which the diverse sources of knowledge affect innovation performance.

Own-generated knowledge

Explorative innovation often involves a shift to a different technological trajectory (Benner and Tushman, 2003). Compared with exploitation, exploration is inherently riskier; the returns from explorative innovation activities are not only more distant in the future but also are highly variable in outcomes (March, 1991). As a result, firms pursuing an explorative-oriented innovation strategy will inevitably face a higher chance of failure and a longer time frame for learning. In addition, when new knowledge is gained via exploration, firms have to integrate new knowledge into their knowledge bases by establishing links to existing knowledge (Rothaermel and Deeds, 2004). The newly generated knowledge may be transformed into the firm's absorptive capacity (Cohen and Levinthal, 1989), which encompasses a firm's ability to process, screen, evaluate and take advantage of new knowledge (Rothaermel and Alexandre, 2009). This implies that generating new knowledge in-house plays a dual role of contributing new innovations and improving a firm's absorptive capacity to explore unknowns (Vega-Jurado et al., 2009).

Among the three sources of knowledge, own-generated knowledge has a relatively high potential to be compatible with a firm's existing knowledge. It also has a robust level of transferability and full scope of appropriability. Therefore, when firms conduct explorative innovation activities, relying on own-generated knowledge could help firms on one hand reduce technological and/or market uncertainties, and on the other hand explore and absorb new unknowns. Empirically, it has been found that firms' investment into generating new knowledge in-house has a significantly positive influence on innovations related to launching new products or entering a new market, but an insignificant effect for innovations related to cost reduction (Vega-Jurado et al., 2009). The need for own-generated knowledge should increase as a firm's innovation strategy is more oriented towards exploration.

We therefore hypothesize that own-generated knowledge will have a higher marginal effect on a firm's innovation performance in the presence of a higher level of exploration in innovation strategy. Along the same line, we expect to observe a stronger marginal effect of own-generated knowledge on innovation performance when the importance of explorative objectives is relatively higher than that of exploitative objectives in a firm's innovation strategy.

H1a. The marginal effect of own-generated knowledge on innovation performance will be higher when the importance of exploration increases.

H1b. The marginal effect of own-generated knowledge on innovation performance will be higher when the innovation strategy comprises higher levels of exploration than exploitation.

Bought-in Knowledge

Exploitative innovation involves improvements in existing components and is built upon the existing technological trajectory (Benner and Tushman, 2003). Firms conducting exploitative innovations are mainly focused on "the use and development of things already known" (Levinthal and March, 1993) and attempt to create reliability in experience and thrive on productivity and refinement. As a result, firms following an exploitative-oriented innovation strategy often need returns that are more proximate in time and are less risky (Garcia et al., 2003).

Among the three sources of knowledge, bought-in knowledge has the strength of having the shortest time horizon (for example, the least time to launch a new product to market). In addition, because bought-in knowledge often provides existing solutions or market-ready equipment, it contains fewer market or technology uncertainties than the two other sources. A survey conducted in the manufacturing context found that purchase of machinery and equipment has a significantly positive impact on the development of new production processes (Vega-Jurado et al., 2009). As such, we expect that bought-in knowledge will have a higher marginal effect on a firm's innovation performance in the presence of a higher level of exploitation in innovation strategy. Moreover, the positive marginal effect of bought-in knowledge on innovation performance will be higher when the importance of exploitative objectives is relatively higher than that of explorative objectives in a firm's innovation strategy.

H2a. The marginal effect of bought-in knowledge on innovation performance will be higher when the importance of exploitation increases.

H2b. The marginal effect of bought-in knowledge on innovation performance will be higher when the innovation strategy comprises higher levels of exploitation than exploration.

Co-developed-knowledge

In practice, explorative and exploitative innovations should not be viewed as "dichotomous" (i.e. one initiative must fall into one *or* another) but rather a spectrum with two extreme situations at either end. On one hand, investments into exploiting existing knowledge could increase firms' ability to discern new opportunities and integrate new knowledge into the existing knowledge system (Rothaermel and Deeds, 2004) because "the degree to which firms learn about new opportunities is a function of the extent of their participation in related activities" (Levinthal and March, 1993). This implies that firms pursuing exploitative-oriented innovation strategy could naturally perform well in explorative innovations. On the other hand, exploration generates discovery of new opportunities and, at the same time, the potential for exploitation, which is dependent on the existence of an exploitable set of resources, assets, or capabilities under the control of the firm (Rothaermel and Deeds, 2004). As a result, firms investing heavily into explorative innovations also have a strong need to exploit newly discovered opportunities.

Among the three sources of knowledge, co-developed knowledge has the highest potential of creating breakthrough innovations (Duysters and Lokshin, 2011) and provides access to information and resources that cannot be generated internally. We therefore can expect that co-developed knowledge should have a higher marginal effect on a firm's innovation performance in the presence of a higher level of exploration in innovation strategy. At the same time, the newly explored knowledge broadens a firm's scope of subsequent exploitation, which creates an indirect positive impact on the firm's innovation performance. In addition, a broader scope of innovation exploitation enables firms to absorb, search, and explore a wider spectrum of possibilities, which further contributes to a greater return from innovation exploration (Cassiman and Veugelers, 2006). As such, the reinforcing loop from exploration to exploitation, and then back to exploration, increases the positive impact of co-developed knowledge on innovation performance when a firm's innovation strategy comprises high levels of *both* exploration- and exploitation-oriented objectives (e.g., Prospectors).

H3. The marginal effect of co-developed knowledge on innovation performance will be higher for Prospectors than Defenders, Analyzers and Reactors.

METHODOLOGY

Database and sample selection

The database used in this paper is the Community Innovation Survey (CIS2008) collected from 14 European countries, including Bulgaria, Cyprus, Czech Republic, Estonia, Germany, Hungary, Italy, Latvia, Lithuania, Portugal, Romania, Slovakia, Slovenia and Spain. Specifically, our sample includes 9,054 firms from manufacturing and services sectors and each firm in our sample has more than 10 employees. Table 1 summarizes the characteristics of firms in our data.

Table 1. Sample Profile

Variables	Nº	%
<i>Part of a group</i>		
Yes	4,259	47.04
No	4,795	52.96
	9,054	100
<i>Nº employees (Size)</i>		
10-49	3,272	36.14
50-249	3,349	36.99
250 and above	2,433	26.87
	9,054	100
<i>Main economic activity^a</i>		
High technologic manuf.	2,951	32.59
Low technologic manuf.	2,300	25.4
Knowledge-intensive service	2,370	26.18
Low-knowledge-intensive service	1,433	15.83
	9,054	100
<i>Country</i>		
Bulgaria	309	3.41
Cyprus	197	2.18
Czech Republic	937	10.35
Estonia	692	7.64
Germany	711	7.85
Hungary	416	4.59
Italy	1,198	13.23
Lithuania	184	2.03
Latvia	69	0.76
Portugal	905	10
Romania	319	3.52
Slovenia	410	4.53
Slovakia	173	1.91
Spain	2,534	27.99
	9,054	100

^a See Table 3 for a description of the variables 錯誤! 找不到參照來

CIS2008 survey has a comprehensive coverage, including direct measures of innovation performance and a wide variety of factors influencing innovation such as innovation objectives, sources of information, innovation expenditures, and cooperation partners. It was executed under the supervision of Eurostat, collecting information on firms' innovation activities between 2006 and 2008. For each country involved in the survey, Eurostat staff performed the usual consistency and logic tests, as well as corrections for possible bias associated with non-response at the firm level.

Description of measures and variables

The measurement of the analysis variables is based on the questions in the survey and is derived from a thorough literature review.

Explanatory Variables

Innovation strategy is modeled as a multidimensional construct where efficiency and effectiveness are considered as two representative dimensions. We measured firms' innovation strategy orientation, or innovation objectives that firms pursued when developing products (goods or services), by using the interviewees' answers to nine different aspects of the same question: How important were each of the following objectives for your innovation activities between 2006 and 2008? (See Table 2 for a description of each aspect.) Each firm was asked to evaluate the importance of each objective by using a Likert scale from zero (not important at all/not used) to three (very important). Objectives concerning efficiency denote the degree to which innovation aims to increase the quality of goods, improve process flexibility and capacity, enhance health and safety or reduce labor cost. Objectives concerning effectiveness denote the degree to which innovation is oriented to increasing the scope of goods or services, replacing outdated products or processes, entering new markets or increasing market share.

Table 2. Definition of Constructs and Internal Consistency Measures

Construct	Item	Mean	S.D	Loading Factor ^a	Eigenvalue	Variance extracted	Cronbach α
Efficiency (Exploitation)	Improve quality of goods or services ^b	2.05	.94	-			
	Improve flexibility for producing goods or services	2.53	.73	.91			
	Increase capacity for producing goods or services	2.00	.96	.82	2.83	33.9%	0.76
	Improve health and safety	1.74	1.08	.64			
	Reduce labour costs per unit output	1.87	1.00	.78			
Effectiveness (Exploration)	Increase range of goods or services	2.46	.81	.73			
	Replace outdated products or processes ^b	2.07	.99	-	1.38	26.1%	0.68
	Enter new markets	2.14	.97	.80			
	Increase market share	2.25	.90	.77			

^a Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalization.

^b Items dropped after EFA. Loading factor below 0.3

We checked construct validity with exploratory factor analysis (EFA). Usually, 0.3 is the lowest significant factor loading to define valid constructs (Hair et al., 1998). We conducted an EFA that included all items simultaneously, and the results show that the objectives can be comfortably tapped into the stipulated constructs. On Table 3, we can see that all retained factor loadings are larger than 0.3, implying that all constructs satisfy the unidimensionality requirement. We further checked construct reliability by measuring Cronbach's alpha, and values ranged between 0.68 and 0.76, exceeding the minimum limit of 0.6 (Nunnally, 1978).

Another key explanatory variable of our study is the *knowledge source* that firms utilized in their innovation activity. *Own-generated knowledge* is measured by the ratio between in-house R&D expenditure and turnover. In-house R&D includes all creative work undertaken within the firm to increase the stock of knowledge for developing new and improved products and/or services.

Bought-in knowledge is measured by the ratio between the expenditure on bought-in R&D and turnover. This includes the acquisition of external R&D and machinery, as

well as other forms of external knowledge such as the license to use intellectual property and specialized services.

Co-developed knowledge is measured by firms' involvement in cooperative activities. The survey does not directly provide information regarding the number of cooperation agreements in a firm. We therefore need to rely on other information to infer a firm's cooperative R&D activities. The survey asks whether the firm cooperated formally in any innovation activity with other enterprises or institutions and the type and geographical location of cooperative partners. In terms of the relationship with the focal firm, the survey distinguishes seven types of partners: firms within the same group, suppliers, clients or customers, competitors, consultants or commercial R&D labs, universities and government research institutions. In terms of geographical locations, the partners can be grouped into five geographical areas: in the same country, other European country, United States, China or India and all other countries. Each possible combination of type of partner and location is recorded as a binary variable, coded 1 if the firm is part of that co-operation relationship and 0 if not. To construct a variable representing co-developed knowledge, we summed the binary variables for the 35 forms of cooperation (7×5). Numerous existing studies (e.g., Laursen and Salter, 2006; Leiponen and Helfat, 2010; Mol and Birkinshaw, 2009) have adopted a similar approach in other contexts to measure the firms' collaborative R&D activities.

Innovation performance is measured by the proportion of turnover due to innovation. This indicator provides information on the impact of product innovations on the overall makeup of turnover (i.e., the share of turnover from new products and services) and on the degree of innovativeness of the firm.

Table 3. Variable Definition

Variable	Type	Construction
<i>Dependent variable</i>		
Innovation performance	Share	Proportion of innovation sales
<i>Independent Variables</i>		
Own-generated knowledge	Share	Ratio between in-house expenditures and turnover
Bought-in knowledge	Share	Ratio between bought-in expenditures and turnover
Co-developed knowledge	Categorical	Sum of number of different types of cooperation partners by location
<i>Control variables</i>		
Part of a group	Binary	One, if the firm is part of a business group
Small / medium firm	Binary	One, if the number of employees is below 250
High tech. manuf.	Binary	One, if the firm is from NACE C19-C23; C26-C30
Low tech. manuf.	Binary	One, if the firm is from NACE C10-C12, C16-C18, C24-C25, C31-C33
Knowledge-intensive serv.	Binary	One, if the firm is from NACE J58-J63, K, M69-M75
Low knowledge-intensive serv.	Binary	One, if the firm is from NACE E, G, H52-H53, I, L, N
Country dummy	Binary	One, if the firm is from each country included

Control variables

The CIS questionnaire provides further information which allows us to control the potential impact of firm-specific characteristics on innovation performance. In this respect, we considered four control variables in this study. First, we regarded the possibility that firms which are members of a business group may gain additional innovation performance due to the effect of intra-group knowledge spillovers (Frenz and Ietto-Gillies, 2009; Mairesse and Monhen, 2001). To control the potential *spillover effect*, we used a binary variable to indicate whether or not a firm is part of a group. Second, we controlled *firm size* by using a binary variable to distinguish small and medium (1 = fewer than 250 employees) and large firms (0 = 250 or more employees). Third, we controlled for the firm's *industry of operation*. Following De Faria et al. (2010), we included three binary variables indicating the firm's technological level according to the Standard Industry Aggregation by Technological Level of the OCDE. (See Table 3 for details of this classification.) Finally, we added a country dummy for each country included in the analysis except for Slovakia.

ANALYSIS AND RESULTS

Our analysis followed several steps: first, we identified the patterns/profiles of innovation strategy; second, we compared the choice of knowledge sources under each innovation strategy category according to the taxonomy identified in the first step; third, we estimated how innovation strategy can potentially influence the impact of each type of knowledge source on innovation performance.

Steps of Analysis

In the first step, we employed cluster analysis to classify firms based on their profiles of objectives to develop products (goods or services), thereby identifying underlying dimensions of each firm's innovation strategy. In the second step, we used ANOVA and Tukey-b comparison tests to identify the different patterns of knowledge source combinations across innovation strategy categories identified in the first step. In the third step, we ran regressions for each type of strategy to test the hypothesis, using firms' innovation performance as dependent variables and the three types of knowledge sources as explanatory variables. Because the dependent variable, the proportion of turnover due to innovation, is a fractional response variable with a range between 0 and 1, we adopted a generalized linear model with logit link to guarantee that predicted values lie in the unit interval (Papke and Wooldridge, 1996).

Results

Considering that the major objective of the clustering technique is to determine the number of clusters, we conducted two additional checks to ensure that the clusters were correctly classified. First, Ward's hierarchical method based on Euclidean distance was used to determine the number of clusters. The choice of the number of clusters was guided by the Duda-Hart Je(2)/Je(1) index and the Pseudo T-Squared value. Generally speaking, the larger the value of the Duda-Hart Je(2)/Je(1) index, and/or the lower the Pseudo T-Squared value, the more distinctive the clustering (Duda et al., 2001). The Duda-Hart index became highest and the Pseudo T-Squared lowest when the number of clusters was four. This result indicates that four clusters were sufficient (see Table 4). Second, we used K-means cluster analysis with random seeds to generate three-, four- and five-cluster solutions. For the two constructs in our analysis, the means differed significantly across all clusters in the four-cluster solution. Due to the robustness of the

four-cluster solution across these two checks, we present the results based on that solution.

<i>Table 4. Number of Clusters</i>		
Number of clusters ^a	Duda- Hart Je(2)/Je(1)	Pseudo T-Squared
2	0.46	6,287.04
3	0.49	2,842.91
4	0.65	1,986.33
5	0.52	2,674.89
6	0.51	756.21

^aWard's hierarchical method using Euclidean distance

Table 5 shows the differences in terms of orientation towards efficiency (exploitation) and/or effectiveness (exploration) among four identified clusters. Cluster 1 includes 840 firms with low levels of exploration and exploitation and therefore corresponds to Reactor innovation strategy according to the typology by Miles and Snow. Cluster 2, comprising 4,425 firms, is characterized by high levels of exploitation and exploration and corresponds to Analyzer strategy. Cluster 3, formed by 2,314 firms, shows a high level of exploration and a low level of exploitation and therefore represents the Prospector strategy. Cluster 4, including 1,475 firms, shows a high level of exploitation and a low level of exploration and reflects Defender strategy. ANOVA F-statistics also support the discriminatory power of using efficiency and effectiveness dimensions.

Table 5. Results of Cluster Analysis of Innovation Strategy (K-means)

Innovation Objectives	Mean (SD) of cluster group				TOTAL	F-ANOVA ^a
	Reactors	Analyzers	Prospectors	Defenders		
Efficiency (Exploitation)	1.51 (0.64)	3.35 (0.48)	1.69 (0.68)	3.42 (0.54)	2.76 (1.0)	6333.7 (0.00)***
Effectiveness (Exploration)	2.25 (0.78)	4.13 (0.47)	4.25 (0.53)	2.34 (0.77)	3.69 (1.0)	5933.6 (0.00)***
N	840	4425	2314	1475	9054	

^a In brackets p-value

Next, we used ANOVA and post-hoc pairwise multiple comparisons methods (Tuckey-B and Duncan tests) to test for significant differences among the mean levels of knowledge sources across four types of innovation strategies (clusters) identified above. Table 6 shows descriptive statistics (mean and standard deviation values) and summarizes the results of ANOVA tests and the post-hoc analysis.

The results show that the means of using different knowledge sources are significantly different when innovation strategy varies. Mean differences are more significant for own-generated knowledge (F-statistic 22.3, p-value 0.00) and co-developed knowledge (F-statistic 101.7, p-value 0.00) than bought-in knowledge (F-statistic 3.3, p-value 0.019). For own-generated knowledge, the largest differences are detected between Prospectors and Defenders, with Prospectors having the highest level of own-generated knowledge. For bought-in knowledge, results of Tuckey-b and Duncan tests show that innovation strategies with a high level of exploitation (Analyzer and Defender) also contain a higher level of bought-in knowledge than those with a low level of exploitation (Reactor and Prospector). For co-developed knowledge, we find that firms with an innovation strategy of high levels of both exploration and exploitation (Analyzer) present the highest level of co-developed knowledge, followed by firms with

an unbalanced innovation strategy configuration (Defender and Prospector) and those with low levels of both exploration and exploitation (Reactor).

Table 6. ANOVA analysis for source of knowledge by innovation strategy groups

Variable	Mean (SD) of cluster group					F-ANOVA ^b
	Reactors	Analyzers	Prospectors	Defenders	TOTAL	
Own-generated knowledge	0.049 (0.13)	0.038 (0.10)	0.059 (0.12)	0.032 (0.10)	0.044 (0.11)	22.3 (0.00)***
Bought-in knowledge	0.028 (0.07)	0.033 (0.08)	0.028 (0.07)	0.034 (0.08)	0.032 (0.08)	3.3 (0.019)**
Co-developed knowledge	2.844(2.41)	4.588(3.80)	3.582 (2.95)	3.522 (2.82)	3.994(3.39)	101.7 (0.00)***
N	840	4425	2314	1475	9054	
	Main group differences (Tukey-B Test)					Homogeneous groups (Duncan Test)^c
Own-generated knowledge	(1-2)** (1-4)*** (3-2)*** (3-4)***					(4-2) 1 3
Bought-in knowledge	(2-3)* (3-4)*					(1-3) (2-4)
Co-developed knowledge	(1-2)*** (1-3)*** (1-4)*** (2-3)*** (2-4)***					1 (4-3) 2

^b In brackets p-value

^c Significant level 0.05

*** p- vale<0.01, **p-value<0.05, *p-value<0.1

Finally, to examine the contingent effect of innovation strategy on the relationships between the different sources of knowledge and innovation performance, we split firms according to the innovation strategy adopted (clusters) and then regressed innovation performance on the knowledge sources plus the control variables. The results of the regressions for four innovation strategy categories are presented in Table 7 and Table 8.

Our results confirm the differential impact of innovation strategy. Not a single source of knowledge has a statistically significant effect on innovation performance when firms adopt an innovation strategy featuring low levels of both exploration and exploitation (Reactor), whereas all three sources of knowledge positively contribute to the success of innovation when the strategy is associated to high levels of both exploration and exploitation (Analyzer). In the case of Prospectors, own-generated knowledge and bought-in knowledge matter, while for Defenders only bought-in knowledge has a significant impact on innovation performance.

Comparing average marginal effects at the mean of the covariates and significant levels (Table 9), the results also show that the effect of own-generated knowledge increases as we move from Defenders (margin 0.108, p-value>0.1) to Analyzers (margin 0.233, p-value<0.01) and from Reactors (margin 0.134, p-value>0.1) to Prospectors (margin 0.402, p-value<0.01). This implies that the marginal effect of own-generated knowledge on innovation performance is higher when the importance of exploration in the innovation strategy increases. Therefore, H1a is supported.

We also find that the estimated marginal effect of own-generated knowledge for Prospectors (margin 0.402, p-value<0.01) is higher than the estimated marginal effect for Defenders (margin 0.108, p-value>0.10). Thus, the higher the importance of exploration in innovation strategy (Prospector vs. Defender), the higher the effect of own-generated knowledge on innovation performance, supporting H1b.

Our hypotheses for bought-in knowledge are only partially supported. H2a foresees a higher impact of bought-in knowledge on innovation performance when the importance of exploitation increases. The estimated marginal effect increases when we move from Reactor (margin 0.112, p-value>0.1) to Defender (margin 0.254, p-value<0.05) and from Prospector (margin 0.306, p-value<0.01) to Analyzer (margin 0.339, p-value<0.01). However, the second difference turns out not to be significant. In addition, the marginal effect of bought-in knowledge for Defender strategy (margin 0.254, p-

value<0.01) is lower than the marginal effect for Prospector strategy (margin 0.306, p-value<0.01). Thus, H2b is not supported.

Table 7. Regressions Results of Innovation Performance on Knowledge Sources for Different Innovation Strategies (Generalized Linear Model with Logit Link)

	Reactors Coef/(se)	Analyzers Coef/(se)	Prospectors Coef/(se)	Defenders Coef/(se)
<i>Independent variables</i>				
Own-generated knowledge	0.641 (0.41)	1.063*** (0.21)	1.872*** (0.27)	0.500 (0.38)
Bought-in knowledge	0.533 (0.67)	1.546*** (0.27)	1.426*** (0.40)	1.183** (0.41)
Co-developed knowledge	0.021 (0.02)	0.014** (0.01)	0.017 (0.01)	0.001 (0.02)
<i>Control variables</i>				
Part of a group	-0.166 (0.12)	-0.019 (0.05)	0.001 (0.06)	0.061 (0.09)
Small / medium enterprise	0.223 (0.15)	0.326*** (0.05)	0.262** (0.09)	0.425*** (0.10)
High tech manuf.	0.223 (0.16)	0.013 (0.06)	-0.027 (0.10)	0.225* (0.12)
Low tech manuf.	-0.034 (0.18)	-0.110 (0.07)	-0.045 (0.10)	0.095 (0.12)
Knowledge-intensive serv.	0.220 (0.16)	0.054 (0.07)	0.138 (0.10)	0.218* (0.12)
Bulgaria	0.982** (0.39)	0.899*** (0.18)	0.950** (0.39)	0.524 (0.41)
Cyprus	-1.050 (1.52)	-0.296 (0.21)	0.151 (0.43)	-0.675 (0.53)
Czech Republic	-0.086 (0.37)	0.229 (0.17)	0.448 (0.36)	0.219 (0.36)
Germany	0.311 (0.39)	0.033 (0.18)	0.379 (0.36)	0.246 (0.39)
Estonia	-0.002 (0.42)	0.038 (0.17)	0.947** (0.37)	-0.161 (0.37)
Spain	0.759** (0.34)	0.560*** (0.16)	0.714** (0.35)	0.499 (0.35)
Hungary	-0.178 (0.55)	-0.004 (0.18)	0.008 (0.38)	-0.272 (0.50)
Italy	0.220 (0.35)	0.136 (0.17)	0.422 (0.36)	0.112 (0.36)
Lithuania	1.078** (0.45)	0.413** (0.20)	0.808** (0.41)	0.753* (0.40)
Latvia	-0.607 (0.89)	-0.626* (0.36)	0.434 (0.49)	-0.005 (0.58)
Portugal	-0.629 (0.56)	-0.133 (0.17)	0.119 (0.37)	0.156 (0.37)
Romania	0.662 (0.43)	0.464** (0.18)	0.490 (0.40)	0.417 (0.40)
Slovenia	-0.485 (0.77)	0.192 (0.17)	0.388 (0.39)	0.036 (0.43)
Constant	-1.405*** (0.37)	-1.218*** (0.17)	-1.620*** (0.37)	-1.494*** (0.37)
N	840	4425	2314	1475
LogL	-236.0	-919.0	-516.9	-398.9
Chi2 (p-value)	83.5 (0.00)	363.3 (0.00)	208.8 (0.00)	79.3 (0.00)
AIC	516.0	1882.0	1077.9	841.8
BIC	620.1	2022.7	1204.3	958.3

In brackets robust standard errors. *** p-value<0.01, **p-value<0.05, *p-value<0.1

As for co-developed knowledge, we only find a significant effect on innovation performance when the innovation strategy presents high levels of exploration and exploitation (Analyzer), supporting H3.

Table 8. Average Marginal Effect of Knowledge Sources on Innovation Performance for Different Innovation Strategies (Generalized Linear Model with Logit Link)

	Reactors Margins/(se)	Analizers Margins/(se)	Prospectors Margins/(se)	Defenders Margins/(se)
Own-generated knowledge	0.134 (0.09)	0.233*** (0.05)	0.402*** (0.06)	0.108 (0.08)
Bought-in knowledge	0.112 (0.14)	0.339*** (0.06)	0.306*** (0.08)	0.254** (0.09)
Co-developed knowledge	0.004 (0.01)	0.003** (0.00)	0.004 (0.00)	0.000 (0.00)

In brackets robust standard errors. *** p-value<0.01, **p-value<0.05, *p-value<0.1

DISCUSSION

Improving a firm's innovation performance continues to be an important management concern. Following both resource- and capabilities-based perspectives of the firm, own-generated knowledge, bought-in knowledge and co-developed knowledge could be viewed as complementary resources which are bundled to develop a dynamic innovation capability (Sirmon et al., 2007). Consequently, innovation capability can be leveraged to create and protect a firm's competitive advantage, although its impact is contingent upon the specific context. Building on extant literature, this study responds to calls for research on how different sources of knowledge are combined in specific contexts (e.g., Cassiman and Veugelers, 2006) and how they influence the firm's innovation performance under the conditions of varying innovation strategies.

This study has broad implications for both researchers and practitioners. It provides empirical evidence to justify Miles and Snow's (1978) strategy typology in the context of innovation management and highlights the trade-offs of achieving a balance between two key, albeit competing outcomes—efficiency and effectiveness—for innovation. Furthermore, our ANOVA results show that companies pursuing different innovation strategies might exhibit different combinations of knowledge sources.

As expected, firms following Prospector strategy (featured with a high level of exploration and a low level of exploitation), invest heavily in creating own-generated and co-developed knowledge with external partners, yet allocate fewer resources for bought-in knowledge. In practice, Apple is an example of Prospector strategy. The company aggressively invested in exploring new solutions to develop and perfect the design and technologies embedded in products but completely outsourced the manufacturing to suppliers (Narasimhan and Narayanan, 2013). Our findings confirm that firms pursuing Prospector strategy, with an objective of developing new products and taking advantage of market opportunities (Miles and Snow, 1978), tend to be exposed to a more competitive market environment and are more likely to search for new knowledge outside their organizations. Own-generated knowledge becomes a prerequisite of absorbing new knowledge and transferring it internally. In addition, by engaging in co-developed knowledge activities, Prospectors could gain access to a greater volume and diversity of information and knowledge assets and become more

likely to create breakthrough innovations. Few investments into bought-in knowledge are consistent with a low level of exploitation in these firms' innovation strategy.

In contrast, when firms follow Defender strategy (featured with a high level of exploitation and a low level of exploration), most resources were spent on acquiring bought-in knowledge, with moderated reliance on co-developed knowledge and few resources devoted to the development of own-generated knowledge. The dominant impact of bought-in knowledge implies that Defender strategy is mostly implemented via initiatives with short-term horizon and low risk. In addition, co-developed knowledge is perceived by Defenders as a useful means to share risk only when the expected returns from innovation are highly uncertain. Although both Prospectors and Defenders present a moderate level of involvement into co-developed knowledge, they differ in terms of the main knowledge source: Prospectors predominantly invest in own-generated knowledge while Defenders mainly invest in bought-in knowledge. Low investment into own-generated knowledge provides Defenders less capacity for absorbing new knowledge. This in turn weakens the effectiveness of co-developed knowledge on innovation performance for Defenders.

Firms following Analyzer strategy (featuring balanced high exploration and high exploitation) need to use the three knowledge sources simultaneously, with a main reliance on co-developed and bought-in knowledge and a moderated reliance on own-generated knowledge. Among all four innovation strategy categories, Analyzer presents the highest level of investment into co-developed knowledge, giving access to multiple sources of information and knowledge, as well as the ability to respond quickly to changes in the environment without having to build up full internal R&D capacity. This finding implies that firms aiming to strike a balance between efficiency and effectiveness need to collaborate with partners to share innovation risks, and at the same time maximize opportunities for achieving short-term profits. The balanced exploration-exploitation innovation strategy is in line with the recent trend that firms build core-competencies in-house but search outside for non-core competencies (Zacharia et al., 2011). One example echoing this point is Google. Driven by Analyzer strategy, Google attempts to both launch a new product to the market and improve the reliability of its existing products (for example, the Android system). Unlike Apple, Google made the Android operating system available to the Open Handset Alliance (OHA) and allowed smart phone manufacturers to customize the software.

Our results show that Reactors, whose innovation strategy contains low levels of both exploration and exploration, mainly rely on internal knowledge (own-generated) rather than external knowledge (bought-in and/or co-developed). It implies that these firms do not use their absorptive capacity (investment in internal R&D) to access and positively leverage external knowledge. One potential explanation for this interesting finding is that Reactors, lacking a clear innovation objective, may perceive that protection of own-knowledge (appropriability) is more important than searching for external knowledge and developing it. Firms that put high priority on protecting their own knowledge tend to be resistant to collaboration and unwilling to expose knowledge assets to third parties (De Faria et al., 2010). As such, Reactors may allocate resources simply according to the perceived risks, engage solely in their internal generation of knowledge and be unable to behave proactively.

In sum, the sharp differences among four innovation strategy categories regarding the choice of knowledge sources do provide empirical support for the theoretical framework of Miles and Snow's argument (1978) and expand understanding of how to design R&D portfolios (Chao and Kavadias, 2008, 2013). Our results offer additional evidence of the context-specific nature of complementarities among multiple knowledge

sources (Parmigiani, 2007) and contribute new insights regarding how and why firms pursue concurrent knowledge sourcing.

Another important issue is the contingent effect of innovation strategy on the relationship between different sources of knowledge and innovation performance. With respect to own-generated knowledge, our results support H1a that the marginal effect of own-generated knowledge on innovation performance is higher when the importance of exploration increases. Accordingly, the impact of own-generated knowledge on performance is positive and significant only for Analyzers and Prospectors, with a greater impact for Prospectors than Analyzers. Likewise, our findings support the prediction that the marginal effect of own-generated knowledge on innovation performance will be higher for Prospectors than Defenders (H1b). Although Analyzers and Defenders show similar behavior in terms of involvement in own-generated knowledge, the impact is only significant for Analyzers, not for Defenders. Perhaps other contingencies affect the outcome. For example, it is possible that engagement in collaborative R&D not only creates a direct impact on innovation performance, but also moderates the influence of own-generated knowledge on innovation performance.

Interestingly, our study finds that although Reactors invest heavily in creating own-generated knowledge, there is a lack of support for a significant positive relationship between own-generated knowledge and innovation performance. This result suggests that own-generated knowledge, in isolation, may not be a significant driver of a firm's innovation output when there is no a clear innovation strategy and the firm exhibits a state of almost continual instability.

With respect to bought-in knowledge, H2a is partially supported. Our findings show that the positive impact of bought-in knowledge on innovation performance is significantly higher for Defenders (low exploration/low exploitation) than Reactors (low exploration/high exploitation). However, contrary to our hypothesis, we do not observe the same pattern when we compare Prospectors (high exploration/low exploitation) and Analyzers (high exploration/high exploitation). In addition, our results do not show significant differences for the impact of bought-in knowledge on innovation performance between Defenders (exploitation oriented) and Prospectors (exploration oriented). This surprising result is contrary to our prediction in H2b. One potential explanation is that bought-in knowledge is also important for firms attempting to maintain their reputations as innovators and succeeding in product and market development (Prospectors). Moreover, heavy investment into own-generated knowledge enables Prospectors to absorb bought-in knowledge easily. This argument is consistent with previous studies in absorptive capacity (Cohen and Levinthal 1989). Alternatively, one can argue that a low level of investment into own-generated knowledge (Defender) may reduce the positive effect of bought-in knowledge on innovation performance. The arguments from both directions accord with Cassiman and Veugelers (2006) and provide support that complementarity between multiple sources of knowledge is context-specific.

With respect to co-developed knowledge, our findings indicate that it is the least likely among the three sources of knowledge to be effective in increasing firms' innovation performance. In fact, co-developed knowledge has a significantly positive impact on innovation performance only for Analyzers, supporting H3 that the marginal effect of co-developed knowledge on innovation performance will be higher for Analyzers than other innovation strategy categories. Frenz and Ietto-Gillies (2009) also reported a similar result when analyzing the CIS data derived from the UK. This finding suggests that issues related to the appropriability of the outcomes might weaken hammer the R&D collaboration.

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A BIBLIOMETRIC ANALYSIS ON ONLINE SHOPPING RESEARCH AREA

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ABSTRACT

Online Shopping is increasingly becoming popular across the globe. This is relatively a new area of research, which gained significant growth and attention in last decade. This study conducts a bibliometric analysis of the “Online Shopping” research area by collecting research papers and data from Web of Science (WOS) for the period of 2000 to 2014. A total of 772 papers with 7,313 citations from WOS were found. Based on these papers and citations, it evaluates the research performance of journals, authors, and papers related to “Online Shopping” research area on the three evaluation criteria of productivity, sustainability, and impact. It was found from the analyses that Journal of Business Research, Marketing Science, Information & Management, and Psychology & Marketing are the top journals from all the three evaluation criteria of productivity, sustainability, and impact. However, research publications on Online Shopping or e-Commerce are fragmented and depending on the content and author’s preference, researches get published in various journals, sometimes related to Technology, Marketing, Operations, or Management area. Benbasat, Izak was the top author from productivity and sustainability perspective. He wrote 10 papers in 7 different years in the period 2000 to 2014. However, the highest cited paper had 995 citations, written by Gefen, D et al in 2003.

KEYWORDS

Online Shopping, e-Commerce, Bibliometric Analysis.

1. INTRODUCTION

With the technological development in internet technologies and increased ease in using them, the scope of internet is constantly increasing. It has already acquired a significant share of commerce i.e. buy and sell transactions for various products and services. Although there is an increase in the number of researches in this area but still being a multi-disciplinary area, its exact positioning is often not very clear. Sometimes, online shopping is considered a part of Commerce area, sometimes a part of Marketing area and sometimes a part of Technology, Operations, or Management area. Because of this challenge, researches on online shopping area appears in multiple journals and publications depending on the research perspective and

depending on the expertise and choice of the researcher. Considering Online Shopping and e-Business are relatively new areas of research and are multi-disciplinary in nature it is difficult to guess which journals are the best to refer for the research in this area. For the young researchers it may pose a challenge and hence this paper is written to summarize the active journals and researchers in this subject area.

In this paper, bibliographic analysis of journal articles from year 2000 to 2014 is conducted.

2. METHOD

Web of Science (WOS), which is one of the major bibliography databases is selected for collecting the journal articles. On 1st Jan 2015, “Online Shopping” was used as the keyword to retrieve all the published articles, and their citations in the following filtered areas.

- A. Business
- B. Computer Science Information Systems
- C. Management
- D. Information Science Library Science

In total, 772 research papers/articles were retrieved.

3. RESULTS

There were 1,789 authors, who published their studies in 163 journals. Number of articles published each year is found to be increasing from year 2000 and the peak was in year 2011 when 115 articles were published. There is a downward trend in the number of articles published each year thereafter. In 2014, 68 articles were published.

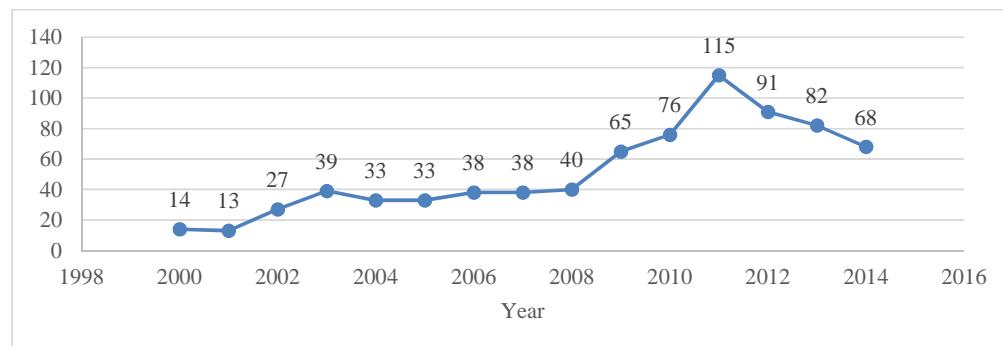


Figure 1: Number of research papers

Further analysis of the dataset was conducted based on three criteria i.e. productivity, sustainability and impact.

3.1. Productivity

Productivity indicates number of papers published in a journal during a defined period or the number of papers published by an author in a defined period. As shown in Table 1, Journal of Business Research, Electronic Commerce Research and Applications, and Internet Research are the top 3 journals in terms of number of studies published during the period in this area, constituting around 15% of total 772 research papers.

Table 1: Productivity of Journals

Journals	Number of Papers	% of Total
JOURNAL OF BUSINESS RESEARCH	52	6.74%
ELECTRONIC COMMERCE RESEARCH AND APPLICATIONS	34	4.40%
INTERNET RESEARCH	29	3.76%
JOURNAL OF ELECTRONIC COMMERCE RESEARCH	27	3.50%
DECISION SUPPORT SYSTEMS	26	3.37%
ONLINE INFORMATION REVIEW	23	2.98%
INFORMATION & MANAGEMENT	22	2.85%
MARKETING SCIENCE	21	2.72%
PSYCHOLOGY & MARKETING	21	2.72%
EUROPEAN JOURNAL OF MARKETING	20	2.59%

As shown in Table 2, Benbasat, Izak is the most productive researcher. He published total 10 papers followed by Punj Girish, Forsythe Sandra, Beatty Sharon E, and Damhorst Mary Lynn, who published 4 papers each during the period.

Table 2: Productivity of Authors

Authors	Number of Papers	% of Total
Benbasat, Izak	10	1.30%
Punj, Girish	4	0.52%
Forsythe, Sandra	4	0.52%
Beatty, Sharon E.	4	0.52%
Damhorst, Mary Lynn	4	0.52%

3.2. Sustainability

Sustainability indicates the number of years when any paper on Online Shopping research area was published during the selected period from year 2000 to 2014. As shown in table 3, Journal of Business Research remains the top journal which contained the Online Shopping related research paper for 14 years followed by Marketing Science, Information & Management and Journal of Retailing with 11 years each.

Table 3: Sustainability of Journals

Journals	Number of Years
JOURNAL OF BUSINESS RESEARCH	14
MARKETING SCIENCE	11
INFORMATION & MANAGEMENT	11
JOURNAL OF RETAILING	11
DECISION SUPPORT SYSTEMS	10
JOURNAL OF COMPUTER INFORMATION SYSTEMS	10
ELECTRONIC COMMERCE RESEARCH AND APPLICATIONS	9
INTERNATIONAL JOURNAL OF ELECTRONIC COMMERCE	9
SERVICE INDUSTRIES JOURNAL	9
PSYCHOLOGY & MARKETING	9
ONLINE INFORMATION REVIEW	9

Top journals from both the perspective of productivity and sustainability are Journal of Business Research, Marketing Science, Information & Management, Decision Support Systems, Electronic Commerce Research and Applications, Psychology & Marketing, and Online Information Review. These journals secured position both in the list of top 10 journals from productivity perspective and also in the list of top 11 journals from sustainability perspective. For creating the list of top sustainability journals, 11 journals were included so as to keep the uniformity in judgment in including all the journals with 9 years of publication.

Journals which exist in the list of top 10 journals from productivity perspective, but not in top 11 journals from sustainability perspective are Internet Research, Journal of Electronic Commerce Research, and European Journal of Marketing. On the other hand, the journals which exist in the list of top 11 journals from sustainability perspective, but not in top 10 journals from productivity perspective are Journal of Retailing, Journal of Computer Information Systems, International Journal of Electronic Commerce, and Service Industries Journal.

Table 4 shows the sustainability of authors. Benbasat, Izak tops the list with research paper publications in 7 different years in the period 2000 to 2014. Damhorst, Mary Lynn published in 4 different years and there were 19 authors, who published their papers in 3 different years in the period 2000 to 2014.

All the authors listed in Table 4, except Haubl, G published their research papers after year 2006. In the list of top authors from sustainability perspective, Haubl, G is the earliest researcher. However, Haubl, G published research papers only till the year 2003.

Table 4: Sustainability of Authors

Authors	Number of Years
Benbasat, Izak	7
Damhorst, Mary Lynn	4
Roman, Sergio	3
Wan, Yun	3
Chiu, Chao-Min	3
Hansen, Torben	3
Punj, Girish	3
Breugelmans, Els	3
Al-Natour, Sameh	3
Haubl, G	3
Forsythe, Sandra	3
Bell, David R.	3
Sia, Choon Ling	3
Cebollada, Javier	3
Beatty, Sharon E.	3
Kim, Minjeong	3
Campo, Katia	3
Verhoef, Peter C.	3
Centefelli, Ronald T.	3
Lee, Matthew K. O.	3
Teo, Hock-Hai	3

3.3. Impact

Impact is another indicator to analyze the academic contribution of various journals, authors and articles. Table 5 summarizes the highest cited journals. Marketing Science tops the list with total 1,583 citations followed by Information Systems Research, Journal of Retailing, Journal of Business Research and MIS Quarterly, each having more than 1,000 citations.

Table 5: Top 10 Journals with Highest Citations

Journal	Citation #
MARKETING SCIENCE	1,583
INFORMATION SYSTEMS RESEARCH	1,555
JOURNAL OF RETAILING	1,285
JOURNAL OF BUSINESS RESEARCH	1,266
MIS QUARTERLY	1,116
INFORMATION & MANAGEMENT	690
JOURNAL OF SERVICE RESEARCH	545
PSYCHOLOGY & MARKETING	428
JOURNAL OF MANAGEMENT INFORMATION SYSTEMS	375
MANAGEMENT SCIENCE	347

Table 6 shows the top journals with highest number of citations per paper in a journal. Journal of Service Research tops the list with average 273 citations per paper followed by California Management Review and MIS Quarterly each having more than average 100 citations per paper.

Table 6: Top Journals with highest number of citations per paper

Journal	Number of Citations per paper
JOURNAL OF SERVICE RESEARCH	273
CALIFORNIA MANAGEMENT REVIEW	182
MIS QUARTERLY	159
INFORMATION SYSTEMS RESEARCH	91
ORGANIZATION SCIENCE	90
JOURNAL OF STRATEGIC INFORMATION SYSTEMS	85
MARKETING SCIENCE	75
JOURNAL OF RETAILING	68
MANAGEMENT SCIENCE	58
JOURNAL OF MARKETING	48
INTERNATIONAL JOURNAL OF SERVICE INDUSTRY MANAGEMENT	48

Table 7 shows the list of research papers, which had more than 200 citations. “Trust and TAM in Online Shopping: An integrated model” published in year 2003 had highest 995 citations (Gefen et al, 2003). Only other two papers, which had more than 500 citations are “Measuring the customer experience in online environments: A structural modeling approach” (Novak et al, 2000), and “Applying the technology acceptance model and flow theory to online consumer behavior” (Koufaris, 2002). Two out of the top 3 research papers are related to technology acceptance model.

“E-S-QUAL - A multiple-item scale for assessing electronic service quality” is the only paper published after year 2003, which had more than 200 citations. This paper conceptualizes, constructs, refines and tests a multiple-item scale E-S-QUAL for measuring the service quality delivered by web sites on which customers shop online (Parasuraman et al, 2005). Research paper titled “The measurement of web-customer satisfaction: An expectation and disconfirmation approach” had 408 citations, and this paper was written to develop theoretically justifiable constructs for measuring web customer satisfaction during the phase in which customers search for information regarding their intended purchases (McKinney et.al, 2002). Next highest cited paper was “Hedonic and utilitarian motivations for online retail shopping behavior”, which supports the differential importance of immersive, hedonic aspects of the new media as well as the more traditional utilitarian motivations (Childers et al, 2001). Research paper “Consumer decision making in online shopping environments: The effects of interactive decision aids” had 329

citations and this paper investigates the nature of the effects that interactive decision aids may have on consumer decision making in online shopping environments (Haubl et al, 2000).

Another highly cited paper related to quality in online retail is “eTailQ: dimensionalizing, measuring and predicting etail quality”. This paper had 327 citations and focusses on establishing the dimensions of etail experience and develops a scale for the measurement of etail quality (Wolfinbarger et al, 2003). “Antecedents of B2C channel satisfaction and preference: Validating e-commerce metrics” (Devaraj et al., 2002) and “Wine online: Search costs affect competition on price, quality, and distribution” (Lynch, 2000) were the only other two papers, which had more than 200 citations. In total, only 10 research papers could get more than 200 citations.

There was no research paper published after 2005, which could get 200 citations. This may reflect that research papers written in the recent time are not very impactful, but partially this may be due to the reason that the research papers written after 2005 has not got the enough time to have many citations. However to arrive at any conclusion, further analysis may be needed in coming years to track how the impact of the research papers increases over the years. Also, the sensitivity analysis of the time on the research paper impact will help in segregating the effect of time on the research impact and enabling the forecast of the research impact over the time.

Table 7: Papers with more than 200 citations

Year	Authors	Title	Citation #
2003	Gefen, D; Karahanna, E; Straub, DW	Trust and TAM in online shopping: An integrated model	995
2000	Novak, TP; Hoffman, DL; Yung, YF	Measuring the customer experience in online environments: A structural modeling approach	584
2002	Koufaris, M	Applying the technology acceptance model and flow theory to online consumer behavior	540
2005	Parasuraman, A; Zeithaml, VA; Malhotra, A	E-S-QUAL - A multiple-item scale for assessing electronic service quality	433
2002	McKinney, V; Yoon, K; Zahedi, F	The measurement of web-customer satisfaction: An expectation and disconfirmation approach	408
2001	Childers, TL; Carr, CL; Peck, J; Carson, S	Hedonic and utilitarian motivations for online retail shopping behavior	387
2000	Haubl, G; Trifts, V	Consumer decision making in online shopping environments: The effects of interactive decision aids	329
2003	Wolfinbarger, M; Gilly, MC	eTailQ: dimensionalizing, measuring and predicting etail quality	327
2002	Devaraj, S; Fan, M; Kohli, R	Antecedents of B2C channel satisfaction and preference: Validating e-commerce metrics	280
2000	Lynch, JG; Ariely, D	Wine online: Search costs affect competition on price, quality, and distribution	263

4. CONCLUSION

From the various analyses it could be concluded that the number of research papers published every year has increased significantly in last decade but the impact of the research papers measured by the number of citations was relatively more for the research papers published between years 2000 to 2003. Partially this may be due to the reason that during the early years of this century, internet businesses were witnessing growth and foundation theories of e-Business and e-Commerce were being set-up during this period. But, it is possible to argue that comparatively a longer period of time has passed for the papers written between year 2000 to 2003, which naturally is resulting in higher number of citations for these papers and hence the higher impact.

Benbasat, Izak was the top author from productivity and sustainability perspective. He wrote 10 papers in 7 different years in the period 2000 to 2014. However, Gefen, D et al. wrote the paper which had 995 citations, which is the highest number of citations for any paper written on the subject area.

With online shopping becoming increasingly popular it is expected that more impactful papers and active work will continue in the near future also. However, it could be noticed that there is no single prominent journal for the subject area. Research publications on Online Shopping or e-Commerce are fragmented and depending on the content and author's preference, researchers publish their papers in various journals, sometimes related to Technology, Marketing, Operations, or Management area. Still, Journal of Business Research, Marketing Science, Information & Management, and Psychology & Marketing are the top journals from all the three evaluation criteria of productivity, sustainability, and impact on the subject area.

5. LIMITATIONS

This study is conducted based on the search results on WOS by inputting search keywords of "Online Shopping". It is possible that research work may have got published on the related content by using some other synonyms/key-words. Also, there is a possibility of error if the researcher may have changed the names used in publication over the time. Also, the effect of time elapsed, needs to be segregated from the impact of research papers so as to make comparisons of the impact of papers published across different time periods.

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IMPROVING RECYCLING AND REDUCING CONTAMINATION OF RECYCLABLES THROUGH INNOVATIVE BIN DESIGN

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ABSTRACT

The human population is growing at an alarmingly rate towards the 10 billion mark. This human population growth demands a huge amount of resources to sustain. Plastic, aluminum and paper used for food packaging in the global food supply chain are becoming scarce in order to support this growth. Recycling these resources is one of the key strategies that can help to alleviate this challenge. However, driving an effective recycling program is not a trivial endeavor, as there are myriad of factors that may influence the recycling intention of individuals. This study sheds insight on how to increase recycling and reduce the contamination rate during the recycling process through an innovative bin design. The study describes a community-based participatory research (CBPR) methodology that had been undertaken by the research team, the Singapore's National Environment Agency, a statutory board, and Ngee Ann Polytechnic, an institution of higher learning, to achieve the identified objectives. As far as we know, the study is one of the few studies that looked into the influence of bin design on the individual's recycling intention. Our results showed that by improving the bin design, the recyclables collected had increased by 48%, while the contamination rate had fallen by 26% in the polytechnic's campus. This provides empirical support to justify the importance of a well-designed recycling bin in a recycling program. Our study contributes to research and practice by providing a roadmap on how to design a better recycling bin that can increase recycling through the adoption of our CPBR methodology. It also provides bin design that practitioners can readily adapt to improve recycling. This is important as involving the community and achieving high recycling are critical in sustaining the demands of our global food supply chain.

KEYWORDS

Sustainability, Recycling, Food Supply Chain

INTRODUCTION

It took all of human history until around 1800 for the world population to reach one billion and in just one century to grow to 6 billion (Worldometers, 2015, WorldWatch, 2015). The current world population stands at around 7 billion as of January 2015 and is expected to reach between 8 and 10 billion by 2050 (UN-Report, 2013, UN-Report, 2003). This explosion in population growth exerts enormous demand on the supply of natural resources (Das and Hughes, 2006, WorldWatch, 2015). Natural resources such as plastic, aluminum, and paper have been widely used in the packaging of food products (e.g. milk, beverages, and mineral water) to support the growth of our population and the global food supply chain. For most of us, these natural resources are inseparable as part of our everyday life (Das and Hughes, 2006). Increasingly, the world is facing a serious shortage of these resources to support the growth of our global food supply chain. This threatens our livelihood. Hence, it is imperative that we develop strategies that can ensure the protection of these resources for our current and future generation.

To meet this challenge, recycling of these resources has been touted as one of the key strategies that is vital to the global food supply chain (Millbank, 2004, WorldWatch, 2015). Recycling is '*a form of primary prevention that protects the environment and natural resources*' (Largo-Wight et al., 2012, pp. 66). Recycling helps reduce the needs to harvest these resources and the production-related energy needed to convert these resources into packaging for food (Das and Hughes, 2006). It also helps to reduce the harmful effects to our environment when these resources are not sent to the waste incinerators and landfills (US-EPA, 2015) and/or are being disposed into our ocean (WorldWatch, 2015). Furthermore, plastic, aluminum and paper are well known as materials that are highly recyclable (Das and Hughes, 2006) and can generate significant economic benefits if we are able to achieve a high recycling rate (Millbank, 2004).

Existing research has shown that a number of interventions can modify and increase the occurrences of appropriate disposal and recycling behavior in individuals, which in turn can lead to high recycling rates (e.g. Jacobs et al., 1984, Witmer and Geller, 1976, Brothers et al., 1994, Ludwig et al., 1998, Largo-Wight et al., 2012, Largo-Wight et al., 2013). Largo-Wight et al. (2013) and O'Connor et al. (2010) have demonstrated that by just increasing the number and/or changing the locations of bins, the recycling rate can increase substantially. Notwithstanding research in the extant literature to explore ways to improve recycling rate and the enormous environmental and economic benefits of recycling, many countries continue to struggle to get its plastic, aluminum and paper recycled efficiently and effectively (WorldWatch, 2015, Cooper, 2010). Furthermore, as far as we are aware of, there is no research in the area of recycling that looks into how to reduce the contamination of recyclables in a recycling bin. Contamination of recycling bin is a relevant and important issue during the recycling process. The presence of contamination in a recycling bin has significant cost implications to the process of recycling. It not only increases the cost of sorting and filtering out the contaminants from the recyclables, but also potentially can reduce the recycling rate. Hence, reducing the amount of contamination of recyclables inside a recycling bin can also be a critical success factor in a recycling program.

Motivated by the recent call of several authors to go beyond the investigation of the number and location of the recycling bins to improve recycling rate (e.g. Largo-Wight et al., 2013, O'Connor et al., 2010), we posit that the design of the bins can play a significant role in

inducing an appropriate disposal and recycling behavior. In turn, this can lead to a higher recycling and less contamination of recyclables. Our study is guided by the research question: *What kind of design of a recycling bin can effectively improve recycling, while reducing the contamination of recyclables?*

As far as we know, our study is the first of its kind to investigate the effect of bin design in both improving recycling and reducing contamination of recyclables. We believe our study will help to address the existing challenges in recycling plastic, aluminum and paper that are used in food packaging. We think this is crucial in supporting the global food supply chain.

LITERATURE REVIEW

The extant literature surrounding recycling can be broadly classified into three key areas. The first area of the literature looks at the economic values to enact in recycling activities (e.g. Steuteville, 1993, Accorsi et al., 2014). These studies provide justifications on why recycling is an important activity that organizations should consider, especially given the mandated government policy and the social pressure to pursue corporate social responsibility initiative. For instance, Steuteville (1993) highlighted that by recycling a single can, it helps to save the industry an estimated 95% of the energy used to mine and smelt aluminum. Accorsi et al. (2014) argued that packaging in the food supply chain is one of the most relevant waste sources and should be effectively recycled to assure the economic viability of the food supply chain.

The second area of the literature examines the factors that influence individual's disposal and recycling behavior (e.g. Viscusi et al., 2011, Largo-Wight et al., 2012, Manika et al., 2015). Manika et al. (2015) investigated the role of environmental friendly organizational citizenship behavior within a corporate social responsibility initiative to identify the various individual and organizational factors that influence 'green' employee behavior (consisting of recycling, energy savings and printing reduction). Their results highlighted the importance of having a well-designed social marketing intervention that can effectively target each type of 'green' employee behavior in the workplace. Largo-Wight et al. (2012) created an expanded version of the Ajzen (1991)'s theory of planned behavior consisting of the following independent variables: (1) attitudes; (2) perceived behavioral control; (3) social norms; (4) perceived moral obligation; and (5) descriptive norms. They adapted and tested their expanded model on students studying in a campus and found that these five independent variables explained almost 50% of the variance surrounding the dependent variable, recycling intention. Viscusi et al. (2011) took a policy view of promoting recycling and investigated whether private values on recycling, social norms, and economic incentives provided by the state can have an influence on a household's recycling intention. Their research provided insights on how policy makers can adjust their recycling policy based on these factors.

The final area of the literature focuses on what are the factors that will increase the recycling rate (Largo-Wight et al., 2013, O'Connor et al., 2010, Das and Hughes, 2006, Buffington, 2012). Das and Hughes (2006) used the six sigma methodology to examine the recycling process to identify various factors within the process that may affect the recycling rates of aluminum. Their results provided evidence to explain why aluminum recycling rate had been declining in Kentucky in the United States and how the state can improve its recycling process to improve its recycling rate. Buffington (2012) looked similarly at the issue of declining aluminum recycling rate but instead investigated the role of supply chain

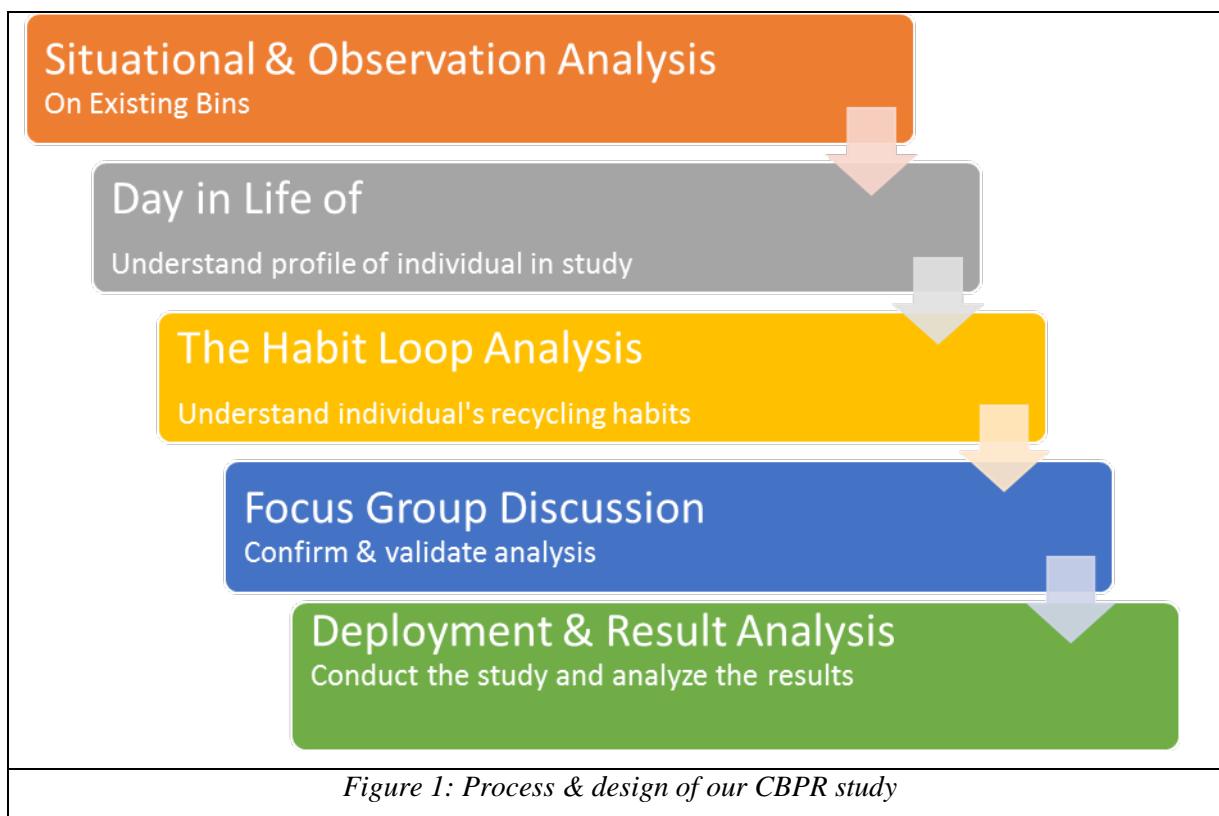
innovation at the production end. His study provided insights on the challenges faced by producers of aluminum in the supply chain that limited the recycling rate of aluminum cans. Taking a more consumer perspective, Largo-Wight et al. (2013) conducted an experiment on three buildings (one control building and two treatment buildings) within a college over a period of eight weeks. They provided empirical support to assert that by simply providing more recycling bins and at strategic locations both indoors and outdoors, the recycling rate increased substantially. In similar fashion, O'Connor et al. (2010) conducted an experiment on three buildings within a University. They tested out whether by manipulating the appearance of the bins (changing the bin from grey bin to blue bin), increasing the number of recycling bins in common areas, and placing the recycling bins at strategic locations such as classroom can increase the recycling rate. Their results provided evidence to support that placing the recycling bins at strategic locations increased the recycling rate, while the remaining two measures did not.

Notwithstanding all the studies on recycling done within the extant literature, there is, as far as we know, no study that investigates into ways to improve the recycling rate of plastic, aluminum and used beverage paper cartons in a recycling bin as a whole. All of the identified studies in the literature either focused on plastic bottles or aluminum cans. In addition, none of these studies investigated into ways to reduce the contamination rates during the recycling process. With the exception of O'Connor et al. (2010), none of the studies examined the design of the recycling bins in influencing the recycling rate. In the study conducted by O'Connor (2010), the design of the bins was only restricted to just a mere change in its color. We think that a good design with strong visual cues can potentially induce recycling intention of consumers and thereby increase the rate of recycling.

These are gaps in the literature that we wish to fill. We posit this because of the following reasons: (1) As plastic, aluminum, and used beverage paper cartons are commonly used for packaging of many food products, analyzing them in totality seems to be more appropriate than to look at ways to increase their recycling individually. Furthermore, the recent advancement in recycling technologies has made it possible for vendors to easily separate them after collection; (2) The key challenge of the use of recycling bins lies with how we can reduce the contamination of the recyclables, which is currently lacking in the literature. This is an important inquiry because every contamination represents a loss in productive efforts to recycle the resources; and (3) we posit that the appropriate design of the recycling bins should go beyond just a change in color and include well-designed visual cues on the bins. We think these visual cues are vital in effectively influencing the recycling behavior of individuals.

RESEARCH METHODOLOGY

We have designed a community-based participatory research (CBPR) study that involved the research team, the staff and students in the National Environment Agency of Singapore (NEA), a statutory board, and the Ngee Ann Polytechnic (NP), an institute of higher learning in Singapore, in a collective effort to improve recycling and reduce contamination of recyclables in the existing recycling bins deployed in 20 locations across the NP's campus. We adopted the CBPR method because we firmly believe that improving recycling is a collective effort that should involve all stakeholders especially in the process of designing the study and in collecting the data (Braun et al., 2012, Wallerstein and Duran, 2010). Our CBPR study design is depicted in Figure 1.



PLANNING, DESIGN & IMPLEMENTATION

The study started in 2014 and began with the meeting between the research team and NP's Environment committee to form a working team. The campus in NP had recycling bins deployed across 20 locations and the old design of the recycling bin is shown in Figure 2. The research team highlighted during the initial meet up that preliminary observations showed that the recycling amount using the existing bin design was poor and the contamination rate was also high.



Figure 2: Existing recycling bins integrated with 'General Waste' component deployed in 20 locations of NP campus

Phase 1: Situational & Observation Analysis. In the first phase of our study, the research team conducted a situational and observation analysis on the use of recycling bins in the campus. This was done by stationing staff at key locations at different timings to observe students' behavior in using the existing recycling bins. Detailed notes and photos of the recycling content in the bins at various locations and different times were captured during this process (see Figure 3) and shared with the team.



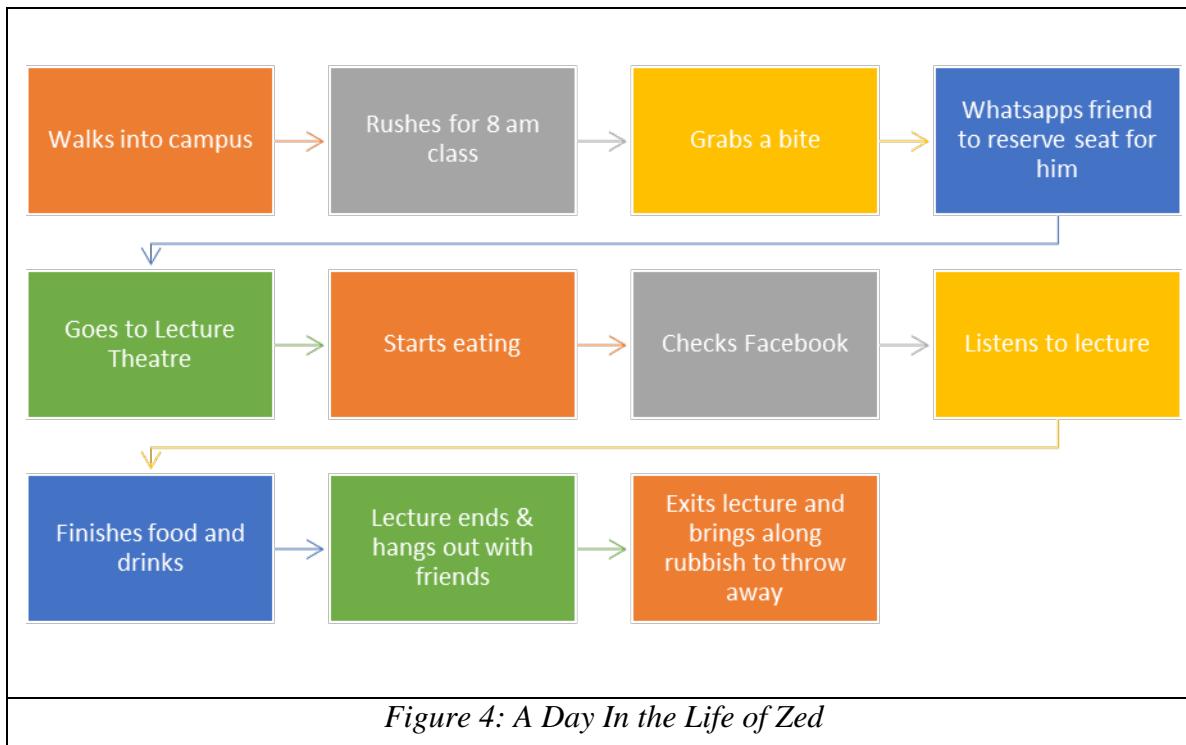
Figure 3: Sample Photos of a Recycling Bin's Content

From the notes and the photos that were systematically and comprehensively captured, the team confirmed that the campus's recycling was ineffective with high contamination rate. To understand the reasons behind the low recycling and high contamination rate, the observation data was systematically categorized, analyzed and discussed. The discussion concluded that the reasons can be broadly categorized into two key areas: namely, infrastructural factors and awareness factors (see Table 1). To resolve the infrastructural barriers, the team focused on bin redesign to improve campus recycling.

Infrastructure	Awareness
<ul style="list-style-type: none"> • Insufficient recycling bins, compared to the prevalence of rubbish bins • Not intuitive bin design (color & signage) • Trash component in-between recycling components • Contaminated bins discourage responsible usage • Lack of prominent visual cues 	<ul style="list-style-type: none"> • Inadequate knowledge on the different types of recyclables • Lack of publicity effort on recycling

Table 1: Factors that can explain low recycling & high contamination rate in NP campus

Phase 2: ‘Day in Life of’ Analysis. Using the insights developed through the situational and observation analysis, a ‘day in life of’ analysis was performed to examine the daily activities of a typical and common consumer within the NP campus (i.e. student). A student profile was developed to help the team understand the unique traits and characteristics of a student in NP. This resulted in the creation of a fictitious character called Zed who was deemed to possess the following traits and/or characteristics: (1) A sociable individual; (2) Has short attention span; (3) Always hangs out with friends in a group; (4) A self-conscious individual; (5) Individual who is constantly looking out for novelty in its surrounding; (6) Always connected to the social media; and (7) Generally not environmentally-conscious. The typical daily activities of Zed were also developed as illustrated in Figure 4.



By coming up with the typical daily activities of Zed, the team examined the various steps involved that can encourage Zed to carry out the desired disposal and recycling behavior. They did this by enacting in a role play scenario which resulted in the findings as shown in Figure 5.

Recycling Role Play Scenario

- Zed is with his group of friends after lecture. He has an empty Coke bottle in his hand and intends to deposit it into the nearest rubbish bin.
- He spots a nearest recycling bin, Zed is sub-consciously aware of the 3 components in the recycling bin (see Figure 3).
- As he is about to throw the plastic bottle into the bin:
 - He does not pay attention to the labeling or signage
 - He sees a variety of different items in all three components which are visually messy
- **He mindlessly drops the bottle into any of the component as he moves along to his next destination with his friends.**

Figure 5: Recycling role play analysis

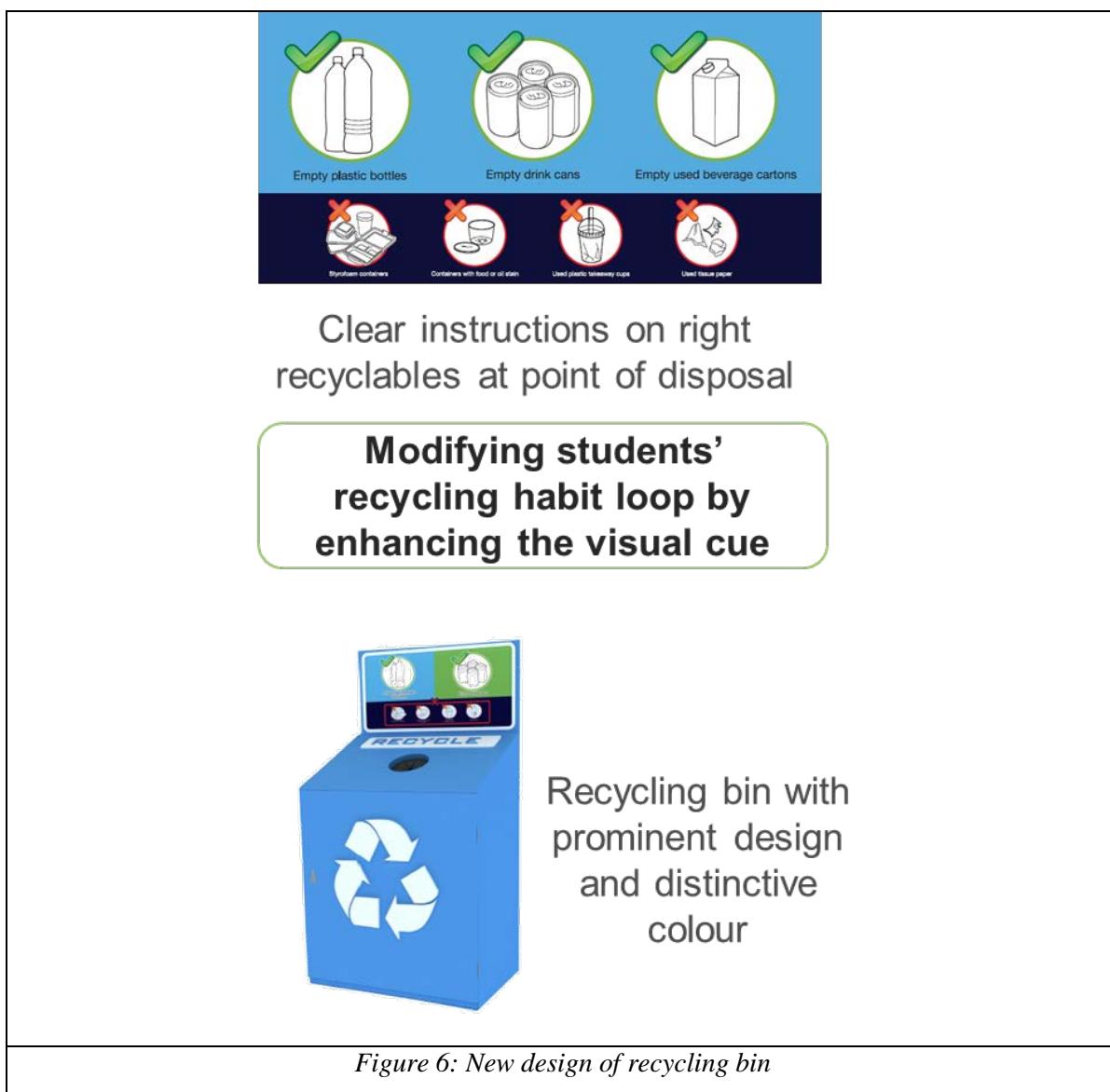
Phase 3: Habit Loop Analysis. By analyzing the role play scenario using the Duhigg (2014) habit loop model, the team was able to gain an in-depth understanding of the process from the student's point of view and what can be done to facilitate the acceptance of behavior. In the habit loop model, a habit is often triggered by a cue (e.g. a specific time of the day or a visual cue), which leads to the execution of a routine in order to acquire a specific reward (Duhigg, 2014). In the case of normal waste disposal habit, the cue is the empty plastic bottle that is in the hands of Zed. This leads to the routine to find a rubbish bin to throw and the reward is that Zed no longer needs to carry the empty bottle around. To encourage Zed to recycle more, the team realized through the habit loop analysis that they needed to develop a combination of clear and salient visual cues that can: (1) trigger Zed's intent to recycle; (2) provide intuitive information at point of sight and disposal; and (3) meet Zed's original need to throw away the rubbish item. By creating these clear and salient visual cues, it is believed that overtime the modified recycling habit loop will eventually replace the existing waste disposal habit of Zed.

Phase 4: Focus Group Discussion. A focus group discussion was conducted involving key stakeholders (such as students and staff) in NP campus to validate the results and to attempt to capture more detailed information about the reasons for the low recycling in campus. It involved three key activities and they are summarized as follows:

1. **Knowledge on what can be recycled** – Participants were given a list of common rubbish items and were asked to select the items that can be recycled.
Result: Half of the participants were unable to differentiate the type of recyclables under the plastic category. Majority of participants did not know that used beverage cartons can be recycled.
2. **Reasons for low recycling** – Participants were asked to comment on the potential reasons why recycling in campus was low.
Result: (1) Inconvenience of having to empty and sort the recyclables; (2) Lack of recycling bins; and (3) Inconvenient location of recycling bins
3. **Recycling Infrastructure in Campus** – Participants were asked to comment on the existing recycling infrastructure on Campus

Result: Participants felt that distinctive color to differentiate general waste and recycling bins would be effective in increasing recycling. They also felt that visual cues to show the actual recyclables on the bin can help to improve recycling.

Phase 5: Deployment and Result Analysis. After analyzing all the data that had been collected in the past four phases, the team iteratively and collaboratively worked with key stakeholders to come up with the design of the new recycling bin as shown in Figure 6. The new design featured several visual cues on what types of recyclables were accepted and what were not. It was painted in bright blue in line with Singapore's national recycling campaign. This was done because the team believed that the color blue was now more widely associated with recycling in the minds of Singaporeans. The material of the new design was made of high quality fiber glass with a smaller disposal opening to limit the occurrences of contamination. A special door with lock was created at one side of the new bin to make it easy for a cleaner to retrieve the recyclables.



DATA COLLECTION AND RESULTS

An eight-week data collection plan was developed. In the first four weeks, the recyclables collected from the existing recycling bins as shown in Figure 2 at 20 locations were manually counted daily. The contamination rate using the existing recycling bins was also derived. This formed the baseline of the recycling and contamination rate of the existing recycling bins. In the next four weeks, the newly designed bins were deployed to the exact same 20 locations to replace the old recycling bins there. A general waste bin was placed beside each new recycling bin. Figure 7 shows the actual photo of how the new recycling bin and a general waste bin were deployed in three of the locations in NP campus.



Figure 7: Actual deployment of newly designed recycling bin and general waste bin at 20 locations in NP campus

The recyclables were also collected and counted on a daily basis over the four-week period. To ensure that the improvement in recycling and contamination rate can be strongly associated to the new bin design, the team made deliberate attempts to ensure that there was no effort made to promote recycling across the campus. In short, they worked hard with key

stakeholders to keep the four weeks as normal and typical as possible. The data collected from these two periods was comprehensively analyzed to produce the results as shown in Table 2.

	Existing Recycling Bins	New Recycling Bins
Amount of recyclables collected	133.75 kg	198.00 kg ▲ by 48%
Recycling contamination rate (no. of contaminants/no. of recyclables and contaminants) * 100%	6 out of 10 contaminated	3.4 out of 10 contaminated ▼ by 26%
General Observation	<ul style="list-style-type: none"> • Recycling bins contained mixed content • Recyclables found in general waste bins 	<ul style="list-style-type: none"> • Recycling bins contained large proportion of recyclables • No. of recyclables found in general waste reduced significantly

Table 2: Comparison between existing and new recycling bin design

By just replacing the old bin design with the new one, the amount of recyclables (in kg) which consisted of plastic bottles, aluminum cans and used beverage paper cartons increased by 48%. The contamination rate decreased by 26% from 60% to 34%. The number of recyclables in the general waste bin also reduced substantially. This result was achieved without any increase in the number of bins and without changing the locations of the existing bins. Hence, this led us to conclude the effectiveness of the innovative bin design that was created collaboratively with key stakeholders in this study.

CONCLUSIONS

In this paper, we set out an agenda to try to improve recycling and reduce the contamination rate during the recycling process through an innovative recycling bin design. We argued that, as far as we know, our study is the first of its kind that looks at the effects of bin design on recycling behavior of consumers. We argued that this is an important endeavor because plastic, aluminum and used beverage cartons are used for packaging of food which is essential in supporting our growing global food supply chain. Similar to Largo-Wight et al. (2013), we adapted a community-based participatory research methodology to guide the design and implementation of our study. In so doing, we posit that our study contributes to research and practice in the area of recycling in three ways.

First, we have provided a detailed implementation roadmap on how to design and conduct a CBPR study in recycling. In line with Largo-Wight et al. (2013), we believe the use of CBPR as a methodology is ideal to investigate recycling intention of consumer. This is because the drive to improve recycling and reduce contamination rate during a recycling

process inevitably depends heavily on the active participation of all key stakeholders in the community. This is especially so since recycling intention of consumers has been identified as highly contextual in nature and can be influenced by many factors such as perceived behavioral control, social norms and organization culture (Viscusi et al., 2011, Largo-Wight et al., 2012, Manika et al., 2015). Therefore, we think adopting a CBPR approach in tackling recycling issues can help provide in-depth understanding of the community's recycling behaviors. This is essential in helping researchers and/or practitioners develop effective measures to improve recycling and reduce the contamination rate during the recycling process.

Second, unlike Largo-Wight et al. (2013) that approximated the amount of recyclables in their bins, our study counted recyclables and contaminants on a daily basis over a period of 8 weeks. Hence, it provided highly accurate data to justify the effectiveness of the bin design in influencing the appropriate disposal and recycling habits of consumers at NP's campus. We believe that practitioners looking for ways to improve their recycling can consider adopting/adapting our bin design at its current state. This should, in principle, help to improve the recyclables collection in their bins.

Third, as far as we know, our study is one of the rare few studies that looks at the influence of appropriate visual cues in the design of the recycling bin to modify the recycling habits of consumers. We have shown the importance of visual cues in bin design and we posit that this is one of the critical success factors in a recycling program. Future research in the area of recycling should take this into consideration when designing the study.

There are, however, some limitations of our study. First, there was a clear lack of an experimental control group as a result of our CBPR approach. Similar to prior CBPR studies, a myriad of stakeholders was involved in the design of the study and the collection of data (Braun et al., 2012, Wallerstein and Duran, 2010) which limited the possibility of setting up an experimental control group in our case. Nonetheless, the weakness of our CBPR approach is also its strength. By leveraging upon the knowledge and experiences of key stakeholders, the findings of our study are likely to be more relevant to practice and can provide clearer guidance to inform policy and decision making (Braun et al., 2012, Wallerstein and Duran, 2010). Second, we have made a conscientious attempt to isolate and attribute, as much as we could, the improvement of recycling and contamination rate to the new design of our recycling bins. However, we were unable to rule out the potential influences of community-related factors (e.g. national campaign to promote recycling) that may influence our results. Future field studies can consider including a more comprehensive set of community-related factors that potentially may influence the recycling intention of consumers in their studies.

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ENVIRONMENTAL UNCERTAINTY, PARTNERSHIP QUALITY, AND SUPPLY CHAIN PERFORMANCE IN TWO COUNTRIES: TAIWAN AND GAMBIA

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ABSTRACT

The main focus of this study is to develop antecedents of partnership quality, to examine how moderating role of environmental uncertainty effects on the relationship between partnership quality and supply chain performance, and to compare the situations between Taiwan and the Gambia. Collecting data from Gambia and Taiwan, this study found that commitment and partnership quality have positive impacts on partnership quality and supply chain performance, respectively, in both countries. However, in Taiwan trust positively influences partnership quality, while in Gambia information sharing has a positive impact on partnership quality. Because of the advanced technology in Taiwan, information sharing is a minimum requirement for Taiwan's companies, causing no significance in the model. On contrary, information infrastructure is not well established in Gambia, resulting in that information sharing is significant in Gambia's model. Also, only Gambian data show that environmental uncertainty has a moderating impact on the relationship between partnership quality and supply chain performance. From the results, this study offers a roadmap for companies to expand their markets into other countries.

KEYWORDS

Environmental Uncertainty, Partnership Quality, Cultural Comparison

INTRODUCTION

In today's network economy, most organizations depend on external suppliers for critical resources and complementary capabilities (Holweg et al., 2005). Miles and Snow (1984) suggested that firms matching with their environmental context can improve their performance, but those that have a mismatch, or respond too slowly to change, court failure and poor performance. Supply chain models have predominantly utilized two different

performance measures: cost and a combination of cost and customer responsiveness (Beamon, 1999). Bidault and Salgado (2001) suggested that effective and efficient collaboration with external entities is crucial in the context of supply chains, and Johnston and his colleagues (2004) have examined the role of key partnership components, including, trust, commitment as well as mutual adaptation.

Carson and his colleagues (2003) argued that the relationship between various partnership dimensions of the exchange partners and subsequent performance may be contingent on other factors, including environmental uncertainty (EU). Davis (1993) suggested that there are three different sources of environmental uncertainty: demand uncertainty, supply uncertainty and technological uncertainty. In this study, we concentrate more on the technological uncertainty as moderator to the partnership quality and supply chain performance. A major implication of resource dependence theory is the identification of dependence and uncertainty as the key antecedent variables underlying the formation of inter-firm relationships (El-Ansary and Stern, 1972). This is why the formation of close long-term relationships is one means of creating governance mechanisms to reduce uncertainty and manage dependence (Fynes et al., 2004).

This research is aim to investigate the most important antecedents of formation buyer-supplier partnership quality in the Gambia and Taiwan, also to study to what extend does environmental uncertainty influence the relationship between buyer and supplier partnership quality and supply chain performance. By exploring our research in detail and discussing issues above in the supply chain industry, we expect to contribute within academy and practice.

From the past research, our conceptual model is established in Figure 1. Based on the research motivation and objectives, we address the following research questions to examine the antecedents of forming a partnership quality between a buyer and suppliers. Also try to find out whether the partnership quality has a positive impact on supply chain performance. The moderating role of environmental uncertainty on the relationship between partnership quality and supply chain performance is also examined.

1. What are the difference and similarities on antecedents for partnership quality in The Gambia and Taiwan?
2. Can the relationship of buyer-supplier partnership quality and supply chain performance be applied in both countries?
3. To what extend is the relationship between buyer-supplier partnership quality and supply chain performance moderated by environmental uncertainty in both countries?

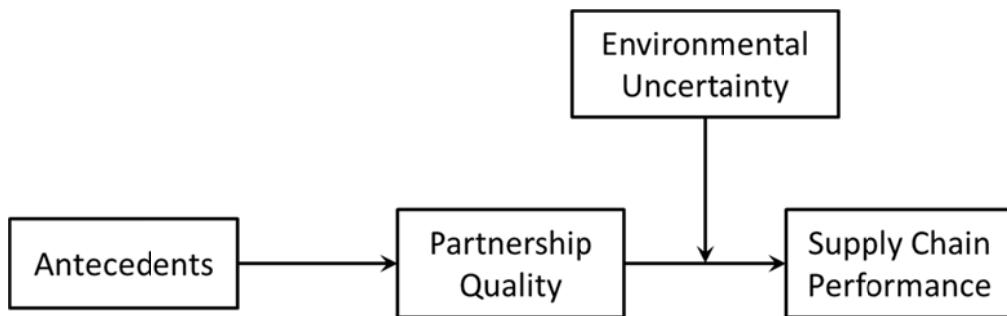


Figure 1 Conceptual Model

The paper is organized in the following section. First, we will discuss the past related literatures and establish the hypotheses. Next, we will illustrate our methodology and the results will follow methodology. Last, we will make conclusion and discuss our contributions and limitations.

LITERATURE REVIEW

Buyer and supplier partnership quality

Partnership in collaboration is define as a relationship between two independent members in supply channels through increase level of information sharing to achieve specific objectives and benefits, including reducing total cost and inventories (Yu et al., 2001). In addition, partnership quality is define as long-term buyer and supplier relationships that offer sustained competitive advantages for both firms through benefit sharing and joint problem solving (McCutcheon and Stuart, 2000). Partnership is also define as purposive strategic relationships between independent firms who share compatible goals, strive for mutual benefit, and acknowledge a high level of mutual interdependence (Naudé and Buttle, 2000). Supply chain relationship quality is defined as the degree to which both parties in a relationship are engaged in an active, long-term working relationship and operationalize the construct using indicators of trust, adaptation, communication and co-operation (Fynes et al., 2004).

Firms that are able to accumulate resources and capabilities those are rare, valuable, non-substitutable, and difficult to imitate will achieve a competitive advantage (Barney, 1991). More specifically, partnership quality is conceived in this work as a relational resource that may render superior performance outcomes (Srinivasan et al., 2011). These theoretical frameworks have all contributed to the modeling of supply chain relationships both in their identification of the underlying dimensions of relationships (Fynes et al., 2004). Ryu and his colleagues (2007) proposed that firms relying on high quality partnerships with suppliers are better equipped to adapt to unforeseen changes, identify and produce well-crafted solutions to

organizational problems, and reduce monitoring costs, all of which help improve the economic outcomes.

Antecedence of Buyer and Supplier Partnership Quality

The primary reasons derive from markets becoming more international, dynamic and customer driven and are customers who demand more variety, better quality, and greater service. Relationship marketing aims at developing lasting relationships based on long-term benefits and mutual affinity between buyers and suppliers (Achrol, 1997). Commitment, trust, group cohesiveness, and motivation of alliance participants are identified as critical to inter-firms strategic alliances (Achrol, 1997). Close partnerships based on mutual trust and commitment can reduce transaction costs and can have positive impact on performance outcomes (Zaheer et al., 1998). In addition, close relationships are based on trust and cooperation, mutual sharing of risks and benefits, between the buyer and the supplier, may have beneficial performance effects (Srinivasan et al., 2011).

Combining these factors, we propose that the partnership quality comprises of the information sharing, trust and commitment to key specific partners for long-term relationship. Inferring to causes of bullwhip effect in supply chain performance, forming a long-term partnership between the buyer and supplier would immensely help in reducing the impact of bullwhip effect could have on supply chain performance (Lee et al., 1997). With the most used antecedents such as information sharing between the buyer and supplier which foster trust to stay and finally build committed partners for a long-term relationship.

Trust

Trust is define as the willingness to rely on an exchange partner has confidence in . In addition trust is defined as the perception of confidence in the exchange partner's reliability and integrity (Morgan and Hunt, 1994). Trust has been also defined as the firm's belief that another company will perform positive actions for the firm, as well as not take unexpected actions that would result in negative outcomes for the firm (Anderson and Narus, 1990). Trust lowers purchasing cost with a supplier as the level of control and costly safeguards against supplier opportunism can be lowered gradually (Ghoshal and Moran, 1996). Trust implies that one believes the partner will stand by its word, not take unexpected actions with a negative impact on the firm, fulfill promised role obligations, and conform to the norms of cooperative behavior (Anderson and Narus, 1990) .

Furthermore, purchasing cost decreases through improved coordination, information quality and process reliability (Zaheer et al., 1998). Gulati and Gargiulo (1999) state that reliable partner will involve in the cooperative behavior and first introduced the concept of

inertia effects to link the evaluation factors (reciprocity, alliance performance and industry-specific experience) in the process of past partners selection. With the repetitive exchange behaviors, trust-based relationship will be formed and further enhance the firm's desire to collaborate with partners in the future (Mohr and Spekman, 1994). In other words, the firm's perception of partner's reliability positively influences its long-term orientation (Ganesan, 1994) which closely relates to relationship commitment and result in cooperative members working together to increase mutual gains. The insight implies that the reliable partners would involve in exchange behaviors for the future benefits and stable cooperation relationship, and thus improves the chance of integrating each other's resources. The trust-based relationship has numerous advantages; it can eliminate many of the monitoring and oversight costs; it opens up inter-firm channels for ideas and improvements; it can reduce product development times by avoiding bureaucratic delays. Trust, however, is a two-way street, regardless of the buyer's trust, special benefits may not develop unless the supplier also trusts the buyer (Dyer and Chu, 2011).

In each case, a firm exposes itself to risks of failure or opportunism for which there may be no legal redress. High levels of inter-organizational trust create an environment that prohibits opportunistic behavior, and makes partners more focused on engaging in committed relationships. Trust also plays a significant role in allowing firms to develop dependencies on suppliers (McCutcheon and Stuart, 2000). As a result, inter-organizational coordination could achieve smoothly. Hence, this study presents the hypothesis that:

H1: *The level of trust between buyer and supplier has a positive impact on partnership quality.*

Information Sharing

Information sharing is defined as a process that facilitates the chain members to capture and disseminate timely, relevant, and accurate information such that the recipient is able to plan, execute, and control supply chain operations (Simatupang and Sridharan, 2004). Information sharing provides a unifying visibility for the efforts of chain members to improve operational performance, thereby enabling the chain members to forecast accurately, reduce order variability, shorten delivery lead time, and reduce inventory levels (Fisher, 1997). Moreover a lack of relevant information by supply chain partners may create uncertainty party to attempt to take advantage of others (Kwon and Suh, 2005). Such supply and demand mismatch in the supply chain is often caused by uncertainty and usually brings about a bullwhip effect, which further paralyzes the supply chain process (Yu et al., 2001). Fisher (1997) finds that information sharing can yield significant performance improvements in all chain members, such as cohesive market focus, better coordination of sales and demand fulfillment, and

minimum risks associated with demand uncertainty. Open and honest communications are not a privilege in supply chain rather they are essential requirements in the competitive market (Kwon and Suh, 2005).

Suppliers are likely to be committed to relationships with buyers who share information since information sharing helps the supplier to provide products or services more effectively and efficiently a buyer sharing important information signals their commitment to the supplier to the relationship in return (Nyaga et al., 2010). Effective inter-firm communications is a key part of information sharing that increases understanding of both parties and contributes positively to better partnership quality (Lee and Kim, 1999).

H2: The level of information sharing between buyer and supplier has a positive impact on partnership quality.

Commitment

We borrows the definition from (Morgan and Hunt, 1994) who defines it as an exchange partner believing that an ongoing relationship with another is so important as to warrant maximum efforts at maintaining it that is, the committed party believes the relationship endures indefinitely, and commitment is central to all the relational exchanges between the firm and its various patterns. Commitment also refers to the willingness of trading partners to exert efforts on behalf of the relationship (Porter et al., 1976). Morgan and Hunt (1994) argued that when both commitment and trust not just one or the other present, they produce outcomes that promote efficiency, productivity and effectiveness.

It suggests a future orientation in which partners attempt to build a relationship that can weather unanticipated problems (Mohr and Spekman, 1994). The nature of commitments in all relationships, including inter-organizational and interpersonal relationships stands for stability and sacrifice (Ryu et al., 2009). In sum, commitment is a way to represent their efforts and reflects the belief that a partner is ready to take any potential high-risk action for the furtherance of the relationship, and will not elect to engage in any opportunistic options in alternative situation (Ryu et al., 2009). A high level of commitment provides the context in which both parties can achieve individual and joint goals without raising the specter of opportunistic behavior. Without commitment, business relationship and subsequent transactions become fragile and vulnerable (Kwon and Suh, 2005).

H3: The level of commitment between buyer and supplier has a positive impact on partnership quality.

Partnership quality and Supply Chain Performance

A close bond between the buyer and the supplier enables the buyer to focus on its core competencies without having to worry about the risks associated with opportunism by the partner firm (Williamson, 1985, Williamson, 2008). Hult and his colleagues (2006) suggested that four competitive priorities, speed, quality, cost and flexibility, are critical in the measurement of supply chain performance . A good partnership quality between the focal firm and its supplier allows both parties to achieve these performance objectives and build a competitive advantage that a stand-alone partner cannot easily accomplish (Cousins and Lawson, 2007). When the relationship of the focal firm with its suppliers is based on trust, effective communication and intimacy, both parties find it easier to understand each other's objectives and expectations which, in turn, improves supply chain performance (Srinivasan et al., 2011). Improved supplier performance should also ensure that customer order fill rate and cycle time are impact positively. In the same way, however a partnership with high-trust would enjoy open communication and willingness to take risks. People in high trust relationships are not afraid to share all information and believe in the information they receive. Furthermore, greater willingness to take risks occurs beyond sharing information within high-trust relationships (Kwon and Suh, 2005).

In addition, if both partners share a good relationship, they are likely to be more familiar with each other's knowledge-base which enhances the resulting performance (Srinivasan et al., 2011). Conversely, the absence of a good partnership quality between a firm and its supply chain partners implies that transactions that are usually conducted at an arms-length. Studies with regard to partnership quality–performance relationship support our contention (Srinivasan et al., 2011). Narasimhan and Jayaram (1998) observed that higher levels of buyer–supplier partnership quality lead to superior operational performance. Krause and his colleagues (1998) studied reactive and strategic supplier development and found that the strategic focus on supplier development brings operational benefits such as shorter order cycle times, higher quality levels and increased delivery reliability.

Such transactional relationships often fail to motivate suppliers to go beyond their usual capacities and deliver a higher level of service to the buyer (Srinivasan et al., 2011). Partnership quality improves supplier's product quality and on-time delivery often has long-term performance enhancing consequences. More effective buyer-seller relationships help both parties manage uncertainty and dependence, increase efficiency by lowering total costs, and enhance product development and market orientation through better knowledge of customers and their customer needs (Cannon and Perreault Jr, 1999). In fact, such endeavors may actually help provide better product quality and increased delivery performance to end-users, which, in turn, increase customer satisfaction.

H4: *The level of buyer and supplier partnership quality has a positive impact on the supply chain performance.*

Moderating effect of Environmental Uncertainty

Environmental uncertainty refers to the rate of change and the degree of instability in the environment (Dess and Beard, 1984) dynamic environments may be characterized by changes in technologies, variations in customer preferences, and fluctuations in product demand and or the supply of materials. Environmental uncertainty also refers to the degree to which firms external environment in terms of its competitors actions, technology, and consumer tastes and preferences, is characterized by an absence of pattern unpredictability, and unexpected change (Fynes et al., 2004). As Ettlie and Reza (1992) point out, environmental uncertainty can also be viewed as unexpected changes of customers, suppliers, competitors, and technology. Davis (1993) suggest that there are three different sources of uncertainty in supply chains: demand uncertainty, supply uncertainty and technological uncertainty. Environmental uncertainty includes factors that are external to the supply chain, entails factors that are strategic in nature (Srinivasan et al., 2011), for instance, changes in product or process technology, competitor behavior, changes in consumer tastes and preferences etc.

In other words environmental uncertainty cannot be estimated, it can result in significant disruptions along the supply chain, severely impacting a company's ability to continue operations, similarly, such interruptions and unpredictable market fluctuations could potentially influence the extent to which the focal firm may benefit from close collaboration with its suppliers (Fynes et al., 2004). The effectiveness of a collaborative strategy depends on the environmental dynamics within which the exchange partners are embedded (Fynes et al., 2004, Holweg et al., 2005). There are two opposing viewpoints exist regarding the effect of environmental uncertainty on exchange relationships. Pfeffer and Salancik (2003) posit that when faced with high uncertainty, firms will coordinate their activities more closely in an attempt to reduce uncertainty. While the other stream of literature, based on transaction cost economics, argues that firms attempt to maximize their flexibility in uncertain environments by reducing their reliance on inter-firm relationships (Heide and Miner, 1992). Transaction cost theory also supports the idea that integration or quasi-integration may be due to uncertainty in the environment (Williamson, 1985).

Furthermore, the failure to foresee pertinent contingencies in uncertain environments creates difficulties for a focal firm in coordinating the relationships with its suppliers, this negatively affects the focal firm's ability to assess supplier performance (Williamson, 1985). Since superior partnership quality may involve excessive and often blind reliance on external information gathered by the exchange partners, as uncertainty limits the information

processing capability of partners, inaccurate and incomplete information may result in sub-optimal decision making (Srinivasan et al., 2011). The need to integrate is enhanced in situations where there is uncertainty, either behavioral or due to changes in the environment-demand uncertainty may take either form, where customers act in a self-interest seeking manner (Fynes et al., 2004).

To the extent that environmental uncertainty leads to communication and monitoring distortions, it may have significant negative influence on partnership quality-supply chain performance relationship (Srinivasan et al., 2011). Conversely, in a more stable environment it may be easier for the focal firms to exchange information, evaluate supplier performance, and gauge the relevance of mutual organizational objectives (Srinivasan et al., 2011). Thus, Wong and his colleagues (2011) posit that, under a high environmental uncertainty, the associations between internal integration and delivery performance and production flexibility will not be strengthened, but those between supplier and customer integration, and delivery performance and production flexibility, will be strengthened.

Reliance on a partner without proper checks may also cause strategic blindness which constrains the ability to scan the external environment effectively and efficiently (McEvily et al., 2003). Firms with newer technologies undergoing rapid change are expected to benefit more from positive supply chain relationships than those with stable technologies (Slater and Narver, 1994). The model of this study is illustrated in Figure 2.

H5: The environmental uncertainty has a moderating effect on the relationship between the partnership quality and the supply chain performance.

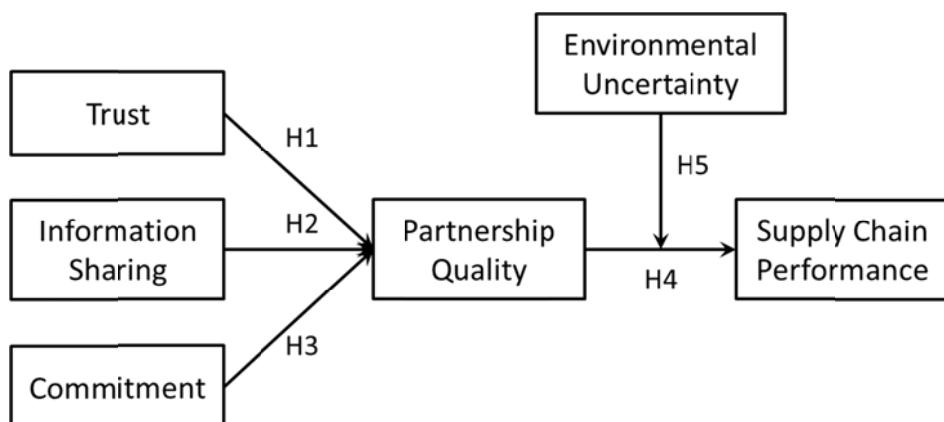


Figure 2 The Hypotheses Model

Cross Cultural Comparison

According to Hofstede (1991), culture is the collective programming of the mind, which distinguishes the members of one group from another. Our day-to-day business activities are

being influenced by culture differences especially across nations. A particular partnerships antecedent for partnerships might work in particular country while it is doomed to fail in another. It is necessary to conduct a cross-cultural comparison between two different countries (Taiwan and the Gambia) to find out whether similarities or differences in regards to the culture dimensions will reflect on the partnership development. One of the reasons why so many antecedents do not work or cannot be implemented is because differences I thinking among the partners cultural values have been ignored (Hofstede and Hofstede, 2005). We will first need to familiarize with each country's ranking and scores about dimensions culture, which we would use in the discussion section.

It is noted that Gambia is not listed directly as a country among the index but is well presented by West Africa because Gambia is located in the West coast of Africa. Firstly looking at power distance, Taiwan is rank 43 to 44 on the PDI index while West Africa ranks 17-18. Social relationships should be handle with care if there is small power distance, status should be balance with restraint (Hofstede, 2007). In terms of individualism and collectivism (IDV), both countries close enough with ranks 64 for Taiwan and 56-61 for West African. People in individualist cultures have a greater sense of privacy (Schumann et al., 2012) Taiwan and West Africa are also close in terms of masculinity and femininity (MAS). These countries both live in a more masculine society. However, in a masculine society described as, challenge, earning, recognition and advancement are important while relationship and quality of life are important for feminine societies.

In terms of uncertainty avoidance, Taiwan has more uncertainty avoidance than Gambia but with a difference of just 13 in rank. The cultural value with the strongest effect on the motivation to provide information is uncertainty avoidance (Schumann et al., 2012). Taiwan and Gambia are very close only in terms of individualism and collectivism, masculinity and femininity which have been proven in (Schumann et al., 2012)

METHODOLOGY

The main discussion of the literature review emphasizes the moderating role of environmental uncertainty to buyer supplier partnership quality and supply chain performance and the antecedence of buyer-supplier partnership quality. The antecedent consists of three indictors (Information sharing, trust and commitment) to buyer and supplier partnership quality. The research model will examine the relationships among these model elements.

After the pilot study, the official questionnaire was set up. The survey was posted online via survey monkey for easy distribution to Gambian and Taiwanese procurement officials. The Taiwanese demographics include EMBA students enrolled in Yuan Ze University and procurement officials. The method used to send the survey was via facebook, personal

massages with the link sent to Gambians through Facebook. The total number of respondents sent to the link was 147. The data collection period for Gambia range from 15th July to 13th October and the number of responses collected within this period was 72 with responses rate at 48.97%. The survey was downloaded in to excel format for analysis.

For Taiwanese survey, a link was created of which was divided two for EMBA students respondent from Yuan Ze University and others via Facebook. The total number of responses received for Taiwan is 75 and four items were deleted due to invalidity. The data collection period for Taiwan ranged from September 17th 2014 to November 10th 2014.

As all data were been collected, we adopted the software Statistical Package for Social Science (SPSS 15.0) and Partial least square Model (PLS Graphics 2.0) software to make sophisticated analysis of our data. Firstly, we use SPSS 15.0 in descriptive analysis to illustrate basic data including the means, frequencies, and other descriptive statistics about the information of the respondents. Secondly, we use PLS which is the most appropriate method for this study because of relatively small sample size. Furthermore, Smart PLS was used to examine the hypothesized relationships in the structure model. The reliability and validity and the structural model of supply chain performance assessed the measurement model.

Reliability analysis used to make sure of the stability and consistency of the measuring instruments. Cronbach's alpha coefficient is mostly adopted for testing of consistency reliability (Cronbach, 1951). According to Guilford (1942), it is highly accepted when Cronbach's alpha is over 0.7, acceptable when the value is 0.35~0.7, and must be rejected when the value is lower than 0.35.

RESULTS

Descriptive Statistics of Taiwan

The information includes age, type of organizations, number of closet suppliers, number of employees and organizational capital. The total number of responses analysis is 71, and four questions deleted because of invalid responses. The majority of respondents are aged between the 35 to 44 accounts of 25.4%. The type of organizational majority are from manufacturing which accounts for 52.1% , closest number of suppliers accounts for 39.4% .The majority of the respondents have more than 251 employees which accounts for 60.6% Finally the capital of organization majority of the respondents are from small organization of less than \$2,000,0000 of 39.4%.

Scale reliability

The internal reliability was by means of Cronbach's alpha coefficient and composite reliability. The Cronbach's alpha coefficients of all constructs are all over the appropriate

level of 0.7, ranging from 0.75 to 0.86, which indicate the high internal consistency of measure of reliability (Nunnally and Bernstein, 1978). Furthermore, the value of composite reliability also all over the appropriate level of 0.7, ranging from 0.84 to 0.89 that indicated the measurement was reliable.

Validity Analysis

The questionnaire items used in this study were based on previous literatures and scales were being modified to suit the purpose of this study. Based on this, the measurement of this study has content validity. The convergent validity was measured by average variance extracted (AVE), the ratio of the construct variance to the total variance among indicators. The values of AVE for six constructs all exceed 0.5, which demonstrated satisfactory convergent validity of measures and meet the requirements (Hair Jr. et al., 2006). To ensure convergent validity and to the assumptions, 16 of the lowest loading variables were deleted before it meets the assumptions.

Discriminant validity is the extent to which a construct is truly distinct from the other constructs. High discriminant validity provides evidences that a construct is unique and captures some phenomena that other measures do not (Hair Jr. et al., 2006). The examination of discriminant validity in this study was by identifying the square root value of AVE and correlations among constructs. Correlation of constructs of matrix is the square root value of the average variance extracted. For adequate discriminant validity, diagonal elements should be greater than corresponding off-diagonal elements.

The Structural Model and Moderation Analysis Results

After conducting the confirmation factor analysis and all criteria being met, we then move on to the structural model and moderation analysis. This part includes examining the indices of the path analysis as well the hypothesis testing which includes the moderation effect. The results of the PLS estimate the antecedence of partnership quality and the relationship between partnership quality and finally the moderation of environmental uncertainty. We used the bootstrap technique of PLS to determine the significant paths on the hypothesized relationship. For the first hypothesis, which is the level of trust between buyer and supplier has a positive impact on partnership quality is confirm (path coefficient =0.38, $t= 6.74$, $p>0.001$) which means H1 was supported. The level of information sharing between buyer and supplier has a positive impact on partnership quality is not significant (path coefficient =0.04 $t=0.83$ $p>0.05$) which means H2 was not supported; but it is leading to the predicted direction of our hypothesis, although the Taiwan have a medium-strong desire for uncertainty avoidance (Hofstede and Hofstede, 2005). According to Schumann and his colleagues (2012),

people in high uncertainty avoidance cultures have a generally higher level of anxiety and feel threatened by unknown situations. Therefore, they are more reluctant to provide information. This sense should be particularly pronounced when they are uncertain of what a firm will do with their information (Schumann et al., 2012).

The level of commitment between buyer and supplier has a positive impact on partnership quality is confirmed (path coefficient =0.24, $t=3.87$, $p<0.001$) H3 is supported, from the results the Taiwanese perceive that forming a partnership relationship between buyers and suppliers trust and commitment are the most important antecedents. The level of buyer and supplier partnership quality has a positive impact on the supply chain performance (path coefficient =0.34, $t=3.23$, $p<0.001$) H4 is supported. Finally, the environmental uncertainty has a moderating effect on the relationship between the partnership quality and the supply chain performance (path coefficient =0.22, $t=1.33$, $p>0.05$) is not significant which represent H5 not supported. These t-values respectively are all significant at $p> 0.001$ confidence levels. Based on the above discussion 3 hypotheses were supported which are H1, H3, and H4, Taiwanese results reveals information sharing is important but less willing to share information basically majority of the respondents are from small organization based on the respondent's demography. Table 1 contains the detailed information of significant and insignificant hypotheses.

Table 1 Hypothesis Testing—Taiwan

Path / Hypotheses		Path Coefficient	t-test	Results	P-value
Hypothesized Relationships					
Trust→Partnership Quality	H1	0.389425	6.7440***	Supported	< 0.001
Information Sharing→Partnership Quality	H2	0.044381	0.8348	Not supported	0.203
Commitment→Partnership Quality	H3	0.243878	3.8700***	Supported	<0.001
Partnership Quality→Supply Chain Performance	H4	0.346342	3.2306***	Supported	<0.001
Partnership Quality * Environmental Uncertainty→ Supply Chain Performance	H5	0.223054	1.3352	Not supported	0.093.

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

This study assessed the model fit of the proposed structural model by an evaluation of R-square, followed by a bootstrapping 300 resampling procedure to test the proposed hypotheses using t-tests. There are two hypotheses (H2, H5) are not significant, tested

significant hypotheses are H1, H3, H4. The table of hypothesis testing of Taiwan on the appendix contains the detailed information of significant and insignificant hypotheses.

Descriptive Statistics of the Gambia

The information includes age, type of organizations, number of closest suppliers, number of employees and organizational capital. The total number of responses analysis is 72. The majority of respondent between ages the 25 to 34 account for 61.10%. The organizational type the majority of the respondents are from others which accounts for 43.10%, the closest suppliers the majority of the respondent have 30 or fewer closest suppliers accounting for 52.80%. . The majority of the respondents have number 50 employees or fewer, which accounts for 38.90%. Final the capital of organization the majority of the respondents are from small organization of less than \$2, 000, 0000 accounts for 34.70%.

Scale Reliability

The internal reliability was by means of Cronbach's alpha coefficient and composite reliability. The Cronbach's alpha coefficients of all constructs are all over the appropriate level of 0.7, ranging from 0.46 to 0.83, it is highly accepted when Cronbach's alpha is over 0.7, acceptable when the value is 0.35~0.7, and must be rejected when the value is lower than 0.35 (Guilford, 1942), which indicate the high internal consistency of measure of reliability. Furthermore, the value of composite reliability also all over the appropriate level of 0.7, ranging from 0.84 to 0.89 that indicated the measurement was reliable. The appendix shows the details statistics of the confirmation factor analysis for the Gambia.

Structural Model and Moderation analysis Results of The Gambia

After conducting our CFA and AVE all criteria been met, we then move on to the structural model and moderation analysis. This part includes examining the indices of model fit as well as the results of hypothesis testing. We used the bootstrap technique of PLS to determine the significant paths on the hypothesized relationship. The results of the PLS estimate the antecedence of partnership quality and the relationship between partnership quality and finally the moderation of environmental uncertainty. For the first hypothesis, which is the level of trust between buyer and supplier has a positive impact on partnership quality (path coefficient=0.015, t=0.270, p>0.05) which means H1 was unsupported. According to Hofstede and Hofstede (2005) cultural dimension West African was rank 56 as a collectivist culture that provides insights why organizations from collectivist cultures like the Gambia have lower levels of trust, particularly for external partners. As Triandis (1995) note, individuals from collectivist societies are acculturated to have less trusting attitudes and

behaviors toward out-group than in-group members. This makes it difficult to develop trusting relationships with external partners.

When they must develop relationships with outsiders, collectivists take great time and care to evaluate a partner and nurture the relationship so that the outsider can essentially be brought into their in-group. This process, is as a result of an initial lack of trust, may save transaction costs that could come from a partner's opportunistic behavior, but it increases transaction costs needed to develop the relationship, and limits opportunities that could come if trust were higher to begin with (Hardin, 1992, Yamagishi et al., 1998). Also in *Ex ante*, in an environment fraught with uncertainty the parties to the exchange finds it difficult to develop long lasting and trusting relationships as such relationships involve mutual commitment and drafting, negotiating and monitoring complex contracts (Williamson, 2008).

The level of information sharing between buyer and supplier has a positive impact on partnership quality as significant (path coefficient =0.413 t=8.44 p>0.001) which means H2 was supported. The level of commitment between buyer suppliers has a positive impact on partnership quality is confirm (path coefficient=0.230, t=3.801, p>0.001) H3 is supported; from the results the Gambian results indicate that information sharing and commitment most important antecedents to partnership quality. The level of buyer and supplier partnership quality has a positive impact on the supply chain performance (path coefficient= 0.293, t= 4.393, p<0.001) H4 is supported. Finally, the environmental uncertainty has a moderating effect on the relationship between the partnership quality and supply chain performance, (path coefficient =-0.191, t= -6.434, p<0.001) is significant which represent H5 was supported, similarly O'Leary-Kelly and Flores (2002) found positive relationships between marketing/sales planning decision integration and firm performance under a high, but not a low environmental uncertainty. The implication for management is that, regardless of the level of technological uncertainty, companies need to invest in effective supply chain relationships in order to commit and share information. These t-values respectively are all significant at the p< 0.001 confidence levels. Based on the above discussion four hypotheses were supported which are H2, H3, H4 and H5, Gambian results may indicate that trust not important antecedents for forming partnership with suppliers. Table 2 contains the detailed information of significant and insignificant hypotheses.

Table 2 Hypothesis Testing—Gambia

Path / Hypotheses		Path Coefficient	t-test	Results	P-value
Hypothesized Relationships					
Trust→Partnership Quality	H1	0.0159	0.2709	Not supported	0.393

Information Sharing→Partnership Quality	H2	0.4139	8.4433***	Supported	<0.001
Commitment→Partnership Quality	H3	0.2304	3.8015***	Supported	<0.001
Partnership Quality→Supply Chain Performance	H4	0.2934	4.393***	Supported	<0.001
Partnership Quality * Environmental Uncertainty→ Supply Chain Performance	H5	-0.191	-6.434***	Supported	<0.001
*p<0.05, **p<0.01, ***p<0.001					

This study assessed the model fit of the proposed structural model by an evaluation of R-square, followed by a bootstrapping 300 resampling procedure to test the proposed hypotheses using t-tests. There is one only hypothesis H1 insignificant tested, significant hypotheses are H2, H3, H4, and H5. The hypothesis testing table in the appendix provides a detailed information of significant and insignificants hypotheses.

Hypotheses Comparison of Taiwan and Gambian

The comparison between The Gambia and Taiwan are based on the hypotheses testing on the similarity and the difference. In terms of hypotheses, it can be notice that some of the hypotheses testing for Taiwan are the same as that of the Gambia while others are significantly different. The hypothesis trust was supported for Taiwan while it was not supported for the Gambia. The hypothesis information sharing was supported for the Gambia while it was not supported for Taiwan but in the same direction as predicted as already mention early in Hofstede cultural dimension (Hofstede and Hofstede, 2005), Taiwan is ranked 39 in the uncertainty avoidance higher than Gambia is ranked 52. The Gambians lack trust in the initial stage of any relationship and prefer nurturing the relationship with sharing information to know the partner before building trust. However it may save transaction costs that could come from a partner's opportunistic behavior in high volatile environment, and limits opportunities risk that could come if trust were higher to begin with.

On the other hand Taiwanese are different because trust is the most important indicator foster long term relationship, which means that they initially build trust with their partners before sharing propriety information. However, they are more concern about the information security and how the information shared would be used for. Results from both countries indicate commitment important for partnership quality and that partnership quality leads to high supply chain performance. In term of the moderating effect, environmental uncertainty has no moderation effect on the relationship between partnership quality and supply chain

performance in Taiwan, which might indicate the Taiwan's environment is more stable and conducive for high partnership quality and better supply chain performance.

While in the Gambian results show there was high moderating effect of environmental uncertainty negatively weakening the relationship between buyer and supplier and supply chain performance. After analysis both results of Taiwan and Gambia, brings us to conclusion that though these countries share similarities in some aspects, but still encompass differences in other areas and hence the same concept cannot be fully adapted in both countries.

DISCUSSION AND CONCLUSION

Research Conclusions

In the beginning, supply chain performance model adopted and modified to become antecedence of partnership quality and supply chain performance model based on the past literatures. The research model was designed to specifically investigate three specific questions and is examined in this study, (1) the most important antecedents for partnership quality for the Gambia and Taiwan. (2) Relationship between supply chain performance and partnership quality in both countries; (3) the influence of environmental uncertainty on the relationship of partnership quality and supply chain performance. These two studies show similarities in antecedents of partnership quality which is commitment to suppliers. However, the difference of antecedence varies from country to country, Taiwanese respondent perceived trust and commitment important, while information sharing insignificant, but leading to prediction. On the same way, the Gambian respondents perceived information sharing and commitment has positive impact on partnership quality.

The second findings that partnership quality perceived by all that it leads to high and positive supply chain performance in both countries, which significant results confirms our prediction. The study of Gambia reveals high negative moderating effect of environment uncertainty negatively weakening the relationship of partnership quality and supply chain performance however no moderating effect of EU on the relationship in Taiwan's study. This study also brought to attention that environmental uncertainty could negatively influence the relationship between partnership quality and supply chain performance, in that way pressured firms to form close partnership in order to reduce the hazards from the environment. These results provide insights for companies to increase their partnership quality with other companies, and suggest the positive relationship between partnership quality and supply chain performance.

Contribution and Implications

Academic Contributions

Previous research of buyer-supplier partnership quality and supply chain performance: moderating role of risk and environmental uncertainty, antecedences of partnership quality were not included in their model. However in our model three antecedences trust, information sharing and commitment added to examine partnership quality. The results of the Gambian study show that information sharing, and commitment are most significant, and trust was not significant. While comparing Taiwan's study results show that information sharing and commitment significant and considered important antecedents for partnership quality.

Previous research found environmental uncertainty negatively significant moderation and weakening the relationship between partnership quality and supply chain performance. Comparing to our study, we found similar results, significant negatively moderation of environmental uncertainty weakening the relationship between partnership quality and supply chain performance in the Gambian. On the other hand the study of Taiwan shows no significant moderation of environmental uncertainty on the relationship between partnership quality and supply chain performance. This study also highlighted the role of antecedences in comparison which antecedences most vital in forming partnership in these two countries which share some cultures values and different in many ways. These countries are different economically, market size based on the population, and environmental condition. The Gambia is an underdeveloped country and its economy is characterized as traditional subsistence agriculture and huge dependence on tourism industry with a stunted growth of manufacturing sector. Gambian population is smaller compare to Taiwan. Comparing Taiwan to Gambia, Taiwan is a developed country and its economy is characterized as industrialized, where majority of its industries are concentrated in ICT industry, chemical industry, metal and machinery and consumer good. Taiwan's business environment is much more stable and conducive for expansion of businesses partnership strategy than the Gambia.

Managerial Implications

It is vitally important for managers to consider the ways in which they could improve their partnership quality of firm. Furthermore, this study also offers a roadmap for companies to expand their markets into other countries. Both trust and commitment stimulates a relational bond between suppliers and buyers. Therefore, managers look for ways in which they can increase the levels of trust and commitment in their supply chain partners. Building the trust and open culture are needed in a slow and difficult process (Fawcett et al., 2009). Information availability plays a positive role in building trust, and subsequent commitment. While information sharing affects commitment in supply chain partners, in the same way managers

should make an effort to reassess, and weigh the risks and benefits, of making certain information available to other firms within the supply chain. The supply chain partners should also understand that uncertainty arising from the business environment may negatively impact the performance of their supply chain partnership. Appropriate measures should be taken by the managers, such as proactive environmental scanning, or proactive planning to create a more stable environment, since it may be easier for the focal firms to collaborate and coordinate in such an environment leading to enhanced effectiveness of the partnership quality.

Managers should be carefully when adopting partnership strategy from different culture, they should therefore note collectivist societies are acculturated to have less trusting attitudes and behaviors toward out-group than in-group members. This makes it difficult to develop trusting relationships with external partners (Triandis, 1995). That is to say, managers in Taiwan should be careful about adopting partnership strategy which notes that Taiwanese buyers are more concerned about building trust and commitment before sharing information. Because of the different results between Gambia and Taiwan, managers are suggested to localize partnership strategy to conform to cultural values.

Limitations and Future Research Directions

One limitation of this research is that data collection method was based as the survey link sent via Facebook and hence most people seldom log into their Facebook account. Secondly the small sample size ($n=143$) used for this study is another limitation, particularly negatively effects on the results. Further research could do a study of this model in other geographical spaces or of other nationalities to further test if the model is applied to. In addition, we think future research could consider adding more antecedents, such as forecasting, mutual benefit and risk sharing for partnership quality.

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SUPERIOR SUPPLY CHAIN PERFORMANCE BY CLOUD COMPUTING: LESSONS LEARNED FROM SCM WORLD

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ABSTRACT

In any supply chain companies to achieve their upside potential, more efficient means of collaboration, communication, shared risk and orchestration are needed. Information technology (IT) refers to the use of computer-based programs to store and manipulate information. IT advances directly can correlate to supply chain management improvements, such as through the rise of effective virtual supply chains. Supply chain information collaboration system bases on cloud computing technology provides efficient supply chain information system like software as a service (SaaS), platform as a service (PaaS) and infrastructure as a service (IaaS). With the availability at anytime and anywhere cloud services provide sharing of resources of its services to Supply Chain. We discuss the basic idea of cloud computing to provide an efficient and scalable solution for Supply Chain Management (SCM) and also give real-world examples of application and highlight some vendors who provide cloud computing for SCM.

KEYWORDS: Supply chain management, cloud computing, performance improvement

INTRODUCTION

Supply Chain activities cover everything from product development, sourcing, production, and logistics, as well as the information systems needed to coordinate these activities [6]. According to the National Institute of Standards and Technology (NIST), Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction [4].

Cloud computing mainly refers to network-based services. Some virtual server serves up real server hardware so that the program can run on one or more real machines. Such virtual servers

do not physically exist and can therefore be moved around and scaled up (or down) on the fly without affecting the end user.

In the increasingly competitive business world, efficiency becomes one of the crucial keys to success. Consumers want their products arrive as early as possible without mistakes, and firms also need to track goods in a timely manner. Business intelligence and data analytics are becoming more important in today's business, but cloud computing is a tool for information that is up-to-date and accessible. According to North Dakota Information Technology Department [5], "Information Technology means the use of hardware, software, services, and supporting infrastructure to manage and deliver information using voice, data, and video."

Information in a Supply Chain can only be useful when it is accurate, accessible, right and shared. All of these characteristics can be realized based on Cloud Computing. For example, inventory information can be stored on a cloud server, and any warehouse or offices would access to those information accurately and immediately. It makes supply chain more centralized and consolidated. Also, each warehouse can update the inventory information instantaneously. Sharing data helps avoid misunderstanding and information asymmetry, so that supply chain managers can make adjustments accordingly, especially for international companies who need to manage factories and warehouses in remote locations.

Example: UPS Order WatchSM

In early 2013, UPS introduced their new cloud-based technology platform UPS Order WatchSM. UPS Order Watch uses scalable cloud based supply management technologies to enable better streamlining of the management of vendors, but also manage all of the inbound shipments via a single platform. In addition, UPS order watch will create efficiencies in ocean freight shipments by improving container usage which translates to cost savings. Lastly, UPS Order Watch will send alerts to help enable vendor adherence to customer requirements and provide approvals online [8, 7]

Other features includes greater accuracy and timeliness of overseas vendor bookings; improved processing and management of suppliers; automated exception management; near real-time shipment status and detailed line-level visibility of in-transit inventory; improved internal operational processes; and facilitation of purchase order (PO) consolidation and optimized shipping plans.

Risk of IT Adoption

IT in supply chain management seems a powerful tool to improve efficiency, save costs, enhance service level. However, IT could also bring risks to supply chain management and no exception for cloud computing. Since we are in a "big data" era, business heavily relies on data collection and analysis. In order to get more convenient data access and real-time information, more companies use cloud computing to store data. It should be our concern if the development of cloud computing would be in the same pace with data increase. How do we deal with information congestion? In the old time, supply chain management needs to tackle with uncertainties of customer demands, but what IT could bring even bigger and more challenging uncertainties.

In the following Section 2, we provide an overview of the significance of cloud computing in the SCM and how supply chain performance could be improved by means of cloud computing.

Furthermore, the paper also provides specific areas in the SCM that are easily adoptable to cloud computing.

SIGNIFICANCE OF CLOUD IN THE SCM

In the modern world companies are investigating ways to optimize both cost and operational efficiency of each phase of their supply chain, such as planning and forecasting, sourcing and procurement, logistics and service and spare parts management. We may define Supply Chain Management (SCM) as the "design, planning, execution, control, and monitoring of supply chain activities with the objective of creating net value, building a competitive advantage, leveraging worldwide logistics, synchronizing supply with demand and measuring performance globally."⁷ Recent development in technologies enables the organization to make information easily available in their premises. These technologies are helpful to coordinate the activities to manage the supply chain. SCM, then, is the active management of supply chain activities to maximize customer value and achieve a sustainable competitive advantage.

It represents a conscious effort by the supply chain firms to develop and run supply chains in the most effective and efficient ways possible [6]. Cloud computing emerges as a useful technology that contributes to this optimization by providing infrastructure, platform and software solutions for the whole supply chain via Internet. The utilization of cloud-based services in the SCM leads to both financial and operational benefits. Lower cost in contrast to on-premises infrastructure costs, supply chain visibility, platform scalability and flexibility through supply chain partners' collaboration are some notable examples. Cloud computing is a term, which involves virtualization, distributed computing, networking and web services. Cloud computing or a Cloud can be defined as "a type of parallel and distributed system consisting of a collection of interconnected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service level agreements established through negotiation between the service provider and consumers" [2]. Cloud consists of several elements such as clients, data center and distributed servers. It includes fault tolerance, high availability, scalability, flexibility, reduced overhead for users, reduced cost of ownership, on demand services etc. Main advantage of cloud-based systems is their simplification.

Cloud eliminates the compatibility problem using the same platform access and provides easy connection to every part of the supply chain. It enables supply chain information collaboration between partners on one and the same supply chain. Members of the supply chain can enter into the collaborative environment of the cloud using member ID and password. After that, all users are authorized to operate in a simple process and application on the same platform, which reduces response time of supply chain partners. Another benefit is the visibility which provides timely connectivity along multiple supply chain participants. Therefore, visibility is a key issue for SCM as it does not only helps such companies to coordinate their operations and manage many different customers, but also allows the customer network to have a transparent view of the entire system. Cloud-based systems are able to provide real time visibility of inventory and shipments and improve logistics tracking. By using cloud computing, companies can control their system capacity more accurately. In periods where demand is high, companies need enough capacity in order to be able to face this increasing demand. Consequently, using common on-premises systems, they should own the necessary database for the whole year in order to respond to the

excessive demand just for a short period. However, with the advent of cloud technology, companies are given the opportunity to adjust their capacity automatically according to their needs and scale their computing power depending on demand fluctuations [6].

So that, in cloud computing, the application of supply chain is innovative and generate a new field of research. Two or more parties are linked by cloud services in cloud supply chain to provision cloud services, related information and funds [6].

A. Forecasting and planning

Cloud-based platforms are going to help companies to improve their service levels by collaborating the chain's partners (retailers, suppliers and distributors) that are playing a major role in demand forecasting. These cloud-based platforms get the data from Internet and perform basic operation like analytics as well as perform more accurate demand forecast for all supply chain partners. This will help the chain partners to be aware in case there is a volatility of real demand, and they can handle it easily.

B. Source and procurement

Sourcing includes acquisition, receipt and inspection of incoming materials as well as procurement process. Cloud-based platform operate on database that contains multiple data from different suppliers and can provide efficient and different benefit for companies that handle thousands of them. On the other hand, companies are able to select between suppliers that are able to provide appropriate margin of their specification within time. Cloud-based tools also enable companies and suppliers to mutually develop contracts and enhance contract management.

C. Inventory Management Using Wireless Devices

Inventory management is enhanced by many organization using bar coding technologies and wireless services. RFID system integrates with the cloud-based centralized data management system to deliver the global identification and tracking of any items or goods across the global supply chain management lifecycle [1].

D. Collaborative Design and Product Development

Along with the development of Information Technology, Internet network transmission technology is maturing gradually, its security, stability, compatibility is constantly improved, and all application range is expanding continually [3]. Collaborative product development includes the use of product design and development techniques across multiple branches of the same organization or between different organizations. All the development process is shared over secure network between different organizations. These processes include specific information, test result and design changes as well as customer feedback.

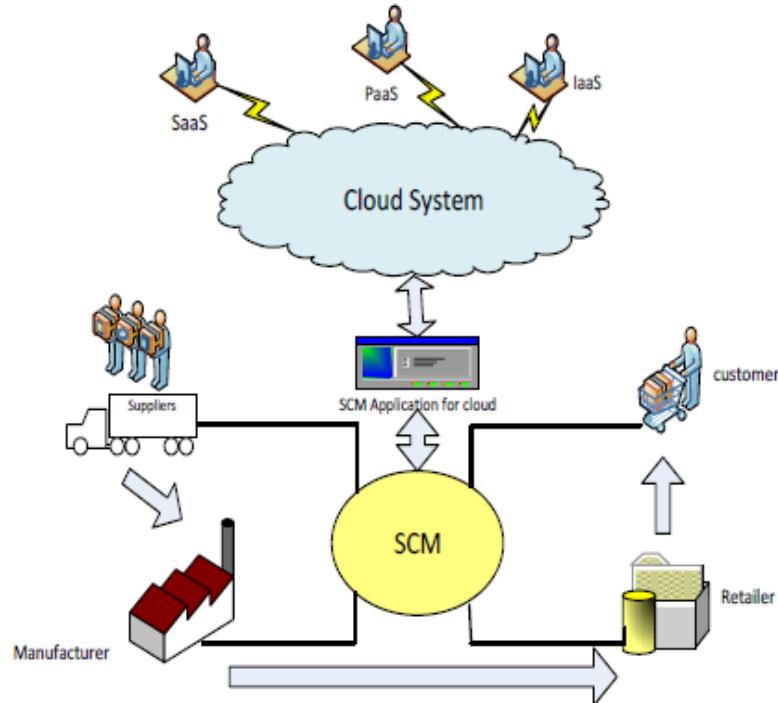


Fig. 1 SCM architecture in cloud computing [6]

E. Logistics management

Logistics involves process of material acquisition, warehousing and transportation process. Logistics information management system keeps track on inventory information by using logistic management under cloud and gives the following benefits:

1) On demand self-service

Consumers can have parallel requests and use computing capabilities without any human interaction with their service provider. Here Internet access allows users to consume computing capabilities by means of client's platforms like mobile phones, note books or PCs.

2) Resource Pooling

In order to fulfill the demand from multiple consumers, the cloud computing service providers pooled their resources. The provider dynamically assigns or reassigns physical or virtual resources to consumers. Consumers on the other hand have no knowledge about the resource location which is assigned to consumers.

3) Elasticity

In cloud computing it is the ability of providers to quickly add and release the resources as soon as possible to match changes in consumers demand. This should be done in efficient manner.

4) Scalability

Scalability means that a system “maintains its performance goals/SLAs even when its workload increases (up to a certain workload bound).” Whereas an elastic system dynamically adds or releases more resources when service demand increase or decreases respectively. So elasticity adds dynamic component to scalability.

SUPPLY CHAIN PERFORMANCE IMPROVEMENT WITH CLOUD COMPUTING APPLICATIONS

Cloud computing system uses lot of technology like standardization technology, virtualization technology, data management technology and platform management technology in supply chain information collaboration. Flexibility is great power of cloud computing system. It has the ability to increase or decrease computing power as required by users. This term is referred as scalability. Scalability ensures that computing services available to the users at any point in time. Scalability is highly concern issue in supply chain management system. Because supply chain is distributed in nature and each firm wants to grow its supply and distribution, there should be need to scale IT services of supply chain at big level. Distributed datacenter provide better bandwidth and traffic for supply chain users in cloud.

Cloud provide on demand services by which a supply chain user use when required. The firm or company which is using supply chain has different branches in different geographical regions like Asia, Europe and North America. If the supply chain of any firm is distributed globally then it requires a distinct infrastructure of cloud for each of its branches. Information sharing must be reliable and secure between different supply chain users so there is a need of its own private cloud system. In private cloud information sharing has done reliable and secure way. So besides using a centralized cloud data center, a company or firm should use distributed data center under private cloud circumstances. Using distributed data center under private cloud has fallowing benefits over the centralized one.

A. Efficiency

Centralized system takes request from users globally which create more loads on servers. So there will be a chance of increment in latency. This will create time delay between request and response. On the other hand, local datacenter under distributed cloud environment gives more fast response to their users.

B. Scalability

A system would be scalable if a cloud gives least amount of latencies during information sharing and collaboration between two or more users.

C. Security

In private cloud the firm creates its security policy according to their own requirement. If it is distributed then policy has great effect due to their regional information sharing policy. A single supply chain company can use different security policy for different users in different regions.

A recent study authored by SCM World titled “Supply chain and the future of applications” provides several interesting insights into how cloud computing applications and platforms are

improving supply chain performance. The methodology is based on a combination of qualitative interviews and data analysis to break the question of cloud applications down with an eye to simplifying the issue for operational leaders. The sampling frame is SCM World members globally.

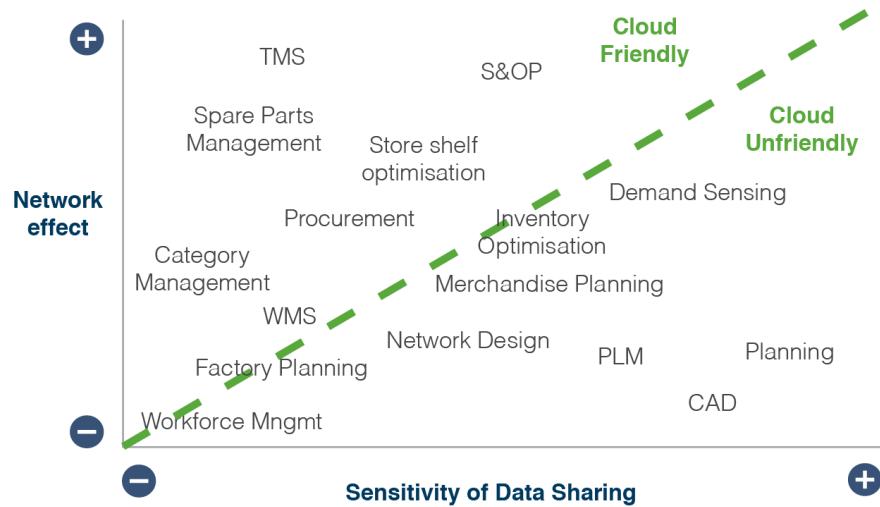
SCM World is the leading global community of senior supply chain professionals with over 150 companies participating and contributing, including P&G, General Mills GIS +0.42%, Nestlé, Samsung, Lenovo, Nike, Walgreens, Merck Merck, Jaguar Land Rover, Raytheon RTN +0.62%, Chevron CVX +0.38%, BASF, GlaxoSmithKline, Intel and AT&T.

Key Take-Aways:

Sales & Operations Planning (S&OP), Transportation Management Systems (TMS), Spare Parts Management and Store Shelf Optimization are the four supply chain strategies that are the most cloud-friendly and have the greatest potential to deliver the network effect throughout a supply chain. The following analysis compares the relative contributions of the network effect versus the sensitivity of data sharing. According to the report, “the network effect is maximized for functions that are best served when a large number of suppliers and/ or customers benefit from rapid access to information that can streamline business.”

Cloud computing adoption in the supply chains is heavily dependent on the legacy ERP systems in place, as they provide the system of record corporate-wide. 56% of survey respondents have standardized on SAP ERP systems followed by Oracle (including PeopleSoft & JD Edwards) 16% and the remainder being multiple ERP systems. 7% of respondents don’t have an ERP system today. The report notes that the technology stacks of respondent companies attempting to migrate to the cloud have been developed and deployed in layers and is generally hard to modify in response to changing business conditions. Applications in these stacks include specialty tools including transportation systems (TMS), warehouse management systems (WMS), etc.

Supply chain in the cloud: where to start



Source: SCM World

Fig. 2 Supply Chain in the Cloud

ERP Systems used by SCM World members

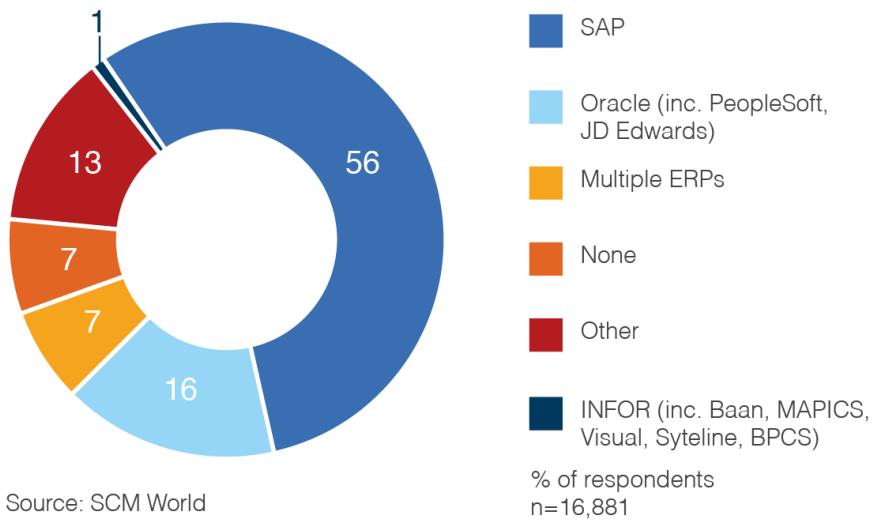
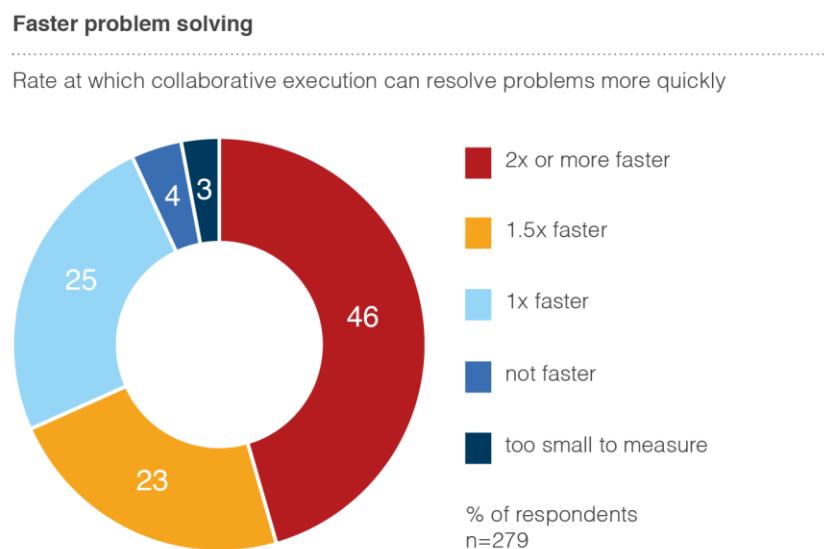


Fig. 3 ERP systems used by SCM World members

- Companies continue to lean on their IT departments to do more with less. Reality is that IT departments are focused on maintenance of existing systems and infrastructure and only allocate, on average, about 11% of their budget to new applications.
- Only 12% of enterprises have “extensive” communications with their network, while over a quarter are still relying on emails, phone calls and faxes. The study uses a case study based on The Limited which is a large apparel retailer based in the Midwest of the United States to show why more agile, real-time communication throughout a supply chain is essential for growth.
- The majority of suppliers (60%) have a moderate level of collaborative execution with Electronic Data Interchange (EDI) and other automatic/scheduled communications being commonplace. A leading global heavy equipment manufacturer had been managing their multi-billion dollar business emails, faxes and phone calls. This manufacturer chose GT Nexus to create a platform for all the carriers in their network to send their EDI messages, which significantly improved visibility across their \$500M per day of in-transit inventory.
- On-boarding new trade partners continues to be problematic for the majority of supply chain organizations with less than 30% of a recent survey of 374 respondents claiming they had no problems “connecting or on-boarding new trade partners.” The report concludes that with greater electronic integration, the many benefits of the network effect will be gained across global supplier networks.
- 46% of respondents report that greater supply chain collaboration leads to problems being solved twice as fast. Cloud computing platforms are becoming more pervasive in large-scale supply chains as enterprises look to gain agility and speed in resolving complex problems through more effective collaboration.



Source: SCM World Survey, March 2012

Fig. 4 Faster problem solving

We feel important to give here an example of cloud computing for SCM by IBM.

Example: IBM use of cloud computing in supply chain

IBM offers cloud solutions for supply chain including IBM Demand Tec Deal Management, IBM Sterling Transportation Management, IBM Sterling Supply Chain Visibility, IBM Sterling Supplier Portal, IBM Sterling B2B Collaboration Network and IBM Analytic Answers.

IBM Sterling Supply Chain Visibility is a cloud-based solution that optimizes inbound supply and outbound fulfillment processes across the supply chain network through real-time with end-to-end visibility. [9]

CONCLUSIONS

Initially supply chain companies start using cloud computing for using cloud services. Various infrastructures of cloud is available, but need to be explored fully. In this paper we present how supply chain can adopt the cloud computing for cloud services and also discuss the potentials of the architecture of distributed cloud datacenter comparing to the centralized cloud datacenter which gives more efficient and scalable infrastructure for supply chain users and partners resided in different regions. This type of architecture will best suit for information tracing or sharing highly used for forecasting and logistics management of the supply chain. Therefore, companies who are willing to improve their services of information collaboration and want to scale up their services at high level can use a distributed cloud datacenter [6].

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TEACHING CONCEPT-BASED SUSTAINABLE ARCHITECTURAL DESIGN

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ABSTRACT

A “concept-based” type of approach to sustainable design implies a systems integration viewpoint within which interdependencies and feedback loops between different systems are harnessed to achieve a coherent, high performing, whole building.

The paper discusses a sustainability capstone-level coursework sequence for Master of Architecture students aimed at introducing students to concept-based sustainable design in order to prepare them for future collaboration with engineers and consultants, as well as to provide the students with a framework from which to engage the world of products and suppliers. The sequence comprises two complementary elective courses. The first course, titled “Systems Integration”, is a capstone technology and sustainability seminar course that strives to establish a strong foundation in concept-based sustainable design. The second is a short course that travels abroad to Germany, a leading country in sustainable design innovation, where students tour exemplary sustainable buildings and meet with their design team, users and/or operators. During the trip, students also have a unique opportunity to attend a large architecture and construction trade fair.

The question the paper asks is: to what extent this teaching model succeeds at raising a student’s awareness and understanding of integrated, concept-based, sustainable design strategies?

The method to evaluate the effect of this teaching setup is based in student surveys as well as examination of samples of the work produced by students. The analysis of the survey responses shows that most students find the courses’ goals, format and content engaging and that the students generally are aware of and understand what concept-based sustainable design entails. The analysis of the work shows promising results but also certain limitations to be expected from non-experts.

KEYWORDS

Teaching, concept-based, architecture.

INTRODUCTION

There are many shades of architectural sustainable design: (Guy and Farmer, 2001) identify six broad categories of approaches to sustainable architecture: eco-technic, eco-centric, eco-aesthetic, eco-cultural, eco-medical, and, eco-social. Contrasting “concept-based” and “product-based” approaches to sustainable design, as this paper proposes, implies that even within the technology-grounded and performance-oriented eco-technic logic outlined by Guy and Farmer, at least a duality of approaches coexist.

As an architecture faculty, I use the pair of qualifiers, “concept-based” and “product-based,” to help my students distinguish between two fairly distinct kinds of sustainable architectural design approaches. The comparison between the two attitudes to sustainable design and perhaps also the exact wording came up in conversations with Matthias Schuler when he was consulting with an architecture studio that I was co-teaching with John Durbrow at Illinois Institute of Technology, Chicago, IL, over ten years ago (Schuler, 2003). Schuler is

a co-founder of Transsolar, a green technology consultancy based in Stuttgart, Germany, with offices also in Munich, New York and Paris (Transsolar, 2015). As their German website indicates, Transsolar's niche or métier is "Klimaengineering." Attempting to translate "Klimaengineering" in English as "Climate Engineers/ing" would result in overemphasizing the outdoor climate where, in contrast, "Klima" in German is used to refer to both outdoor and indoor environments.

Concept-based, product-based, what's the difference? The concept-based approach is the good, higher-level kind one. It is presented to the students as the one they should aspire for. A concept-based approach implies that the design team was smart, collaborated very well and that it came up with a very integrated, coherent, and high-performing solution in light of the client needs, the building program and location, the specifics of the climate, and all sorts of other considerations. The concept-based approach masters the integration of different systems, and their mutual interactions. It also entails a non-linear design process in which architect, engineers, consultants, client and fabricators/supplier have collaborated early to identify possible strategies and tested them in an iterative fashion until a coherent response was found and adopted. To be a leader in this high-level collaboration, the architect has to broaden and deepen his/her knowledge base with enough overlap with the knowledge bases of the engineers and consultants so as to be able to ask them hard questions as well as to contribute to the formation of the overarching building concept.

The product-based approach does not have the same aura of being a very thoughtful design solution to a complex problem. Sometimes it is derogatively called something like "slapping photovoltaics panels on a roof." The criticism here is that the end-result is merely a collection of readily available off-the-shelf products labelled –sometimes, depending on the context, debatably so—as green. The product-based approach lends itself to the most acerbic criticism when it consists of using high-tech green products onto a building that otherwise misses the point on more fundamental passive solar design principles as basic as solar orientation for example. The product-based approach does not yield the kind of synergies between systems that its concept-based counterpart does. Ironically, the simplicity—or arguably, it being simplistic—of the product-based design approach makes the marketing of the building possibly easier because it can be boiled down to a concise formula like "Building X and its five green features" that are listed in turn. Sometimes in real life, it is the zealous value-engineering of a project started within a concept-based framework that is responsible for the loss of the project's integrative quality and its "downgrading" to the category of the product-based sustainable project. On other instances, it is the fact that the design team worked in a more linear fashion, one in which the architect completed its design and passed it on to the engineers with insufficient feedback loops along the process, that is the cause of the project's overall lesser systems integration achievement. In the latter case, the benefits of a collaborative non-linear design process described by (Intrachooto, 2002) are lost in the linearized process.

The following example of an office building in a mid-latitude temperate region can help illustrate the integrative basis of the concept-based approach. In such an example, the climate affords that the building can harness the summer day-night temperature swing in its favor for the purpose of naturally ventilating the building at night, to cool it in preparation for the next work day. In such a case, there is an obvious benefit for the building structure to be built out of a material with a good specific heat capacity, possibly concrete, and to leaving the underside of the concrete floor slab at least partially exposed so as it can act as a heat sink during the day (knowing that the heat stored in the concrete will be flushed at night possibly

by natural ventilation). With the concrete soffit so exposed, it becomes preferable to use a so-called displacement mechanical ventilation system that, unlike its mixing ventilation counterpart, is better at letting a certain amount of air temperature stratification in the room. This will take most advantage of the thermal capacity of the exposed concrete soffit and result in a smaller air handling mechanical system, better air quality and very good thermal comfort. One could go on and mention other interrelated positively impacted items such as: daylighting, hygrometric modulation and its health implication, fire resistance, acoustics, etc.

Beyond the particulars of this example, the point being illustrated here is that, in the concept-based approach, many different systems work together in an integrated fashion to deliver a more desirable, more comfortable, more attuned to the environment, and more efficient building than is the case with the product-based approach.

As we will see later again, in reality, things are a little more nuanced: concept-based and product-based approaches to sustainable architectural design are not mere opposites. In the context of the classroom, however, the terms concept-based and product-based seem conveniently self-explanatory and memorable enough to the student that the reduction that comes with their use seems an acceptable trade-off. There is also perhaps an added benefit to using the term “concept-based. Because architecture students do talk about their overall “building concept” with their architectural studio instructor all the time, perhaps, calling the approach “concept-based” might make systems integration more appealing to students who are more design-inclined than technology-oriented.

As a reminder, architecture education in the US is typically delivered via a mix of classroom-based course and architectural design studios (Schön, 1984, 1985, Ledewitz, 1985). The idea of studio-based education has gained traction over the years to include science studios and even accounting studios (Yourstone & Tepper, 2014). Architectural studios typically have students working on “pretend” building design problems. The studio space itself is usually a large space open 24/7 in which each architecture student has a table assigned to him/her for the semester along with his/her studio section classmates. Usually, one architect serves as design studio instructor and teaches to a 10- to 15-student studio section. Studio typically meets several times a week for a total of customarily nine to twelve hours a week.

The faculty at our school of architecture made the curricular choice not to assign sustainable design to any one particular studio (besides the requirement placed in the US by the National Architectural Accrediting Board (NAAB) of the sustainability component in the so-called Comprehensive Studio (NAAB, 2009)). This means that instruction in sustainable design is distributed across many courses. This paper argues that at our school and others like it, the systems integration perspective offered in the coursework presented in the next section is essential to bridge between various background subjects and advanced design thinking skills.

THE TEACHING SETUP /COURSEWORK SEQUENCE

The implemented teaching setup comprises two elective courses that complement each other and that are both taught by the author. Students can chose to take one of the two courses only or both of them in whatever order.

The systems integration course

“Systems Integration” is a graduate elective seminar. It acts as a capstone technology course that draws on student’s prior knowledge in areas of not only building materials and construction methods, architectural detailing, structures, and, mechanical systems, but also site, environment, costs, and human behavior. The course is semester-long (15 weeks of classes) and is offered once a year. It meets twice a week for 80 minutes each. The attendance is capped at 16 graduate students.

“Systems integration,” as the course title partially indicates, means that different building systems and assemblies can be made to work together with the climate and the building usage pattern for the purpose of achieving greater sustainability and higher performance with fewer resources –an agenda that has become more important with the realization that building are very large consumers of resources. As an example of interdependencies across systems, a so-called green roof assembly enables the downsizing of the rain water drainage systems which in turns, if generalized at a location, minimizes the overload-type failures of the municipal storm water system while at the same time promoting water retention in the grass and green roof substrate with the added environmental benefit that soil and plant evaporation-transpiration contributes to locally curtailing the urban heat island effect. Other energy-related advantages have been also identified among other benefits.

“Systems Integration” is grounded in the type of concept-based approach to sustainable design already mentioned. However, other drivers of sustainability such as cultural, economic or business-oriented motivations are present in the discussion. For example, the seminar discusses how it is ultimately a goal of enhancing workers’ productivity, creativity, and innovation along with reducing absenteeism that motivates the decision to build a high performance sustainable office building. Insofar energy costs are only a fraction of labor costs for companies operating in advanced economies, the benefit of saving energy is only a by-product from making a good building that balances individual occupant user control over his/her comfort – access to daylight, natural ventilation for example—with building-level resource utilization optimization.

In the course’s most recent implementation, the semester is divided in two halves. The first half consists of teacher-delivered short lectures and student presentations of exemplary buildings. Lecture topics cover building physics, human comfort, climate, etc. The lectures help remediate some common misconceptions, such as for example, the notion that a ceiling fan cools the room air, instead of cooling only the person standing within reach of the fan thanks to the increase in that person’s evaporative cooling rate and convective heat transfer rate. The students work in groups of two to prepare what we call a “precedent analysis,” which is a kind of case study that examines an exemplary building and its systems in as much detail as possible. Students present their precedent analysis to the class in the form of a PowerPoint presentation with both graphics and text. One goal of this assignment is for students to sharpen their analysis skills and better grasp the integration between systems implemented in their building precedent. Another goal is that, individually and collectively, student build a memory store of exemplary buildings towards later recall during future design endeavors for the purpose of comparing building concepts, both globally and at the systems-

level. One requirement of the precedent study is that students have to produce an in-depth analysis of the climate at the building's location to understand how the climate was taken into account by the design team.

Another assignment occurring on a by-weekly basis throughout the semester is intended to help students improve their skills in adequately reading technical detail drawings and diagramming them down. Typically, students receive a set of drawings depicting a recently completed building. In addition to general drawings and photos illustrating the building, detail drawings at scale 1:5 of the building enclosure –oftentimes, a so-called curtain wall—are included. Such detail drawings originate from either the façade consultant or the curtain wall integrator/manufacturer. Students are tasked with reading the detail drawings correctly and diagramming the building enclosure at a smaller scale. The result is a section diagram at scale 1:20 that accurately depicts the building envelope concept as it relates to the structure of the building and integrates basic thermal enclosure, water shedding and solar shading concerns. The individually submitted diagrams enable the instructor to check that the students correctly read and interpreted the source detail technical drawing, discriminating between excess detail information and the building enclosure's primary functions.

The second part of the semester is articulated around two interrelated poles: design feedback and research. The design feedback pole revolves around instructor-lead and peer-to-peer feedback to each student in the course on his/her concurrently on-going design studio work. This provides students with an opportunity to have their peers and instructor critiquing their current studio project design work. This is meant to help the individual student bridge between material/concepts encountered in the Systems Integration course and the application of such material/concepts in the design arena. This feedback-giving classroom activity is also meant to give an opportunity for the class peers to try on the hat of the “consultant” collaborating on a design project with its lead designer. The research pole consists of students individually researching a topic of advanced knowledge in the area of construction and building systems that directly supports one issue at play in his/her concurrent design investigation. They present their research to the class using a PowerPoint presentation. The research assignment requires from these architecture students that they explore the mostly unfamiliar territory of scientific journal articles and conference papers and that they not limit themselves to simple internet searches using Google or other search engine.

The travel abroad, in-the-field, short winter course

This travel abroad field-trip based elective course is offered every two years –since 2011— in January during our University's winter intersession. The short three-week long course is open to both undergraduate and graduate students, and is capped at 12 attendees. Only two students enrolled in the 2015 winter course had already completed the Systems Integration course.

The course addresses the relative lack of exemplary concept-based-driven sustainable buildings nearby for students to see up-close and experience. The travel-abroad destination was chosen to be southern Germany, an important region within one of the leading countries in terms of sustainable buildings, energy saving codes, export of sustainable products as well as export of sustainability-related expert knowledge. The goal of the course is to have students be exposed to the local culture and to a sizable number of exemplary concept-based-designed sustainable buildings. In addition, the course also includes meeting with several architecture firms, engineers, and a façade consultant office. We tour building as a group by ourselves or with representatives of the occupants, clients, real estate marketing persons, or building managers. In some instances, in the case of a sustainable high-rise building, the person in

charge of sustainability and energy optimization for the company, a large re-insurance company, as well as a technician on the team of the contracted building mechanical systems operator, gives us a very systems-level detailed tour of the building. Several building managers give us in-depth tours because they are proud of the building they oversee, which arguably illustrates the point made earlier on the business case for such advanced building – that these advanced building results in their users' enhanced engagement and consequently, productivity.

The winter in-the-field course strives to reinforce the notion of concept-based sustainable design by exposing students to buildings designed with this approach as well as by encouraging the students to look at the environment –such as public transportation infrastructure, for example —and other urban amenities –parks, pedestrian and bike paths, recycling infrastructure, etc.—in the cities we visit through that particular prism.

There are three assignments for this short course. The first assignment asks students to each individually research and analyze a different building on the to-be-toured list. This precedent analysis is initiated prior to class start and is also revised after the actual visit to the building so as to correct inaccuracies and/or integrate new knowledge about it gained during the building tour. Another assignment is for each student to maintain a blog on a topic of his/her choosing that includes sketches drawn and photographs taken during the trip. Lastly, another assignment is fact-finding- and research-based and revolves around our attending Europe's largest architecture and construction trade fair in Munich, Germany that typically take place during our winter travel period –this was true in 2011 and 2013, but unfortunately did not occur in 2015 because the trade fair was scheduled later than usual.

The trade fair is called BAU –the German word for “construction”—(BAU Messe München, 2015). It is very large in terms of exhibit surface area, number and geographical origin and business specialty of exhibitors, as well as attendees count and in terms of its five days duration. Trade fairs in Germany come from a long history (Rodekamp, 2003), and, have been singled out as contributing to economic innovation by facilitating “interactive learning and knowledge creation” (Bathelt and Schuldt, 2008). In the US, while numbers of students, primarily those associated with the American Institute of Architecture Students (AIAS, 2015), visit the yearly American Institute of Architecture convention, the review of the literature on visits to trade fairs as part of an architecture course has not yielded any results so far. Taking US students to BAU is, to our knowledge, unique to our architecture program. Perhaps among the reasons for this being unique is a reticence by academics among architecture faculty –unlike their practicing adjunct colleagues—to interface with the universe of suppliers and manufacturers. For this author, such reluctance is not completely absent, but it is also largely mitigated in the case of a visit to BAU by several factors, among which: 1) weaved in the trade fair exhibit are also several lecture series with prominent architects and/or engineers as featured speakers that provide a less product-oriented perspective –students are required to attend a number of these lectures; 2) the distance between the culture of construction in the US and in Germany that, in itself, makes it an interesting learning experience to witness how similar problems are solved differently in the two different contexts, and; 3) the advance in terms of sustainability product offering that Germany currently enjoys which makes every visit at BAU seem like a peek into technologies that might –or might not—be exported and adopted in the US sometimes in the future.

METHOD AND RESULTS

The method to examine the extent to which these two courses succeed at raising student awareness and understanding of integrated, concept-based, sustainable design strategies comprises analyses of student surveys/questionnaires and of the work produced in the two classes.

Spring 2015 “Systems Integration” course

A paper-based questionnaire was administered in the on-going spring 2015 Systems Integration course one-third into the semester at the end of regular class time. Out of the 13 students taking the course, all 12 students present on that day completed the questionnaire. The 17-item questionnaire included nine questions testing general background knowledge learned since the beginning of the semester, three systems integration-based questions including one on the precedent studies presented by the students up to that point in time, three questions testing the student's familiarity and understanding of the “concept-based” vs. “product-based” pair, and two more questions (see below).

The results of the nine general knowledge questions show that students generally begin to be equipped with background knowledge on building physics, climate, and human comfort, but also show some misunderstandings that need to be addressed. The answers to the three systems integration-based questions show promising results in terms of the student's developing systems thinking capability, but also often show a lack of precision when recalling and diagramming the concept of one of the buildings precedents seen in class.

The students' answers to the three questions testing their familiarity and understanding of the “concept-based” vs. “product-based” pair show that, even fairly early on in the course, students are either familiar or somewhat familiar with the two terms as they relate to sustainable design. When asked to define the two terms, a few students gave a very clear definition, a majority of student gave generally acceptable—with some minor inaccuracies—definitions that correctly contrasted, on one hand, the higher-level design endeavor that involves interacting systems within an overarching “concept”, and, on the other hand, the more “disjointed” addition of products into/onto a design. Two students did not provide a definition although they had selected “I have heard about it but I am not really sure” in the question about their familiarity with the pair of terms. The last one in this group of three questions asked the student to give an example of an existing building representative of the concept-based approach. Students' answers to this question predictably correlate with the responses to the two prior questions.

The penultimate question in the questionnaire asked the Systems Integration course students if “their current Studio work had been influenced by what they have learned in the class so far?” Because it is still relatively early in the semester, most responses can be paraphrased as “not yet, we have not so far along the design in my studio”. Although this is on the face of it a valid justification, this kind of answer can also be seen as the sign of the student's lack of understanding that the concept-based approach is not limited to technical resolution after the “formal” design has been resolved, but genuinely ought to be an integral part of the overall building concept/design, and therefore, should be considered early on in the design process.

The last question asked the students for suggestion on how to improve the course and our school's handling of sustainability and systems integration. Students suggested more active and situated learning opportunities such as field trips and construction site visits for up-close seeing of systems integration examples. Some students called for more hands-on work in

class, less PowerPoint slides, more drawing/diagramming, and, the use of videos. One student advocated that the Systems Integration course “(...) be taught in tandem with studio so the things we learn about sustainability and systems integration can be incorporated in our projects”. The design-feedback activities during the second part of the semester respond to the latter request.

The analysis of the work produced by students over the duration of the semester shows positive signs of students’ evolving view of sustainable design from a primarily product-based viewpoint to a more all-encompassing concept-based understanding. Specifically, and in chronological order, the big picture of the in-depth climate analysis that was part of the precedent analysis was mostly under control but some nuances were not fully accounted for. Similarly, the building precedent analyses demonstrated a nascent grasp of the general interaction among various building systems and of the concept-based approach undergirding each building precedent. However, the fine-grain level of the sustainability concept of the particular building precedent still tended to consistently require varying degrees of additional clarification by the instructor during the student presentation to the class. Unsurprisingly, this tended to be more so the case when it came to concept-based solutions that are fairly unique and most-likely unknown from the students at the outset. There were instances in which sustainability claims by the design team or the developer were insufficiently scrutinized by some students, arguably perhaps because these students assumed that because the precedents had been selected by the instructor, they must have been exemplary and truthful at all levels.

The by-weekly “diagramming-down” assignment produced the expected result in terms of improving the student’s diagramming skill as well as facilitating discussions/information exchange on building envelope-specific issues.

The design-feedback activities during the second part of the semester seem to have been beneficial to the students in promoting a concept-based approach to their design project. One potential hindrance appears to be when the studio instructor of the concurrent studio project does not seem to support the student’s systems integration effort. It is probably fair to say that some student’s approach was still somewhere along the continuum between the product-based and the concept-based. Most students expressed positive views on their acting as “consultants” when they critiqued and advised each other. This does not come as a surprise insofar our school promotes venues for peer learning throughout the curriculum and around design studio activities in particular.

The research assignment was usually successful at introducing students to different sources –journal articles and /or conference papers—with the positive outcome that many of them brought to the attention of the class new issues and knowledge.

Winter 2013 Germany travel abroad short course

The student survey of the 2013 winter short course was administered via a web-based application eight weeks after class end. Ten out of the 13 students in the class responded to the concise four-question questionnaire. Students’ responses show that they were engaged with the building tours, the various office visits and other meetings with consultants, engineers, building managers, etc. Students were very positive about the travel-abroad learning opportunity as is generally the case as studied by (Culver, 2011). Student unanimously valued the experience of getting to see up-close buildings and systems they had heard about and seen images of in lecture classes along the technology curriculum. Touring a building that has been analyzed prior to traveling abroad helped adjust expectations and refine one’s judgment of it. Although we are not equipped to verify if all sustainability claims made

about a given building are valid or not, touring and examining it up-close helps us form an opinion and see aspects not visible on websites, magazine articles or books.

Students were also very positive about attending the BAU trade fair, to a level actually surprising to this author. Students really appreciated the quality of the lecture presentations by many noteworthy architects and engineers occurring at the fair. Students all said that the sheer size and density of the BAU trade fair exhibit was overwhelming at first but that having been tasked to research a particular topic helped them to be more selective and develop “mechanisms” to “find their bearing”. Students did not experience major language barrier issues while interacting with exhibitors during their fact-finding effort. Students said they valued the relative freedom afforded by the program to explore the trade fair on their own. They felt it was a rare opportunity for them to see and touch so many products, many of which had some level of novelty or innovative and/or sustainable character to them, all in one location. They expressed being fascinated by full scale mock-ups and real 3-D full wall sections, and they voiced the view that attending BAU felt like a natural and valuable extension of coursework they have already completed at our school in the area of materials and methods of construction in particular.

Perhaps tainted by their overall positive experience, students’ responses tended on average to exude a fairly high-level of confidence in their authors’ understanding of their building precedent analysis, as well as in the comprehensiveness of their research /documentation collection) done while at BAU. The analysis of the work submitted suggests a more nuanced picture. Across all three assignments, students who had also taken the “Systems Integration” course performed better and used concept-based design notions more centrally in their work. For other students, the limited amount of time to complete the assignments along with the reduced quantity of instructor feedback within the shorter duration of the course had an impact reflected in a slightly lesser overall work quality.

Regarding the precedent analyses, the work seems to indicate that non-Systems Integration students gained some level of familiarity with the concept-based nature of the design of their building precedent beyond their prior understanding. However, while visiting the building helps the student understand it better –and improve this assignment re-submission—, it seems to arguably improve it only so far. One should account for the facts that not all building precedents are at the same level of concept-based approach to sustainable design –some have indeed traits of product-based designs—and not all building tour provides us with the same access to the ‘guts’ of the building. Perhaps the building visits are either too short or not comprehensive enough, or conversely, too overwhelming for the student who has not taken the “Systems Integration” course and therefore had not been primed to absorb such level of detailed information. This, arguably, make the case for taking the two courses in sequence.

The individual blog assignment has yielded higher quality, more reflective and synthetic content than the “journal” assignment assigned during a prior winter short course offering did; the latter tended to be too much of a listing of things students had experienced on each day. The theme and content of the blog was self-selected by the individual students. The blogs produced across the course display a range of level of architectural reflection spanning from the relatively superficial kind to the quite impressively ambitious kind that demonstrates high-level thinking and a good grasp of the concept-based approach to sustainable design and systems integration.

The research/ fact-finding/ exploration of the BAU trade fair looking for products with similar purpose is the assignment that presented most deficiencies, possibly due to a lack of

time and/or deficiencies in the way the assignment was framed by the instructor. Potential remedies are briefly alluded to in the next section.

DISCUSSION/ LESSONS LEARNED

Clearly, the two courses are appealing and engaging to students. Tellingly, among the students who joined the winter Germany short program were actually a few who had already completed all their degree requirements, which meant they did not need the credit, but were just interested in the learning experience abroad. The in-the-field winter Germany program, although “too short” according to some of the students who took it, responds in part to the request for more site visits voiced by some students in the “Systems Integration” course. Among other ideas, perhaps a design-oriented activity aimed at solidifying the student’s learning could be considered for inclusion as a means to reinforce the breadth of learning modes in the short in-the-field course.

While each of the two courses are still work-in-progress requiring fine-tuning at many levels, there seems to be value in offering both of them because of how they appear to reinforce each other. The few students who have taken them in sequence at the graduate level seem to have performed better. The students who went on the winter Germany short course as undergraduates and who later took the “Systems Integration” course seemed to have benefitted somewhat less from the Germany short course. One could argue that the reason for this is because they were not equipped with a conceptual framework that help them make sense of and subsequently remember what they were seeing while in the field and at the BAU trade fair.

Dynamics

An important aspect brought about decisively to consciousness in the student with the concept-based approach --and all its systems integration, interdependencies and feedback loops— is the enhanced sense of the dynamic nature of the building. We can see evidence of that in the student preparing several diagrams depicting the building’s response to different day, night and other changing seasonal conditions. This is a significant step forward for the student who might otherwise be somewhat deceived by the apparent static character of the plans he/she has drawn.

From awareness ... To understanding?

The two courses, individually or bundled together, seem to achieve good strides towards introducing the contrasting notions of concept-based and product-based sustainable design, both at the awareness level and the understanding level.

There is a difference between knowing a building from its plans in a book and knowing it from direct physical/corporeal personal experience. Similarly, there exist also a difference in nature between forming a mental model of the integration among various systems in a building –using the precedent analysis method and tools—and, confronting this mental model to the reality of being there and directly experiencing the same sustainable building’s exemplarily integrated systems. Based on the observation of the different students, it seems that the knowledge of both the drawings – including systems integration concepts diagrams—and the building itself –via a tour—complement each other for higher-level understanding and memory retention. Anecdotal evidence of this is found in the higher-quality precedent analysis re-submissions after the field trip, as well as, through conversations between student and instructor. For clarity sake, this section’s point is not only to reiterate that the two courses

reinforce each other, but also to shine a light on the fact that the level of detail and complexity of some of the concept-based designs seem to be better grasped by students when both “pathways”, the paper-based one and the experientially-based one, are activated.

... To ability to integrate a concept-based approach in one's design process

The concept-based approach to sustainable design requires that the designer (and/or team) synthesizes many factors into a coherent design. Students are not yet operating at such high-level usually associated with experts (Cross, 2004). Students at the graduate level are neither novice, nor are they experts. They are being shown a way of looking at architectural reality beyond what they have learned so far. They display enhanced, but sometimes fallible, understanding of buildings designed with a concept-based approach, and this understanding only begins to translate into a higher-order autonomous self-aware concept-based design capability. Simply put, the students are becoming more successful at juggling while also adding to the number of balls they are juggling in the air!

The missing team

In general, across the two courses, in their precedent studies, students tend to under-acknowledge the role consultants and engineers and others. This might be symptomatic that the students do not have a clear idea of a collaborative design team and/or simply do not realize the extent of the contribution of the consultants and engineers. Perhaps, the fact that not every architect's website or printed publication properly credits these key design team participants, is partially to be blamed for that. Alternatively, perhaps such a lack of understanding of the whole design team on the part of the student originates in part also in the student's relatively solitary and individualized experience of design in studio. While the student does receive input and feedback from his/her peers and studio instructor, these do not constitute the kind of team as can be the case with the practicing architect and a group of engineers and consultant at his/her side. This point highlights the responsibility that we have as faculty to communicate effectively with students on the collaborative nature of the concept-based sustainable design. Additionally, the potential of the learning opportunities brought about by the integration of outside consultants in the studio environment ought to be further considered.

From seeking feedback early enough... to assembling a collaborative design team

“Seek early advice” may seem like a trivial bit of advice. In countless instances, students come to seek advice on systems integration issues from this author about their design in various unrelated studios. Unfortunately, students most often do it simply too late in the semester to possibly positively influence their design. The courses outlined here are forums to promote this simple piece of advice. In concept-based sustainable design, the early advice comes from activating the whole design team early on and from seeking a non-linear design process that generate ideas and has them tested by all team participants iteratively early on.

The climate analysis and the building envelope detail of construction reading exercises in the Systems Integration course outlined above illustrate an important point. Students should of course strive to learn and internalize as much as they can on the subjects of system integration and concept-based sustainable architectural design. However, this effort –and the particular exercises cited above— are not geared toward making the students into a climate specialists or into a building envelope specialists. They are meant nevertheless to make the future architect a knowledgeable contributor to the collaborative design process, someone

who knows how to evaluate and select good team members, someone who can communicate effectively with the consultants on the design team, who can possibly challenge and/or add to what the consultants are proposing, and who knows what to expect from them as well as is able to evaluate the quality of their work.

Products and suppliers

One of the claims made about the coursework presented in this paper is that it helps provide the students with a platform and/or a critical framework to engage products. Is it really delivering on this issue? There does not seem to be a conclusive answer to this question at this point. By design, the “Systems Integration” course content and student work do not go very far in terms of product specifics in order to maintain the focus on the bigger concept-based picture. Similarly, the research assignment linked to the studio design development tends to direct students’ attention to general science-based knowledge and to not revolve around any particular manufactured product available on the market.

In contrast, the building tours and the BAU trade fair visit in the winter travel abroad course do provide direct encounters with a dizzying array of products. However, the submissions for the fact-finding/research assignment the student worked on while at BAU was not really convincing, and tended to somewhat uncritically collect and repeat fabricators/marketers claims. In other words, the work did not show much evidence of higher-level thinking within which products find their place within the broader concept-based framework. Perhaps it was the case in part because the assignment was improperly outlined and did not ask the student to specifically relate a certain product family to a certain concept-based approach. As a remedy, future offerings of the winter short program should probably include more preparation and research prior to travel to BAU as a means to improve the trade fair-based research outcome. Similarly, perhaps a future assignment in the “Systems Integration” course could ask students to research one or several specific products that are part of a larger integrated system.

The product-based within the concept-based

As was mentioned earlier, concept-based and product-based approaches to sustainable architectural design are not polar opposites as it is initially presented to the students. One way of reframing the issue is to acknowledge both, on one hand, the share of one-of-a-kind and tailor-made there is in the concept-based approach when it comes to the place, its climate, its resources, its program, and, on the other hand, the share of the product at the detail, end-solution level –integrated within the overarching concept. The two are in fact more complementary than opposite within the concept-based framework. What it comes down to, is an understanding of the place the product-based legitimately occupies at the implementation level within the concept-based approach.

Arguably, the in-the-field short course, with its building tours and architecture- and construction-themed trade fair attendance, more so than the classroom-based “Systems Integration” course, affords students with an opportunity to revisit the initial opposition between “concept-based” and “product-based” approaches. Students are there in a position to see the role “products” play within the “concept-based” approach itself, and how products are articulated within the overarching architectural and sustainability concepts.

CONCLUSION

The paper has presented the implementation of two graduate architecture elective courses taught by the author aimed at expending the student's view of sustainable design in relation to technology. One course is primarily classroom-based while the other is a travel-abroad in-the-field fact-finding-style immersive experience. The two courses seem to complement each other quite well. Noticeably, the experiential learning aspect of the travelling course enables the students to more deeply understand material seen in the classroom.

A common feature of these two courses is the initial reliance on the presentation in almost Manichean terms of two approaches to sustainable design in regard the way technological products are integrated. On one side of this dichotomy is the virtuous, thoughtfully-designed and well-engineered "concept-based" approach based on systems integration, climatic and cultural intelligence. On the other side is the seemingly expediency-inclined "product-based" approach portrayed as being less preoccupied with systems integration issues. The emphasized contrast between the two so-defined approaches seem to play its intended pedagogical role in helping student discriminate better between different levels of systems integration achievement behind various sustainability claims. What the two courses should continue to deliberately aim for is to help students become informed and critical consumer of products who try hard to find the logical/integrative place for such products within a project's overall architectural and sustainability concept.

The team-based, collaborative aspect of the delivery of concept-based sustainable architectural design solutions seem to be positively reinforced by the in-the-field, building tour-based course during which the students meets with not only architects but also other participants to the design team. This arguably is a motivator for students to broaden their knowledge base and learn how to interface with such consultants and engineers on the design team.

The systems integration perspective at work in the two courses seems to produce promising results on top of which the students can continue to build in other courses or as lifelong learners.

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COMPONENT REUSE MANAGEMENT FOR REMANUFACTURING BASED ON MARKETING DIFFUSION MODEL

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ABSTRACT

Rapid changes in technology and shortened product life cycle precipitate discarding an increasing amount of used products and components. The impacts have been considered one of major environmental issues of our time. To mitigate the side effects of product disposal and reduce associated cost in the entire value chain, sustainable product design has become a major technology challenge for manufacturing industry. Among all the existing sustainable design methods, remanufacturing has been advocated as an important approach by forming a closed-loop product life cycle. In this diagram, end-of-life products are taken back from customers as feedstock in remanufacturing so that environmental issues can be potentially mitigated. The key to fully achieve benefits of remanufacturing lies in the efficient and cost-effective reuse of components from end-of-life products. However, major economic issues confronting remanufacturing management include reuse planning, component proliferation and others. These issues need to be addressed upfront during product design phase. Towards this end, remanufacturing diffusion models are developed based on the Bass model to quantify total component reuse availability considering time delay, loss in reverse logistics and reprocessing operations. We also investigate how product diffusion dynamics in the market affect the volume of component reuse in remanufacturing. Economic acquisition policy of components in end-of-life products for remanufacturers can also be developed accordingly. Numerical analysis is conducted to demonstrate the applicability of our methodology and generate managerial insights. We anticipate that the outcome of this study could contribute to a better understanding and planning of sustainable product design. In a longer perspective, the results may provide the necessary theoretical foundation for accelerating the development and integration of design, manufacturing, and services to improve responsiveness of the overall design chain and its efficiency from both technical and economic perspective.

KEYWORDS

Remanufacturing, sustainability, marketing diffusion model

INTRODUCTION

Product life cycle in manufacturing typically starts with raw material extraction and goes through component production, assembly, testing, and distribution to customers for usage and disposal at product end-of-life. Two ends of this open-loop structure of product life cycle separately affect the earth, which cannot be sustained due to ever increased demands and pollution problems. Recently in order to resolve the challenge of end-of-life products mainly, Extended Producer Responsibility (EPR) is emerging as an environmental policy approach, by which a producer's responsibility for a product is extended to the post-consumer stage of the product life cycle [3]. The ultimate goal of EPR is to minimize total environmental impact

associated with entire product life cycle, in particular to reduce the quantity of waste and environmental pollution from end-of-life product disposal. By means of EPR, both physical and economic responsibility of end-of-life product disposal is shifted upstream to brand owners in manufacturing industry. On one hand, many countries and regions such as EU, Japan and US etc. have promulgated a listing of take-back laws and legislations to impose responsibility of end-of-life products onto manufacturers to avoid “free ride” phenomena. The most prestigious one is the Directive on Waste Electrical and Electronic Equipment (WEEE) requiring all EU member states to impose full cost incurred during handling of end-of-life products on manufacturers [4]. EPR legislations are also expanding worldwide to United States, Japan, South Korea and other countries. Products of the most concern under EPR legislations span a wide range of categories including automobiles, large and small house appliances, telecommunication and IT equipment and so on.

On the other hand, there exist quite a number of successful business cases which can prove the economic viability of implementing appropriate environmentally superior end-of-life strategies such as reuse, remanufacturing and recycling in office equipment industry, electric and electronic industry, household appliances industry, automobile industry. For example, Xerox is one of the most widely cited successful corporations which manage to remanufacture used photocopiers, and toner cartridges from all over the world and have saved millions of dollars with their image boosted as environmentally conscious company [5]. Other examples include Mercedes-Benz and Ford motor company who collected and disassembled their end-of-life vehicles to recover valuable components as spare parts for both consumers and commercial customers [6]. However, it is evident that efforts towards implementing environmentally superior end-of-life strategies to form closed-loop product life cycle are far from being widespread yet. We cannot rely solely on legislations to compel manufacturing companies to take the end-of-life responsibility reactively.

Essentially, it is our designers and engineers who should take initiative and responsibility to resolve the sustainability challenges associated with product end-of-life by forward-looking and systematic design techniques. Therefore, a systematic methodology in product design which can enable manufacturers to analyze economic consequences of product end-of-life management on top of current conventional industrial operations is in urgent need. Particularly, this paper attempts to address the following research questions:

- How to model economic benefits gained from component reuse in the remanufacturing supply chain?
- How do product diffusion dynamics in the market affect component reuse in remanufacturing across multiple product generations?

RELEVANT WORK

Product end-of-life means the point in time when the product can no longer satisfy the initial purchaser or first user [7]. However, some other researchers also claim the product is actually “end-of-use” but still contains significant amounts of value added which can be reused or remanufactured with original functionality [8]. To avoid any misunderstanding, we accept both viewpoints and refer to both terminologies as product end-of-life. In literature, there exist a variety of end-of-life strategy definitions and in fact they are the same in nature [7][9]. In this paper, we adapt definitions of end-of-life strategies characterized by processes which are required to carry out respective end-of-life strategies as follows:

- (Direct) Reuse: Reuse refers to the direct second hand use of subassemblies or components from end-of-life products without further reprocessing operations;

- Remanufacturing: Remanufacturing requires a series of reprocessing operations in which subassemblies or components from end-of-life products are refurbished to certain quality standard. The core processes consist mainly of disassembly, cleaning, inspection, refurbishment, reassembly and testing etc.
- Recycling: Recycling reclaims valuable material from end-of-life products for application as a source of raw material. Recycling is achieved primarily by the processes of disassembly or shredding, screening, refining etc.
- Waste disposal: Disposal mainly includes landfill or incineration of the part of end-of-life products which cannot be handled by the above three end-of-life strategies.

There are a set of well-defined research stream in product design called design for X (DFX) such as Design for manufacturing (DFM), Design for assembly (DFA), Design for Mass Customization (DFMA) and so on. Following the same philosophy, this research is appropriately located under the umbrella of Design for Remanufacturing (DFM), which is a merging research hotspot recently. Some relevant literature on sustainable product design, DFX, economic effects of component commonality will be summarized as follows;

Design for X

Product design has been well recognized to play the most deciding role in product life cycle for issues such as cost and quality. Therefore, effective remanufacturing should also start with product design. In this part, we will review research related to Design for X methodologies as well as design guidelines for remanufacturing.

One important research area in product design is design for X (DFX) methodologies. Starting from design for function, the scope of product design is expanding gradually to cover the entire product life cycle. First of all, in order to break the wall between product designers and producers, both assembly and manufacturing are integrated in product design as the underlying foundation and impetus for DFX philosophies [10][11]. As life cycle thinking and environmental concerns are gaining more and more attention, DFX research evolves to consider issues such as disassembly, material recycling as well as environment [12][13][14].

Design guidelines for remanufacturing

There are some product design guidelines for remanufacturing in research from different perspectives. The joint design guidelines are provided based on the effect of different fastening and joining methods on cost from different product life stages compared with determined remanufacturing cost [14]. Remanufacturable product profile (RPP) is established based on both remanufacturing contexts and remanufactured products properties from 25 products which are remanufactured in industry [15]. Design guidelines are provided for product designers to improve the internal technical attributes of products from a remanufacturing perspective. Case studies of mechanical and electromechanical sector of the UK manufacturing and remanufacturing are conducted to discuss both incentives and barriers of remanufacturing [16].

Based on their interviews and observations, profitability is recognized as the primary remanufacturing incentives while barriers to remanufacturing includes issues related to cost, design characteristics, disassembly, materials, assess to component, component identification as well as assembly.

Economic effects of component commonality

Component commonality refers to the use of the same version of a component across multiple products. In literature, component commonality has already been extensively discussed in different disciplinary domains such as in product family design for mass customization [17], product platform design in custom products [18], evaluation of design commonality in product families [19] among others. But more traditional research on component commonality in literature starts with economic effects of component commonality which covers both cost and revenue sides. Since component commonality effect on revenue mainly concentrate on pricing strategy based on customers' preference on component commonality, it is regarded beyond the scope of our research. Therefore, we focus exclusively on cost effect of component commonality which can be subdivided into two major streams which are risking pooling effect in inventory management and economy of scale effect on cost trade-offs in component variety management respectively.

MANAGING COMPONENT REUSE UNDER PRODUCT DIFFUSION DYNAMICS

Instead of infinite and stationary demand, in most cases new products usually present finite product life cycle in the market with a dynamic diffusion pattern, which proceeds throughout introduction, growth, maturity and decline stages. New product diffusion models thus aim to explain the dynamics of new product sales in market over time theoretically. There are a series of diffusion models existing in literature to capture and forecast new product sales curve during product life cycle in the market, among which the most fundamental one is called the Bass model [20][21]. The Bass model is widely used in both academia and industry to predict new product sales in the market dynamically and is reported to work exceptionally well. In extant literature, the Bass model has been discussed and extended in a large amount of articles in both marketing and operations domains [22]. The basic Bass model attributes underlying impetus for new product diffusion to both external and internal influence on customers, which can be expressed mathematically as follows:

$$f(t)/[1-F(t)] = p + qF(t) \quad (1)$$

Where $f(t)$ is the probability of product adoption by customers at time t and $F(t)$ is the cumulative distribution of adoption until time t . p represents coefficient of innovation and q represents coefficient of imitation, which account for internal and external influence on customers for purchase respectively. The physical meaning of the Bass Model is that the probability of one customer to adopt the new product given he or she has not adopted yet is a linear function of the number of customers who have already adopted the product.

Alternatively, Formula 1 can be expressed in terms of quantity of product sales as follows:

$$n(t)/[m - N(t)] = p + qN(t)/m \quad (2)$$

Where m represents the total market potential, $n(t)=mf(t)$ is the quantity adopted (product sales) at time t , and $N(t)=mF(t)$ is the cumulative quantity (product sales) until time t .

$$n(t) = \frac{p(p+q)^2 e^{-(p+q)t}}{\left[p + q e^{-(p+q)t} \right]^2} m \quad (3)$$

In our research, we developed a remanufacturing diffusion model based on the Bass model to quantify potential component reuse in remanufacturing under the coordination between manufacturing and remanufacturing dynamically, which takes into account time delay, return rate of end-of-life products, yield rate in reprocessing operations as well as technological obsolescence.

After the time delay caused by useful life of products with customers and the lead time in reverse logistics, the first batch of end-of-life products are returned to remanufacturing facility waiting for reprocessing operations such as disassembly, cleaning, refurbishing and so on. The appropriate reprocessing operations in remanufacturing can guarantee that reprocessed components can perform the same as new ones in the reassembly process of remanufactured products. Therefore we assume that remanufactured products can be applied to satisfy the market demand indifferently with their new counterparts. Under this assumption, the available remanufactured products will follow the similar diffusion pattern to satisfy the total demand in the market in collaboration with new product sales until the reflection time point that is called remanufacturing saturation time is reached. Before remanufacturing saturation time point, all remanufactured products can be digested by the market to satisfy customers' demand; however, after this time point, there is no adequate demand in the market for remanufacturing all returned end-of-life products because the total demand in the market determined by product diffusion dynamics have declined to a significant degree. The total component reuse volume will be then covered by the shaded area and can be mathematically expressed as follows:

$$Q^{reuse} = \begin{cases} 0 & 0 \leq t < \tau \\ \int_t^{\tau} \pi r \beta n(t-\tau) dt & \tau \leq t < t^* \\ \int_t^{t^*} \pi n(t) dt & t^* \leq t \leq T \end{cases} \quad (4)$$

where

π : quantity of component i in one product;

$n(t)$: sales quantity of new products at time t ;

β : reuse yield rate of component i;

r : return rate of end-of-life products;

τ : remanufacturing time delay, $\tau = t_{usage} + t_{rl}$;

t_{usage} : product usage time by customers;

t_{rl} : lead time in reverse logistics;

t^* : remanufacturing saturation time;

market demand rate is equal to the rate at remanufacturing diffusion curve.

$$\frac{p(p+q)^2 e^{-(p+q)t^*}}{\left[p + q e^{-(p+q)t^*} \right]^2} = \frac{p(p+q)^2 e^{-(p+q)(t^*-\tau)}}{\left[p + q e^{-(p+q)(t^*-\tau)} \right]^2} r \beta \quad (5)$$

A closed-form solution to the remanufacturing saturation time exists and can be derived as follows:

$$t^* = \tau + \frac{\ln \frac{q}{p} + \ln \left[e^{(p+q)\tau} - r\beta \right] - \ln \left\{ (r\beta - 1) e^{(p+q)\tau} + \sqrt{e^{(p+q)\tau} r\beta} \left[e^{(p+q)\tau} - 1 \right] \right\}}{p+q} \quad (6)$$

$$\text{when } p+q > -\frac{\ln(r\beta)}{\tau}$$

Based on the remanufacturing saturation time derived above, the total quantity of component reuse under product diffusion dynamics can be expressed accordingly as the sum of component use from two time internals as follows:

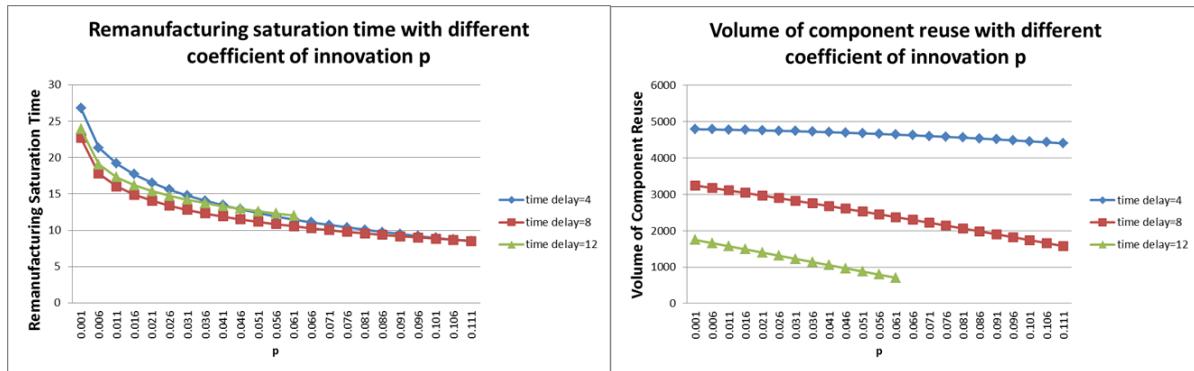
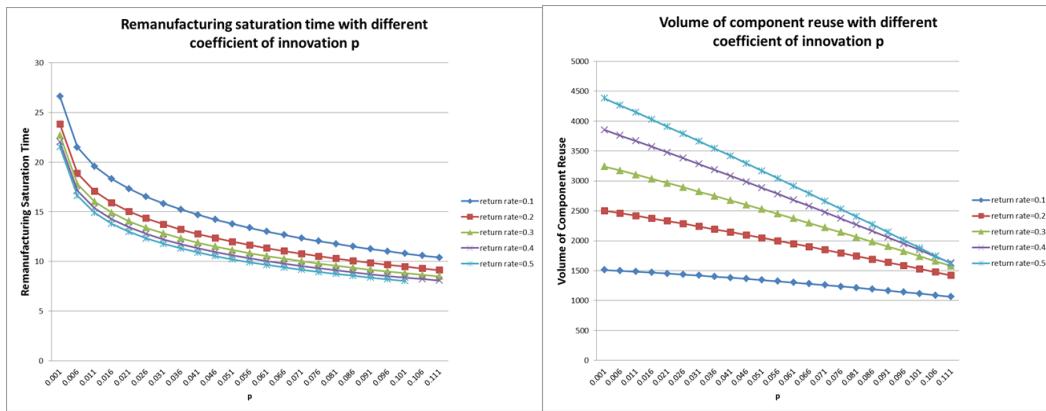
$$\begin{aligned}
Q^{reuse} &= \pi \left\{ \left[m - N(t^*) \right] + r\beta N(t^* - \tau) \right\} \\
&= \pi m \left[1 - \frac{1 - e^{-(p+q)t^*}}{1 + \frac{q}{p} e^{-(p+q)t^*}} + r\beta \frac{1 - e^{-(p+q)(t^* - \tau)}}{1 + \frac{q}{p} e^{-(p+q)(t^* - \tau)}} \right]
\end{aligned} \tag{7}$$

CASE STUDY

Based on the closed-form expressions we derived for remanufacturing saturation time and total volume of component reuse, the following two figures demonstrate how remanufacturing saturation time varies with different coefficient of innovation p under three levels of time delay, which are 4, 8 and 12 time periods respectively. We set total market potential is 20000 units and $q=0.38$ at the average of different industries. In addition, we fix return rate at 0.3 when varying time delay; and fix time delay at 8 when varying return rate in turn.

We can observe in Figure 1 that both remanufacturing saturation time and total volume of component reuse decrease monotonically along with the increase of coefficient of innovation p at each level of time delay in remanufacturing. Moreover, it is more critical to achieve a shorter time delay in remanufacturing when the coefficient of innovation is getting bigger since the drop in total volume of component reuse is getting more significant. It is also worthwhile to notice that for any given coefficient of innovation, the total volume of component reuse goes down straight with longer time delay; however, there is no such a relationship between remanufacturing saturation time and time delay where longer time delay may even surprisingly lead to a longer remanufacturing saturation time as evidenced in the figure. This observation is of interest during coordinating reverse logistics and remanufacturing during product life cycle in the market. Moreover, when time delay in remanufacturing is too long at 12 time periods in this numerical analysis, there will be no opportunities for component reuse when coefficient of innovation is larger than 0.061.

Figure 2 demonstrates how remanufacturing saturation time and total volume of component reuse varies with different coefficient of innovation p under five levels of return rates, which are 0.1, 0.2, 0.3, 0.4 and 0.5 respectively in our numerical analysis. We can observe that it follows conventional wisdom that remanufacturing saturation time in remanufacturing decrease when the return rate gets larger; and it is the opposite for total volume of component reuse which increases when the return rates are larger. Moreover, the trend of change of remanufacturing saturation time with respect to the coefficient of innovation is rather unified at different levels of return rates. However, the effect of return rate on total volume of component reuse in remanufacturing is much more significant when the coefficient of innovation is getting smaller. The major managerial insights for manufacturers are it is more beneficial to increase the return rate in remanufacturing when products diffuse relatively slowly in the market. Last but not least, when the coefficient of innovation is relatively large, there are risks that there will be no component reuse opportunities in the market when the return rates are set over aggressively as evidenced when the return rate is 0.5 while the coefficient of innovation is larger than 0.1.

Figure 1: Remanufacturing at different p under different time delayFigure 2: Remanufacturing at different p under different return rates

CONCLUSION

This paper addresses component reuse under product diffusion dynamics in the market from within single product generation. Remanufacturing diffusion models are thus developed based on the Bass model to quantify potential component reuse dynamics considering time delay, market saturation, loss in reverse logistics and reprocessing operations as well as component obsolescence across multiple product generations. In addition to closed-form analytical solutions, numerical analysis is conducted to demonstrate the impact of different product diffusion patterns on component reuse in remanufacturing.

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The Conceptual and Practical Insights into the Properties of Resilient Supply Chains as Complex Adaptive Systems

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ABSTRACT

The paper seeks to investigate the major properties of resilient supply chains as complex adaptive systems. In order to achieve this aim, the conceptualization of resilient supply chains from the perspective of the complex adaptive systems theory has been developed, followed by the findings of a case study analysis carried out in an exemplary supply chain.

INTRODUCTION

The concept of complex adaptive systems (CAS) is widely recognized as an instrument for explaining the way contemporary organizations operate. Specifically, it offers explanatory power while investigating the dynamic and complex nature of supply chains [1]. Accordingly, it may be used to interpret the behavioral model and distinguish the major properties of resilient supply chains. The concept of resilient supply chain is relatively new in the logistics literature and embodies a modern type of organization, which is insusceptible to disruptive conditions of a turbulent environment. Consequently, resilient supply chains are capable of transiting to another, more desired state after the occurrence of a specific disruption [2], [3]. In other words, resilient supply chains are characterized by the ability to adapt to unforeseeable difficulties and return to their initial state [4]. This is paralleled with the observation by [5], [6], [7] that resilience is the ability of a supply chain to adapt, regain lost strength and provide reactive response to the requirements of the environment.

In the ecological sciences, resilience is “the ability for an ecosystem to rebound from a disturbance while maintaining diversity, integrity, and ecological processes” [8]. It may be beneficial for a supply chain not to return to its original “shape” following a disruption, but rather to learn from the disturbance and adapt to a new configuration [9]. The network theory views a supply chain as an adaptable living system and a resilient supply chain, which therefore should be efficient, adaptable, and cohesive [10]. The adaptive capability is coupled with the complex nature of resilient supply chains. Following the considerations of [1] and [11], we argue that resilient supply chains may be viewed as a complex web of changes or ”epistemic networks”. The complex nature of resilient supply chains may also be referred to as “latent networks”, which denotes that disruptions got outside of normal operational boundaries and a group of companies self-organize into ad hoc networks with no formal structures [12].

In the light of the aforementioned reasoning, we argue that it is valid to explore resilient supply chains through the lens of the complex adaptive systems theory. The general motivation for this study may seem to be trivial, since a resilient supply chain is intuitively perceived from the perspective of its complex structure and adaptive nature. However, this issue requires further in-depth investigation, because other, non-resilient types of supply chains are also complex and their behavioral pattern indicates a certain degree of adaptation. Accordingly, the complexity itself is not only the domain of resilient supply chains, but on the contrary, this property is typical for most of the contemporary supply chains operating in a turbulent environment. [13] highlight that supply chains are typically viewed as linear, often isolated two-dimensional structures, while in reality there are many overlapping supply chains. The complex structure of a supply chain is also indicated in its basic definitions. For instance, [14] argues that “supply chain is a network of organizations, that are involved through upstream and downstream linkages in the different processes and activities that produce value in form of products and services in the hand of the ultimate consumer”. In other words, the structure of contemporary supply chains is not sequential and linear anymore, and instead it is formed by multiple (network) relationships established by different firms representing a variety of industries.

In case of resilient supply chains, the complex structure brings about non-deterministic outcomes. For instance, it means, that even though some environmental uncertainty, potentially affecting supply chains, may be vaguely specified (which is usually rare or even impossible), its prediction often becomes useless as specified disruptions may be amplified exponentially in future [15]. In such a situation, resilient supply chains possess adaptive capability to form a structure which may effectively deal with the changes and uncertainty through a radical reformulation of behavioral pattern and transition from one to another, more desired state. In a broad sense, non-resilient supply chains possess simplified adaptive capabilities, which range from reactive adaptation focused on shrinking deviations to more advanced forms, which may require using sophisticated managerial instruments, such as supply chain risk management.

In the light of previous discussions, searching for parallels between the CAS theory and the concept of resilient supply chains seems to be a challenging, but difficult task. Therefore, the structure of the paper consists of several sections. Firstly, based on the tenets of the complex adaptive systems theory, the properties of resilient supply chains have been distinguished and then investigated in an exemplary resilient supply chain. Finally, a discussion has been carried out and deliverables of the study have been drawn.

THE PROPERTIES OF RESILIENT SUPPLY CHAINS AS COMPLEX ADAPTIVE SYSTEMS

Despite some skepticism and reasonable doubts, the complex adaptive systems (CAS) theory is viewed as an emerging research area in the supply chain management literature. It provides a framework for explaining the emergence of resilient supply chains arising from the interactions between the system's interdependent agents (i.e., people, departments, ideas, information, and resources). Thus, the CAS theory focuses on the relationship between a system and its environment [16]. In this sense, it may be argued that examining resilient supply chains through the CAS lens is particularly relevant, as they operate in an iterative, nonlinear, and co-evolutionary way in today's turbulent and competitive environmental conditions. There are a number of distinctive properties of resilient supply chains which qualify them as complex

adaptive systems. Among many, we highlight the following major properties of resilient supply chains: complex structure, openness, agent-based structure, adaptive capability, as well as ability to oscillate on the edge of chaos and remain in a state far-from-equilibrium.

Modern supply chains have very complex structures covering many parallel physical, information and finance flows, which ensure that right products are delivered in the right quantity, at the right place, at the right time, in a cost effective manner [17]. In other words, material, information and finance flows in supply chains can form a complex network of interlinked activities involving multiple suppliers, manufacturers and distributors [18]. Following the opinion of [19], we identify numerous factors which determine the complexity of resilient supply chains, including the scale of activity, technological novelty, number of sub-system components, degree of product customization, quantity of alternative design and delivery path, number of feedback loops in the production and delivery system, variety of knowledge bases, number of actors in the network, and various stakeholders. Following the opinion of [20], we maintain that complexity contributes to establish a non-linear structure of resilient supply chains delivering non-deterministic outcomes.

Resilient supply chains are represented by open dynamic systems which continually exchange information and energy with the surrounding environment. In other words, resilient supply chains are open systems of interconnected elements, such as suppliers, third parties, customers, which internally include other sub-systems [21], [22]. The openness of the system and the permanent interaction with its environment, outlined by [23], [24] and [25], leads to the conclusion that a resilient supply chain is induced by the system's environmental conditions. It suggests that resilient supply chains are mainly exposed to the factors triggered by external factors, located outside the supply chains. This issue has also been highlighted by [26], who maintain that resilient supply chains are prepared to recover quickly and cost effectively from disruptions caused by natural disasters (such as earthquakes), social factors (employee strikes), medical emergencies (epidemics), economics setbacks (financial crisis), etc. However, it can be assumed that resilient supply chains may also be exposed to disruptions triggered by internal factors, yet their probability and severity of consequences is usually much lower as compared to external uncertainty.

It is significant for resilient supply chains to discover the disruption in a reasonable period of time. [27] argues that executives must be able to identify the source and types of disruptions, and thus to develop methods to discover them in a timely and responsive fashion. The discovery of disruption should then be followed by using appropriate methods to recover from negative effects quickly and prevent them from affecting further links of a supply chain – Fig. 2.

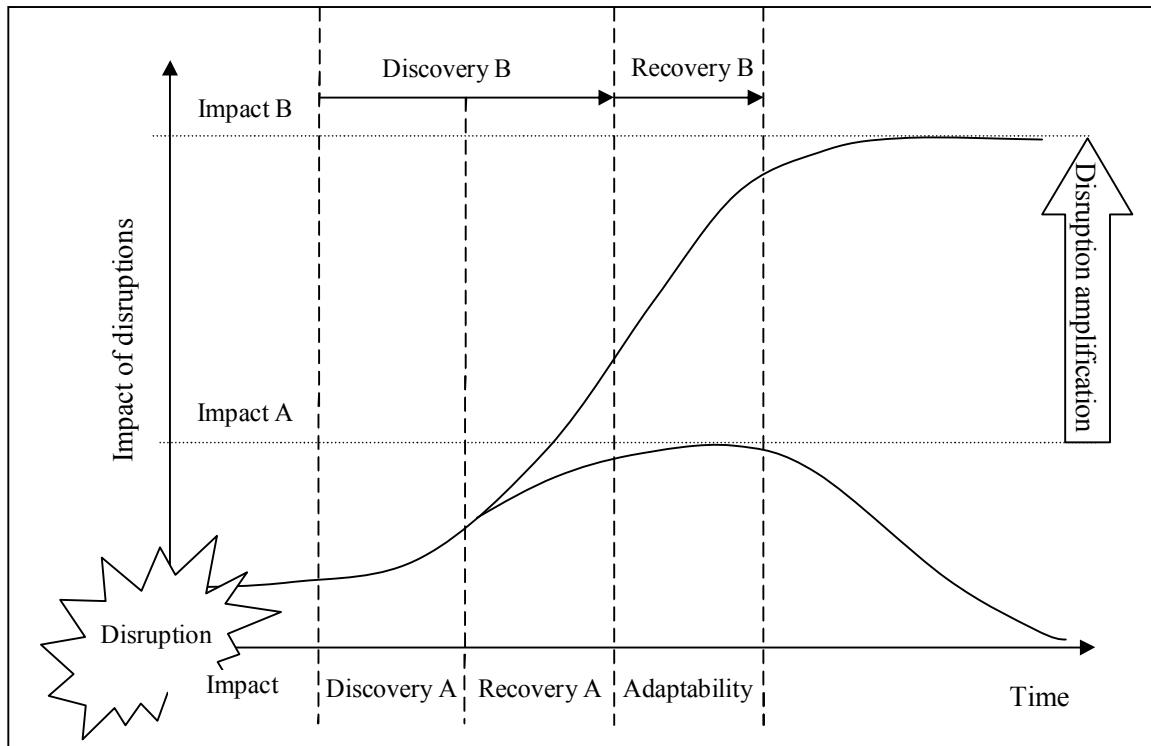


Fig. 2. The phases of lifecycle of resilient supply chains

Adopted from [27]

The companies constituting resilient supply chains are referred to as agents. They are characterized by autonomy, flexibility and internal thread of control in a complex adaptive system [28], [29], [30]. Consequently, the links in resilient supply chains have autonomy, usually driven by financial advantages, they are active and have their individual thread of control. Following the distinction by [31], a prevailing number of agents in resilient supply chains are heterogeneous, which denotes that agents may follow their own goals, which are achieved under different constraints and with the use of diverse action patterns.

Resilient supply chain is a special type of a complex system which is characterized by adaptation. Accordingly, it possesses the capability to consciously alter the system configuration and influence its current and future survival [16]. [32] underline the significance of adaptive capacity of resilient supply chains by referring to proactive resilience. In other words, resilient supply chains remain responsive, flexible, reactive and often deliberately proactive to the disruptions which affect them. Proactive adaptation capacity is therefore a component of resilience that reflects the learning process of system behavior in a response to disruption [33]. Assuming that resilient supply chains are able to learn while organizing themselves, we argue that proactive adaptation is based upon the tenets of the triple learning loop. It significantly distinguishes the concept of resilient supply chain from other kinds of supply chains as a learning organization. Accordingly, [34] posit that the triple learning loop tends to increase the fullness and deepness of learning about the diversity of issues and dilemmas faced, by linking together all local organizations of learning in one overall learning infrastructure, as well as developing the competences and skills to use this infrastructure. In other words, it pertains to the decision making process under uncertainty. On the contrary, non-resilient supply chains usually operate in

line with the tenets of the single or double learning loop, which refer to the decision making process performed under certainty or risk, respectively. The single learning loop manifests an adaptive process with changes in the organization's knowledge and competency without affecting present policies, objectives or mental maps [35]. The occurrence and effects of changes are certain, and the deviations caused by these changes are permanently corrected. Therefore, the single learning loop is usually achieved in the management of integrated supply chains in a stable environment. The double loop learning is achieved when the changes are detected and corrected in ways that involve the modification of underlying norms, policies and objectives [36]. These changes may be induced by risk factors whose probability of occurrence and effects are known. Consequently, we consider this situation as supply chain risk management.

Resilient supply chains are capable to maintain a quasi-equilibrium state, which suggests balancing between complete order and incomplete disorder [37]. When resilient supply chains remain closer to the state of complete order, their behavior is usually repeated over time in a more regular and therefore predictable way, with limited deviations from this stable pattern [38]. In the opinion of [39], regularity and stability is equivalent to death for complex adaptive systems, resilient supply chains pass into far-from-equilibrium state as the result of exposure to disruptions from the external and internal uncertainty. However, it is worth noting that resilient supply chains do not pass fully to the extreme far-from-equilibrium state, as it may lead to organizational chaos. Accordingly, quasi-equilibrium state of resilient supply chains denotes that they are looking for balance called the "edge of chaos" [40]. In other words, oscillating on the edge of chaos ensures to maintain order necessary to effectively produce something and simultaneously react to open-ended changes in the environment. Once the order is reached, a resilient supply chain is capable to pass the edge of chaos again, and yield a state of new order to reduce the tension caused by a new disruption. At the edge of chaos, too much tension brings disorder, which hinders constructive operations performed in a state of order [41].

The edge of chaos is a region of self-organization and emergent behavior [1], [42], [43]. Following the opinion of [44], we argue that self-organization is an internal process of resilient supply chains, not imposed by outside elements. In other words, self-organization results from the autonomous interaction of single agents within a system [45], although external factors of uncertainty may disrupt the current state of order and initiate the transition of resilient supply chain to a new, more desired state of order. Self-organization is carried out by the agents inside the system and yields the emergence.

Drawing on the insights of [46] and [47], the emergence from the perspective of resilient supply chains can be described as the outcome of collective behavior, i.e. interactions among agents (companies) performing something individually, or together, which creates some kind of pattern or behavior which the companies cannot produce individually. Emergence is anchored in the concept of synergy, which demonstrates that the whole is greater than the sum of its parts.

THE CONCEPTUALIZATION OF RESILIENT SUPPLY CHAINS AS COMPLEX ADAPTIVE SYSTEMS – PRELIMINARY ANALYSIS BASED ON SECONDARY RESEARCH

Research Method

In order to identify the major properties of resilient supply chains as complex adaptive systems, the case study method was employed. The goal of the study is very complex and requires a multidimensional qualitative analysis. Therefore, it has to use different data sources. As the study is at its preliminary stage, we collected, integrated and analyzed only data from public sources, including conference papers, articles, public reports and company press releases.

The significance of certain characteristics of resilient supply chains as complex adaptive systems has been provided by several publications containing descriptions of organizations which suffered severely from disruptions. However, the most relevant and thoroughly investigated examples of resilient supply chains as complex adaptive systems have been drawn from the Japanese automotive industry. The literature provides the description of Toyota, which was exposed to severe disruptions caused by the fire at one of its suppliers. As a result, Toyota supply chain had to conduct a recovery process. However, the previous publications mostly analyzed this supply chain from the perspective of long-term collaborative partnerships, knowledge management, reduction of supplier base and sourcing diversification [48], [9], [49], [50].

Consequently, using data from these publications, this paper attempts to analyze the supply chain from a different angle, highlighting the major properties of a resilient supply chain referred to as a complex adaptive system. Accordingly, it reexamines the extant publications and, based on the previous discussion of the properties of complex adaptive systems, it strives to draw implications for resilient supply chains. Thus, the conducted case study analysis served as theory elaboration. [51] noticed that in theory elaboration, general theoretical logic is applied, but does not anticipate the empirical findings by a priori formulation of propositions. Accordingly, the empirical results of this study partly reaffirm the validity of using complex adaptive systems theory to explore the concept of resilient supply chains. However, they also indicate some inconsistency, contradictions and understatements discouraging to make a full use of this theory in the field of resilient supply chains.

Case Study Analysis

The study describes an exemplary supply chain of Toyota, which was exposed to the negative effects of the outbreak of fire at one of its suppliers – Aisin Seiki on February 1, 1997. Its consequences were devastating not only for the supplier, but also for the whole supply chain. The special-purpose machines and drills manufacturing proportioning valves were almost completely destroyed. Furthermore, the supplier was the sole source of p-valves and master cylinders, which led to shut down Toyota plants and halt the operations performed in almost all collaborating companies across the whole supply chain.

The structure of the supply chain, similarly to other supply chains operating in automotive industry, is very complex, as it consists of many links located on many stages of physical flow of products. The complexity of organizations in automotive industry has been investigated by [52], who allude that supply chain structure is multilayered and consists of dozens of echelons serving the specific roles in different parts of a supply chain. Similarly, the complex structure of Toyota supply chain was exposed to severe disruptions caused by the fire.

The analysis of complexity of the supply chain also reveals its agent-based structure. It consists of a huge number of heterogeneous firms playing different roles and serving certain functions for the whole supply chain. It gives the companies a special position in the supply chain. For instance, the relationships between Toyota and Aisin Seiki were extraordinarily filled with mutual trust, commitment and high quality of the delivered offering.

The links in the analyzed supply chain are independent and possess autonomy. Some of them participate in several overlapping supply chains operating in automotive industry, including, apart from Toyota, also such automakers as Mitsubishi, Isuzu, Suzuki, Daihatsu, Nissan [50]. It suggests that particular links are only dedicated to Toyota supply chain, but through the participation in many supply chains of automotive industry, they also obtain their individual, often exclusive goals. This in turn gives them the opportunity to behave in their own manner, which may be instrumental for the supply chain to pass and oscillate on the edge of chaos.

At the very beginning, when the fire showed up and was effectively put out, the disruptions were very unexpected and no one was familiar with their consequences. The communication was difficult and misleading data was released. It may have affected the accuracy of decision making process [48]. Therefore, at first glance the supply chain seemed to be inevitably pushed to the state of total chaos. However, its resilience enabled to overcome inertia and initiate the recovery process. Table 1 presents subsequent behavioral phases of the analyzed supply chain and its properties pertaining to complex adaptive systems. Based on previous publications, we identified the following phases of its behavioral pattern: estimation of disruptions, pre-recovery process, actual recovery process and adaptation.

Although the described processes consisted of several activities, they were performed very fast, showing the ability of the supply chain to react quickly to incoming disruptions. The bottom of Table 1 shows the time of reaction and duration of the certain phase. However, it is very approximate, as it is difficult to indicate the detailed time of a specific phase, since its activities overlap and they are performed in many different supply chain links with diverse time operations. Therefore, its role is rather to demonstrate a quick time of response obtained by the links in Toyota supply chain.

A brief review of Toyota supply chain revealed that the extent and strength of disruptions was overwhelming for the links. Not only was the sole supplier affected by the negative consequences of the fire, which resulted in the complete destruction of the special-purpose machinery and drills, but also, as a consequence, a huge number of assembly lines at Toyota were shut down. This, in turn, initiated a snowball-effect, as we can describe the transfer and amplification of hazardous effects in other supply chain links. In consequence, the operations performed in most of manufacturing companies in Toyota supply chain were halted, and a great number of tiered suppliers and service providers were affected by the disruptions. The reaction of top tier links in the supply chain was immediate.

Although the estimation of the situation induced by disruptions was performed fast, it turned out to be very apt and effective. It enabled to initiate the phase called ‘pre-recovery’, which preceded the actual recovery process. As the organization decided to restore previous manufacturing capacity of p-valves in the supply chain, it started to make efforts to involve in this process as many companies as possible.

Table 1. The behavioral phases of the supply chain as complex adaptive system

Uncertainty factor	Discovery of disruptions estimation of the effect (strength and extent) of disruption	Pre-recovery process	Recovery process	Adaptation
The eruption of fire at the supplier of Toyota	Special-purpose machinery and drills were almost completely destroyed at the supplier	Establishing the “emergence response unit” to centralize and coordinate activities after the outbreak of fire	Gathering all available machines (also including exhibition models from showrooms) in order to replace the ones destroyed in the fire	All Toyota plants were back to normal production of p-valves in the next few days, when companies were in full operation, reaching the previously planned production capacity
	Twenty assembly lines at Toyota were shut down, as nearly in all its vehicles used p-valves from the supplier	Asking potential partners to organize alternative production sites for p-valves	Establishing temporary production sites in existing plants in order to take over the production of p-valves	The share of p-valves manufactured by the supplier was less than 10 percent of the total demand
	The operations performed in most of manufacturing companies in the supply chain were halted	Contacting the clients in order to prepare a priority list of p-valves required by the market	Outsourcing some of the operations to service providers in order to make more space for the production of p-valves	
	Hundreds of tiered suppliers and service providers of Toyota supply chain were affected to a lesser or greater extent by the disruptions	Sending drawing designs to the companies which voluntarily agreed to help	Drafting a coordination plan in order to establish a new division of labor and determine organizational roles in the supply chain	Settling an interorganizational compensation for recovery efforts
Approximate time	February 1 st (the very same day)	February 1 st – 3 rd (Days 0-2)	February 4 th – 9 th (Days 3-8)	February 10 th - (Days 9 and the following)

Aisin Seiki established the “emergence response unit” to centralize and coordinate activities after the outbreak of fire. It also started to ask potential partners to organize alternative production sites for p-valves and contacted its clients to prepare a priority list of p-valves required by the market.

Following these actions, Aisin Seiki sent out the drawing designs to the companies which voluntarily agreed to help, and then approved the prototypes of machines provided by the supplier before starting production. This phase was very difficult to conduct, although it lasted only for a few days.

There were many obstacles encountered, as most of the firms had never produced p-valves and had not possessed the necessary know-how. Moreover, the machines were highly specialized, dedicated for the production of certain p-valves and Aisin’s know-how was highly restricted, which limited easy transfer of expertise between the companies [48]. In order to solve all these problems, the companies initiated the actual recovery process, which was supposed to provide them with necessary production sites enabling to increase the manufacturing capacity of p-valves. They organized the process in many different ways. Some of them gathered all available machines in order to replace the ones which had been destroyed in the fire, some established temporary production sites with prototypes in the existing plants, while the others outsourced the operations to service providers in order to make more space for the production of p-valves. The production of p-valves was geographically dispersed in many sites set up in several supply chain links, which required response units and effective coordination plan to determine a new division of labor and organizational roles in the supply chain.

However, [48] underline that the recovery process not only involved individual efforts to establish manufacturing sites and increase production, but also an intense flow of employees between companies to discuss technical or organizational problems and disseminate solutions. This interorganizational coordination contributed to successful outcome, which was more than a simple sum of individual efforts, and thus yielded synergy. This evidences an important property of emergence. Accordingly, the outcome of collective behavior of companies constituting Toyota supply chain creates new knowledge, bringing about a kind of behavioral pattern which the companies cannot produce individually. [53] argue that the emergent nature of organizational knowledge in Toyota supply chain may be clearly observed when promptness, agility and coordinated activities among the links are required to copy with totally unpredictable factors of uncertainty, such as the eruption of fire.

Although it was Aisin Seiki that initiated the whole recovery process, the following activities undertaken by certain links in the supply chain were carried out with very limited control and no additional valuable time spent on a discussion of technical rights and financial compensation [48]. In the result, the supply chain was able to self-organize through oscillating on the edge of chaos, which enabled to conduct the necessary recovery process quickly and spontaneously.

In the result of the efficiently-conducted recovery process, the supply chain passed to adaptation. During this phase, the supply chain demonstrated a profound capability to learn, as it was able to solve several technical problems emerging from a new quasi-stable state. Firstly, the supply chain had to overcome the issue of p-valve production by machining centers. Therefore, design drawings and process instructions were modified to align them with a new production type. Moreover, the supply chain was able to increase the production volume through the reduction of cycle time and presetting of the machining centers compensation [48]. It shows that in order to adapt, resilient supply chains are able to learn and make full use of diversity and heterogeneity of companies. It also evidences that through the self-organization process, the supply chain was

able to reconfigure its network and processes in order to fill up the gap in the production of p-valves.

As the aftermath of adaptation process, all Toyota plants were back to normal production of p-valves in the next few days, when companies were in full operation, reaching the previously planned production capacity. It clearly shows an adaptive capability of the supply chain and its transition to a new quasi-stable state, as the share of p-valves manufactured by Asin Seiki was less than 10 percent of the total demand. The other example of adaptive skills of the supply chain was to settle an interorganizational compensation successfully for the recovery efforts of all involved companies.

DELIVERABLES AND DISCUSSION

The paper offers insights into the concept of resilient supply chains both in the theoretical and practical frameworks. It complements a theoretical framework of resilient supply chains with evolutional origins of the concept through indicating that resilient supply chains are rooted in the decision making process, which is typically performed with three basic conditions of certainty, risk and uncertainty. Drawing on these tenets, we argue that the concept of resilient supply chains is a response to uncertain environmental conditions, thus it is an extension of supply chain risk management, which typically focuses on predictable and known disruptions. In parallel, we underline that the concept of resilient supply chains complements the behavioral pattern of organizations with other significant properties, borrowed from the complex adaptive systems theory.

Drawing on this theory, the findings show that in order to be truly resilient, supply chains should possess a number of distinguishing properties of complex adaptive systems, namely:

- complex structure, which consists of many network relationships established between structurally differentiated companies;
- openness, describing the open nature of a resilient supply chain, which remains in permanent interaction with its environment and is induced by environmental conditions (especially by uncertainty);
- agent-based structure consisting of a huge number of heterogeneous firms which possess their individual goals, play different roles and serve certain functions for the whole supply chain;
- ability to remain in a far-from-equilibrium state, which is usually typical for the first period, while supply chains are affected by disruptions and inevitably pushed to the state of total chaos. However, resilient supply chains should be able to overcome their initial inertia and start the process of transition to another quasi-stable state;
- capability to oscillate on the edge of chaos, which denotes self-organization and emergent behavior. The first one describes the ability of certain links of resilient supply chains to undertake activities immediately and with a very limited supervision of the leading company. The ability to self-organize enables to conduct the necessary recovery process quickly and spontaneously. The emergent behavior of resilient supply chains is manifested in the outcome of collective behavior of companies. In other words, the emergence of resilient supply chains demonstrates a kind of behavioral pattern which cannot be yielded by individual efforts of companies, and is achieved through synergy;
- adaptive capability which is followed by discovery and estimation of disruptions, pre-recovery and actual recovery process. In case of resilient supply chains, the phase of discovery and estimation reveals that disruptions induced by uncertainty usually have a very

profound and overwhelming impact on the whole system. Therefore, the phases of pre-recovery and actual recovery are needed. They mean that supply chains remain on the edge of chaos for some time, which enables them to acquire necessary strength and effectiveness in order to pass successfully to another, more desired, quasi-stable state. Thus, the system is able to adapt to new environmental circumstances, as well as to gain or sustain its competitive advantage over the market rivals.

To sum up, it is worth noting that there is some theoretical inconsistency, which may discourage the use of the complex adaptive systems theory in explaining the issue of resilient supply chains. Firstly, as the complex adaptive systems theory is extensively developed by many scholars with different backgrounds, representing various scientific disciplines, including physics, biology, ecology etc., there is still a lack of coherence in theoretical foundations. The conceptual confusion increases even more due to the diversity of regions where the complex adaptive systems theory is studied and developed. Tracing the roots of complex adaptive systems theory, [54] distinguish between three stages: European, American and econophysics. However, the inconsistency is not only the issue of terminology and differences concerning the language used in specific fields, but also the assumptions which are drawn to build the essence of theory. They may arise from different research perspectives exploited by academia. Consequently, as the complex adaptive systems theory is anchored in epistemology, there is room for interpretation and subjective opinions, which lead to obvious differences.

It seems to have a profound impact on the extent of using the complex adaptive systems theory to explain supply chains, and particularly the resilient supply chains. For instance, some authors maintain that organizations as complex adaptive systems cannot operate in a stable state, as it would put them to death [39], while others allege that a CAS can pass to a stable state temporarily, in order to be able to operate effectively and achieve organizational goals [55]. These problems usually occur while drawing upon a specific conceptual perspective of the complex adaptive systems theory, which is anchored in the interpretative paradigm [56]. The use of this paradigm determines methodology, which is mostly based on case study analysis. Accordingly, the prevailing share of previous publications on supply chains as complex adaptive systems use qualitative methodology.

On the other hand, the inconsistency may also result from the ontological difference among the phenomena typical for specific disciplines and described by the complex adaptive systems theory. However, in this case a wide-range forum for discussion is necessary to clarify whether the specific phenomenon may be compared across various disciplines, as well as to identify the alleged differences.

Regardless of the aforementioned problems, the study revealed that the complex adaptive systems theory provides a valuable framework to explore the way contemporary organizations operate in a turbulent environment. Specifically, the conceptual analysis and empirical research of practical examples evidenced that complex adaptive systems possess a bunch of major properties typical for resilient supply chains. Although the disruptions caused by uncertainty are difficult to predict, and their strength and impact may be rarely estimated, the preceding efforts for institutionalized development of necessary properties of resilience within supply chains ought to be made. Resilience and its detailed properties drawn upon the tenets of complex adaptive systems theory may protect supply chains against the disruptive effects of uncertainty and increase the chance for surviving and thriving in the contemporary turbulent and unpredictable environment.

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COUNTERACTING THE NEGATIVE EFFECT OF STRONG CUSTOMER TIE ON PRODUCT INNOVATIVENESS

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ABSTRACT

Customer focus is a double-edged sword that seldom has empirical studies to consider its paradoxical impact on firms and how firms can deal with such effect. In this study, we address a research question: given the negative effect of strong customer tie on product innovativeness, how do brand manufacturers achieve product innovation? We established a theoretical model based on the notion of social capital theory by including the counteracting effect from the firms innovative orientation and the capability of exploiting suppliers. The model extends the traditional strategy-performance paradigm by introducing dynamic capabilities as mediators. Using a sample of 560 Chinese brand manufacturers, we find that our theory is supported. The extent of innovative orientation and the capability of exploiting suppliers can counteract and overcome the negative effects of strong customer tie on product innovativeness. As a result, the product innovation can still be achieved.

KEYWORDS: innovative orientation, strong customer tie, dynamic capability

INTRODUCTION

Strong tie to customer has been considered by business practitioners and academia for long as a kind of strategic orientation that determines the competitive advantage. Getting close to customer is central to most modern management approaches (Macdonald, 1995). It stresses the advantages of building close relationship with customer (Fredberg and Piller, 2011; Palmatier et al., 2006; Salter and Narver, 1995) and thus drives the organizations to assess and meet customer expectations, manage the customer relationships, and commit to the customers' requirements (Dean & Bowen, 1994). It therefore unavoidably leads to the implementation of exploited type of process management with a focus not to surprise customers (cf., Ng et al., 2015). However, the impact of strong tie with customers is nevertheless inconclusive in the literature. While the market, strategic management and quality management literature found that it positively influences the market, financial and organizational performance (Dean and Bowen, 1994; Deshpande, et al. 1993; Flynn, et al., 1995, 2001; Im & Workman Jr. 2004; Narver & Slater, 1990; Saraph et al., 1989; Zhou, et al., 2008), the literature of product innovation and disruptive technologies suggests otherwise. Accordingly, a customer-led philosophy is short term and reactive in nature (Slater and Narver, 1998). It is a double-edged sword that its full-stretching can be harmful to the organization (Christensen, 1997). Specifically, the stronger the tie, the less innovative product will be (Christensen and Bower, 1996; Danneels, 2003; Fredberg and Piller, 2011; Henderson, 2006). At best, it leads to incremental and trivial product development efforts (Bennett and Cooper, 1979; Chirstensen and Raynor, 2003).

Such paradox motivates this study in an attempt to address a research question that given the paradox of strong tie to customers, how do brand manufacturers deal with its negative

effect on product innovativeness?

We develop and validate a theoretical model by drawing upon an extended framework of the traditional model of ‘strategic orientation leading to performance’ (e.g., Chandler, 1962; Mintzberg, 1983; Porter, 1985). Researchers are casting doubt on this simple direct relationship and increasingly believe that capabilities may be the mediator of interest (Sinkovics and Roath, 2004). The conceptual model we employ in this study as shown in Figure 1 reveals that it is important for a brand owner to foster its innovative orientation and to resort to suppliers that the negative effect of customer focus on product innovativeness can be attenuated.

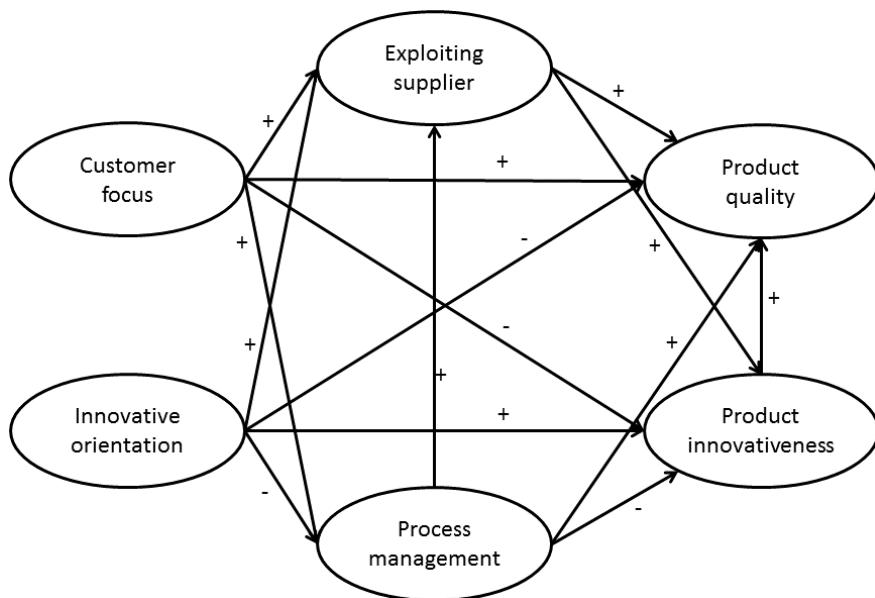


Figure 1 Hypothesized Model

In this model, we propose two firm orientations and two organizational capabilities that interact and counteract with each other. While strong tie with customer drives a firm to exploit its resources in order to meet customer’s requirements, the innovative orientation/culture of the firm helps to balance the exploitation orientation by imposing exploratory elements, both of which are essential to the firm’s competitiveness (Ng et al., 2015). However, orientation requires organizational capability to realize. In this study, we consider the capability of process management and the capability of supply chain partners exploitation. The former capability represents the firm’s ability to maintain, improve, integrate and reconfigure its internal resources (Ng, 2009; Peng et al., 2008) while the latter capability reflects the firm’s ability to acquire, apply and integrate external resources of its supply chain partners (Vickery, et al., 2003; Peterson et al., 2004). The identification of the two capabilities is built upon the theory that both the capability of internal integration and external integration are critical to achieve various firm performances and value creation to customers (Droge et al., 2004; Mitra and Singhal, 2007; Peterson et al., 2004; Song and Benedetto, 2007).

The remaining part of this paper is organized as follows. We first review the relevant literature and develop our hypotheses. Then we delineate the scales development process, questionnaire design, and the measurement quality. We next report the validation result of our proposed. Finally, we discuss the results and their managerial implications, and summarize

our work with remark on the limitation and future research opportunities.

PARADOX OF CUSTOMER FOCUS

Customer focus as a firm's strategic orientation, is a special approach focusing on satisfying existing customers and provides a foundation for firms to generate superior and continuous improved performance (cf., Gatignon and Xuereb, 1997). From the marketing perspective, firms must be customer oriented such that new products should be launched to meet the customers' specific needs (Bennet and Cooper, 1979). Customer oriented businesses strive to understand the customer desires via establishing deeper relationship with customers, and build products and services to satisfy the desires (Slater and Narver, 1998). From the quality management perspective, managing for quality and competitive advantage means a firm must become customer oriented because the competitive quality must be guided by a transformation implied in underlying organizational logic including values, beliefs, assumptions and premises (Lengnick-Hall, 1996). From the social capital perspective (e.g., Adler and Kwon, 2002; Granovetter, 1992), customer focus represents the strong ties with customers which is a strong mental coupling between the firm and the customers characterized by the feelings of respect, the belongingness, and the willingness to engage in cooperative interaction (Fredberg and Piller, 2011). Via the social embeddedness, customer-oriented firms will enjoy the benefits of obtaining fine-grained information from the social network (Uzzi, 1997) characterized by quality, relevance and timeliness (Adler and Kwon, 2002) that helps them to better forecast the future (Uzzi, 1997).

However, "*it locks the firm into certain strategic course, simultaneously locking it out of alternative courses.*" (Danneels, 2003:24) Strong tie with customers leads to strong commitment that makes alternative actions less probable (Danneels, 2003). Particularly, focusing on current customers will paralyze the firms from reacting to the wave of disruptive technologies (Christensen and Bower, 1996) and other strategic opportunities (Henderson, 2006) when the firms becomes captive of satisfying existing customers' needs but are reluctant to search for novel solutions (Christensen, 1997; Fredberg and Piller, 2011). Such captivity stems from the cognitive frame as an information filter which is built upon the collective sense making that emerges from the strong relationship with existing customers (Fredberg

and Piller, 2011; Henderson, 2006). As a matter of fact, "*[t]rue product innovation depends to a large extent on scientific discovery, which often must proceed in the absence of a clear and definable customer need or want.*" (Bennet and Cooper, 1979:77) Therefore, close ties with existing customers will constrain a firm's ability to innovate (Christensen and Bower, 1996; Macdonald, 1995) and sometimes even is a fatal mistake to the organization (Christensen, 1997). In so doing will crowd out the disruptive technologies (Christensen and Bower, 1996), attenuate the firm's ability of competence renewal (Danneels, 2003) and even result in the incapability of serving the new customers (Henderson, 2006). One main reason is that customers are usually lack of foresight (Hamel and Prahalad, 1994). They often resist to changes (Verganti and Buganza, 2005) and are not completely knowledgeable about the latest trend of market and technological development (Frosch, 1996; Hortinha et al., 2011). Furthermore, close tie with customers will induce strategic risks to the firm. It includes the risk of disclosing business information, the handover of sovereignty, the difficulty of adjusting to the demands of other customers and the divergence from the firm's core research (Macdonald, 1995).

Given the antithetical theories, there is nevertheless little empirical evidence to

demonstrate how firms can handle the potential dilemma that strong tie to customer has created. In this study, we suggest that establishing innovative orientation and exercising external capability is the key to handle the paradox.

RESEARCH METHODOLOGY

Sampling and data collection

With the facilitation of China Quality Management Association, a national-wide survey across fourteen provinces has been conducted in China. Stratified sampling method has been employed to draw samples based on the industry (manufacturing versus servicing), sales revenue (five categories) and ownership (state-own, collective, private-own, joint venture, share, and foreign investment). The Association then administered the questionnaire to one key informant, each from the 5000 sampled firms in China. The unit of analysis is at the organizational level. Of the 2675 usable returned questionnaires, we have identified 560 brand manufacturers with top or middle manager as the key informant with the demographics of the organizations shown in Table 1.

Survey instrument

In this study, we identify items with reference to the published Malcolm Baldridge National Quality Award MBNQA assessment criteria and previous TQM studies on MBNQA and process management studies (e.g., Flynn and Saladin, 2001; Wilson and Collier, 2000). We use six items to measure strong tie to customer. They are (1) The company divides customers into different groups and markets to better understand and define customers' needs; and seven for process management.

We adopted four items to measure how innovative oriented a firm is. The items probed the informants about (1) the extent to which the firm collects performance data for product/service innovation; (2) the extent to which the employees involved to improve and optimize the firm's processes; (3) the extent to which the firm assesses and improves the possessed technologies; and (4) the extent to which the firm escalates the technology level and the capability of innovation. Concerning the capability of supply chain partners exploitation, we have developed the new items based on previous researches discussing about customer and supplier involvement in new product development (Tan and Tracy, 2007). We identified five items by asking informants about (1) the extent of close communication with suppliers on product design and quality; (2) the extent to which information and data sharing with supply chain partners; (3) the extent to which supplier is involved in quality improvement; (4) the extent to which focal firm share internally the information collected from supplier; and (5) how likely supplier involved in the stage of product design.

With regard to product innovativeness, we have adopted measures from previous research (Gatignon and Xuereb, 1997; Koufteros et al. 2007; Brockman and Morgan, 2003). Product innovativeness is measured by asking informants about their agreement four aspects of product: more advanced technology adopted in the product/services designed by company, products/services designed by company often causes revolutions in the market, product/service designed by our company are totally new to market, product/service designed by our company is very innovative. Similarly, With reference to Pappu et al. (2006), we measure product quality with four items by asking informants about their agreement on four aspects of products: the extent that quality is continuously improved, the existing quality level, the amount of unique feature, and the level of technology superiority.

Finally, with reference to Narasimhan and Kim(2002) and Vickery et al.(2003), financial performance is measured by asking the extent to which informants evaluate its situation relative to their primary competitors on growth of sales, return on investment(ROI), growth of ROI, return on sales(ROS), growth of ROS.

After generating an initial set of measurement items, we establish a pen-and paper questionnaire and translated the questionnaire from English to Chinese and backward translated to English in accordance with Brislin's (1980). Wordings have been refined accordingly. We have invited three quality experts and one marketing expert in China, who are actively involved in the teaching and the research of operations management and marketing respectively, to assess the content validity of the items. We have further pilot tested the questionnaire by interviewing managers from thirty Chinese brand manufacturers. Based on the result, some minor changes in wordings have been made.

Measurement quality

We estimated the unidimensionality, reliability, convergent and discriminant validity of each construct. They all show satisfactory results.

HYPOTHESIS TESTS AND RESULTS

To answer the question of how firms can counteract the negative effect of customer focus and exploited process management on product innovativeness, we have established a theoretical model and tested it using structural equation modeling (SEM) on the AMOS 19.0 platform. Figure 2 shows that the overall goodness of model fit appears satisfactory ($\chi^2/df=3.564$, RMSEA=.068 [.064, .072], CFI=.924, TLI=.915). The data fits our hypothesized model and demonstrates that innovative orientation and the capability of exploiting suppliers can neutralize the negative effect of customer focus and exploited process management on product innovativeness.

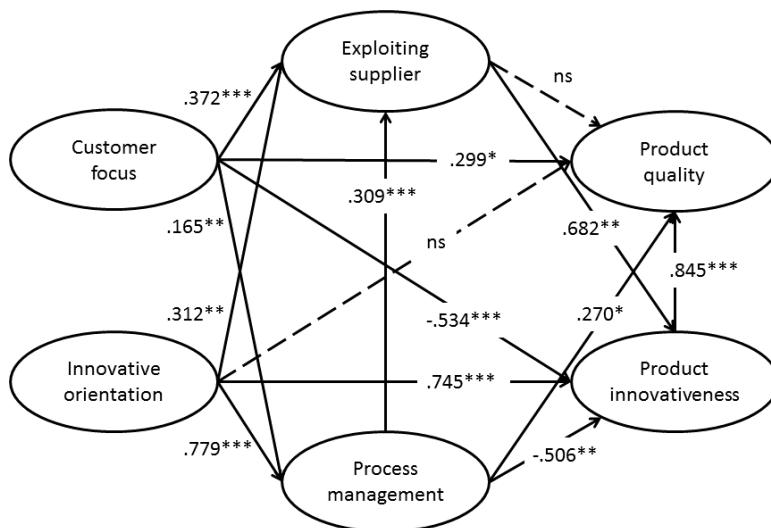


Figure 2 - Result

DISCUSSION

Validation result of the theoretical model

This study is one of those querying the effectiveness of the one-side perspective towards

customer focus and recognizing its double-edged characteristics based upon the perspective of the product innovation literature (e.g., Christensen, 1997; Christensen and Bower, 1996; Henderson, 2006) and that of strong-weak tie emerging from the social capital theory (e.g., Adler and Kwon, 2002; Daneels, 2003; Fredberg and Piller, 2011; Macdonald, 1995; Orton and Weick, 1990; Stanley and Narver, 1998). Therefore different from those studies that admire strong customer-tie monotonically (e.g., Dean and Bowen, 1994; Flynn et al., 2001; Reed et al., 1996; Wilson and Collier, 2000), we cast doubt on such claim but consent that organization should be aware of and prepared for the implied risks. Motivated by this line of thinking, this study is in an attempt to provide a theoretical explanation on the mechanism that firms use to deploy customer focus, given its paradoxical nature. We thus argue that despite the paradoxical effect of customer focus, firms can nevertheless achieve expected performance when appropriate mechanism is implemented. However, existing research effort on theorizing and empirically validating the way that firms deal with the paradoxical effect of customer focus, is nevertheless meager. Our study makes another contribution by extending the conceptual domain of the traditional model to include innovative orientation and organizational capabilities as the means to deploy firms' strategic intent. The result as shown in Figure 2 supports our hypothesized framework. It answers the research question by showing that to counteract the negative effect of customer focus and exploited process management on product innovativeness, firms need to foster strong innovative orientation and to get involved suppliers.

The finding of process management will elicit supply chain partners exploitation not only supports the theories and findings of previous research that internal integration leads to external integration (e.g., Braunscheidel and Suresh, 2009; Koufteros, et al., 2005; Stephen, 1989), but also provides empirical evidence to advance the associated theory. From the social capital perspective (Adler and Kwan, 2002; Kern, 1998; Uzzi, 1999), the firms with more internal connectedness will increase the risk of negative externalities, i.e., it will weaken the tie with external parties because "*feelings of obligation and friendship may be so great between transactions that a firm becomes a 'relief organization' for the other firms in its network.*" (Uzzi, 1997:59) Our result however shows that the phenomenon will be very unlikely in the strong-tie context. Strong tie with customers drives the firms to extend their system control to cover its partners outside the firm boundary and those cross-boundary activities, mainly because to reduce uncertainty by seizing more information (Koufteros et al., 2005) and to obtain new technologies and competencies (McDermott and O'Conner, 2002).

LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

In this study, we put efforts to establish arguments for the double-edged nature of strong-tie with customers but pay less attention to explore the issues related to weak customer-tie. Some may say that strong tie and weak tie are the two extremes lying in the same continuum that the result of strong-tie is opposite to that of weak-tie. However, increasing researchers are querying such perspective and propose a dialectical view of tie (e.g., Orton and Weick, 1990) which states that firms can have both strong and weak tie with customers though researchers are yet to provide a clear distinction between unidimensional and dialectical interpretation of the concept (Orton and Weick, 1990). Therefore, more conceptual works are expected further theoretical development and empirical validation.

Our study can be regarded as the one of the first attempts in the field to integrate strategic orientation and organizational capabilities, and investigate the dynamics among them. However, this study is limited in testing only two capabilities that are hypothesized to affect

product quality and innovation. We have not considered yet the role and effect of other capabilities, such as technological capability (e.g., Argyres, 1996) and absorptive capability (e.g., Cohen and Levinthal, 1990) that are deemed to determine firm's performance and may require the existence of fit. We also focus on the impact of customer orientation and innovative orientation without considering others that may have other sets of mediation mechanisms.

Fit between strategic orientation and organizational capability is worthy for further research effort. Although the needs for fit between organizational elements has been highlighted in previous literature (e.g., Ventraman, 1989; Reed et al., 1996), the application of which in the strategic orientation-capabilities fit has hitherto, been rare. To this end, the fit issue deserves further research effort. Our study has demonstrated different relationship exists between different pair of strategic orientation and organizational capability.

CONCLUSION

We have made several contributions via this study to the operations management (OM) discipline. First, this study is the first attempt to build a theoretical model to explain how firms can deal with the paradoxical effect of customer focus. Second, we shed light on the match of strategic orientation and organizational capability. Third, we have identified the dynamic-operating capability fit that previous studies have never discussed before.

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APPENDIX 1 - Unidimensionality and Reliability for Individual Factor (N=150)

		Factor Loading	Cronbach's α
Customer Orientation		Eigenvalue = 4.10, % of variance = 68.31 %	
CF ₁	Company divides customers into different groups and markets so as to better understand and define customers' needs.	0.86	0.91
CF ₂	Companies systematically listen and understand the needs and preferences of different groups of customer and markets.	0.86	
CF ₃	Company continually improves customer service process so as to facilitate customers to acquire information, make transaction and complaint.	0.86	
CF ₄	Company systematically measures the level of customer satisfaction and loyalty for the improvement of product/service processes.	0.83	
CF ₅	Company takes initiative to build up partnership with customers.	0.82	
CF ₆	Top management regularly discuss with customers face-to-face.	0.71	
Supply Chain Partner Involvement		Eigenvalue = 2.71, % of variance = 67.81%	0.84
ES ₁	Company shares its data and information with supply chain partners	0.86	
ES ₂	Company actively requests suppliers to be involved in the quality improvement activities.	0.88	
ES ₃	Company acquires and applies knowledge from supply chain partners	0.84	
ES ₄	Suppliers are involved early in company's project in product/service design project.	0.85	
Process Management		Eigenvalue = 4.62, % of variance = 65.97%	0.91
MP ₁	Key production/service processes have distinct and measurable performance indicators.	0.82	
MP ₂	Company standardizes and documents various production/service processes.	0.79	
MP ₃	Company instills the knowledge of new technology and organization into the design of production/service processes.	0.81	
MP ₄	Company maintains a clean and organized workplace in order to enhance work efficiency.	0.83	
MP ₅	Company uses statistical methods to control the variation of production/service processes.	0.82	
MP ₆	Efficiency and effectiveness will be taken into consideration when company designs production/service processes (e.g., cycle time, productivity, cost control, etc.)	0.85	
MP ₇	Company encourages front-line employees to participate in process improvement activities.	0.77	
Product Quality		Eigenvalue = 2.76, % of variance = 69.07%	0.85
PQ ₁	Company's product quality is improving.	0.66	
PQ ₂	Products/services designed by company have better quality than the same types of products in the market.	0.89	

		Factor Loading	Cronbach's α
PQ ₃	Products/services designed by company have more unique features than the same types of products in the market.	0.90	
PQ ₄	Products/services designed by company have better technical performance than the same types of products in the market.	0.85	
Product Innovativeness		Eigenvalue = 3.09, % of variance = 77.32%	0.90
PI ₁	Products/services designed by our company adopt more advanced technology.	0.87	
PI ₂	Products/services designed by our company often cause revolutions in the market.	0.90	
PI ₃	Products/services designed by our company are totally new to market.	0.88	
PI ₄	Products/services designed by our company is very innovative.	0.87	
Financial Performance		Eigenvalue = 4.19, % of variance = 83.86%	0.95
FP ₁	Growth of sales	0.88	
FP ₂	Return on Investment (ROI)	0.91	
FP ₃	Growth of ROI	0.93	
FP ₄	Return on Sales (ROS)	0.93	
FP ₅	Growth of ROS	0.93	

IT'S ROLE AND VALUE IN SERVICE INNOVATION

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ABSTRACT

Information technology (IT) is increasingly applied to develop new services, being a crucial role in innovation. However, as IT is becoming a commodity, most companies cannot create a unique advantage through using IT alone. More importantly, some characteristics of IT (e.g., automation, standardization) may restrict creativity in innovation processes. Therefore, a disputed issue for researchers and practitioners is whether IT is a stepping stone or a stumbling block in developing innovative services. To illuminate whether and how IT matters in service innovation, this study divides IT resources into two categories: operand resources (i.e. IT infrastructure and human IT resource) and operant resources (i.e. process of utilizing IT to develop innovative services), to examine IT's dual roles and their impacts on service innovation. Using a sample of 247 firms in service industry to test our proposed model, we found that (1) IT's role as operand resource indeed cannot directly affect innovation outcome, but IT's role as operant resource can. (2) Through innovation-oriented HR system, firms can convert IT operand resources into IT operant resources. More importantly, our study proposes and validates that innovation-oriented HR system is a critical role which enables firms to transform IT operand resources to operant resources. The results provide managerial insights that IT is still necessary in service innovation, but firms need an innovation-oriented HR system to trigger employees both within and outside IT department to effectively use IT in service innovation processes, though which, firms receive competitive advantages.

KEYWORDS: Information Technology, Operant resource, Service Innovation,

INTRODUCTION

The importance of goods has declined while the importance of service to continue profitability has grown increasingly (Berry et al., 2006). Therefore, companies aims to not only provide a better service but also create service innovation in order to sustain their competitive advantages. Past studies show that information technology (IT) has become a critical role in all aspects of innovation, including service innovation, making IT as a critical facilitator of innovation ecosystems (Nambisan et al. 2013). However, while IT has also been extensively applied to innovation process, there are still debates about the role and value of IT (e.g., Carr, 2003; Stewart et al., 2003). For example, some studies indicate that IT could enhance work efficiency, promote productivity growth (Bartel et al., 2007) and keep companies innovative (Gordon & Tarafdar, 2007), but there are also studies argue that universal use of IT make companies unable to create a unique advantage through IT. Competitors can replicate IT-related resources easily. IT capabilities rapidly become available to all, and each of these reduce firms' competitive advantage by using IT alone (Carr, 2003). Furthermore, some characteristics of IT (e.g., automation, standardization) may also restrict creativity and innovation in existing processes (Gordon & Tarafdar, 2007). Therefore, it becomes critical for firms to understand how to operate IT in a positive way, and enable IT to support rather than hinder service innovation.

In the past, researchers had focused on a goods-dominant logic (GDL) which tangible output and discrete transactions were central, rendering academics have largely focused on tangible offerings. Researchers consider these tangible resources as operand resource. Overtime, trade gradually shift from goods exchanged toward intangibles exchanged (e.g., skill, service, knowledge), and people understand the intangibles may be firms' core competences. Researchers consider these intangible resources as operant resources (Vargo & Lusch, 2004). In short, paradigm shift from a GDL toward a service- dominant logic (SDL), in which intangibility, exchange processes are central (Vargo & Lusch, 2004). The paradigm shift also occurred in the evolution of IT. In the past, IT is an expensive and rare resource with few companies can afford it. The few companies owning IT assets can develop new services through IT and get competitive advantages. Overtime, however, IT physical assets become ubiquitous and easy to be acquired. Firms, therefore, turn their focus from the tangible IT resources to intangible IT resources such as IT application, IT skill, or IT specialized knowledge, in order to sustain their competitive advantages.

Following the transition, literature started to discuss the dual roles of IT in service innovation; that is, IT as an operand resource and IT as an operant resource. Nambisan (2013) defines *operand resource* are those resources (often tangible and static) that an actor acts on to obtain support for executing a task, whereas *operant resources* are those resources (often intangible and dynamic) that act on other resources to produce effects. In other words, companies can acquire and purchase IT as an operand resource (e.g., IT infrastructure, MIS employees) to develop innovation, and IT mainly plays a passive role in the innovation process. On the other hand, firms can develop IT as an operant resource (e.g. IT enabled innovation knowledge) which plays a proactive role as an innovation trigger to act on other resources rather than being operated on (Nambisan, 2013).

However, while a handful of studies have analyzed the role of IT as operand resources to improve the innovation success (e.g. Banker et al. 2006, Durmusoglu and Barczak 2011, Kleis

et al. 2012, and Pavlou and Sawy 2006), partially because operand resources are easily to observe, the role of IT as operant resources receives much less attention. Thus, the purpose of this article is to (1) examine the roles of IT as operand and operant resources on the impact of service innovation outcome, and (2) illuminate whether and how the role of IT as an operand resource can be converted into an operant resource.

THEORETICAL FOUNDATION

The purpose of this paper is to illuminate the effects of IT's dual roles respectively on service innovation outcome from the perspective of SDL view, and examine how IT's role as an operand resources can be converted into operant resource. Since IT is still an inanimate object until people manipulate it, human resource could be a crucial element to transform IT's role. Thus, this study proposes that companies need an "innovation-oriented HR system" to train their employees to leverage IT resources. The research framework is shown in Figure 1.

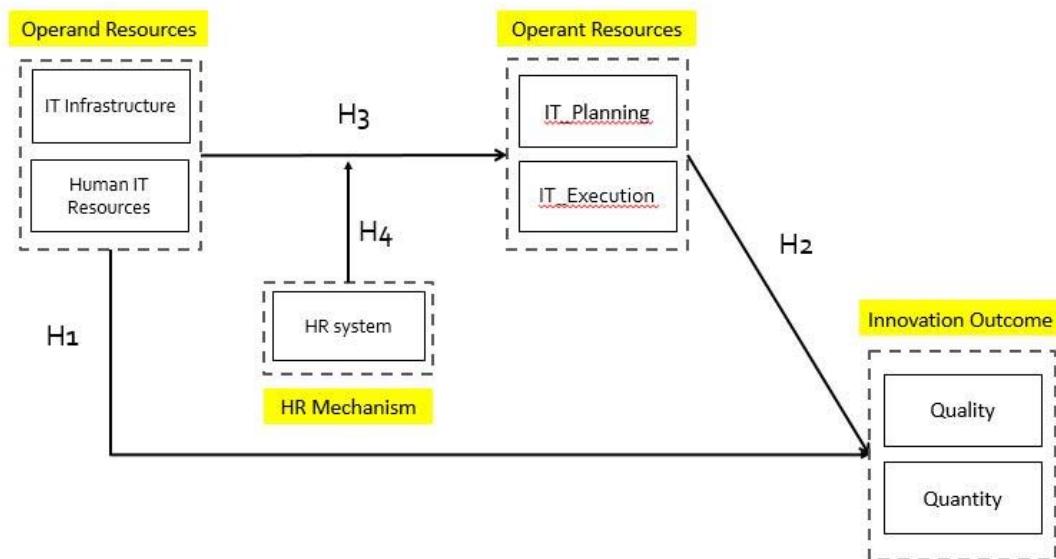


Figure 1 Research Framework

Perspective of Service Dominant Logic (SDL)

The SDL proposes that service is "the application of specialized competences (knowledge and skills), through deeds, processes, and performances for the benefit of another entity or the entity itself" and is an overarching approach for any economic exchange (Lusch & Vargo, 2006; Vargo & Lusch, 2004). Compare with GDL, the biggest difference of SDL is that SDL pays attention on the action of operant resources, such as knowledge and skills which are core competence of companies, while GDL pays attention on operand resources (i.e., goods). Moreover, in the SDL view, operant resource can produce effects by acting upon operand resources or goods, and enable human to generate the value of resource and to create more operant resources (Vargo & Lusch, 2004). Accordingly, with dominant logic shifted from GDL toward SDL, companies cannot only focus on the exchange of tangible resources but take the value of intangible resources into account.

IT's role as Operand Resources

Firms can purchase tangible IT-related resources to support the daily operations of the company. In fact, a number of studies suggest that IT-related resources have several dimensions, such as the physical IT assets (e.g., Bharadwaj, 2000; Ross et al., 1996), the IT-business partnership (e.g., Bharadwaj et al., 1999; Sambamurthy et al., 2003), and IT application of relevant skills (e.g., Bharadwaj, 2000; Ray et al., 2005). However, among these three dimensions, both of the physical IT assets and IT application of relevant skills has commonly been used in the IT literature, for the physical IT assets are basic tool for IT-related innovation, and IT tool are readily available; moreover, IT human assets can manipulate complex IT projects, and their technical skill can address business problems by envisioning feasible solutions (Ordanini & Rubera, 2010). Nevertheless, both of IT infrastructure and human IT resource are easily acquire, which also easily be replaced, and any company can acquire the resources through purchase, which is hard to make difference among competitors. Thus, according to the definition of operand resources, we consider IT infrastructure and human IT resources as the role of IT as operand resource. IT infrastructure is one of the tangible IT resources that comprise sharable technical platform, database, and computer and communication tech which support daily operation. Characteristics of tangible IT resources can decrease costs and provide cost-effective support (Bharadwaj, 2000; Ross et al., 1996). Firms can get IT competence through purchasing IT infrastructure to explore service innovation. Human IT resources incorporate technical IT skill, which is the IT-related know-how build on IT application or operation, and managerial IT skill, which include management's abilities to deploy IT applications on business problem solving or other business functions support (Bharadwaj, 2000). In this article, we investigate whether service companies have sufficient IT employees to support daily operations. Accordingly, we hypothesize:

H1: The higher use of IT as operand resource is associated with outcome of service innovation.

IT's role as Operant Resources

When IT's role is treated as an operant resource, it is defined as an innovation trigger which initiates new innovation processes or related routines of firms (Nambisan, 2013). Thus, we consider the process which utilize IT-related resources to develop new service as an IT enabled operant resource. New service development process (NSD) is a useful lengths that helps us understand the progression of new services. NSD comprises four stages: design, analysis, development, and final launch (Johnson et al., 2000). Menor et al. (2002) suggested that the cycle efforts are highly iterative and nonlinear processes, and is one of crucial elements to facilitate successful development. In some cases, the NSD process cycle can represent by two convergence, planning and execution. Johnson et al. (2000) suggest the planning phase consist of the first two stages of the NSD process cycle, design and analysis, which incorporates idea generation, concept development, and need to consider market viability, internal resources, and capabilities when making decisions. The final two stages of the cycle, development and launch, represent the execution phase which comprises service delivery system design, use of enabler, and cross-functional development efforts.

IT is an enabler in the NSD process cycle to facilitate the design of the service delivery

system. Nevertheless, IT has different functions and influence in the different development phase (Malhotra & Majchrzak, 2004). In the planning phase, the focus of this phase is to make preliminary market and business analysis of new service, and generate considerable ideas based on the assessment (Ozer, 2000). Thus, IT is tools to research and identify opportunities in this phase. In the execution phase, the ideas generated on the previous phase is to develop, test, and commercialize. In order to ensure the concepts and ideas is worth invested, companies need to evaluate the ideas continually and be tested throughout the process to make certain that customer needs are met (Durmuşoğlu & Barczak, 2011). Thus, IT is tools for project evaluation, and assists companies to launch new service to market in this phase, such as decision support systems is designed to enhance decision-making and enable companies to assess which ideas will be implemented and be a superiority services (Durmuşoğlu & Barczak, 2011; Rangaswamy & Lilien, 1997). Therefore, we focus on leverage dimension of IT capability which incorporates IT infrastructure and human IT resource to NSD process cycle and have hypotheses the following:

H2: The higher use of IT as operant resource is associated with outcome of service innovation.

The transformation of IT's role

In the above discussion, we respectively illuminate the dual roles of IT. However, how can firms convert the role of IT from an operand resource into a more attractive role of operant resource? Prior studies on IT capability, which refers to a firm's ability of shifting IT assets and capability to strategic applications, could serve as a foundation (Sambamurthy et al., 2003). Rooted in the perspective of resource-based theory, numerous studies suggest that firm's IT capability derive from the integration of IT-related resources (e.g., Bharadwaj, 2000; Ross et al., 1996; Sambamurthy et al., 2003). Bharadwaj (2000) define IT capability as the ability to organize and utilize IT-related resources of firms, and combine with other resources and capabilities to support business strategies. That is, companies rely on their IT infrastructure and IT human resource to develop service innovation, however, these IT operand resources can be easily acquired and owned by every companies. Thus, companies build service innovation through applying IT in innovation process, and combine IT operand resources with other firm resources to form IT capability (i.e. IT operant resources). Through the combination, IT's role can be converted into operant resources. Accordingly, we hypothesize the following:

H3: When combined with other firm resources, IT as an operand resource can be converted into (or is associated to) IT operant resource.

Innovation oriented HR system

IT is an inanimate object and needs to be manipulated by human to form IT capability. The debates about the importance of IT suggest that "IT never mattered, and what matters are the people who deploy and use them." The strategic advantage which built by IT comes from human manipulation and intellectual capital (Stewart et al., 2003). Therefore, in the viewpoint of Stewart et al (2003), human play a key role to make IT alive. Firms require a mechanism associated with human resource management to be a pivot which can leverage IT operand resources to IT operant resources.

Development of new services is uncertainty and risky (Atuahene-Gima, 1996; Durmuşoğlu & Barczak, 2011), firms need competent employees to cope with the variability when develop innovation activities. Madsen & Ulhøi (2005) claim that firms can rely on creative employees who are problem-sensitive and risk-taking, and the employees can tolerant of ambiguity. Firms can function creative and innovative characteristics as criteria to selects qualified employees, and the employees can be a major source to generate diversity of ideas to innovation (Brockbank, 1999). Thus, companies need the HR system to select qualified and creative employees to develop innovative service and make employees effectively utilize IT-related resources in innovation process. However, not every set of HR practices have effect on firm performance. Different type of HR practices will lead to different firm performance (Lau & Ngo, 2004). An HR system must with certain fit and alignment of organizational strategies (Wright & Snell, 1998).

An innovation-oriented HR system can develop an innovative organizational culture to foster innovative behaviors (Lau & Ngo, 2004). Moreover, for innovation-oriented companies, the practices of HR system are innovation center, and companies use the practices to support and enhance firms' innovation performance. The innovation-oriented HR system differs from a conventional HR system (Searle & Ball, 2003). Accordingly, our definition of the innovation-oriented HR system is a mechanism which focus on encouragements of service innovation, and the practices include innovation-oriented recruitment, training and reward. For example, firms consider creativity as employees hiring and selection criteria, train employees in creativity way, and innovative performance-based reward.

Traditionally, firms' IT capability is narrow within the IT unit (Pavlou & El Sawy, 2006). Recently, it is argued that to develop a competitive IT capability, firm should leverage this IT capability to construct full competitive potential of IT resources to all company units, and not limited to internal IT department (Ray et al., 2005; Pavlou & El Sawy, 2006). Pavlou & Sawy (2006) claim that IT capability should also be arisen outside of IT unit to effectively leverage IT-related resources. Therefore, manager need to focus on human development outside of IT unit, such as normal employees' recruiting and training toward using IT in service innovation processes. Following the proposition of Pavlou & Sawy (2006), we propose that an innovation-oriented HR system can assist employees to fully utilize IT-related resources and effectively leverage IT infrastructure and human IT resources in NSD process, so that IT operand resources can be converted into IT operant resources. Accordingly, we hypothesize:

H4: The innovation-oriented HR system can enhance the effects between IT as operand resource and IT as operant resource.

DATA ANALYSIS AND RESULTS

We conducted a survey to collect data from service companies in Taiwan which has implemented service innovation project within the past three years, and investigate how they apply IT to develop service innovation. The sample was selected from a list of top 5000 Taiwanese firms, published by the China Credit Information Service Incorporation, including firms in retailing (22.9%), transportation (17.6%), trading (9%), telecommunications (14.3%) and information (36.2%). Our target respondents are senior service managers of each firm. In total, 247 valid response was received for testing our research model and related hypotheses.

We measure our variables following previous studies' operationalization. Furthermore, composite reliability of each reflective construct is greater than or equal the 0.7, which possess a convincing reliability (Bagozzi & Yi, 1988). The factor loading show a range from 0.59 to 0.96, and AVE value for each of constructs in our study is greater than 0.5, thus, demonstrating a support for convergent validity (Hair et al., 1995; Shih, 2004).

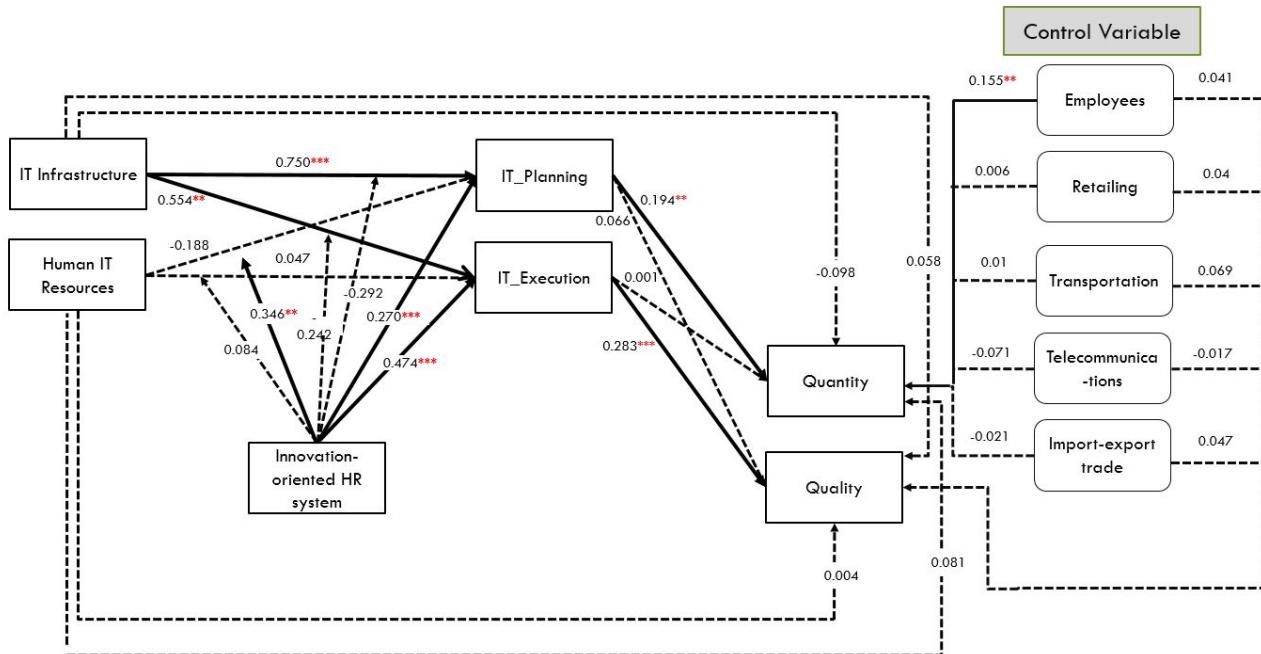


Figure 2. Results of the structural Model

We use SmartPLS 2.0 to test the proposed hypotheses, and results are shown in Figure 2. First of all, we examine the effects of IT as operand resource on service innovation outcome. Our results reveal that IT infrastructure has no significant impact on quantity (-0.098) and quality (0.058) of service innovation, which means companies cannot solely rely on IT operand resources to build competitive advantage. Furthermore, human IT resource has no direct effect on the quantity (0.081) or quality (0.004) of service innovation. These results empirically confirm that when IT is merely an operand resources, which can be purchased or duplicated easily by competitors, it is hard for firms to maintain permanent advantage (Carr, 2003; Mata et al., 1995).

The result of H2 reveal that when the role of IT is operated as an operant resource, using IT in different stages of NSD would have different impacts on service innovation quality and quantity. In other words, IT used in the NSD planning phase would significantly affect quantity of service innovation (0.194**), while it has an insignificant effect on quality of service innovation (0.066). Interestingly, the results of using IT in the NSD execution phase are very different. Our results show that using IT in NSD execution phase has a significant and positive effect on quality of service innovation (0.283***), but has no influence on quantity of service innovation (0.001).

We further examine H3, which verifies the role of IT as an operand resources is associated to the role of IT as an operant resource. Although IT infrastructure and human IT resource have no direct relationship with service innovation outcome, our results indicates that IT

infrastructure have significant and positive impact on IT-planning phase (0.75***) and IT-execution phase (0.554**). The result suggests that IT infrastructure does matter for NSD, and IT Infrastructure is an antecedent of IT operant resources. Converse to IT infrastructure, human IT resource have no impact on IT-planning phase (-0.188) or IT-execution phase (0.047), which represents IT employees are not necessary for NSD. The results imply that companies can acquire technical IT staff through outsourcing rather than recruitment. Therefore, our results partially support H3.

In terms of testing H4, we examine the two effects of innovation-oriented HR system on service innovation (i.e. direct and moderation effects). Our findings show that the innovation-oriented HR system has positive and significant effect on IT-planning phase (0.270***) and IT-execution phase (0.474***). Because human resource development functions can reshape attitudes and capabilities of employees, and influence on the development of innovation activities (Collins & Clark, 2003; Scarbrough, 2003). These findings represent that the HR system can impact innovation process, and companies can encourage employees to generate diversity of ideas through strategic HR practices. The HR system makes employees who has no technical background can effectively utilize IT and combine with their innovation capability in the NSD process.

Then, we investigate how innovation-oriented HR system is served as a moderator, changing the relationship between the role of IT as operand resource and the role of IT as operant resource. The results reveal that the innovation-oriented HR system cannot significantly moderate the relationship between IT infrastructure and the NSD process (IT-planning phase:-0.292, IT-execution phase:-0.242). However, our result shows that the relationship between human IT resource and IT-planning phase can be significantly moderated by the innovation-oriented HR system (0.346**), which means the innovation-oriented HR system can be a mechanism to align IT employees with innovation-oriented strategy of company. Stewart et al. (2003) indicates that companies have to deeply understand their IT, and increase its alignment with strategy in order to improve the results gained from IT. Accordingly, the innovation-oriented HR system can help IT employees with innovative thinking to effectively utilize their professionals to develop new services.

CONCLUSION

Our findings indicate that IT as an operand resource has no direct effects on service innovation outcome, whereas IT as operant resource does. Moreover, among the operand resources, IT infrastructure is a necessity to be converted into operant resource, while IT human resources can be outsourced. At the same time, we found that the innovation-oriented HR system can not only moderate the relationship between human IT resource and IT-planning phase but influence on the NSD process. Our results also show that human is a key to operate IT assets, and companies need a mechanism to select the competent employees. We found the innovation-oriented HR system can make all employees, not just IT employees, have innovation capability to effectively utilize IT on the NSD process. Moreover, the innovation-oriented HR system plays a pivot to convert the role of IT in service innovation. Through the practices of the HR system, IT employees can have innovative thinking to operate IT tools in the planning phase of NSD.

Our study contributes to theory in the following way. First, based on SDL, this study

verifies the evolving literature on SDL, and extends the research on exploring the role and value of IT, as an operand resource and as an operant resource, in service innovation context. Our findings provide empirical support for the proposition of Vargo & Lusch (2004) that paradigm shift from GDL toward SDL, which indicates that operand resources are not advantage anymore and operant resources gradually become important resources of companies. Furthermore, this study extends the human resource research on service innovation. As mentioned earlier, IT as an operand resource can be converted into operant resource. Nevertheless, IT operand resource will not automatically be changed, and IT is still an inanimate object until people manipulate it. Thus, IT needs human to operate it and convert the role of IT into operant resource. At the same time, companies need the HR system to select competent employees to convert IT's role. In this article, we found the innovation-oriented HR system can not only be a pivot to convert IT's role, but make all employees, not just IT employees, have innovation capability to effectively utilize IT on the NSD process, leverage IT capability outside of IT unit. Our findings also offer practical suggestions for firms to manage IT investment in service innovation. That is, IT investment and IT infrastructure are still necessary for companies to develop service innovation. However, our findings reveal that IT employees are not important for developing service innovation. Thus, companies can consider to acquire technical IT staff through outsourcing.

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FINANCIAL CONSTRAINTS AND MOMENTUM

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ABSTRACT

Current studies have shown that stock price may be influenced by financial constraints, which further influence the stock returns. Moreover, if the investors overreact, abnormal fluctuations will occur in stock price. Therefore, abnormal return can be gained by adopting momentum strategy. As existing literature has not studied the relation between financial constraints and momentum effect directly, this paper aims to classify different degrees of financial constraints with three methods, namely dividend payout ratio, WW index and KZ index, and use the prior period cumulative return rate of individual share as the base for establishing price momentum strategy. It attempts to discuss whether it is feasible to operate momentum investment strategy by financial constraints. The results indicate that, momentum strategy that includes financial constraints has obvious momentum return. Therefore, financial constraints play an important role in momentum profiting strategy.

KEYWORDS: Financial Constraints, Momentum

INTRODUCTION

Stock market is not only the channel for corporate financing, but also a trading market favored by many investors. For investors, their primary concern is how to maximize profits by developing feasible investment strategy. This is also the topical subject in research. Past studies have tried to explain abnormal returns with different methods, in order to use different investment strategies to gain abnormal returns. In traditional financial theory, it is assumed that investors in the market are all rational and make investment decisions under maximized rational expectation, risk aversion and utility function. According to Fama (1970), if market information is open and no extra cost is needed in gaining information, the information should be immediately and accurately reflected on stock price.

However, recent studies have observed abnormal phenomena that cannot be explained by traditional financial theories. Such phenomena, including January effect, Size effect, Monday effect and Momonetum effect, are obviously against the hypothesis of efficient market. Momentum investment strategy refers to that, after differentiating investment portfolio based on some past information of individual share, buying in the winner portfolio that has the highest return and sell the loser portfolio that has the lowest return. If taking the previous return of individual share as the investment basis, it is called price momentum strategy.

As for price momentum strategy, the study by Jegadeesh and Titman (1993) is most representativeness. They studied the U.S. stock market and proposed that the overreaction of

investors in information is a long-term phenomenon. In a short term, the winners who have good performance would continue to outperform the losers, which is the phenomenon of the strong become stronger while the weak become weaker. Therefore, investors should buy stocks with good performance and sell stocks with poor performance to form a profit-making investment portfolio.

As financial market gradually opens up, financing methods, including bank loan, stock issue, corporate bonds issue and increment of cash, of companies in financial market are increasingly diversified. Under information asymmetry, financing units cannot fully know the return of company's investment plan and all possible risks. Hence, the company should reserve some equity capital to deal with funds needed in future investment.

When the capital market is incomplete, the cost of external financing of a company is larger than that of internal financing, in which external financing and internal financing cannot be completely replaced. As for the company, it cannot gain necessary funds entirely from the external funds market. Due to information asymmetry, investors do not know the investment quality of the company, hence, the cost of external funds is higher than that of internal funds. Thus, the company may fail to receive enough funds for its investment plan, which causes financial constraints.

Therefore, constructing good investment strategy has been a topical subject. Research has shown that abnormal return can be made by taking advantage of investors' overreaction or underreaction in information. Stock price is the investment target of investors and financial constraints can influence the company's stock price. To our best knowledge, there is no discussion on the relationship between financial constraints and momentum effect. Therefore, this paper aims to discuss whether it is feasible to operate momentum investment strategy by financial constraints. The degrees of financial constraints are classified with three methods, namely dividend payout ratio, WW index (Whited and Wu, 2006), and KZ index (Kaplan and Zingales, 1997).

The research targets are common stocks that are listed in Taiwan Stock Exchange (TWSE) during 1998 and 2012. The methods of payout ratio, KZ index, and WW index, are used to classify listed companies based on whether there is financial constraints. The prior period accumulative return rate of individual share is used as the basis for constructing price momentum, in order to develop a better investment portfolio strategy.

LITERATURE REVIEW

Financial constraints

In real world, there are transaction cost, financial crisis cost, land tax and other levies, information asymmetry and agent cost, which may lead to adverse selection and moral crisis. These factors are the cause of imperfection of capital market. Financial constraints refer to that, in an imperfect capital market, financing units cannot fully know the return of company's investment plan and all possible risks due to asymmetric information, so they do not easily finance for the company. In such a case, the company cannot obtain necessary funds from external capital market, and it needs to reserve relatively large equity fund to prepare for the future capital needed. Taking manufacturers in Japan from 1965 and 1986 as the targets, Hoshi, Kashyap and Scharfstein (1991) studied the relationship between companies and banks, and found that factors of uncertainty and asymmetric information are relatively more in small-scale or non-group companies in which external funds are hard to be financed and the cost of financing is also high.

When the company has a profitable investment plan, the manager attempt to realize the plan in order to increase the company's value and maximize shareholders' profits. According to the Pecking-Order Theory, a company would use internal funds to deal with the cost of investment. By taking 422 large-scale manufacturers in the U.S. from 1970 to 1984 as the targets, Hubbard and Petersen (1988) probed into the influence of financial constraints and investment expenditure on internal cash flow. They found that the company with high financial constraints tends to have high external financing cost and the capital needed in investment plan tends to be paid with internal funds. In other words, when the company has higher financial constraints, the investment expenditure on internal cash flow is more sensitive. This also indicates that the company's investment activity is related to capital structure. Therefore, payout ratio can be taken as a classification standard for financial constraints. Later, Bond and Meghir (1994) took 626 large-scale manufacturers in Britain from 1974 to 1986 as the targets, and reached the same conclusion as Fazzari, Hubbard and Petersen (1988). They found that the company with high financial constraints tends to deal with investment plan with internal capital. Meanwhile, Devereux and Schiantarelli (1990) conducted an inverse research, by taking companies in the U.K. as the targets, to probe into the relationship between movement of funds and investment in companies with financial constraints. The results showed that it is easier for companies with financial constraints to increase overall quota for all expenditures when internal capital is increased.

Taking manufactures in he U.S. from 1970 to 1984 as the targets, Kaplan and Zingales (1997) investigated 49 manufacturers in Fazzari, Hubbard and Petersen (1988) with low dividend and high influence of internal cash on investment expenditure. They formulated KZ standard, which includes the proportion of cash flow to the total capital, Tobin's Q, proportion of liabilities to the total capital, and proportion of cash dividends to the total capital, for determining whether the company has financial constraints. The proportion of each project is of some certain restriction. That study probed into the relationship between investment expenditure and internal cash flow when manufactures are facing with different financing situation. The results showed that the investment of the company without financial constraints is more sensitive on cash flow. Due to different results of previous research, many studies on financial constraints were conducted. The correlation between investment and cash flow sensitivity in different classifications of financial constraints has been widely discussed.

In the aspect of financial constraints influencing the company's stock price, Owen, Christopher, and Jesus (2001) discussed the influence of financial constraints on stock price. The results showed that whether a company has financial constraints indeed could influence its value. Hence, financial constraint is an important issue for companies with financial constraints. Companies with financial constraints bear more risks than those without such constraints, which is the reason that financial constraints could affect the company's stock price. Baker, Stein, and Wurgler (2003) treated companies with financial constraints as the targets, and discussed the influence of market performance on companies relying on equity financing. They discovered that the investment of companies with financial constraints is more sensitive to stock performance than that of companies without financial constraints.

Momentum and contrarian

In existing literature, Levy (1967) used relative performance of individual shares to establish investment portfolio strategy application, and proposed relative strength strategy, namely buying the stock with a price higher than the average in 27 weeks to obtain remarkable excess return. This lays a foundation for the development of momentum strategy. Jegadeesh and

Timtman (1993) first proposed price momentum. They took the month data of companies that are listed in AMEX and Nasdaq from 1965 to 1989 as the targets, and discovered that the trading strategy of buying winner portfolio and selling loser portfolio can gain remarkable positive average return by holding stocks within 3 to 12 months. However, abnormal return gradually disappears one year later. The profit of this strategy is not caused by system risk and the delayed reaction of stock price on general factors.

Later, Griffin, Ji, and Martin (2003) found that 32 countries have positive price momentum profit among 40 countries including the U.S. Price momentum effect exists in most European and American countries. Meanwhile, Chui, Titman, and Wei (2000), Hameed and Kusnadi (2002) found that Asian countries including Taiwan, Hong Kong, Singapore, Malaysia, South Korea, and Thailand have no obvious profitable price momentum strategy, which indicates that the price momentum phenomenon in Asian countries is less strong than that in European and American countries.

Besides probing into whether price momentum is prevalent in many countries, literature has discussed the source of return. Overall, the factors for the source of return can be divided into two levels, namely risk and behavioral finance. First, in the aspect of risk, it includes market state of the overall economy, prosperity factors, surplus quality, industry, and turnover. Many studies have attempted to explain the momentum effect by overall economics and prosperity factors. Cooper, Gutierrez and Hameed (2004), by taking month data as the research object, studied the U.S. stock market during 1926 and 1995, and discussed the difference of momentum strategy based on market state. The result shows that when the market state is relatively good, momentum strategy can get positive average excess return; while when the market state is poor, momentum strategy will get negative average return. Chordia and Shivakumar (2002) found that obvious price momentum effect exists during prosperity expansion period, but momentum return is unapparent negative during prosperity austerity period. This study verified the overall economy variate related to prosperity circulation, which can be used to explain the average return of price momentum strategy.

In the aspect of earning quality of firm-specific information, Rouwenhorst (1998) found that the continuity of momentum effect is inversely proportional to the company's scale. In other words, the scale of the company can explain for momentum effect. According to the study of Moskowitz and Grinblatt (1999), it is found that price momentum effect will remarkably reduce after industry momentum is controlled. Therefore, the opinion that industry can explain individual share momentum effect is put forward.

In the aspect of behavioral finance, it is thought that momentum effect comes from the overreaction or underreaction on information of initial stock price. Theoretically, underreaction refers to that security price does not immediately or fully react when the new information in market occurs, but will gradually and slowly go to the direction guided by the new information. In other words, the original stock price will continue increasing if the initial stock price was increasing, or decrease if it was decreasing. That's why the situation that the strong become stronger while the weak becomes weak would occur. Under the condition that the underreaction theory is true, the investor can adopt the zero-cost investment portfolio of buying in the originally increasing stocks and selling out the decreasing ones to gain abnormal return. Chan, Jegadeesh and Lakonishok (1996) conducted a research on the monthly data of stocks listed in Top 3 stock exchanges in the U.S., aiming to study whether the success of momentum strategy is caused by the underreaction on information of market. The research result shows that the continuity of stock price momentum is the most obvious, which indicates that the stock price is gradually reflecting the information of market, so the investor can gain

abnormal return through momentum strategy. However, the research of Barberis, Shleifer and Vishny(1998), together with reverse and momentum investment strategy, put forward that underreaction may occur on the unexpected new information in the initial stage due to that the investors hold the attitude of skepticism on new information of the company. But if the investors always get good news, they would have the optimistic attitude towards the company's prospect, which result in that the stock price of company may be overestimated in a long term; hence, when the stock price returns to its real value, reversed stock price would occur, which explains the underreaction of momentum effect in market. In the research of Lee and Swaminathan (2000), it is found that the momentum effect occurred in mid-term is caused by the underreaction on information, while the long-term reverse effect comes from the overreaction on information.

The overreaction phenomenon in early stage was put forward by De Bondt and Thaler (1985,1987) who formulated an investment strategy based on the data in past three years and found that the return rate of loser investment portfolio would be 25% higher than that of winner investment portfolio three years later. Excluding company's scale and risk factors, De Bondt and Thaler thinks that that result is related with the investors' overreaction. From then on, many scholars also probed into the existence of overreaction in stock market. Fama and French (1988), by taking stocks in New York Stock Exchange (NYSE) as the research object, studied the serial correlation between stock price changes. The research result shows that unapparent negative correlation exists in short-term stock price return, while obvious negative correlation exists in long-term stock price return, which indicates that the phenomenon of overreaction does exist in the stock market. In addition, according to Chou Chung and Wei (1999), the same asset may be classified into the winner or the loser due to the different time spans of formative period; hence, even under the time series structure of given return rate, the return rate of contrarian investment strategy would also differs according to different time spans of formative period.

Based on the discussion on the above documents, we know that, in imperfect capital market, financing units do not easily finance for the company for they may fail to fully know about the company's return of investment plan and all possible risks due to the asymmetric information; in such a situation, the company cannot get funds needed from the external funds market, so it has to reserve relatively large equity fund. Or else, the company will lose the chance to improve its value or maximize shareholder value when the manager of a company wants to invest the profitable investment plan but has no enough funds inside the company and cannot bear the high cost of external financing. According to documents about financial constraints, it is known that whether there is financial constraints could indeed influence a company's value. Therefore, financial constraints is an important issue for companies.

METHODOLOGY

Data source and sampling period

This paper adopted yearly data in determining the degree of financial constraints and monthly data in momentum investment strategy and the time span of these two kinds of data is from January 1998 to December 2013, totally 16 years. The research object is all listed companies in Taiwan Stock Exchange (TWSE) including those companies that have been in, once existed in and newly joined in during the whole period, which aims to make sure of the completion of research samples and exclude Survivor Bias and Selection Bias. In the research of this paper, the number of stocks adopted is between 686 and 844 and relevant assets include the current dividend payout ratio after the adjustment of stock price, cash flow, debt

ratio, total assets, Tobin's q, annual sales growth ratio of various industries, annual sales growth ratio of individual shares, current-month stock return rate of individual share, which are all from TEJ.

Financial constraints indices

In previous documents, indexes always quoted as financial constraints classification include cash dividends granting, KZ index, WW index, asset size, corporate bonds evaluation, ownership concentration ratio and so on. In this paper, three methods are adopted to determine whether a company has financial constraints:

Dividend payout ratio

This study referred to the research of Farrizi, Hubbard, and Petersen (1988) (FHP) in which dividend payout ratio is taken as the classification criterion for the degree of financial constraints. The company would reserve relatively large internal funds due to that it may face with the problem of asymmetric information which could result in that the company is hard to get external funds or cannot bear the high cost of external financing, thus it will issue less dividends. Hence, the lower a company's pay rate of stocks, the higher its financial constraints is.

KZ index

In the research of Kaplan and Zingales (1997), based on categorical data in the study of Farrizi, Hubbard, and Petersen (1988), they selected the first class of companies constrained by financial affairs and subdivided them into five categories. The classification methods include qualitative data, of which the indexes covering meeting minutes, handlers' statement on the management and operation situation of the company, CEO's speech, clauses for creditors and so on, and quantitative data, of which the indexes covering debt ratio, cash inventory ratio, liquid assets in balance sheet, proportion of dividend to capital and that of cash to capital. Then, Logit regression was used to get the regression coefficients. Lamont, Polk, and Saá-Requejo (2001), by making use of those coefficients, constructed KZ index based on more extensive company samples. When KZ index is larger, it indicates that the degree of financial constraints is higher. Computational formula of KZ index is as follows:

$$KZ_{it} = -1.0019CF_{it} + 0.2826Q_{it} + 3.1392LEV_{it} - 39.3678DIV_{it} - 1.3148C_{it} \quad (1)$$

in which, it uses the proportion of cash to total capital, Tobin's Q, liability, dividend and cash holdings as factors for constructing variates of financial constraints. They are defined as follows:

KZ_{it} : KZ index of company i in t period.

CF_{it} : Proportion of cash flow to total capital of company i in t period.

Q_{it} : Tobin's Q of company i in t period

LEV_{it} : Leverage degree of company i in t period

DIV_{it} : Dividend of company i in t period

C_{it} : Cash of company i in t period

Definition of variates of KZ index:

Cash flow (CF): The proportion of the addition of net profit after tax(Shin and Stulz,1998) and redemptory net cash flow to beginning capital. This rate can be used to explain the cost variance of financing in internal and external capital market.

Tobin's Q: The proportion of the addition of equity market price and debt book value and capital stock of special stock to the book value of total assets.

Leverage degree: The proportion of the addition of long-term liabilities and current liabilities to the addition of total assets and total amount of stockholders' equity

Dividend: The proportion of the addition of ordinary stock dividends and special stock dividends to beginning capital, which is used to observe the amount of dividend payout. The more the dividend payout is, the less the company's internal funds is and more adverse it is to the future expansion and working capital.

Cash holdings: The proportion of cash and equivalent cash to beginning capital.

WW index

Whited and Wu (2006) used sample data from 1975 to 2001 in COMPUSTAT data bank in the research and calculated the WW index to measure the financial constraints of the company. High WW index indicates high financial constraints; while low WW index indicates low financial constraints. The computational formula of computational formula is as follows:

$$WW_{it} = -0.091CF_{it} - 0.062DIVPOS_{it} + 0.021TLTD_{it} - 0.044LNTA_{it} + 0.102ISG_{it} - 0.035SG_{it} \quad (2)$$

where the proportion of cash flow to total capital, whether the company pays dividend, proportion of long-term liability to total assets, natural logarithm of assets, sales growth of industry of the company, sales growth of the company are taken as variate factors of finance constraints. They are defined as follows:

WW_{it} : WW index of company i in t period.

CF_{it} : The proportion of cash flow to total assets of company i in t period.

$DIVPOS_{it}$: Whether company i pay dividend in t period; if it does, the variate is 1; or else, the variate is 0.

$TLTD_{it}$: The proportion of long-term liability to total assets of company i in t period.

$LNTA_{it}$: natural logarithm of assets of company i in t period.

ISG_{it} : Sales growth of industry of company i in t period.

SG_{it} : Sales growth of company i in t period.

Advantage of WW index lies in that structural equation estimation through large sample can avoid such problems as sample selection, simultaneity and metering errors.

Momentum investment strategy

Momentum investment strategy method

This paper adopts momentum investment strategy method of Jegadeesh and Titman (1993), setting the formative period of 6 months and ranking stocks based on the average return of the stocks in previous 6 months, and respectively selects 10% of stocks ranked in the front and the end as the winner and the loser. The computational formula of average return of previous 6 months is as follows:

$$\bar{R}_{i,t-1:t-7} = \frac{\sum_{t-7}^{t-1} R_i}{6} \quad (3)$$

in which, i represents stock classification, t the point in time, and R the return. $\bar{R}_{i,t-1:t-7}$ equals to the average return of stock i during t-1 to t-7 months at t point in time.

Investment portfolio construction method

This study adopts the method of Deaves and Miu (2005) and constructs investment portfolios of different formative periods and holding periods by screening out underlying stocks that meet study conditions from all listed companies from January 1999 to December 2013.

Thereinto, formative periods and holding periods are respectively 3 months, 6 months, 9 months and 12 months, thus forming 16 kinds of different investment portfolios.

Construction method for investment portfolio is after selecting the winner and the loser according to price momentum strategy in prior period, adopt Equally Weighted to form winner and loser investment portfolios and buy in the winner's stocks and sell out the loser's stocks; during the holding period of j , calculate the average return of momentum investment in j months, namely to calculate the average monthly return of momentum investment strategy from t to $t+j$. The average monthly return of momentum investment strategy is as follows:

The average monthly return of winner and loser investment portfolios:

Average monthly return of winner:

$$\bar{R}_{W,t} = \frac{\sum_{n=1}^j R_{W,t+n}}{j} \quad (4)$$

Average monthly return of losers:

$$\bar{R}_{L,t} = \frac{\sum_{n=1}^j R_{L,t+n}}{j} \quad (5)$$

n represents the month n of holding the investment portfolio after being constructed.

$R_{W,t+n}$ and $R_{L,t+n}$ respectively represents the monthly return of month $t+n$ of the winner and loser portfolios.

$\bar{R}_{W,t+n}$ and $\bar{R}_{L,t+n}$ represents the average monthly return of the winner and loser portfolios during j months in t period .

Average monthly return of momentum strategy investment portfolio:

$$\bar{R}_{P,t} = \bar{R}_{W,t} - \bar{R}_{L,t} \quad (6)$$

By taking the investment portfolio with 6-month formative period and 6-month holding period as the beginning, the first investment portfolio's formative date is June 1999 (formative period is from January to June 1999) and holding period is from June to December 1999; similarly, the second investment portfolio's formative date is July 1999 (formative period is from February to July 1999) and holding period is from July 1999 to January 2000, thus the overlapping period is 5 months.

EMPIRICAL RESULTS

Portfolio performance

This paper firstly discussed the issue of financial constraints and judges whether the problem of financial constraints exists in the following year according to the company's information in the previous year. It adopts three judging criterions. First, it is KZ index, which is formed with the cash flow, Tobin's q, liabilities, and cash holding in the previous year of the company. If the index is high, it indicates that the company has financial constraints. In this paper, the median is taken as the criterion; so if the index is higher than the median, it indicates the company has financial constraints, vice versa. Secondly, it is WW index which is determined by cash flow, natural logarithm of assets, long-term liability, whether to pay dividend and sales growth rate. If the index is high, it indicates that the company has financial constraints. In this paper, the median is taken as the criterion; so if the index is higher than the median, it indicates the company has financial constraints, vice versa. Thirdly, it is the company's dividend payout ratio. If the company did not pay dividend in the previous year, it indicates the company has financial constraints; if it paid more than RMB 1 in the previous year, it has no financial constraints.

Next, the paper arranges companies with or without financial constraints based on the average return of formative period (3, 6, 9 and 12 months) from high to low in 10 groups. The highest return represents the winner (R10) with the best performance, while the lowest return represents the loser (R1) with the poorest performance. Then, buy in the winner portfolio and sell out the loser portfolio in t period; according to the cumulative return gained during holding period (3, 6, 9 and 12 months), returns of 16 kinds of momentum investment portfolio are listed.

In the following part, momentum effect of companies with or without financial constraints is discussed based on three criterions.

Distinguish financial constraints with KZ index

According to Table 4-1, based on KZ index as the criterion, contrarian strategy profit, with the formative period being 3 and 6 months, is most obvious when the holding period is 3 months. That's because the loser's return increases with the increasing of holding period, while the loser's return decreases with the increasing of holding period, so the contrarian strategy profit becomes less and less. When the formative period is 9 and 12 months, contrarian strategy profit becomes most remarkable when the holding period is 12 months. That's because returns of the winner and the loser decrease with the increasing of holding period and the loser's descend range is less than the winner's.

Table 4-1 KZ index distinguishing companies with financial constraints

Formative period	Holding period				
	3	6	9	12	
3	R10	0.1199	0.1231	0.1436	0.1225
	R1	0.2225	0.2075	0.1736	0.1659
	R10-R1	-0.1026***	-0.0844***	-0.0300***	-0.0434***
6	R10	0.0937	0.1187	0.1256	0.1120
	R1	0.2622	0.1930	0.1682	0.1691
	R10-R1	-0.1685***	-0.0743***	-0.0426***	-0.0571***
9	R10	0.1391	0.1318	0.1224	0.1075
	R1	0.2125	0.1771	0.1765	0.1867
	R10-R1	-0.0734***	-0.0453***	-0.0541***	-0.0792***
12	R10	0.1261	0.1216	0.1114	0.0979
	R1	0.2222	0.1916	0.1923	0.2058
	R10-R1	-0.0961***	-0.0700***	-0.0809***	-0.1079***

From the result, based on KZ index, it is found that buying in the loser's and selling out the winner's can gain contrarian strategy profit. When the formative period is 3 and 6 months, contrarian strategy profit become most remarkable when the holding period is 3 months; when the formative period is 9 and 12 months, contrarian strategy profit become most remarkable when the holding period is 12 months; and the contrarian strategy profit gained when the formative period is 3 and 6 months is superior to that gained when the formative period is 9 and 12 months. Such result is equal to the conclusion of Chou Chung and Wei (1999). The same asset may be classified into the winner or the lower because of different spans of formative period; hence, even under the condition of time series structure with given return rate, contrarian strategy profit constructed may differ with different spans of formative period.

From Table 4-2, it is found that the company without financial constraints has the highest return rate at the point (6, 6). Investment portfolio with the formative period of 3 and 6 months, of which the winner's stock price return changes with the tendency of increasing first and then descending with the increase of holding period, while the loser's stock price return descends along with the increase of holding period. For the investment portfolio with 9-month formative period and 12-month holding period, its return changes from positive to negative, in which contrarian phenomenon occurs. For the investment portfolio with 12-month formative period, contrarian phenomenon occurs in its stock price. So, the investors can adopt contrarian strategy to gain profit.

Table 4-2 KZ index distinguishing companies with non-financial constraints

Formative period	Holding period				
	3	6	9	12	
3	<i>R10</i>	0.1444	0.1541	0.1528	0.1315
	<i>R1</i>	0.1536	0.1340	0.1188	0.1236
	<i>R10-R1</i>	-0.0092***	0.0201***	0.0340***	0.0079***
6	<i>R10</i>	0.1752	0.1796	0.1648	0.1370
	<i>R1</i>	0.1617	0.1166	0.1092	0.1204
	<i>R10-R1</i>	0.0135***	0.0630***	0.0556***	0.0166***
9	<i>R10</i>	0.1688	0.1590	0.1445	0.1219
	<i>R1</i>	0.1356	0.1150	0.1128	0.1227
	<i>R10-R1</i>	0.0332***	0.0440***	0.0317***	-0.0008***
12	<i>R10</i>	0.1491	0.1393	0.1244	0.1082
	<i>R1</i>	0.1738	0.1403	0.1282	0.1379
	<i>R10-R1</i>	-0.0247***	-0.001	-0.0038***	-0.0297***

According to the result, under momentum strategy of companies without financial constraints, the investors can buy in the winners' and sell out the losers' when the formative period is 3, 6 and 9 months to gain momentum strategy profit which will decrease along with the increase of holding period or even reverse. For the investment portfolio with 12-month formative period, investors can by in the winners' and sell out the losers' to gain contrarian strategy profit. This result is in consistent with the conclusion of Swaminathan (2000), with momentum effect in medium term and reverse effect in long term.

By classifying listed companies in Taiwan into those with or without financial constraints, from Tables 4-1 and 4-2, it is found different strategies are adopted in the two portfolios; for companies with financial constraints, contrarian strategy is adopted to gain profit no matter the formative period is 3, 6, 9 or 12 months. This paper explains that, according to the research of Hoshi, Kashyap and Scharfstein (1991), the company with financial constraints always faces with problem of asymmetric information, resulting in high cost of external financing, which indirectly influence the company's investment strategy and depreciate stock price return and further cause overreaction. After the overreaction, the stock price oversold will rebound, forming the situation that the losers' return rate is higher than the winners'. Therefore, for the investment portfolio with financial constraints, we adopt the method of buying in losers' and selling out winners' to gain contrarian strategy profit. As for the company without financial constraints, its momentum effect is the same with that mentioned in previous documents, in which the winners' show the tendency of continuous rising while the losers' continuous descending in formative periods of 3, 6 and 9 months; so

the investors can buy in the winners' and sell out the losers' to gain momentum strategy profit.

WW index distinguishing companies with financial constraints

From Table 4-3, with WW index distinguishing companies with financial constraints, investment strategies of 3 and 6 months or 9 and 12 months all have reversal effect. For the loser with financial constraints, its return rate is the highest when the holding period is 3 months no matter its formative is 3, 6, 9 or 12 months, and weakens along with the increase of holding period at a fast speed. The return rate of stock price of winners with financial constraints is relatively stable compared with that of losers, and the contrarian effect is the most increase obvious when the holding period is 3 months, which indicates that Taiwan stocks have short-term contrarian effect which will relatively declines when the holding period goes on. Under the momentum strategy with financial constraints, no matter the formative period is 3, 6, 9 or 12 months, the monthly return of stocks is always negative. Hence, this paper puts forward that, contrarian strategy can be adopted to gain contrarian strategy profit under the situation with financial constraints.

Table 4-3 WW index distinguishing companies with financial constraints

		Holding period				
		3	6	9	12	
Formative period	3	<i>R10</i>	0.1303	0.1362	0.1594	0.1403
		<i>R1</i>	0.2589	0.2360	0.2038	0.1947
		<i>R10-R1</i>	-0.1286***	-0.0998***	-0.0444***	-0.0544***
	6	<i>R10</i>	0.1420	0.1562	0.1615	0.1371
	6	<i>R1</i>	0.2837	0.2050	0.1776	0.1781
		<i>R10-R1</i>	-0.1417***	-0.0488***	-0.0161***	-0.0410***
	9	<i>R10</i>	0.1576	0.1663	0.1604	0.1404
		<i>R1</i>	0.2589	0.2033	0.1952	0.2098
		<i>R10-R1</i>	-0.1013***	-0.0370***	-0.0348***	-0.0694***
	12	<i>R10</i>	0.1631	0.1639	0.1574	0.1392
		<i>R1</i>	0.2733	0.2221	0.2252	0.2349
		<i>R10-R1</i>	-0.1102***	-0.0582***	-0.0678***	-0.0957***

As shown in Table 4-4, companies without financial constraints get obvious negative return as well as remarkable positive return in both formative period and holding period and the return rate is the highest at the point (9, 3). Therefore, investors can select stocks based on the return rate of individual shares in past 3 to 9 months from the investment portfolio of companies without financial constraints and can get return when the holding period is from 6 to 9 months.

Table 4-4 WW index distinguishing companies with non-financial constraints

Formative period	Holding period				
	3	6	9	12	
3	<i>R10</i>	0.1342	0.1427	0.1447	0.1256
	<i>R1</i>	0.1547	0.1366	0.1134	0.1180
	<i>R10-R1</i>	-0.0205***	0.0061***	0.0313***	0.0076***
6	<i>R10</i>	0.1450	0.1523	0.1398	0.1259
	<i>R1</i>	0.1690	0.1258	0.1129	0.1207
	<i>R10-R1</i>	-0.0240***	0.0265***	0.0269***	0.0052***
9	<i>R10</i>	0.1622	0.1408	0.1253	0.1063
	<i>R1</i>	0.1229	0.1134	0.1089	0.1190
	<i>R10-R1</i>	0.0433***	0.0274***	0.0164***	-0.0127***
12	<i>R10</i>	0.1331	0.1220	0.1055	0.0908
	<i>R1</i>	0.1405	0.1278	0.1225	0.1365
	<i>R10-R1</i>	-0.0074***	-0.0058***	-0.0170***	-0.0457***

In the investment portfolio of companies without financial constraints, obvious momentum phenomenon indeed exists, but the momentum effect will gradually disappear with the holding period goes on. The result shows that under the momentum strategy without financial constraints, investors can gain momentum strategy profit in the formative period of 3 and 6 months; with the holding period goes on, momentum strategy profit will also disappear and also may reverse. Hence, in the investment portfolio without financial constraints, adopt momentum investment strategy to gain return in formative periods of 3 and 6 months, and adopt contrarian investment strategy to gain contrarian strategy profit in formative periods of 9 and 12 months.

With WW index classifying Taiwan listed companies into those with or without financial constraints, according to Tables 4-3 and 4-4, the winners are generally stable in investment portfolio with financial constraints and have no obvious change no matter the holding period is short or long; while the losers gain the highest return when the holding period is 3 months but will gradually decrease with the holding period goes on, resulting in weak contrarian effect. Losers of two portfolios have the highest return when the holding period is 3 months and their return will decrease with the holding period goes on, with the decreasing extent of losers with financial constraints is larger than that of losers without financial constraints. Due to financial constraints, losers have the problem of asymmetric information; the high cost of external financing could indirectly influence the company's investment strategy and depreciate its stock price return, which will cause bad information and overreaction. After the overreaction, the oversold stock price will rebound, forming the situation that losers' return rate is higher than winners. Hence, for the investment portfolio with financial constraints, adopt the contrarian strategy of buying in losers' and selling out winners' to gain contrarian strategy profit.

Distinguish financial constraints with dividend payout ratio

As shown in Table 4-5, distinguishing companies with financial constraints with dividend payout ratio, it is found the investment strategies with the formative periods of 3 and 6 months as well as that of 9 and 12 months, are all of contrarian effect. Under the momentum strategy with financial constraints, the monthly return rates of stock price, no matter with

formative periods of 3 and 6 months or that of 9 and 12 months, are all obviously negative. Therefore, it is thought that investors, under the condition of financial constraints, can adopt contrarian strategy to gain contrarian strategy profit which made during formative periods of 3 and 6 months is superior to that of 9 and 12 months. The reason may be that, during formative periods of 3 and 6 months, companies with financial constraints have the problem of asymmetric information which could result the overreaction losers' stock price return, resulting in the situation of high return rate; while during formative periods of 9 and 12 months, overreaction gradually disappears, so the contrarian strategy profit also decreases.

Table 4-5 Dividend payout ratio distinguishing companies with financial constraints

Formative period	Holding period				
	3	6	9	12	
3	<i>R10</i>	0.0753	0.0754	0.0953	0.0961
	<i>R1</i>	0.2497	0.2315	0.1679	0.1740
	<i>R10-R1</i>	-0.1744***	-0.1561***	-0.0726***	-0.0779***
6	<i>R10</i>	0.0526	0.0764	0.0883	0.0830
	<i>R1</i>	0.2679	0.1894	0.1632	0.1679
	<i>R10-R1</i>	-0.2153***	-0.1130***	-0.0749***	-0.0849***
9	<i>R10</i>	0.0884	0.0779	0.0827	0.0787
	<i>R1</i>	0.2367	0.1880	0.1851	0.1931
	<i>R10-R1</i>	-0.1483***	-0.1101***	-0.1024***	-0.1144***
12	<i>R10</i>	0.0930	0.0954	0.0893	0.0843
	<i>R1</i>	0.2309	0.2018	0.1987	0.2065
	<i>R10-R1</i>	-0.1379***	-0.1064***	-0.1094***	-0.1222***

According to Table 4-6, distinguishing companies without financial constraints with dividend payout ratio, investment strategies, no matter with formative periods of 3 and 6 months or of 9 and 12 months, are all of contrarian effect. It indicates that short-term contrarian effect exists in Taiwan stocks, but will relatively weaken with the holding period goes on; if the formative period is long, the contrarian effect becomes most obvious when the holding period is 12 months. Therefore, investors can adopt contrarian strategy to gain contrarian strategy profit in the situation without financial constraints.

By distinguishing listed companies in Taiwan into those with or without financial constraints with dividend payout ratio, as seen in Tables 4-5 and 4-6, both companies with or without financial constraints can adopt contrarian strategy to make constrained strategy profit. In investment portfolios with financial constraints, winners have relatively steady performance, no matter the holding period is short or long, and have no obvious changes; while losers have the highest return when the holding period is 3 months, but will decrease with the holding period goes on, which weakens the contrarian effect. The reason may be that companies with financial constraints faces with the problem of asymmetric information and investors have no confidence in financing for those companies, which results in that the companies become too overcautious to invest due to financial constraints and then depreciate stock price; thus, bad news would occur, resulting in overreaction. After the overreaction, oversold stock price will rebound, forming the situation that the losers' return rate is higher than the winners'. Hence, for the investment portfolio with financial constraints, adopt the contrarian strategy of buying in winners' and selling out losers' to make contrarian strategy profit.

Table 4-6 Dividend payout ratio distinguishing companies with non-financial constraints

Formative period	Holding period				
	3	6	9	12	
3	<i>R10</i>	0.1420	0.1323	0.1368	0.1152
	<i>R1</i>	0.1498	0.1420	0.1240	0.1226
	<i>R10-R1</i>	-0.0078***	-0.0097***	0.0128***	-0.0074***
6	<i>R10</i>	0.1455	0.1475	0.1319	0.1070
	<i>R1</i>	0.1770	0.1491	0.1367	0.1385
	<i>R10-R1</i>	-0.0315**	-0.0016**	-0.0048***	-0.0315***
9	<i>R10</i>	0.1366	0.1237	0.1055	0.0891
	<i>R1</i>	0.1656	0.1591	0.1587	0.1590
	<i>R10-R1</i>	-0.0290***	-0.0354***	-0.0032***	-0.0699***
12	<i>R10</i>	0.1136	0.1030	0.0878	0.0808
	<i>R1</i>	0.1942	0.1784	0.1698	0.1733
	<i>R10-R1</i>	-0.0806***	-0.0754***	-0.0820***	-0.0925***

Analysis of Momentum profits

In the previous section, three criterions are adopted to judge financial constraints and the momentum effect of companies with or without financial constraints are analyzed. For modern investors, how to make the maximum profit is what they care about. Therefore, in this section, what investment portfolios can gain the maximum profit based on data in previous section will be discussed.

In the previous section, we find that the differences in stock price return of losers with or without financial constraints distinguished by KZ index and WW index are greatly differed. Hence, these differences are specially probed in this section to analyze whether investors can gain greater return through this investment strategy.

Table 4-7 indicates that by distinguishing return rate of losers with or without financial constraints, investment strategies with formative periods of 3 and 6 months or of 9 and 12 months, are all of momentum effect. As seen, the companies with financial constraints and long formative period have relatively stable return rate. In addition, under momentum strategy of losers without financial constraints, no matter formative periods are of 3 and 6 or 9 and 12 months, the monthly return rates of stock price are positive. Therefore, investors can gain abnormal return by buying in losers with financial constraints and selling out losers without financial constraints. This paper explains that companies with financial constraints have the problem of asymmetric information; losers with financial constraints also have the same problem, resulting in high cost of external financing, which indirectly influence the company's investment strategy and depreciate the stock price; thus, bad news would occur, causing overreaction. After the overreaction, oversold stock price will rebound. Hence, for the investment portfolio with financial constraints, adopt the strategy of buying in losers with financial constraints and selling out losers without financial constraints to gain momentum profit.

Table 4-7 KZ index distinguishing return rate of losers with or without financial constraints

Formative period	Holding period				
	3	6	9	12	
3	<i>FL</i>	0.2225	0.2075	0.1736	0.1659
	<i>NFL</i>	0.1536	0.1340	0.1188	0.1236
	<i>FL-NFL</i>	0.0689**	0.0735**	0.0548**	0.0423**
6	<i>FL</i>	0.2622	0.1930	0.1682	0.1691
	<i>NFL</i>	0.1675	0.1166	0.1092	0.1208
	<i>FL-NFL</i>	0.0947**	0.0764**	0.0590**	0.0486**
9	<i>FL</i>	0.2125	0.1771	0.1765	0.1867
	<i>NFL</i>	0.1356	0.1150	0.1128	0.1227
	<i>FL-NFL</i>	0.0769**	0.0621**	0.0637**	0.0640**
12	<i>FL</i>	0.2222	0.1956	0.1923	0.2058
	<i>NFL</i>	0.1738	0.1403	0.1282	0.1379
	<i>FL-NFL</i>	0.0484**	0.0553**	0.0641**	0.0679**

According to Table 4-8, by distinguishing the return rate of losers with or without financial constraints, investment strategies with formative periods of 3 and 6 months or of 9 and 12 months, are all of momentum effect. Return rate of losers of two portfolios, no matter in formative periods of 3, 6, 9 or 12 months, is the highest when the holding period is 3 months, and will weaken with the holding period goes on, with that of losers with financial constraints inferior to that of those without financial constraints. Such result is consistent with the conclusion of Baker, Stein and Wurgler (2003) in which it is put forward that the investment from companies with financial constraints is more sensitive to stock price than that from companies without financial constraints. The company with financial constraints always faces with problem of asymmetric information, resulting in high cost of external financing, which indirectly influence the company's investment strategy and depreciate stock price return and further cause overreaction. After the overreaction, the stock price oversold will rebound, forming the situation that the losers' return rate is higher the winners'. Therefore, for the investment portfolio with financial constraints, we adopt the method of buying in stocks of losers with financial constraints and selling out stocks of losers without financial constraints to gain momentum profit.

Tables 4-7 and 4-8 indicates that momentum profit gained by buying in stocks of losers with financial constraints and selling out those of losers without financial constraints is greater than that gained by buying in stocks of losers with financial constraints and selling out those of losers without financial constraints. The reason is that the asymmetric information causes relatively large rebound extent of return of losers with financial constraints. It is because companies with financial constraints have the problem of asymmetric information, which causes high cost of external financing and indirectly influence the companies' investment strategy, resulting in depreciated stock price and overreaction. After the overreaction, stock price oversold will rebound.

Table 4-8 WW index distinguishing return rate of losers with or without financial constraints

Formative period		Holding period			
		3	6	9	12
3	<i>FL</i>	0.2589	0.2360	0.2038	0.1947
	<i>NFL</i>	0.1547	0.1366	0.1134	0.1180
	<i>FL-NFL</i>	0.1042**	0.0994**	0.0904**	0.0767**
6	<i>FL</i>	0.2837	0.2050	0.1776	0.1781
	<i>NFL</i>	0.1690	0.1258	0.1129	0.1207
	<i>FL-NFL</i>	0.1147**	0.0792**	0.0647**	0.0574**
9	<i>FL</i>	0.2589	0.2033	0.1919	0.2098
	<i>NFL</i>	0.1229	0.1134	0.1089	0.1190
	<i>FL-NFL</i>	0.1360**	0.0899**	0.0830**	0.0908**
12	<i>FL</i>	0.2733	0.2221	0.2252	0.2349
	<i>NFL</i>	0.1405	0.1278	0.1225	0.1365
	<i>FL-NFL</i>	0.1328**	0.0943**	0.1027**	0.0984**

Comparison of momentum strategies with financial constraints

In this section, different momentum profit performances for judging financing methods are sorted out in Tables 4-9 and 4-10. Table 4-9 includes: (1) KZ index for distinguishing momentum and contrarian strategies of companies with financial constraints; (2) WW index for distinguishing momentum and contrarian strategies of companies with financial constraints; (3) Dividend payout ratio (DPR) for distinguishing momentum and contrarian strategies of companies with financial constraints. Table 4-10 includes: (1) KZ index for distinguishing momentum and contrarian strategies of companies without financial constraints; (2) WW index for distinguishing momentum and contrarian strategies of companies without financial constraints; (3) Dividend payout ratio (DPR) for distinguishing momentum and contrarian strategies of companies without financial constraints.

As seen in Table 4-9, for these three methods of distinguishing companies with financial constraints, the returns of investments with no matter the formative periods of 3 and 6 or 9 and 12 months are of obvious negative figures. For companies with financial constraints distinguished by WW index and DPR, their return rate, no matter the formative periods are of 3, 6, 9, or 12 months, are the highest when the holding period is 3 months; but the contrarian effect becomes smaller and smaller with the holding period goes on. For companies with financial constraints distinguished by KZ index, their return rate is the highest when the holding period is 3 months and the formative periods are 3 and 6 months, rapidly decreasing with the holding period goes on; in formative periods of 9 and 12 months, return rate does not change obviously with the holding period goes on. When the formative period is 3 months, return rate of dividend payout method is the highest, following that of WW index and then KZ index, decreasing with the holding period goes on. Therefore, by distinguishing companies with financial constraints with these three methods, investors, no matter the formative period or holding period is short or long, can buy in losers' and sell out winners to gain contrarian strategy profit. Among these methods, contrarian effect of DPR is the greatest, through which the greatest contrarian strategy profit can be gained.

Table 4-9 Three methods of distinguishing companies with financial constraints

Formative period	Holding period				
	3	6	9	12	
3	KZ	-0.1026***	-0.0844***	-0.0300***	-0.0434***
	WW	-0.1286***	-0.0998***	-0.0444***	-0.0544***
	DPR	-0.1744***	-0.1561***	-0.0726***	-0.0779***
6	KZ	-0.1685***	-0.0743**	-0.0426***	-0.0571***
	WW	-0.1417***	-0.0488***	-0.0161***	-0.0410***
	DPR	-0.2153***	-0.1130***	-0.0749***	-0.0849***
9	KZ	-0.0734***	-0.0453***	-0.0541***	-0.0792***
	WW	-0.1013***	-0.0370***	-0.0348***	-0.0694***
	DPR	-0.1483***	-0.1101***	-0.1024***	-0.1144***
12	KZ	-0.0961***	-0.0700***	-0.0809***	-0.1079***
	WW	-0.1102***	-0.0582***	-0.0678***	-0.0957***
	DPR	-0.1379***	-0.1064***	-0.1094***	-0.1222***

Table 4-10 shows that momentum effects of companies without financial constraints distinguished by these three methods are different, but returns of them are all obvious. In the aspect of distinguishing companies without financial constraints, investors can buy in winners' and sell out losers' stocks from companies without financial constraints distinguished by KZ index and WW index to gain momentum strategy profit during formative periods of 3 and 6 months; and buy in losers' and sell out winners' in formative periods of 9 and 12 months, with contrarian strategy profit gained through WW index is larger than that gained through KZ index. For companies without financial constraints distinguished by DPR, whatever the formative period is, adopt the strategy of buying in losers' and selling out winners' to make profit; when the formative periods are 3 and 6 months, return rate lightly changes with the holding period goes on; if in the formative periods of 9 and 12 months, return rate decreases with the holding period goes on in a narrow range.

Table 4-10 Three methods of distinguishing companies with non-financial constraints

Formative period	Holding period				
	3	6	9	12	
3	KZ	-0.0092***	0.0201***	0.0340***	0.0079***
	WW	-0.0205***	0.0061***	0.0313***	0.0076***
	DPR	-0.0078***	-0.0097***	0.0128***	-0.0074***
6	KZ	0.0135***	0.0630***	0.0556***	0.0166***
	WW	-0.0240***	0.0265***	0.0269***	0.0052***
	DPR	-0.0315***	-0.0016**	-0.0048***	-0.0315***
9	KZ	0.0332***	0.0440***	0.0317***	-0.0008***
	WW	0.0433***	0.0274***	0.0164***	-0.0127***
	DPR	-0.0290***	-0.0354***	-0.0032***	-0.0699***
12	KZ	-0.0247***	-0.0001	-0.0038***	-0.0297***
	WW	-0.0074***	-0.0058***	-0.0170***	-0.0457***
	DPR	-0.0806***	-0.0754***	-0.0820***	-0.0925***

CONCLUSIONS

Momentum investment strategy has always been the hot topic in academic and practical fields. In existing documents, mainly momentum investment strategy and contrarian investment strategy are studied. In the imperfect capital market, companies may have the problem of asymmetric information which will result in hardness in external financing; once the cost of external financing is too high or financing becomes hard, the problem of financing constraints will occur. In such a situation, the company will consider these factors in investment, thus the return of companies may be influenced. Therefore, financial constraints is taken into consideration in this study to probe into the relation between financial constraints and momentum.

This paper takes all listed companies in TWSE as the research object, with its research time span lasting from January 1998 to December 2013, totally 16 years. It adopts KZ index, WW index and dividend payout ratio discuss whether greater return can be gains from Taiwan stock market by the classification of financial constraints. The result shows that investors can adopt the strategy of buying in losers and selling out winners to make contrarian strategy profit in the investment portfolio with financial constraints; and adopt the contrarian strategy of buying in losers' and selling out winners' to make contrarian strategy profit in the investment portfolio with financial constraints. In addition, companies with or without financial constraints can adopt contrarian strategy to make constrarian strategy profit. In the investment portfolio with financial constraints, winners' performance is relatively stable and does not have obvious change whatever the time span of holding period is; while the losers can get the highest return when the holding period is 3 months, but will gradually decrease with the holding period goes on, which results in the weakness in contrarian effect.

Besides, when judging momentum and contrarian of losers with or without financial constraints distinguished by KZ index and WW index, buying in stocks of losers with financial constraints and selling out stocks of losers without financial constraints can make relatively high momentum profit. At last, after comparing momentum strategies of each criterions of distinguishing financial constraints, if investors distinguish that the company has financial constraints by KZ index, WW index and dividend payout ratio, they can buy in losers' and sell out winners' to gain contrarian strategy profit no matter how long the formative or holding periods are, in which the contrarian effect of that distinguished by dividend payout ratio is the highest and the maximum abnormal return can be gained; if the company is distinguished to be that without financial constraints, investors can buy in winners' and sell out losers' when the formative periods are 3 and 6 months to gain momentum strategy profit, and buy in losers' and sell out winners' when the formative periods are 9 and 12 months, in which abnormal return gained through WW index is larger than that gained through KZ index. For companies without financial constraints distinguished by dividend payout ratio, buy in losers' and sell out winners' to gain contrarian strategy profit.

This paper studied all listed companies in TSEC and analyzed their situation of momentum investment strategy profit with financial constraints, in which obvious abnormal return is discovered. Therefore, the significance of this paper is that it provides investors with the criterion of financial constraints to construct a set of investment portfolios with excess return.

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THE RESEARCH ON DEVELOPING A SUPPLY CHAIN RISK MANAGEMENT STRATEGY EVALUATION SIMULATION MODEL

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ABSTRACT

As part of the division of labor and globalization, enterprises, customers and suppliers are located in various countries and regions. Complex, globalized supply chain network have greatly increased total supply chain risks. Therefore, improving the management of risk associated with the supply chain has become important to many enterprises. A supply chain risk management strategy evaluation simulation model is proposed in the present research. The simulation model, which constructed by using System Dynamics approach and the supply chain risk factor framework proposed by Chen and Lin (Chen & Lin, 2013), is used to evaluate the performance of supply chain risk management strategies, and is a useful tool for managers to assess supply chain risks as well as to test and select proper supply chain risk management strategies.

Keywords: supply chain risk management; risk management strategy; simulation

INTRODUCTION

In order to reduce costs and improve overall supply chain efficiency, enterprises are looking for the best solutions over the world. Partners of the enterprise formed an extremely complex global supply chain network, and this situation also makes supply chain risk has been severely tested. Miyagi earthquake occurred on 11 March 2011 in Japan and after that a tsunami impact Japan east coast. Japan Miyagi earthquake and tsunami happened, many enterprises industry experienced supply chain interruption like Apple i-Devices, Boeing 787 airplane etc.

In the same year Thailand floods impact computer industry. Hard drive shortages cause related enterprises supply chain disruptions, and also caused huge losses in sales. We can find that want be the best companies in the supply chain could ignore the risk out occur probability. Manuj and Mentzer noted that global supply chains have numerous links interconnecting a wide network of firms. These links are prone to disruptions, bankruptcies, breakdowns, macroeconomic and political changes, and disasters leading to higher risks and making risk management difficult(Manuj & Mentzer, 2008). Elangovan et al. noted that Supply chain risk will have a very large impact, and even further become supply chain disruptions situation (Elangovan et al., 2010). As a result enterprises suffer great harm. Therefore supply chain risk management is very important for the enterprise. Companies must pay more attention to issues of supply chain risk management strategy to reduce supply chain risk probability of occurrence. Blos et al. noted that supply chain risk management has become an important issue facing by all companies currently. Hence, this research will focus on the issue "how to reduce the impact of the occurrence of the supply chain risk effectively" (Blos et al., 2009). This paper uses Chen and Lin proposed the interrelatedness of risk factors, and used it to establish model for researching related risk management policies (Chen & Lin, 2013). The research results can help enterprises develop related strategies to the effectiveness and reduce the impact of the supply chain its members. This paper purpose is to propose a supply chain risk management strategy decision model and use the simulation method to validate the effectiveness of the model.

LITERATURE REVIEW

The goal of this research is to establish a supply chain risk management strategy decision model. This chapter will review the relevant literature.

Supply chain operations reference model

Supply Chain Council (SCC) has developed a Supply Chain Operations Reference model (SCOR-model) to be a reference model for supply chain management cross industry. The model spans all customer interactions, spans all product transactions, from your supplier's supplier to your customer's customer; and spans all market interactions, from the understanding of aggregate demand to the fulfilment of each order. The SCOR-model ver.9 comprises five components: Plan, Source, Make, Deliver and Return. Each of these components is considered both an important intra-organizational function and a critical inter-organization process. This framework can be viewed as a strategic tool for describing,

communicating, implementing, controlling, and measuring complex supply chain processes to achieve good performance.



Figure 1 – supply chain operations reference model

Supply chain management (SCM)

According to Blos et al. (2009, p247), they define SCM is “the management of material, information and finance through a network of organizations (i.e. suppliers, manufacturers, logistics providers, wholesales/distributors and retailers) that aims to produce and deliver products or services for the consumers (Blos et al., 2009). Craighead et al. (2007, p134) defined SCM is “A supply chain comprises different entities that are connected by the physical flow of materials. These different entities are involved in the conversion, the logistics, or the selling of materials, with the materials reaching final customers in some desired form and quantity.” (Craighead et al., 2007) And the supply chain (SC) concept originated in the traditional logistics. SCC definition the SCM is the process of all activities from production to delivery of the final product to the customer. And members include a series of suppliers, manufacturers to the final customer.

Supply chain risk management (SCRM)

Presently supply chain risk management is very important for enterprises. Jing et al. noted that SCRM main purpose is to control, monitor or evaluate supply chain risk and guarantee the continuity of the supply chain and the pursuit of best interests. And SCRM uses strategy, human resources, process, technology and knowledge to pursue the best architecture and consultation process (Jing et al., 2012). Manuj and Mentzer noted that a globalized supply chain network is easy in chaos, collapse and lead to a greater risk due to political and economic change (Manuj & Mentzer, 2008). Researchers think SCRM is an assessment and identification

process of risk by loss in supply chain, and reduce or avoid the damage caused by the enterprise through the implementation of appropriate policy coordination among members of the supply chain. Tummala and Schoenherr noted that Supply chains become longer and more complex than before but its performance improvements are not achieving the expected because possibility of failure has increased (Tummala & Schoenherr, 2011).

Classification of supply chain risk factors

Papers about risk factors have been research for long time, and have different define and classification methods. Elangovan et al. classified risk factors in 6 parts (improper selection of materials and supply, improper use of machines and equipment, improper manpower utilization, etc.) (Elangovan et al., 2010). Manuj and Mentzer classified risk factors in 4 parts (supply, requirement, operations, and security) (Manuj & Mentzer, 2008). This paper use Chen and Lin propose supply chain risk factors (Chen & Lin, 2013). Their research use previous supply chain risk factors research papers and build an enterprise overall risk factor patterns model based on SCOR model. The supply chain risk factors table as Table 1. In Table 1, Source phase 4 risk factors, Make phase 3 risk factors, Deliver phase 3 risk factors, and Return phase 3 risk factors. Total 12 have mutual influence and more important risk factors.

Table 1 – classification of risk factors

Stage	Risk factor
1.Source	1.1 Suppliers supply enterprises with poor-quality raw materials.
	1.2 The enterprises have weak planning of raw materials.
	1.3 Enterprise has only one supplier.
	1.4 Poor information transparency between enterprise and suppliers.
2.Make	2.1 The enterprises have weak planning of manufacturing.
	2.2 Flexibility of manufacturing is poor.
	2.3 Cost of inventory is too high.
3.Deliver	3.1 Forecast of customers' demand is incorrect.
	3.2 The enterprises have poor flexibility of replenishment for customers' order.
	3.3 Poor information transparency between enterprise and customers.
4.Return	4.1 Quality of recycling is uncertain.
	4.2 Lead time of recycling is uncertain.

Supply chain risk management strategy

Supply chain risk management strategy literature can be divided into two categories: principle strategies and case strategies. Principle strategies, for example: Manuj and Mentzer noted that

we can use six methods to solve supply chain risks, which are postponement, speculation, hedging, control/share/transfer, security and avoidance (Manuj & Mentzer, 2008). Gaudenzi and Borghesi propose four phase to problems: risk assessment, risk reporting and decision, risk treatment, and risk monitoring (Gaudenzi & Antonio, 2006). Case strategies are against risk situations in cases. This paper use case strategies to match the risk factors in Table 1.

System dynamic and simulation

System Dynamics is an approach to understanding the behavior of complex systems over time. It is a process-oriented research method and deals with internal feedback loops and time delays that affect the behavior of the entire system. System Dynamics is also a methodology and mathematical modeling technique specializes in a lot of variables, studies of higher order nonlinear for understanding, and discussing complex issues and problems and it developed to help corporate managers improve their understanding of industrial processes. My main research method is system dynamic. Simulation is the imitation of the operation of a real-world process or system over time. The act of simulating something first requires that a model be developed; this model represents the key characteristics or behaviors/functions of the selected physical or abstract system or process (Law & Kelton, 2000). The model represents the system itself, whereas the simulation represents the operation of the system over time. In this paper we use simulation method to operate the model and prove the model is useful.

RESEARCH METHOD

This research use System Dynamics approach to construct a supply chain risk management strategy evaluation simulation model. And then we use this simulation model to evaluate the performance of risk management strategies. This research has three stages. The first stage use the supply chain risk factors proposed by Chen and Lin (Chen & Lin, 2013) to search the related risk management strategies. The second stage is to build a supply chain risk management strategy evaluation simulation model. And the final stage is to use this simulation model to evaluate the performance of risk management strategies. The below tables are the risk management strategies found for the supply chain risk factors proposed by Chen and Lin (Chen & Lin, 2013).

Source stage:

Table 2 – SCRM strategies in source stage

1.1 Suppliers supply enterprises with poor-quality raw materials.	
Tse & Tan, 2012; Managing product quality risk and visibility in multi-layer supply chain	S 1.1-1
Yoo et al, 2012; Inventory models for imperfect production and inspection processes with various inspection options under one-time and continuous improvement investment	S 1.1-2
1.2 The enterprises have weak planning of raw materials.	
Snyder, 2006; A tight approximation for a continuous-review inventory model with supplier disruptions	S 1.2-1
Schmitt, & Singh, 2012; A quantitative analysis of disruption risk in a multi-echelon supply chain	S 1.2-2
1.3 Enterprise has only one supplier.	
Sawik, 2013; Selection of resilient supply portfolio under disruption risks	S 1.3-1
Nicola & Roberta, 2010; Choosing between single and multiple sourcing based on supplier default risk	S 1.3-2
1.4 Poor information transparency between enterprise and suppliers.	
Wakolbinger & Cruz, 2011; Supply chain disruption risk management through strategic information acquisition and sharing and risk-sharing contracts	S 1.4-1
Jing et al., 2012; Supplier risk management: An economic model of P-chart considered due-date and quality risks	S 1.4-2

Tse and Tan proposed quality management strategy include improved the visibility of risk in supply chain and used marginal incremental analysis method to solve problem (Tse & Tan, 2012). Yoo et al. proposed continuous inspection strategy include linear programming method (Yoo et al., 2012). Snyder proposed economic order quantity with disruptions (EOQD) method (Snyder, 2006). Schmitt and Singh proposed flexibility strategy included case study method (Schmitt & Singh, 2012). Sawik proposed a mixed integer programming sources portfolio assess strategy (Sawik, 2013). Nicola and Roberta proposed real options approach supplier evaluation model strategy (Nicola & Roberta, 2010). Wakolbinger and Cruz proposed linear programming sharing information framework policy strategy (Wakolbinger & Cruz, 2011). Jing et al. proposed P-chart solution sharing information policy strategy (Jing et al., 2012).

Make stage:

Table 3 – SCRM strategies in make stage

2.1 The enterprises have weak planning of manufacturing.	
Yoo et al., 2012; Lot sizing and quality investment with quality cost analyses for imperfect production and inspection processes with commercial return	M 2.1-1
Yoo et al., 2009; Economic production quantity model with imperfect-quality items, two-way imperfect inspection and sales return	M 2.1-2

Lee et al., 2013; Discrete lot sizing and scheduling problem under batch processing constraints in the semiconductor manufacturing	M 2.1-3
Li & Marianthi, 2009; Integrated production planning and scheduling using a decomposition framework	M 2.1-4
Taj et al., 2012; A spread-sheet model for efficient production and scheduling of a manufacturing line cell	M 2.1-5
2.2 Flexibility of manufacturing is poor.	
Das, 2011; Integrating effective flexibility measures into a strategic supply chain planning model	M 2.2-1
Kumar et al., 2010; A closed loop outsourcing decision model for developing effective manufacturing strategy	M 2.2-2
2.3 Cost of inventory is too high.	
Yang & Lua, 2011; The use of a multiple attribute decision-making method and value stream mapping in solving the pacemaker location problem	M 2.3-1
Al-Refaie et al., 2010; A System Dynamics Approach to Reduce Total Inventory Cost in an Airline Fueling system	M 2.3-2

Yoo et al. proposed best mass economic production quantity production strategy (Yoo et al., 2012). Yoo et al. proposed maximize profits Inventory production strategy (Yoo et al., 2009). Lee et al. proposed mix integer programming planning model strategy (Lee et al., 2013). Li and Marianthi proposed integrated decision-making and scheduling production planning framework strategy (Li & Marianthi, 2009). Taj et al. proposed production planning and scheduling solution strategy (Taj, 2012). Das proposed mixed integer decisions strategy (Das, 2011). Kumar et al. proposed assessment mode architecture (Kumar et al., 2010). Yang and Lua proposed integrated multi-attribute decision-making strategy (Yang & Lua, 2011). Al-Refaie et al. proposed dynamic systems computing strategy (Al-Refaie et al., 2010).

Deliver stage:

Table 4 – SCRM strategies in deliver stage

3.1 Forecast of customers' demand is incorrect.	
Petrovic & Petrovic, 2001; Multi criteria ranking of inventory replenishment policies in the presence of uncertainty in customer demand	D 3.1-1
3.2 The enterprises have poor flexibility of replenishment for customers' order.	
Karimi & Konstantaras, 2013; An inventory control model with stochastic review interval and special sale offer	D 3.2-1
Lee, 2014; Dynamic pricing inventory control under fixed cost and lost sales	D 3.2-2
Timmer et al., 2013; Cooperation and game-theoretic cost allocation in stochastic inventory models with continuous review	D 3.2-3
3.3 Poor information transparency between enterprise and customers.	
Wakolbinger & Cruz, 2011; Supply chain disruption risk management through strategic information acquisition and sharing and risk-sharing contracts	D 3.3-1
Jing et al., 2012; Supplier risk management: An economic model of P-chart	D 3.3-2

considered due-date and quality risks	
---------------------------------------	--

Petrovic and Petrovic proposed fuzzy linear programming replenishment policy (Petrovic & Dobrla, 2001). Karimi and Konstantaras proposed linear programming inventory control mode strategy (Karimi & Konstantaras, 2013). Lee proposed dynamic pricing inventory control strategy (Lee, 2014). Timmer et al. proposed linear programming flexibility replenishment strategy (Timmer, 2013). Wakolbinger and Cruz proposed linear programming sharing information framework policy strategy (Wakolbinger & Cruz, 2011). Jing et al. proposed P-chart solution sharing information policy strategy (Gaudenzi & Antonio, 2006).

Return stage:

Table 5 – SCRM strategies in return stage

4.1 Quality of recycling is uncertain.	
Teunter & Flapper, 2011; Optimal core acquisition and remanufacturing policies under uncertain core quality fractions	R 4.1-1
Kim et al., 2006; Supply planning model for remanufacturing system in reverse logistics environment	R 4.1-2
Nenes et al., 2010; Inventory control policies for inspection and remanufacturing of returns: a case study	R 4.1-3
Alinovi et al., 2012; Reverse Logistics: a stochastic EOQ-based inventory control model for mixed manufacturing/remanufacturing systems with return policies	R 4.1-4
4.2 Lead time of recycling is uncertain.	
Kim et al., 2006; Supply planning model for remanufacturing system in reverse logistics environment	R 4.2-1
Alinovi et al., 2012; Reverse Logistics: a stochastic EOQ-based inventory control model for mixed manufacturing/remanufacturing systems with return policies	R 4.2-2

Teunter and Flapper proposed linear programming purchase decision mode strategy (Teunter & Flapper, 2011). Kim et al. proposed integrated remanufacturing mathematical model framework strategy (Kim et al., 2006). Nenes et al. proposed remanufacturing inventory assessment model strategy (Nenes et al., 2010). Alinovi et al. proposed integrated manufacturing and remanufacturing strategy (Alinovi et al., 2012).

THE PROPOSED SIMULATION MODEL AND RISK MANAGEMENT STRATEGY EVALUATION

Model established

This research uses the System Dynamics software, Powersim Studio 10, to establish the

proposed supply chain risk management strategy evaluation simulation model. The model is based on SCOR model. And we use those risk factors and SCRM strategies we collected to establish the model completed. The system dynamics causal loop diagram of the model is shown in figure 2.

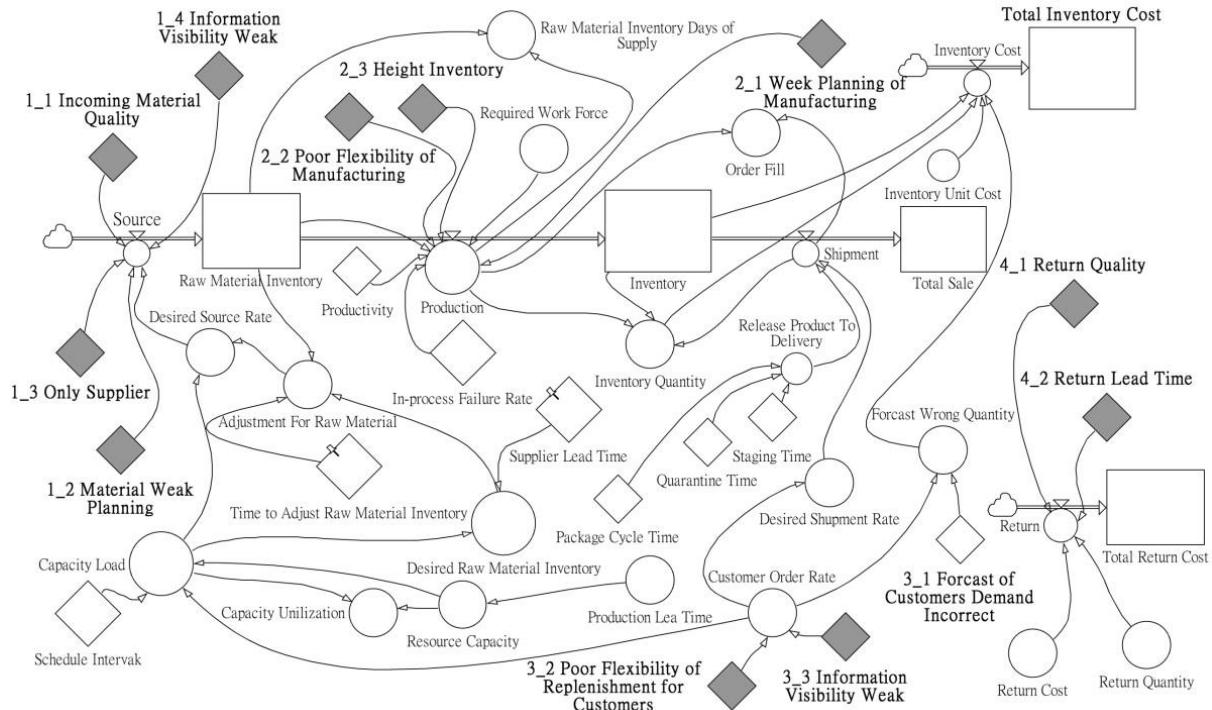


Figure 2 – system dynamics causal loop diagram of the proposed supply chain risk management strategy evaluation simulation model

This model simulates an enterprise situation. The process start from source, production, shipment, and return. Total Cost (TC) is the compare item for those SCRM strategies we introduced above. Experimental data demonstrate in appendix.

Experiment process

Experiment first run without any SCRM strategy represent enterprise do not use any SCRM strategy. We record data for finally experiment analysis and we record each experiment data every process. We observation every risk factor result by used different SCRM strategy. For example, we observation risk factor S 1.1 result under running SCRM strategies S 1.1-21 and S 1.1-2 simulation experiment. Experiment data are recorded and used statistics hypothesis testing method to analysis which strategy is more useful. Other risk factor experiment process is the same. Finally we run all SCRM strategies and find the best combine strategies for all risk process. In this research we observation the total cost for main compare item. And TC is

including production cost, inventory cost, deliver cost, return cost, and information cost. The following table is experiment initial parameters:

Table 6 – parameters

dt	requirement (Default :600)
wk	Unit time (week, total 52weeks)
CRMI	Per unit raw material cost =2
CRI	Per unit return cost =1 (t=0)
RMI	raw material inventory = 400(t=0)
SI	Deliver inventory=0
URMI	Per unit raw material holding cost =1
USI	Per deliver production holding cost =4
RG	Inspection classification costs =5
I	Information share cost =3
σ	Demand fluctuations =2.5%
t	Period
CMI	Per unit inventory cost =4
CSI	Per unit deliver cost =6
MI	Production inventory = 0(t=0)
RI	Return inventory =0(t=0)
UMI	Per unit production holding cost =2
URI	Per unit return production holding cost =1
Rc	Return cost= 3
Sh	Shortage (Default :0)

We use Law and Kelton (Law & Kelton, 2000) proposed method to calculate simulation times. Formula demonstrates below and ‘n’ we calculate is 10.

$$n_r^*(r) = \min \left\{ i \geq n : \frac{t_{i-1, 1-\alpha/2} \sqrt{\frac{s^2(n)}{i}}}{|\bar{x}(n)|} \leq r' \right\} \quad (1)$$

Experiment analysis

After the experiment, we use hypothesis test method to find the better SCRM strategy for each risk factor. For instance, risk factor S 1.1 hypothesis test process demonstrates below. All SCRM strategies are demonstrating in table 7, and the experiment results are in the appendix.

Table 7 – risk factor S 1.1 hypothesis test

	S 1.1-1	S 1.1-2
1	1994804.891	3938265.832
2	1984124.233	3947982.321
3	1979919.306	3953091.89
4	1988102.789	3941474.217
5	2000717.684	3948436.051
6	1986595.65	3934705.725
7	1996638.076	3951316.36
8	1991981.871	3972903.487
9	1987311.844	3951672.267
10	1981778.955	3965310.92

Hypothesis steps:

1. Establish a hypothesis

$$H_0(\text{Null Hypothesis}) : \mu_S 1.1-1 \geq \mu_S 1.1-2$$

$$H_a(\text{Alternative Hypothesis}) : \mu_S 1.1-1 < \mu_S 1.1-2$$

2. Use Minitab 1.6

	N	DF	T	P-value
S 1.1-1	10	9	-461.31	0.000
S 1.1-2	10	9		

3. P-value=0< α =0.05, Reject H0, we have significant evidence to prove $\mu_S 1.1-1 < \mu_S 1.1-2$ true.

4. We find that S 1.1-1 is better than S 1.1-2

Table 8 – better SCRM strategies

Stage	Risk factors	Authors	Name
Source	1.1 Suppliers supply enterprises with poor-quality raw materials.	Tse & Tan, 2012	S 1.1-1
	1.2 The enterprises have weak planning of raw materials.	Lawrence V. Snyder, 2006	S 1.2-1
	1.3 Enterprise has only one supplier.	Nicola & Roberta, 2010	S 1.3-2
	1.4 Poor information transparency between enterprise and suppliers.	Wakolbinger & Cruz, 2011	S 1.4-1
Make	2.1 The enterprises have weak planning of manufacturing.	Yoo et al., 2012	M 2.1-1
	2.2 Flexibility of manufacturing is poor.	Das, 2011	M 2.2-1
	2.3 Cost of inventory is too high.	Yang & Lua, 2011	M 2.3-1
Deliver	3.1 Forecast of customers' demand is incorrect.	Petrovic & Petrovic, 2001	D 3.1-1

	3.2 The enterprises have poor flexibility of replenishment for customers' order.	Karimi&Konstantaras, 2013	D 3.2-1
	3.3 Poor information transparency between enterprise and customers.	Wakolbinger & Cruz, 2011	S 3.3-1
Return	4.1 Quality of recycling is uncertain.	Alinovi et al., 2012	R 4.1-4
	4.2 Lead time of recycling is uncertain.	Alinovi et al., 2012	R 4.2-2

After doing the experiment, we validate the effectiveness of the proposed supply chain risk management strategy evaluation simulation model. And through this model we find that in the risk factors circumstances enterprise has better performance than do not use any SCRM strategies.

CONCLUSION

The main purpose of this paper is to propose a supply chain risk management strategy evaluation simulation model. The model we proposed can be start up in different situation style by user requirement. And the model could assessment SCRM strategies on different risk factors, observation the impact in simulation enterprise, and evaluation the better SCRM strategies for simulation enterprise. We can use this model to reduce the impact of supply chain risk for enterprises. Our research results can be guidelines on relevant research. The proposed model can applicable to various industries for reducing the impact of supply chain risk. Above all, the proposed model can be effectively help enterprises raise avoid impact of risk in today complexly supply chain. In the future, we suggest subsequent research can complex risk factor and in different industry environment.

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APPENDIX

TC(RAW)	S 1.1-1	S 1.1-2	S 1.2-1	S 1.2-2	S 1.3-1	S 1.3-2
4103058.37	1994804.891	3938265.832	2966019.622	4175752.784	3503776.824	2934339.21
4124312.85	1984124.233	3947982.321	2986668.194	4183130.275	3499119.058	2926574.36
4109949.65	1979919.306	3953091.89	2950509.163	4184865.752	3483985.211	2921397.75
4126625.88	1988102.789	3941474.217	2963500.669	4189659.388	3487613.265	2927268.97
4093990.59	2000717.684	3948436.051	2966800.929	4175170.384	3513164.494	2939671.74
4116403.76	1986595.65	3934705.725	2948836.443	4175706.744	3522733.88	2931944.35
4133670.95	1996638.076	3951316.36	2962641.481	4188753.393	3497374.036	2926687.06
4113951.47	1991981.871	3972903.487	2967704.744	4200839.104	3510925.683	2931447.42
4107268.33	1987311.844	3951672.267	2962065.702	4182309.1	3531199.77	2925796.62
4093941.44	1981778.955	3965310.92	2941380.175	4160785.716	3483326.175	2924351.47
S 1.4-1	S 1.4-2	M 2.1-1	M 2.1-2	M 2.1-3	M 2.1-4	M 2.1-5
2998991.192	3155547.629	3709585.91	3938245.685	3878055.834	3717073.173	3973977.73
2983247.668	3144060.407	3714722.1	3944021.345	3894386.05	3750964.8	3990192.84
2998247.247	3148190.712	3709192.188	3946378.18	3898298.134	3746918.975	3985105.03
2999971.631	3139007.993	3702813.186	3938160.214	3866647.94	3725960.322	3991985.39
2998258.405	3153469.318	3674569.167	3957619.284	3884085.546	3732066.814	4000341.5
3002011.032	3135964.881	3722332.89	3957182.577	3880641.846	3725213.543	3990026.54
2985411.76	3151455.244	3701601.964	3952534.626	3890735.919	3719411.041	3980585.73
2987013.086	3160470.278	3709478.927	3936190.617	3873549.897	3717870.882	3964612.46
2992854.386	3154688.263	3704087.303	3930315.425	3888614.713	3770016.068	3974382.33
2993142.704	3140311.147	3704972.544	3960169.91	3905020.363	3720435.246	3999064.31

M 2.2-1	M 2.2-2	M 2.3-1	M 2.3-2	D 3.1-1	D 3.2-1	D 3.2-2
3872258.814	4020673.428	3563584.419	4079434.576	4074250.718	4085643.239	4087929.685
3861380.715	4000684.72	3578128.927	4076364.66	4103249.385	4088666.444	4089038.913
3881935.326	3991623.23	3574645.934	4099513.483	4113723.09	4070607.803	4095204.226
3898373.399	3983182.222	3574760.938	4089380.932	4132689.905	4067962.244	4091209.777
3878539.899	4006168.231	3570115.945	4074417.689	4116311.593	4083385.715	4098790.599
3873183.383	4010831.743	3578287.57	4086869.872	4100372.831	4098642.271	4077846.833
3871346.453	3986577.594	3574252.356	4072459.286	4111893.267	4073442.934	4088251.856
3871977.419	4020748.451	3571736.507	4079381.133	4087123.64	4089929.924	4092420.26
3873674.262	4012229.852	3568867.307	4083119.832	4099027.535	4085725.553	4083712.176
3877243.202	4003906.109	3572725.648	4091594.281	4096574.273	4071042.488	4082082.804
D 3.2-3	D 3.3-1	D 3.3-2	R 4.1-1	R 4.1-2	R 4.1-3	R 4.1-4
4100691.854	4065297.148	4078980.175	4097713.353	4127551.317	4088774.973	4121828.552
4103544.509	4053712.971	4075812.115	4113312.45	4114683.759	4106448.991	4090622.498
4093861.624	4067322.685	4100804.312	4135909.721	4121641.242	4112320.064	4136710.462
4104450.935	4075057.538	4072574.463	4126031.02	4124038.126	4116122.084	4075359.591
4086533.48	4068602.462	4072804.981	4134452.066	4108712.071	4107626.924	4109770.165
4083918.691	4073977.087	4062134.903	4101908.097	4126203.686	4104357.108	4109939.855
4084143.792	4066484.164	4069000.287	4115291.19	4122086.109	4086767.693	4098691.038
4092884.611	4078054.965	4082314.804	4108712.535	4104863.07	4103880.241	4103708.15
4092695.164	4055421.581	4090781.087	4105074.103	4110598.31	4104747.026	4121099.16
4097413.909	4059339.742	4080420.088	4110666.409	4119180.468	4095287.927	4118752.234
R 4.2-1	R 4.2-2					
4100136.716	4095357.351					
4107941.841	4114421.497					
4139305.684	4104703.372					
4123619.981	4135411.342					
4117693.331	4102997.401					
4122908.901	4099756.392					
4108779.82	4098686.991					
4114254.922	4107565.561					
4125992.92	4103351.406					
4092412.425	4130480.476					

USING MARKOV MODELING FOR POPULATION FORECASTING TO ASSESS INPATIENT DEMAND

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ABSTRACT

The change of the population structure affects health care system, especially the significant change in the number of the elderly. The study of demographic change is crucial for long-term planning on health care system. The rapid increasing of the elderly has impacted the population structure of many countries, leading the societies to become the aging societies. Such changes have affected the social, economic, as well as resource allocation mechanism in the long run. It is essential to study population structure to support health care service system and to accommodate an increase of the elderly in any society. Therefore, this research aims to use the Markov Modeling to forecast population and patient demand in hospitals of interested area. The study examines both the changes in the age and gender demographics. Annual demand of population will be predicted and used to assess the expected resource requirement for patient service in the long run. The results show that the elderly population and the proportion of service for elderly at hospitals tends to increase during 2015 to 2025 so the average daily demand for beds is growing, especially for those used by the elderly. Results from this study can be used as a tool for decision-making to determine resources required for the health care.

KEYWORDS: Population, Elderly demand, Markov Modeling, Health care

INTRODUCTION

The study of health care demand in hospitals is very crucial, because elderly people have grown continually [1]. The population structure in many countries has become the aging societies. Demands for hospital care are also increasing due to the fact that the elderly need more medical care than the other ages. The study of demand prediction for elderly and other ages in the institutional care is necessary. The change of population structure will directly affect the requirement of health care service in hospitals significantly. According to the limitation of resources, especially available beds in hospitals, the estimation of demand in the future is very important information for resource planning in the long run. Therefore, this research aims to assess the demand for services in the institutional care, emphasizing services in hospitals, in order to evaluate the needs for resources in long term. In hospitals, the services focus on treatments for inpatients. The factors of the study considers both the changes in the age and gender demographics. The results from this study is the essential information to plan for health care system in the long run.

In the literature, the change of population structure depends on the uncertainty of demography. To response to the inconsistent changes, the stochastic method is applied to population forecasting. [2], Lee and Tuljapurkar, presented methods and results for population forecasts based on stochastic time series model. Another stochastic method, proposed by [3], is the Markov model to predict population age structure in Shanghai. They conclude that aging trend is growing in the next 10 years in Shanghai. Another population forecast is suggested by [4]. This paper presents the stochastic forecast combining opinions from several experts to be used as the basis for the forecasts. The forecasting results show the Italian population from 2010 to 2065. The previous studies of population forecasting show that the elderly is increasing continually. The forecasting results can be used to be the basic information for long-term planning.

The demographic change affects to health care services. The result from population forecasting is the strong information to prepare services in hospitals especially those services for inpatient demand of the elderly. The estimation of future demand for long-term care (LTC) was conducted by [5]. This paper presents how projected demographic development may influence future demand for human resources for LTC for older people in Sweden during 2000–2030. Afterwards, another research aims to investigate the future sustainability of the UK system for the provision of long-term care (LTC) by [6]. This study considers demand for LTC and sufficient supply to meet demand. Another research that focuses on the length of stay of the elderly in institutional long-term care is proposed by [7]. The development of a Markov continuous model in this paper is to study the length of stay for the elderly moving within and between two compartments, which are residential home care and nursing home care. Other similar studies to improve the length of stay problem are studied by [8] and [9]. These papers present a model-based approach with high-level length-of-stay patterns of residents in long-term care. In addition, [10], Hare et al, developed a deterministic multistate Markov model of the Home and Community Care (HCC) system. The model validates and predicts for future client counts for various HCC client groupings. [11], Cardoso et al., proposed a simulation model, which is based on a Markov cycle tree structure to predict demand for LTC services annually. The objective of the study is to inform the planning of the services at the small-area level in recent years.

The previous studies show that the Markov chain is the popular method used to forecast the population and long-term care demand. However, the study of population change and the demand in hospital are still conducted separately. Moreover, the Markov model of long-term care demand in hospital in the literature considers only the mortality factor and does not consider the impact of the migration factors as mentioned in the study of [11]. The migration component is the main factor for the demographic change associated with the long-range demand in hospitals inevitably. Therefore, this study proposes the change of population from children to elderly combining to the inpatient demand in hospital and also considers the factors of migration in each gender and age group. The population change affects to demand services in the hospitals when entering to the aging society. The study of population and demand prediction cover the period during 2015-2025. The service demand obtained from the model used to assess the adequacy of hospital resources in the long term.

This paper is organized as follows: section 2 introduces the problem definition. Section 3 presents the methodology. Computational results are given in section 4, and the solution is concluded in section 5.

PROBLEM DEFINITION

The study is to develop Markov Model to predict population and annual demand of all hospitals in a certain area. The objective of this research aims to predict inpatient demands when population structure change to the elderly population in order to estimate resources, focusing on estimating the number of beds for all hospitals in the affected area as shown in figure 1. The study examines both the changes in the age and gender demography together with the factors of migration.

1. Problem definition

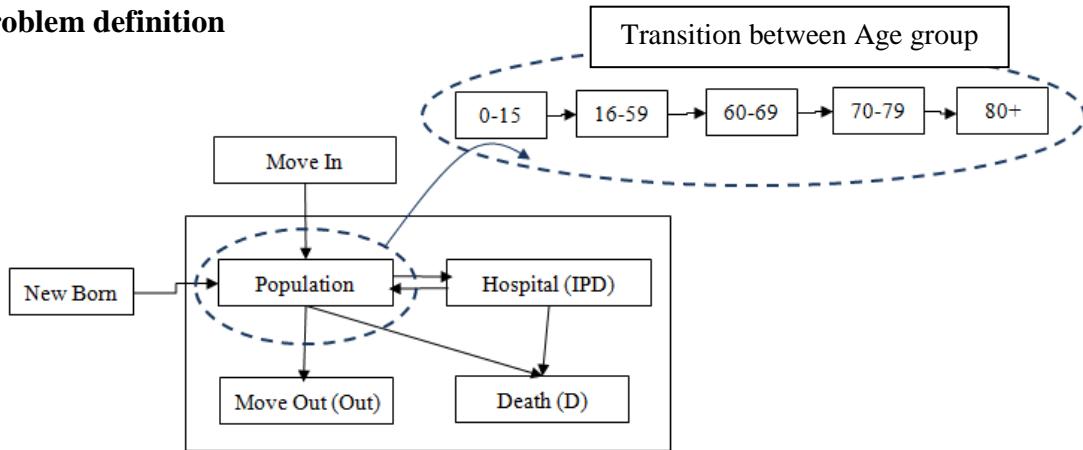


Figure 1 Flow Model

The population changes in figure 1 consist of moving between age groups, the migration (move in and move out) and the death.

The transition matrix of each gender consists of population change in each age group transfer to the next state in one year. The beginning is the childhood state (0-15 years old) which transfers to each four states consisting of working age state (16-59 years old), inpatient state, move out state and death. The childhood state is integrated with the new-borns and the immigration people. Next, the working age state transfers to each four states consisting of the beginning elderly age state (60-69 years old), the inpatient state, the move-out state and the death. The working age state is integrated with the immigration people. Then, the beginning elderly age state transfers to each four states consisting of the middle elderly age state (70-79 years old), the inpatient state, the move out state and the death. The beginning elderly age state is integrated with the immigration people. After that, the middle elderly age state transfers to each four states consisting of the oldest elderly age state (80 years old and more), the inpatient state, the move out state and the death. The middle elderly age state is integrated with the immigration people. Next, the oldest elderly age state transfers to each three states consisting of the inpatient state, the move out state and the death. The oldest elderly age state is integrated with the immigration people. Finally, the inpatient state transfers to each age group, and the death.

The calculation begins with historical data to estimate birth rates, transition probability rates between age groups, transition probability rates to hospitals, migration rate and mortality rate. These transition rates are the composition of one-year transition matrix for each gender. The transition matrices are used to estimate annual population changes and annual demands in

hospitals from 2015 to 2025. These result shows annual demands for hospital services especially for the elderly people in such a way that resources can be managed and utilized effectively.

2. Model Assumptions

2.1 This study focuses on the overall population and all inpatient demands in Nakhon Ratchasima province, Thailand. It is not aimed to focus on each separated hospitals. Overall the number of population in 21 districts in this province is approximately 2.59 million which are male 1.27 and female 1.30 million, respectively).

2.2 The immigration and emigration mean the moving in and moving out of population from other areas to Nakhon Ratchasima, Thailand.

2.3 The transition probability rate of each age group, the transition probability rate to hospital, and the transition probability rate of death and the birth rate depend on time dependent covariates such as total population or calendar years.

2.4 The transition rate of each age group, the transition probability rate to hospital, and the transition probability rate of death and the birth rate are modeled by logistic regression.

2.5 Due to the lack of information and uncertainty, the transition probability rates of moving out and moving in are analyzed by Monte Carlo method .

2.6 The population used in this research are gathered from the database of National Statistical office and Official Statistics Registration Systems. The population used in this study are assumed to be identical regardless of any types of diseases.

METHODOLOGY

The use of the Markov model implies stationary transition probabilities over the sample period considered.

1. Data Source

The data consist of demographic information and the available data services in hospitals from 2009 to 2012. The demographic information consists of number of births, deaths and migrations disaggregated by ages and genders. The information is gathered from the registration systems of the Official Statistics Registration Systems [12] and the National Statistical Office of Nakhon Ratchasima Province [13]. The information of available services in hospitals is gathered from the Nakhon Ratchasima Provincial Public Health Office [14], Public Health Resource Report system [15] and the National Statistical Office of Nakhon Ratchasima Province [12]. The proportions of the inpatient demand and the length of stay by ages and genders are calculated from the database OP/PP individual records. The lists of data and sources are shown in table 1 below.

Table 1 The lists of sources of demographic information and the overall data services in hospitals

Data	Sources
Annual Demographic Data (Number of population, births, deaths and migrations)	National Statistical Office, 2014;[12] Official Statistics Registration Systems, 2014 [13]
Data services in hospitals - Number of inpatient/year - Proportion of inpatient/age group - Number of hospital visit/year, - Length of stay(days)	Public Health Resource Report system [15] database OP/PP individual records [14] database OP/PP individual records [14] database OP/PP individual records [14]

2. Data Analysis

The historical information is use to calculate birth rate, population transfer rate, inpatient proportion rate, migration rate and mortality rate which can be calculated as following.

I) Birthrate (by gender) - Calculate from

$$\frac{\text{Number of newborn in year } t}{\text{Total Population in year } t - 1} \quad (1)$$

II) Population transfer rate between age group by gender - Calculate from

$$\frac{\text{Number of population from age } i \text{ year } (t - 1) \text{ transfer to age } (i + 1) \text{ in year } t}{\text{Total population in age } i \text{ in year } (t - 1)} \quad (2)$$

III) Inpatient proportion rate by gender and age group - Calculate from

$$\frac{\text{Number of population from age } i \text{ to inpatient age } i}{\text{Total population in age } i} \quad (3)$$

IV) Migration proportion rate by gender and age group - Calculate from

$$\frac{\text{Number of migration age } i}{\text{Total population age } i} \quad (4)$$

V) Mortality proportion rate by gender and age group - Calculate from

$$\frac{\text{Number of death people age } i}{\text{Total population age } i} \quad (5)$$

The proportion rates from above use to analyze transition probability function by time-dependent as following.

3. The Markov Model

The Markov model is applied in this study to predict population change by five age groups and genders. The sets, variables and parameters of the model are defined in details below.

(1) Subscripts:

i, j = State of Markov chain $i, j \in \{1, \dots, 8\}$ when $1 = P_{(0-15)}$, $2 = P_{(16-59)}$, $3 = P_{(60-69)}$, $4 = P_{(70-79)}$, $5 = P_{(80 \text{ and more})}$, $6 = \text{IPD}$, $7 = \text{MoveOut}$, $8 = \text{Death}$

k = Age group k ; $k \in \{1, \dots, 5\}$ when $1 = (0 - 15)$, $2 = (16 - 59)$, $3 = (60 - 69)$, $4 = (70 - 79)$, $5 = (80 \text{ and more})$

t = Prediction period t ; $t \in \{1, \dots, T\}$

g = Gender g ; $g \in \{1, 2\}$ when $1 = \text{male}$, $2 = \text{female}$

(2) Sets:

N = $\{s_{i,g,t}\}$; $i \in \{1, \dots, 8\}$, $g \in \{1, 2\}$, $t \in \{1, \dots, T\}$ - The set of number population of gender g at each stage i at each prediction period t

(3) Parameters:

$s_{i,g,0}$ - Initial number of population of gender g of state i at time 0

$Bed_Capacity_t$ - Bed capacity at time t

T - Total number of predicted periods

(4) Variables:

$s_{i,g,t}$ - Number of population of gender g of state i at time t

$IPD_{k,g,t}$ - Number of inpatients with age k , gender g at time t (the people who use services in all hospitals)

$MoveOut_{k,g,t}$ - Number of population of gender g , age group k who emigrate from interested area at time t

$MoveIn_{k,g,t}$ - Number of population of gender g, age group k who immigrate to interested area at time t

$Death_{g,t}$ - Number of people who are passed away from interested area at time t

$NewBorn_{g,t}$ - Number of new-borns of gender g in time t

$BirthRate_{g,t}$ - Birth rate of gender g in time t

$MoveIn_Rate_{k,g,t}$ - Immigration rate of people by gender g and age group k at time t

$MoveOut_Rate_{k,g,t}$ - Emigration rate of people by gender g and age group k at time t

$a_{i,j,t}$ - Transition Probability from State i to State j at time t

$TM_{g,t}$ - Transition Matrix of gender g at time t

$TotalPop_{g,t}$ - Total population of gender g at time t

$PD_{k,g,t}$ - Patient Days of gender g and age group k at time t

TPD_t - Total Patient Days at time t

$LOS_{k,g}$ - Length of Stay of age group k and gender g per time hospital visit

$NHV_{k,g,t}$ - Number of hospital visits by inpatients of age k, gender g at time t

(5) Transition Matrix:

I) Transition probability rate

In this section is the calculation of transition probability rate of the non-homogeneous model. In order to make the model realistic, logistic regression [16] is used to find transition rate of each state including the transition probability rate of each age group and each gender ($s_i \rightarrow s_i, s_i \rightarrow s_j$)_g, the transition probability rate of population to hospital ($s_i \rightarrow IPD_k$)_g, the transition probability rate of population to death ($s_i \rightarrow Death_k$)_g, the transition probability rate of inpatients back to population ($IPD \rightarrow s_i$)_g) and the transition probability rate of inpatients to death (($IPD \rightarrow Death_k$)_g). By using logit model as shown in (6) together with equations (7) and (8), the transition rate of each state can be calculated as shown in (9).

$$\log it(p) = \ln(\pi) = \alpha + \beta x \quad (6)$$

where α and β are parameters to fit in SPSS on time-dependent covariates $x = x_1, x_2, \dots, x_n$ such as total population and calendar years. Example of calculated rates is shown in table (4) and figure 3. And π is Odds of logistic model, which can be computed by

$$\pi = \frac{p}{1-p} \quad (7)$$

where p is probability rate.

$$p = \frac{e^{\alpha+\beta x}}{1 + e^{\alpha+\beta x}} \quad (8)$$

From eq.(8) transition probability rate ($a_{i,j}$) from state i to j with α_{ij} and β_{ij} parameter can be computed by

$$a_{i,j} = \left(\frac{e^{\alpha+\beta x}}{1 + e^{\alpha+\beta x}} \right)_{i,j} \quad (9)$$

Many factors including demographic, economic, social, and environment factors have impact to transition probability rates of population moving in (immigration) and moving out (emigration). Due to the fact that the obtained information is incomplete, in this study, both transition probability rates will be generated using Monte Carlo Simulation with uniform probability distribution as shown in tables (2). Monte Carlo Simulation with 1000 iterations is used to calculate immigration transition probability rates and emigration transition probability rates in each time t.

Table 2 Uniform probability distribution of immigration and emigration transition probability rates

Age Group	Move In (Immigration)		Move Out (Emigration)	
	Male	Female	Male	Female
0-15	Uni(1.26e-3,2.89e-3)	Uni(9.45e-4,2.37e-3)	Uni(3.15e-3,1.01e-2)	Uni(5.90e-3,1.19e-2)
16-59	Uni(8.02e-3,1.85e-2)	Uni(8.27e-3,1.63e-2)	Uni(1.41e-2,3.23e-2)	Uni(7.67e-3,3.30e-2)
60-69	Uni(4.07e-5,4.17e-4)	Uni(1.13e-4,3.27e-4)	Uni(3.88e-5,6.17e-3)	Uni(6.91e-4,1.03e-2)
70-79	Uni(2.57e-5,2.29e-4)	Uni(7.05e-5,2.03e-4)	Uni(2.92e-3,9.84e-3)	Uni(8.20e-4,7.31e-3)
80+	Uni(8.59e-6,7.14e-5)	Uni(2.92e-5,8.76e-5)	Uni(9.34e-3,1.76e-2)	Uni(4.81e-3,1.49e-2)

II) Transition Matrix

The transition matrix of annual periods has 8×8 dimensions. The structure of Markov Model of each gender g at anytime t is shown in figure 2 and the time-dependent transition matrix($TM_{g,t}$) for each gender g, $g \in \{\text{Male, Female}\}$ is shown in eq. (10)

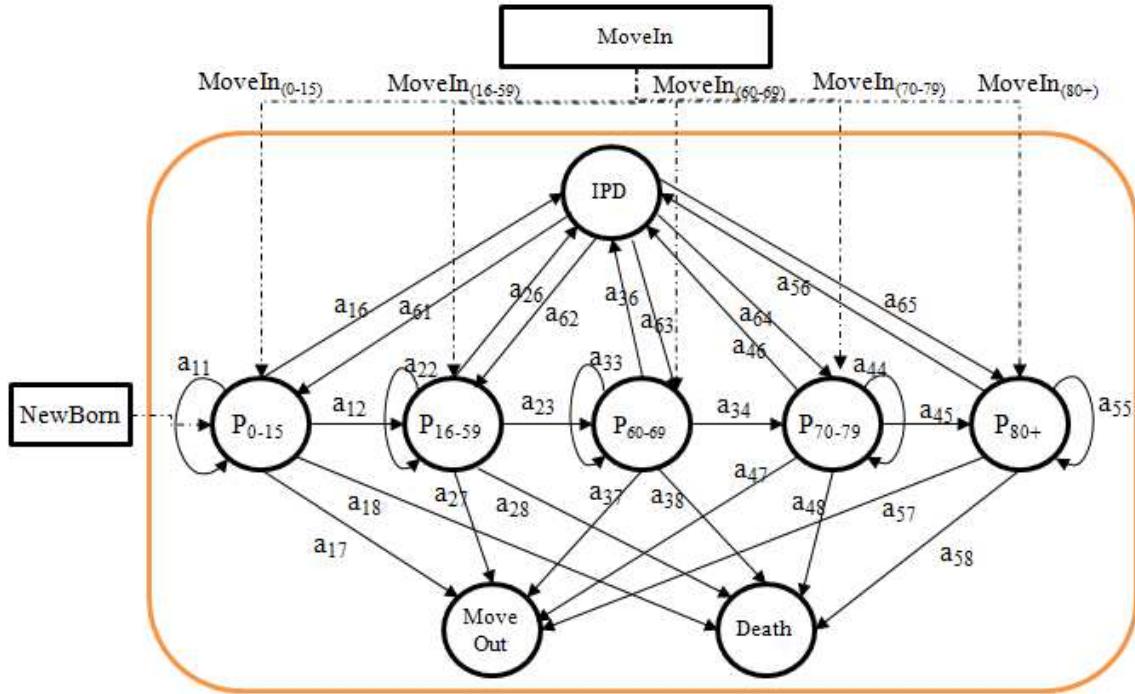


Figure 2 Structure of Markov Model

$$TM_{g,t} = \begin{bmatrix} a_{11} & a_{12} & 0 & 0 & 0 & a_{16} & a_{17} & a_{18} \\ 0 & a_{22} & a_{23} & 0 & 0 & a_{26} & a_{27} & a_{28} \\ 0 & 0 & a_{33} & a_{34} & 0 & a_{36} & a_{37} & a_{38} \\ 0 & 0 & 0 & a_{44} & a_{45} & a_{46} & a_{47} & a_{48} \\ 0 & 0 & 0 & 0 & a_{55} & a_{56} & a_{57} & a_{58} \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & a_{66} & 0 & a_{68} \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}_t \quad (10)$$

Set of absorbing state is {MoveOut, Death}. The transition probabilities of values in the Markov model are non-negative and the summation of each raw equals to one as shown in (11)

$$\sum_j^n a_{ij} = 1 , i, j \in S \text{ for } i = 1, 2, \dots, 8 \quad (11)$$

The number of population for each state of each gender for the year (t+1) is calculated using equations (12) and (13)

$$N_{k,g,t+1} = (N_{k,g,t} \times TM_{k,g,t}) + NewBorn_{g,t+1} + MoveIn_{k,g,t+1} , \text{ for } k = 1, g \in \{1, 2\}, t \in T \quad (12)$$

$$N_{k,g,t+1} = (N_{k,g,t} \times TM_{k,g,t}) + MoveIn_{k,g,t+1} , \text{ for } k \in \{2, \dots, 5\} , g \in \{1, 2\}, t \in T \quad (13)$$

$$TotalPop_{g,t} = \sum_{k=1}^5 N_{k,g,t} , \text{ for } g \in \{1, 2\}, t \in T \quad (14)$$

$$NewBorn_{g,t} = BirthRate_{g,t} \times TotalPop_{g,t}, \text{ for } g \in \{1,2\}, t \in T \quad (15)$$

$$MoveIn_{k,g,t} = MoveIn_Rate_{k,g,t} \times TotalPop_{g,t}, \text{ for } g \in \{1,2\}, t \in T, k \in \{1, \dots, 5\} \quad (16)$$

4. Resource Requirement

The Database OP/PP individual records are used to find the length of stay (LOS) and the number of hospital visits per person per year of each age group. This database consists of inpatient admissions until discharge from all hospitals in Nakhon Ratchasima Province, Thailand. First, the number of in-patients of each age group and each gender in time t is calculated from Markov model using equations (12) and (13) and is used to estimate the number of bed requirement in time t . Then, analyze the proportion of the number of hospital visits (NHV) per year and the proportion of length of stay (LOS) of each age and gender group. After that, calculate the number of hospital visits per year of each age and gender group and the total days of patients need to stay in hospitals per year according to equations (17) and (19). Finally, calculate bed requirement and bed occupancy rate by using equations (20) and (21) respectively.

$$NHW_{k,g,t} = IPD_{k,g,t} \times (\text{proportion of NHV})_{k,g} \times (\text{NHW of each proportion})_{k,g}, \text{ for } g \in \{1,2\}, t \in T, k \in \{1, \dots, 5\} \quad (17)$$

$$PD_{k,g,t} = NHV_{k,g,t} \times (\text{proportion of LOS})_{k,g} \times (\text{LOS of each proportion})_{k,g}, \text{ for } g \in \{1,2\}, t \in T, k \in \{1, \dots, 5\} \quad (18)$$

$$TPD_t = \sum_{g=1}^2 \sum_{k=1}^5 PD_{k,g,t}, \text{ for } t \in T \quad (19)$$

$$\text{Bed Requirement}_t = \frac{TPD_t}{365}, \text{ for } t \in T \quad (20)$$

$$\text{Bed Occupancy Rate}_t = \frac{TPD_t}{(Bed_Capacity)_t \times 365}, \text{ for } t \in T \quad (21)$$

Remark Bed Capacity = 4100 Beds (Nakhon Ratchasima Provincial Public Health Office)

5. Sensitivity Analysis

Due to the fact that the number of using hospital services is uncertain, it is assumed that when the length of stay is lower, more hospital beds are available to other patients. Thus, hospitals are able to manage resources more effectively. In this case, we assume that the hospital can discharge elderly inpatients to rehabilitate at home or to be back to good health faster than the average hospital stay calculated from historical data (from Database OP/PP individual records). These two different scenarios mean that the length of stay of elderly decrease 10% and 20% from historical data as shown in table (3). The analysis of the level of length of stay is proposed to develop long-term health service system to utilize hospital resource efficiency. However, the long-term health service system should develop continually to discharge patients from hospital as soon as possible. When elderly inpatients are discharged from hospital, the services of home care from both formal and informal should be developed to support rehabilitated elderly at home.

Table 3 The two different scenarios of LOS of elderly

Scenario	LOS of elderly of each proportion decrease from historical data
1	-10%
2	-20%

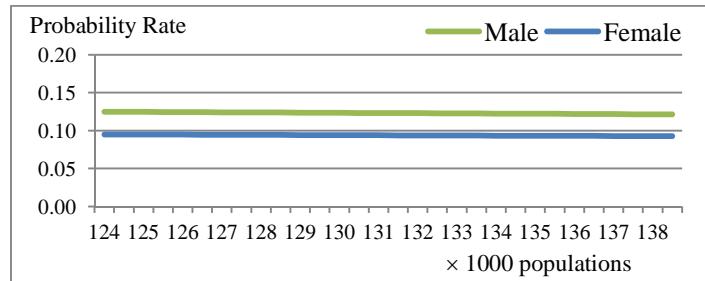
COMPUTATIONAL RESULTS

1. Transition Probability Rates

The parameters of birthrate of logistic function by gender are shown in table (4) (based on time-dependent with population covariate). The curve of probability rate in figure 3 slightly decreases when the number of population increases.

Table 4 Parameters of Birth Rate for each gender

Parameters	α	β
Male	-1.6702	-2.23E-06
Female	-2.0147	-1.93E-06

*Figure 3 Probability rates of new born varying on total population covariate for each gender*

The transition probability rates between age group for each gender (based on time calendar covariate) are shown in figure 4. The trends of probability rate slightly increase in all age groups of female and groups P(16-59) to P(60-69) of male. Whereas the trends of probability rates highly increase in age group P(70-79) to P(80+) of male.

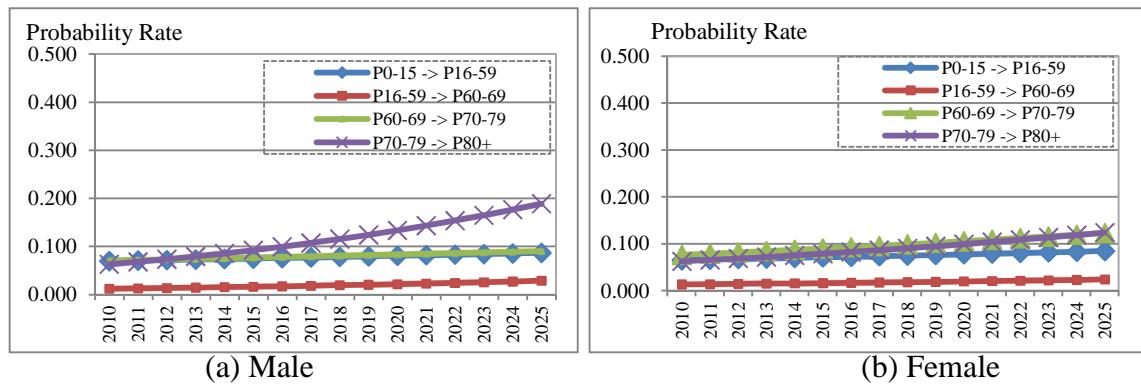


Figure 4 Probability rates between age group on time-calendar covariate for each gender (a) Male and (b) Female

The transition probability rates from population to inpatient (based on time calendar covariate) are shown in figure 6. The trends of probability rates slightly increase in age groups childhood (P0-15) and working age groups (P16-59) of both male and female. Whereas the trends of probability rates increase significantly in elderly age group (P(60-69), P(70-79) and P(80+)) of both male and female.

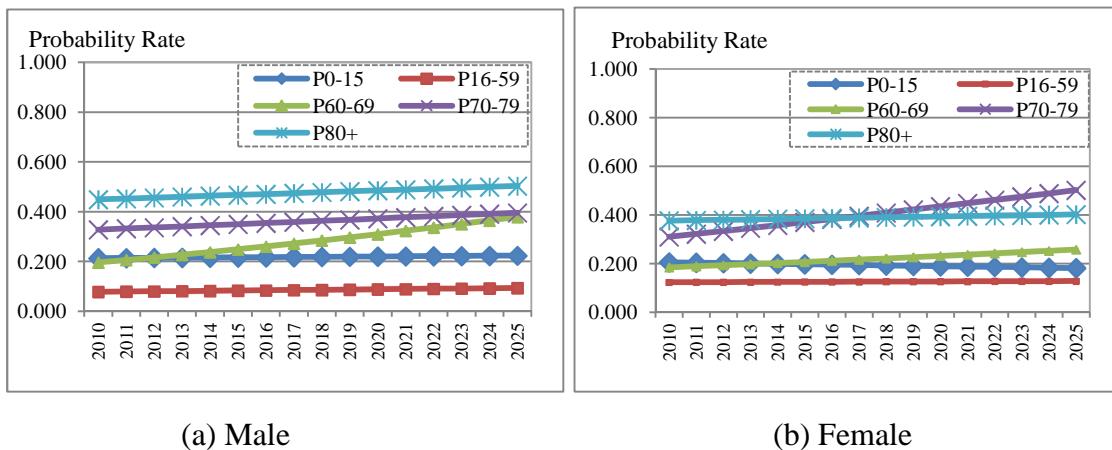


Figure 5 Probability rates from population to inpatient on time-calendar covariate for each gender (a) Male and (b) Female

2. Transition Matrix

An example of transition matrix for males in year 2010 is shown in tables (5). In this table, the transition Matrix shows the transition probabilities between states in one year. For example, at the beginning of the elderly state (60-69), there are 7.09% of beginning elderly in this year transferring to the middle elderly state (70-79) in the next year, there are 19.61% transferring to use services as inpatients in hospitals in the next year, there are 0.31% transferring to move out from area in the next year and there are 1.16% transferring to the death state in the next year. After that, the number of people in each state calculated from the transition matrix will be integrated with the new-born and the move in people for each age and each gender group using equations (12), (13) and (15). In the following year , transition

Matrix of each gender group will be changed based on time-dependent from logistic function and uncertainty analysis.

Table 5 Transition Matrix of Male in 2010

	P0-15	P16-59	P60-69	P70-79	P80+	IPD	MoveOut	Death
P0-15	0.7096	0.0697	0	0	0	0.2134	0.0066	0.0007
P16-59	0	0.8879	0.0124	0	0	0.0783	0.0189	0.0025
P60-69	0	0	0.7182	0.0709	0	0.1961	0.0031	0.0116
P70-79	0	0	0	0.5800	0.0631	0.3278	0.0060	0.0230
P80+	0	0	0	0	0.5017	0.4491	0.0126	0.0366
IPD	0.3715	0.3986	0.0868	0.0799	0.0342	0	0	0.0290
MoveOut	0	0	0	0	0	0	1	0
Death	0	0	0	0	0	0	0	1

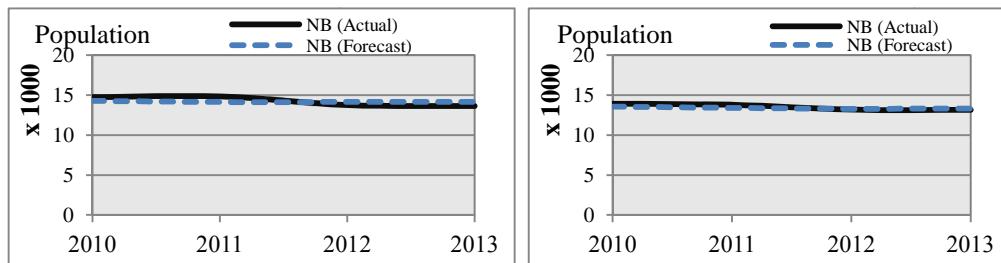
3. Validation Result

To compare the efficiency of the forecast results, it is necessary to validate the reliability of the calculations by comparing between real and prediction data or calculate the Mean Absolute Percent Error (MAPE). The historical data from 2009 to 2012 are used to calculate Markov model. Therefore, the validation of the model will compare with data in 2010-2012. The comparison, in table (6), shows that the predictions of population have less difference with the real data. When compare between age groups and genders, it is found that the predictions of population for childhood and working age have differences between actual and predicted data less than 1.2%. In the elderly age, there are differences between real and predicted data ranging from 0-4.4% in 2011 and 1-6.5% in 2012. The difference of each age group is due to uncertainty factors such as mortality rate by chronic. Thus, the future study should consider the transition rate by considering other impact factors such as chronic of population. However, the difference or MAPE of total population is less than 1%. Therefore, the predicted population and demand from model can be used to estimate resource requirement appropriately.

Table 6 Mean Absolute Percent Error (MAPE) between real and predicted values for population during 2010-2012 in Nakhon Ratchasima

Age Group	Δ% 2010			Δ% 2011			Δ% 2012		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
0-15	0.1%	0.8%	0.4%	0.6%	1.0%	0.8%	1.2%	0.7%	1.0%
16-59	-0.1%	-1.0%	-0.5%	0.5%	-1.2%	-0.4%	1.2%	0.0%	0.6%
60-69	-0.4%	0.1%	-0.1%	-0.3%	0.9%	0.3%	-0.3%	2.5%	1.2%
70-79	2.5%	1.4%	1.9%	4.4%	1.4%	2.7%	6.5%	1.1%	3.5%
80+	-0.2%	1.1%	0.6%	-4.3%	0.0%	-1.6%	-4.6%	-0.1%	-1.8%
Total	0.0%	-0.4%	-0.2%	0.6%	-0.5%	0.0%	1.2%	0.4%	0.8%

The comparisons of newborn between actual information and forecast from Markov Model are shown in figure 6. The graphs show less difference between actual and forecast for both male and female during 2010-2013



*Figure 6 Comparisons of Newborn between Actual information and Forecast from Markov Model of
(a) Male and (b) Female during 2010-2013*

The comparisons of inpatient between actual information and forecast from Markov Model show in figure 7. The graphs show less difference between actual and forecast for both male and female during 2010-2012

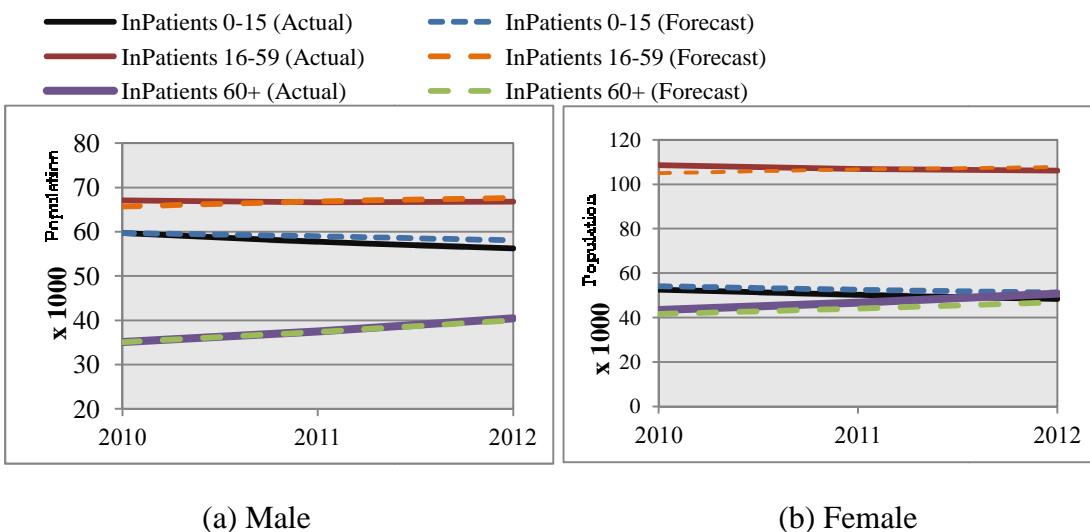


Figure 7 Comparisons of inpatient for each age and each gender groups between Actual information and Forecast from Markov Model of (a) Male and (b) Female during 2010-2012

According to all above validation information, it can be said that there are no difference between actual information and forecast from Markov Model. Thus, the Markov model can be used to analyze the population and hospital demand prediction appropriately.

4. Population and Hospital demand predictions

The predictions of the overall population from 2015 to 2025 are summarized in Figure 8. The result shows that the trend of aging population is likely to increase for both male and female. The proportion of the elderly will increase from 14.6% in 2015 to 22.6% in 2025. However, working age population and children age are likely to decline and the number of female population is slightly higher than males. The number of elderly will increase and exceed the number of childhood group in 2020.

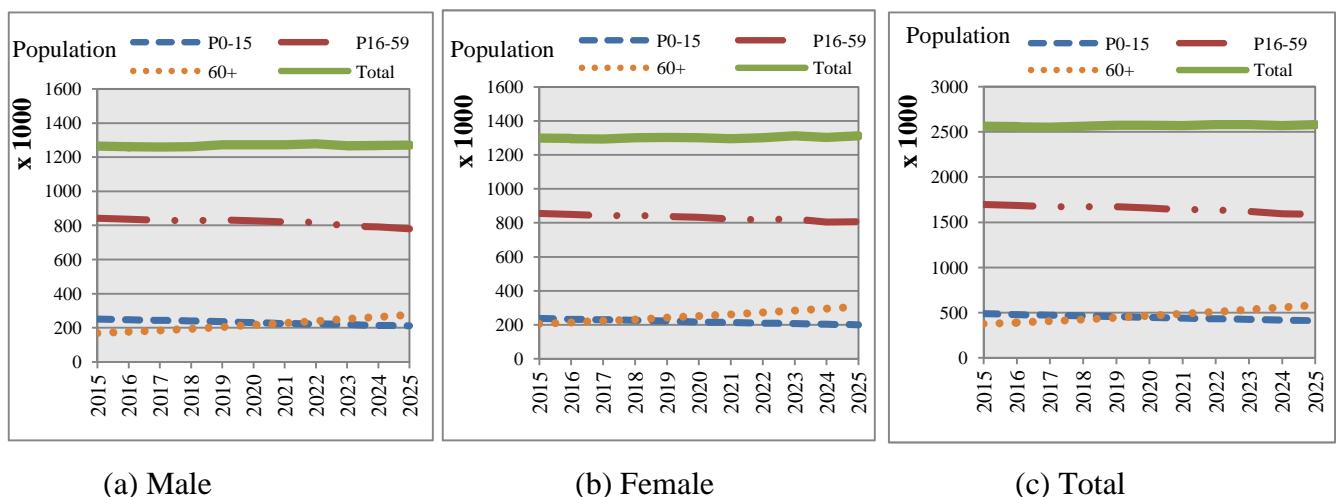


Figure 8 (a) Male, (b) Female and (c) Total Population Prediction disaggregated by age group from 2015 to 2025

The increase of the elderly population affects demands for services in hospitals, as shown in figure 9. The predicted demand of the elderly has increased continually from 2015 to 2025 for both males and females, and females tend to have higher demand for hospital services than males. The hospitals should manage services to correspond to the changing needs of each age group. In this research, the estimation of resource requirement is analyzed to plan a number of beds according to predicted demand change.

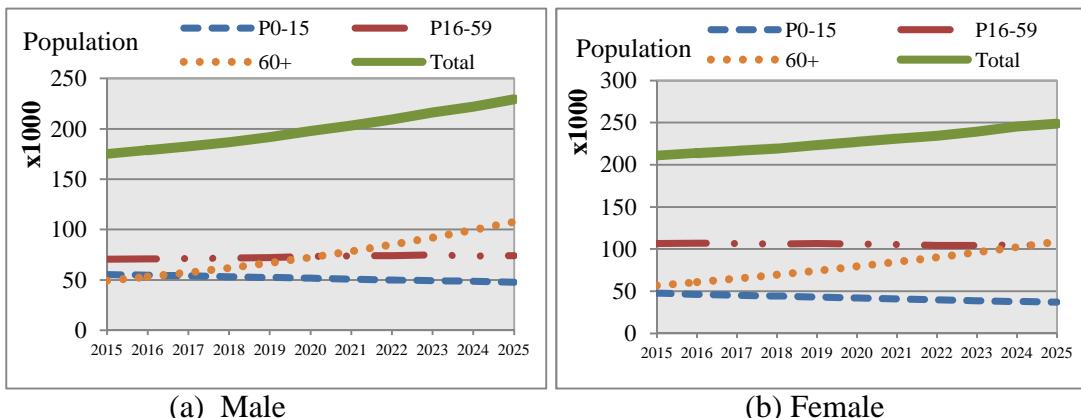


Figure 9 (a) Male and (b) Female Patient Hospital demand Predictions disaggregated by age

5. Resource Requirement

The analysis of the length of stay (LOS) and the number of hospital visits per year of each age and each gender groups are calculated from the OP/PP individual records database in 2012-2013. The proportions of number of hospital visits/year/person of each age groups are shown in figure 10 and the distributions of LOS are shown in figure 11. The average length of stay per time and the number of hospital visits per year per person are shown in table 7. Regarding to figure 10 and table 7, the results show that the older population are, the more population for hospital visits will be. Whereas figure 11 and table 7, the results show that the older population are, the long length of stay in hospitals will be.

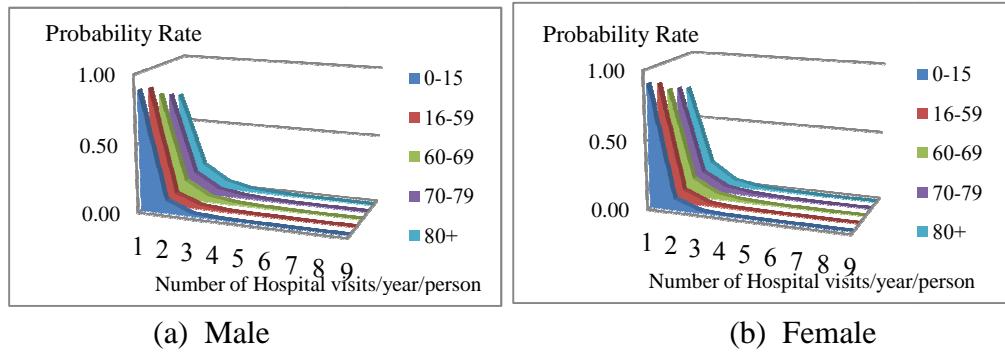


Figure 10 The proportion of Number of Hospital visits/year/person for each age and each gender

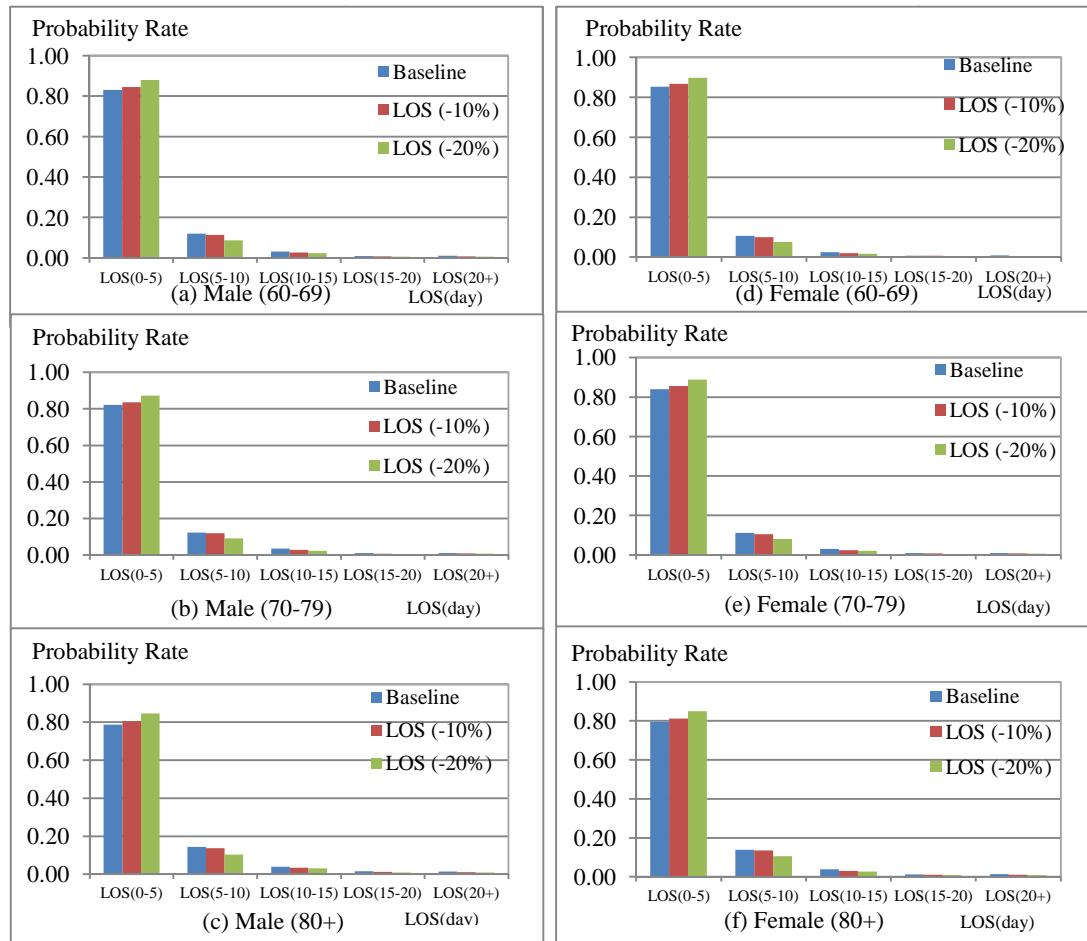


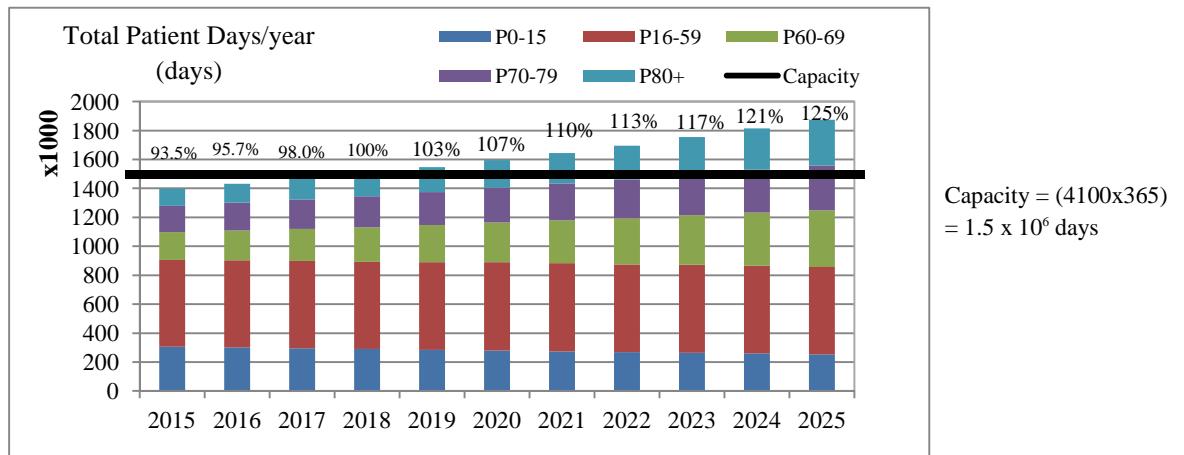
Figure 11 The proportion of LOS of elderly for each age groups and each gender of baseline (the past data), scenario 1 (LOS -10%) and scenario 2 (LOS -20%)

Table 7 Average Length of Stay per Time and Number of Hospital Visits per year

Ages	Length of Stay per Time		Number of Hospital Visits per year	
	Male	Female	Male	Female
0-15	3.063	2.915	1.159	1.135
16-59	3.840	3.103	1.218	1.185
60-69	4.490	4.046	1.349	1.329
70-79	4.944	4.396	1.421	1.372
80+	5.723	5.221	1.476	1.403

Table (7) shows the average length of stay and the number of hospital visits per year of the elderly group (age more than 60). The group of age more than 80 requires longer length of stay than other age groups.

The predicted demands in hospitals affect the need for beds, which are likely to increase, especially for the elderly age group, as shown in figures 12 and 13. The average bed occupancy rate in 2015 is 93.5 and it will be increased to 125% in 2025. These rates show that the number of beds cannot support all demands from 2019 to 2025.

*Figure 12 Bed Occupancy Rate and Total Patient Days/year from 2015 to 2025*

The sensitivity analysis of bed requirement compared to annual available beds is shown in figure 13. The results show that the decrease of length of stay has an impact to the decrease of bed requirement. Analyzing the past data of the length of stay (LOS), the current beds can support all demand until 2017. If the length of stay (LOS) of the elderly decreases 10% and 20% from the past data of LOS, the current beds can support all demands until 2019 and 2020 respectively. However, the decrease of length of stay of the elderly should not impact the elderly life. The development of medical technology to decrease length of stay in hospitals is very crucial. Moreover, the home care system should be developed to support the elderly, who are discharged from hospitals to rehabilitate at home as well.

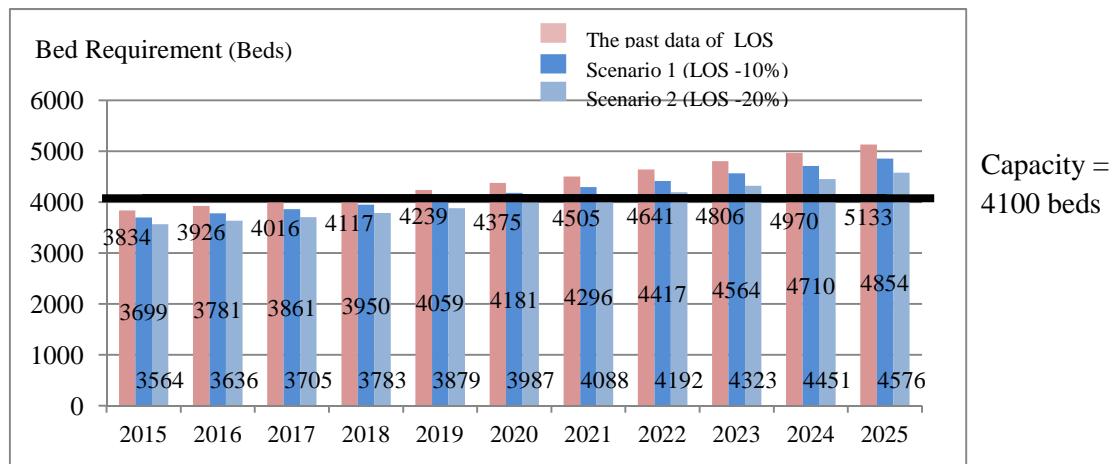


Figure 13 Number of beds requirement from 2015 to 2025 if the length of stay is decreased.

CONCLUSION AND DISCUSSION

This research shows the prediction of population to find demands for hospital services using Markov chain and to consider the migration of the population in the proposed model. The result shows that the elderly population tends to increase from 14.6% in 2015 to 22.6% in 2025. The average daily demand for beds is growing, especially for those used by the elderly. The decrease of length of stay of elderly has a significant impact to the decreasing of bed requirement. If the length of stay of elderly decrease from the past data of LOS 10% and 20%, the current available bed can support all demands until 2019 and 2020, respectively. The information from the predicted model can be used as preliminary data to study long-term care system in the future research.

This research has several limitations in terms of the data availability and the analysis of factors related to the services at the hospitals. In future study, to better reflect the real situation appropriately, the determining of transition probability between states should depend on time changes. In addition, the other factors related to demand services in hospitals should be considered such as type of diseases, patient service areas and other socio-economic factors.

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Strategic Communication in Shadow Negotiation toward Alliance Building in the Logistics Industry: The Case of the Land Transport Federation of Thailand

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ABSTRACT

The case reviews the overall background of an organization called The Land Transportation Federation of Thailand (“LTFT”). Founded in 1998 to consolidate the six powerful players of logistic service providers as the founders, its initial aims were to survive during great economic crisis facing the country during that time, and to fight collectively against corruption practices. LTFT had practiced the art of negotiation to increase their leverage and visibility among multi-stake-holders (particularly the government), playing the roles of watchdogs and game maker in the logistics industry.

In 2008, in anticipating the needs to strengthen the whole logistics industry, LTFT ignited the existing system by initiating moves to recruit more member organizations to join forces in pushing forward the establishment of Thailand Logistic Council (TLC). Fourteen more organizations were willing to work collaboratively towards becoming TLC as strategic alliances. This could not be accomplished without support from the Ministry of Transport and Communication. The concept of Quanxi -- the Chinese concept long practiced in Thailand, which emphasized the importance of social linkages and social obligations based on reciprocity in face saving and face giving, and the harmonious relationships -- was conscientiously put into practice.

With the 2016 approach of the ASEAN Economy Community, LTFT anticipated both opportunities and threats lying ahead. Two targeted groups of the logistics industry “Super Power Players” that LTFT had to learn to cooperate and negotiate with were the local Thai Super Powers and the foreign Super Powers. The case illustrates that business must be done within the framework of negotiated relationship. The case also illustrated other related factors -- i.e., power, time, information, etc. -- were critical to the success of the multi-partied negotiation, and demonstrated that LTFT leaders, in performing roles as negotiators, took into serious account.

Reflecting on what the Land Transport Federation of Thailand (“LTFT”) had accomplished since its inception in 1998, Yoo Chienyuenyongpongⁱ, the third and current chairman of the organization, had reason to be both pleased with, as well as concerned about, the progress that the LTFT had made in advancing the status of the logistics sector in the Thai economy. Among other achievements, he could point to the significantly increasing degree of organizational visibility from working collaboratively with the government and multi-stake-holders in strengthening the logistics industry of the country for continuous improvement that had gone some distance in resolving some of thorniest of the pre-LTFT problems that had afflicted the industry. However, with eyes on the

imminent arrival of the ASEAN Economic Community in January 2016, he also had reason to be somewhat concerned about whether the logistics sector in Thailand was fully prepared for the fierce challenges that increased inter-state competition was expected to bring. In particular, he was aware that much remained to be done in the areas of expanding the capability of the local logistics service providers, further developing human resources through strategic consolidation among key players, enhancing the multi-modal transport infrastructure, and ensuring that the future path of LTFT in becoming the Thailand Logistics Council (TLC) was in line with the overall strategic thrust of the industry of the country.

As had occurred in every other modern economy since the 20th century, logistics had come to be increasingly regarded as a critical factor of competitive advantage in South East Asian countries, including Thailand. Principal driving forces had been rapid globalization, greatly increased international trade, and the development of more regional economic alliances. In South East Asia, the imminent launching of the ASEAN Economic Community (“AEC”) portended a dramatic expansion in external trade among the ten member countries, thereby resulting in increased demand for more efficient and effective logistics services. In this connection, it was more than a little worrying to Chairman Yoo that despite Thailand’s strategic location in the centre of the ASEAN region, with a long coastal areas, deep-sea ports, and modern infrastructure, and despite logistics having been part of the national agenda since 2003, the Thai logistics industry had not yet achieved its goal to become the regional logistics hub of ASEAN.

Among the main challenging factors that had forestalled achievement of this goal had been the peculiar way in which the Thai logistics sector had evolved and developed. More specifically, logistics in Thailand had pursued its own “glocalized” ways for years amidst a highly fragmented industry with disparate local logistics service providers, operators and players under the context of the country’s shaky politics. Thus, despite the fact that Thailand had been attempting to strengthen its local logistics operators and amend the legislative framework to allow for greater facilitation of the logistics industry, the government had not yet achieved effective enactment of the national policies to push the industry forward, thereby rendering it incapable of becoming truly strategic to the country’s economic growth and development.

Indeed, the relative lack of a truly strategic focus for the industry had been the initial impetus for the formation of LTFT, which over the years had set about consolidating the key logistics and transportation associations in Thailand to coordinate and cooperate as strategic alliances in order to increase their collective leverage and their performance efficiency and effectiveness. The task had proved daunting -- in part because of the necessity of ongoing wide and far-ranging dialogues among all stakeholders (e.g., LTFT member organizations, the government, and others), and in part because of the lack of readiness on the part of a series of governmental regimes to engage in substantive dialogues with multi-stakeholders in the logistics industry. In addition, in pursuing its objectives of making the new system of logistics management more strategic, representative, inclusive, and participative, LTFT had had to negotiate both within its organization and across organizational boundaries in striving to reform the basic assumptions underlying the traditional logistics management paradigm and processes that had prevailed for many decades.

In these endeavors, the LTFT had found it prudent to employ as its primary *modus*

operandi the practice of “shadow negotiation” -- a process in which “negotiation happened both before and after the formal or actual negotiation started and ended,” with the aim of increasing the Federation’s visibility, legitimacy, and credibility of the Federation. These behind-the-scene maneuvers using power and interpersonal relationships had proved critical to the success of the organization to date.

Notwithstanding the enormous challenges that he perceived to lie ahead, Chairman Yoo had reason to be hopeful for LTFT and the future of the logistics sector in Thailand. Unprecedented reform in logistics management was well underway and even flourishing, due in no small measure to the concerted efforts of LTFT over the past decade. But, looking ahead to the launch of the AEC, Chairman wondered whether the continued application of the lessons learned from LTFT’s participative approaches to its strategic and tactical communication with multiple stakeholders would be sufficient to continue the advancement of the Thai logistics industry. He wondered, also, how LTFT could expeditiously make the transition to becoming the Thailand Logistics Council that he deemed to be absolutely crucial to ensuring that Thai logistics operators would be able to compete successfully in the upcoming era of the AEC.

In the Beginning: The Erstwhile “Old Boss” Traditional Paradigm of Managing and Running Logistics Businesses in Thailand

The fundamental logistics task of delivering the appropriate supplies -- in good condition, in the quantities required, and at the needed places and times -- was by no means a new or unknown endeavour in Thailand, as such systems, however rudimentary, had existed for centuries. However, prior to the emergence of the LTFT, the running and managing of the logistics industry in Thailand had long been a neglected area of business activity by the Thai government. In fact, not until the year 2003 was the Office of the National Economic and Social Development Board (“NESDB”) – the government’s principal development planning body -- even aware of the critical need to develop the local industry. It was only in that year that the NESDB, in identifying discrete business frameworks within this neglected sector, belatedly undertook to even designate particular types of logistics activities: 1) cargo transportation inside and outside the country, by road, rail, sea, and air; 2) cargo storage, warehousing, packaging, and cargo distribution 3) customs formalities; 4) other auxiliary logistics works; and, 5) postal and parcel services.

According to Thongyu Khongkanⁱⁱ, Managing Director of T.K. Logistics and Supply Chain (Thailand) Co., Ltd., former-President to Imports-Exports Transport Association, Vice President of Thai Logistics Services Provider Federation, and Consultant to the LTFT, most of the goods and product manufacturers had long been located in the vicinity of Bangkok, with the product retailers located in the old Chinese trade areas in central Bangkok near the Sumpeng, Baube, Pratunam districts, and with about 400 logistics and transport service operators situated in congested areas in and around Bangkok’s Budhamonton district. In these discrete locations, there were close business ties among the “Cho-Huay” (i.e., traditional vendors of goods, food, products and basic items) and the local “traditional” transport service providers, who performed the “typical Thai” logistics services in goods distribution throughout the Kingdom. According to company registration statistics, more than 70% of Thai logistics businesses were small and medium enterprises (SME) with less than THB 5 million capital. Each day, approximately 500 trucks containing commodity goods and products, or 250,000 cartons, operated to deliver services throughout the country. According to Thongyu, from the earliest days of the

logistics sector, a whole range of transport and distribution-related activities in Thailand were usually improvised at the local level, with the locally organized actions reflecting the “domesticated ways of doing things around here”ⁱⁱⁱ and were widely considered – even today -- as the most effective and appropriate.

The initial paradigm of the logistics business embraced some misconceptions on the part of local logistics service providers. Then, as now, the majority of the local service providers still perceived and equated the concept of logistics with the narrow notion of transportation. This reflected the early concept of logistics management as focused merely on the management of transportation and warehouse, as opposed to the later, broader conceptualization of logistics as being concerned with *both* the flow of goods and the coordination of non-material activities necessary for the fulfilment of the service in a cost-effective manner. Thongyu elaborated on the notion of logistics that predominated prior to the formation of the LTFT.

In the past and even up till now, some logistics service providers have not been fully aware of the advantages of having an effective distribution system and thus had not given adequate priority to the development of effective distribution strategies. These “tao-kae” (or senior owners of the logistics services) were used to operat[ing] things manually. Pricing [concerning] the service provision was not standardized. All planning and anticipation for effective implementation of logistics services were mostly based on their “intuitive knowledge and experiential learning” of the operating environment, including technical, physical, geological, and political aspects. Several weaknesses need to be remedied.

The sector was characterized as deficient in basic data and technical information, capital investment, and manpower – each of which was in dire need of remediation. A case in point mentioned by Thongyu: The widespread neglect of monitoring and measuring *lead time* – i.e., the interim time between when new stock was ordered and when it was received and available for use. In theory, when logistics managers evaluated how well a logistics system was meeting its goals, they measured the lead time and tried to reduce it accordingly. Goods should be available to customers at the right time, even before the customer asks for the product. Nevertheless, in practice, the measure of lead time was not being effectively performed among logistics service providers.

Dr. Suratin Tunyaplin^{iv} of the Academic Committee of LTFT, and Vice President of Thai Transportation and Logistics Association (TTLA), as well as Managing Director of Suwanpisan 2010 Co., Ltd., stated that historically Thai logistics had been labour intensive. Compared to the neighbouring countries like Malaysia and Singapore whose logistics systems were more knowledge-based and technology-driven, most of the Thai logistics operators had been still traditionalists in management styles, with a narrow focus on sufficiency of internal cash flow and financial survival as the prime business concerns. These organizations lacked a leading-edge technical and technological platform, although their institutionalized practices for acquiring, integrating, and applying codified knowledge came from their experiential learning and intuitive knowledge, which, to date, had proved to work well in Thailand. However, there were definite drawbacks to this approach, as Dr. Suratin explained:

It is very difficult [for these traditionalist logistics firms] to [determine]

the[ir] actual cost since there exists a great deal of hidden costs [in] doing business in traditional ways, for example, common costs, fixed costs, variable costs, plus other intangible costs. The logistics business owners focus primarily on tangible costs [incurred], without paying serious attention to the concept of true value creation.

Expanding further on “the old boss” style of running business, Dr. Suratin asserted that the previous generation of the management of these logistics service providers, mostly the baby-boomers generation, were very industrious. They had learnt the logistics business the hard way, through the trial-and-error approach, with “pricing,” for example, as the mere key indicator of managing the business and customer satisfaction. Since “the pricing factor” became the key performance index for business survival, other indicators were not taken into serious consideration. “Rough Accounting”, for example, seemed to be sufficient for doing business. At least in part, this is how the practice of price cutting among competitors came to be a common practice. The thinking was that if the job could be gained, the cash flow could continue without interruption, and “*benefits of cutting the pie*” among other local competitors was not seriously harmed, the logistics sector as a whole could marginally survive. The calculation of actual net profits would be close to impossible to measure at the end of the day. Without ability to calculate the fixed, variable, and other costs of doing business using modern knowledge of management, opting out of the business seemed to be the only option left. Dr. Suratin stated that:

I am the second generation to my family logistics business. When I was young, I saw my mom using abacus [to] calculate[e] all the accounting of our company. She woke up at 5 o'clock in the morning and went to sleep at midnight. [By] keeping only pricing in mind, and overlooking other non-price issues, it was real difficult to make the management strategic and gain profits in this industry. It is difficult to teach them to stay current. [But] introduction of the computerized system into the business function of the traditional company is not easy. When my mom starts to operate things via computer, gap[s] happen. Innovation sometimes could lead to bad results. Because she could not fully understand how the whole computer system operates technically, some financial losses began [to emerge].

Low entry barriers to entrants to the logistics industry was another key factor explaining why it was hard for the “traditional” individual owners of the logistics business to remain economically viable and financially healthy in the business as it existed at the time that LTFT was formed. Dr. Suratin summarized the situation as follows:

Newcomers [have] continuously come into the business and play[ed] the price-cutting game. It is rather challenging [to] change the existing situation and to upgrade and uplift the whole system to be more value creation-oriented.

Thus, as implied by Dr. Suratin’s observations, attempts to strategically educate the majority of the existing local logistics operators about the need to incorporate the cornerstones of modern logistics management into their daily operations and performances were not easily achieved.

Prior to the Inception of the Federation: The Daunting Tasks of Building the Negotiated Relationship among the “Big Six”

The traditional Thai logistics sector might well have survived and continued in its well-established ways had not the so-called “Tom Yam Khung” financial crisis struck in 1997. It was the monumental challenges that were precipitated by the severe economic turmoil that accompanied that crisis, and the steps needed to cope with it, that began to usher out the old ways of running logistics businesses and bring forth a new paradigm.

More specifically, largely out “business survival” necessities, entities engaged in the logistics business were forced to grapple with the fact that “business as usual” was no longer a viable way to ensure survival in an industry that was being severely buffeted by the most severe economic downturn in Thailand’s recent history. For example, in pre-crisis times when business conditions had been fairly robust, price-cutting behavior was a widely accepted way of doing business and remaining a reasonably viable, if low-profit, player in the logistics sector. In those days, the “pie” was not “fixed”; and, a firm could employ price-cutting to ensure itself at least a small slice, enough to survive. However, the virtually unprecedented economic problems brought on by the financial meltdown that accompanied the Tom Yam Kung crisis changed all that. With government at the time providing no strategic direction to the logistics industry, and as demand for transportation sharply declined in the face of an excess of supply of logistics, the erstwhile rough equilibrium between demand and supply was completely ruptured. This led to unprecedently fierce competition among local logistics providers.

The situation gravitated to a stalemate, with no one player able to truly win the game. An adversarial attitude in doing business emerged. Hostility arose, with some players turning against one another. In the worst cases, friends turned into enemies. Violence and the abusive forms of power were manifested. The traditional symbiotic relationship among local logistics service providers started to erode.

Aggravating the situation was the impact that ongoing and ever more aggressive price-cutting began to have on logistics companies’ subsequent operating behaviors. More specifically, with prices fiercely cut to the point of barely covering operating costs, some logistics service providers saw no way out but to resort to “*hard-ball*” tactics. Adding some “extra” amount of volume of products or goods to each round of transportation was one such option. A major consequence of this tactic was increased damage to the surface of the road – with the predictable fallout that society at large soon began placing the blame on trucks and the logistics and transportation sector as “major culprits”. The result was something of a vicious cycle – with infrastructural impediments to effective logistics soon triggering normative, albeit illegal, practices of “paying and receiving under-the-table money” among the business owners and the police patrol officers, i.e., the paying of extortion money.

As the situation continued to deteriorate, it dawned on a number of players in the industry that with the supply-demand equation having been thrown completely out of balance, the firms faced the prospect of having to engage in such severe price-cutting behaviors that their collective survival would soon be in jeopardy. Hence, it became clear that the only real hope lay in industry consolidation, absent which the vast majority of players faced the prospect of eventually having to cease operations. Thus it was that the notions of forming strategic alliances and consolidating the industry for purposes of inter-

organizational coordination and integration came to be viewed as the most promising avenues for short- and longer-term survival.

Initially, explained Chairman Yoo, the objective of consolidation among organizations in the logistics industry was “to survive economically, socially, politically, and ethically.” The thinking was, he explained, that as a coalition of industry players joining forces behind a mutual or common interest, their effectiveness and efficiency as an economic sector and perhaps as individual companies would be greatly enhanced. Recalling the epiphany that would eventually lead to the formation of the LTFT, Chairman Yoo continued:

Consolidation was the only option . . . thought of. We consolidated to increase our leverage and visibility. We [sought] strategic directions from the government. We consolidated since we are living in the world where building and maintaining partnership in the logistics industry becomes essential. Back to 1998, we did not even know the exact meaning of the term “Federation,” we just [knew] that we must be ready to consolidate. We first thought about the term “Union,” but we were managers, not labourers. Therefore we came to agree on the use of the term “Federation”.

Recognizing that the planned undertaking would necessarily require the use of manipulative and political activities through lobbying and informal talks prior coming to the negotiating table, Chairman Yoo and his reform-minded allies who would later became the Federation’s founders had begun to focus on two main enabling tasks: 1) the selection of the organization members; and 2) the selection of the leader of the Federation. The criticality of the first question involved the notion of “getting access to the right person”. The next question was about leader selection, which necessarily entailed assessments of which person(s) were most central in the trust and respect network. Chairman Yoo put it this way:

We must select the one who is perceived as charismatic and ethical [and] with intense integrity. Apart from having solid social linkages, he must be committed to the growth of the Federation, and to the country as a whole. [Someone] who has no hidden agenda, and . . . who dares to challenge authorities. We must work side by side to induce some changes to happen.

The process of surfacing answers to these two questions and thereby getting the Federation under way was both structured and iterative. First, a May 21st, 1998 meeting at a Bangkok hotel was convened with “the key players in logistics industry” of the country at that time, with ten senior people (representing the North, North Eastern, and Bangkok and environs). There followed several subsequent monthly meetings at which discussions concerning the possibilities for consolidation continued to be discussed. According to the Chairman Yoo, making contact with the powerful players and making them fully understand the benefits of collaboration on the joint problems facing the business was quite challenging. Different regions presented different types and facets of the problems besetting the logistics industry. For example, about 90% of the logistics industry of the Central region dealt with transportation of goods and commodities, whereas for the North, the logistics and transportation dealt with agricultural products, rice, coal, and construction items; and, the North Eastern dealt with paddy rice and processed agricultural products like

sugar. In actuality, the common problems facing all regions were multi-dimensional. In particular, the extorting of money because of the extra-weight problem that, in turn, had been precipitated by cut-throat pricing among local logistics players was having a severe impact on the industry, given the then economic crisis of the country.

The concept of Quanxi, the Chinese term connoting the building of social linkages based on personal relationships, was brought into practice from the outset, reflecting the importance of the interplay between negotiation and relationship toward collaborative advantage. Speaking on the importance of realizing the power of the patronage system that existed in Thai culture, Chairman Yoo pointed out that power came from social connection. Matters of “whom do you know” and “how to treat them right” were critical to the success of any talks. Moreover, addressing the underlying interests of all parties was critical. Establishing early on what each member could and would contribute in terms of capital and resources was also a lesson learnt in forming successful alliance. Chairman Yoo elaborated on how these concepts were brought to bear on the process of gaining commitment to the formation of the Federation.

What we did was talk, talk, and talk. You must treat the senior people right. Talking in the form of asking for advice from them, rather than exercising your power and not listening, is a wise thing to do in dealing with the powerful players. Learn[ing] to soliciting ideas [from] all parties . . . was important, especially when we have to deal with critical issues, for instance, extorting money, and the future of our Federation. Common incentives and benefits of coming together must be probed and clearly made. Of course, limitation and constraints of coming [together] as [an] alliance must also be discussed.

After several rounds of discussion and debates, “The Big Six” organizations came to a decision to form a strategic coalition with which to found the Federation. They were the Association of Thai Transportation, the Association of Trucks at Nakorn Pathom, the Association of Bus of Thailand, the Association of Fishery at Samut Songkram, the Northern Club of Logistics and Transportation Operators, and the North-Eastern Club of Logistics and Transportation Operators. Chatchaval Pochananupark, the President to the Association of Thai Transportation was nominated as the first chairman of LTFT within that same year. The newly-formed entity called for initiatives in organizational and technical adjustments needed in the organization and for pursuit of the integration of the whole logistics industry, laws enforcement in support of industry, and infrastructure investments and distributive-justice competition policy of the country. These would be judged on the ability of the organizational policies to create impacts and maintain the conditions for organizational unity and progress in the integration of national logistics management. Visibility of the legitimacy of the Federation started to emerge as the Federation, at its very outset, began to introduce their existence to several government bodies. Concerning the criticality and efficacy of these early actions, Chairman Yoo explained:

We got to plant the seeds of ideas early in the mind of both our members and our multi-stakeholders. They [had to] know that we [were] serious about our moves in becoming a Federation. It [was] important that we . . . learn that capitalizing on business opportunities during economic crisis through alliances could enable us LTFT to pursue risks and rewards of mutually compatible goals that would be difficult to achieve alone.

Within the 1998 year of its founding, LTFT succeeded in forming from among powerful associations with shared needs the first truly nationwide voice of the Thai logistics industry. The Chairman wrapped up the description of a major enabling factor in the Federation's success in one pithy sentence: "*To solve our problems we all need[ed] to learn the art of negotiated compromise.*"

Internal Challenges of Power Balancing: Treating LTFT as Community towards "Unified Diversity"

Remembering the highlights of LTFT's evolution and development during his administration, Chairman recalled that it took a decade for him to come into his prime position at LTFT after performing as the First-Secretary to the Federation during the early formation period. Under his strategic leadership, the number of member organizations increased greatly. From the initial six associations, membership expanded to 11 associations^v—11 separate networks, with each association comprised of 200 individual small and medium enterprises, merged into one spirit under the umbrella of LTFT. Chairman Yoo stated that it was absolutely essential for the management to visualize and understand the myriad of relationships that can either facilitate or impede the path of the Federation. LTFT looked for ways to demonstrate its desire to collaborate by coming to the table with a sincere intent to build an internal relationship among Federation members and determine common interests among parties. In Chairman Yoo's words, "*We truly appreciate[d] the power of coalitions because we could ultimately achieve far more by integrating our resources and dividing the effort behind a common cause*".

Toward this "common cause", LTFT tried to keep their members informed of the multi-dimensionality of the problems facing the Federation and the transport sector as a whole. The high costs, high expenses, but low margins of logistics business operation had to be understood. They must be made fully aware of complicated problems facing the organization that were caused by the volatile environment, infrastructural constraints, and an unstable political climate characterized by high degrees of corruption and extortion. With the Federation's vision, mission, goals and objectives kept intact, LTFT had strived to increase its leverage, reduce logistics costs for the whole system, vigorously promote anti-corruption policy and practices, and collectively fight against the problems of extorting money.

Importantly, LTFT attempted to allocate shared benefits based on equity and fairness. Under the decentralization policy, LTFT both strategically and tactically encouraged all parties to invest substantial amounts of time at the executive level to build the relationship. Tactically, each member organization was encouraged to perform their roles and responsibilities as change agents for the development of logistics sectors locally. That is, all local member organizations were challenged to promote their local ties via building local networks in order to enable them to stand impossibly in enhancing the logistics sector in their own regions^{vi}.

Strategically, the major critical and substantial issues facing the collective destiny of all members were directly supervised and handled by the Federation. A strong relationship at the senior level continued to benefit the Federation's alliance through the

subsequent activities of co-designing and co-creating the structure and process of LTFT. Chairman Yoo stated that:

Within [the first decade of our founding], we . . . witnessed a decentralization power being practiced herein LTFT. Our Federation motto was about the policy of decentralization of power. In each region of Thailand, we have encouraged each member to form strong associations and to be outstanding in their regions, either the north, the north-eastern, the Central, and most recently, the South. But when we operate together under the umbrella of LTFT, we must trust each other, respect each other.

According to Dr. Suratin, in attempts to bolster organizational performance and balance power among members in carrying out the Federation's missions, LTFT designed its coordinating structure by dividing its organizational functions into two major divisions: Administrative Management and Academic Affairs. The former comprised the powerful and influential organizations whose "baby boomer" owners have long-established and solid power bases in the country, whereas the latter were composed of the younger generation, mostly Generation X, who were well educated and hence performed as "academicians" to LTFT. In their capacity as the "New Age" leadership cadre, the Academic Affairs division provided strategic education to all LTFT member organizations in coming together to grapple with the complex problems facing the logistics industry as a whole.

Recognizing, managing, and balancing power among members was of cardinal concern throughout Chairman Yoo's administration. He spoke of the overarching importance of LTFT's human assets and the importance of informal talks based on personal connections:

Expertise on the part of all members, and its ramifications must be recognized, including the knowledge of the industry and how to deal with the powerful governments and how the legislature works. How to effectively leverage collective expertise proves to be essential. Highly powerful versus highly expert people must be utilized appropriately. The powerful ones must use their power when needed, whereas the expert ones must be ready to use their knowledge in educating others. The greatest assets of LTFT were human.

Agreed-upon methods for communicating, conflict- and disagreement-handling, and making decisions were then treated as critical in relationship building, particularly when conflicts arose and emotions were high. Despite the fact that LTFT had deliberately established ground rules for interacting with other members early in the relationships before and after the consolidation began, tensions and dissension sometimes arose. Often times, stated Chairman Yoo, conflicts were better *prevented than resolved*:

[From time to time], the threat of pulling out . . . lingered in the background. This was due to the fact that some member organizations [were] very interested in influencing and controlling the joint agenda; and for some major issues, some [were] reluctant to commit resources to them. We . . . try to promote no conflict of interests among members.

Moreover, there were times when a particular relationship could also be severed by

the negotiation process. Chairman Yoo mentioned that negotiation could impact relationship and vice versa. To balance the dual concerns of relationship and substantive outcomes was a must:

Two or more of our member organizations can be in deep dissent on some particular issues. But because of our informal relationship and bonds, we can learn to agree to disagree. On some important issues that affect every party, we know that it is much more powerful to speak in a truly unified voice via LTFT.

With so many constituent organization comprising the Federation, “partnership fatigue” could also become a real issue. Many member organizations were involved in multiple alliances. With the ever-increasing numbers of partnerships and interagency initiatives appearing in the various localities, some member organizations were attending meetings of several collaborative schemes on a more or less regular basis. Subsequently, interpersonal conflicts could be more easily triggered when the involved parties were physically exhausted and/or emotionally drained. Thus the chairman, emphasizing the necessity of continuous effort toward building mutual understanding and developing trust, declared that *“our relationship[s] could be shattered if we don’t learn to nurture our members with good communication and cushion them against the knocks of any conflicts.”*

One of the recurring conflicts and disagreements emerged from the issues of rights and power based on the issue of legitimacy of the Federation. Because the Federation was established without being legally registered as an organization, the organization could not claim legitimization as a juristic person endorsed by Thai law. Some LTFT member organizations voiced discontentment and had sought to rush Chairman Yoo and LTFT’s committee to pursue registration with Ministry of Commerce. However, as Chairman Yoo explained, there were sound reasons behind the decision not to register the organization.

Firstly, in the event that the Federation wanted to enter into any legal business transactions or contracts, the Federation would do it under the name of the particular member organization whose management sat at LTFT as the Federation committee. Secondly, even with such status as unregistered organization, LTFT already existed as a legitimate entity in the eyes of the government and other multi-stakeholders due to its performance and power to push things “behind the scenes”. Thirdly, Chairman Yoo had long anticipated that if legally registered, in face of any conflicts that might emerge between organization members, some organization members, especially the newcomers joining the Federation, might decide to pursue the litigation against one another. This was something Chairman Yoo did not want to see happen, as it could possibly lead to disruption, even dissolution, of the Federation. Summarizing his reasons for not registering LTFT, the chairman allowed that:

Conflict is natural but trust is fragile. The common wisdom is that trust is a precondition for successful collaboration. We then strive for wise agreement among members. Honesty, fairness and benefits to all parties based on trust and harmonious relationship among members is important. Benefits to the country and especially to the overall logistics industry [are] important. We won’t succumb to conflicts or collaborative inertia [just because] we haven’t gone through the registration process. It is easy to register. [W]hat is harder and more important is the strength of trust and

“esprit de corps” among members. Formalization and being too formal could destroy LTFT.

Despite occasional conflicts, there were some valuable trade-offs gained. Members recognized that more substantial benefits were derived from the formation of a strategic alliance under LTFT's roof. In Thongyoo's opinion, since its inception, each chairman of LTFT had worked industriously in pushing forward the vision and missions of the Federation. Based on the LTFT Cooperation Framework, most of the members accepted that they had worked with a commitment to work in the interest of the Federation. To register or not – this was not the real issue at the present time. The government had already started to attentively listen to the unified voice of LTFT.

One of the “tangible” Federation’s achievements concerned the government’s reversal of its initial decision in 2013 to reduce the transportation tax from its initially announced rate, thanks to the continuity of LTFT’s massive lobbying push both, *at the table and off the table*. Of this accomplishment, Chairman Yoo stated:

We have so many successful cases in our pursuit of some important issues. For instance, five years ago the government [wanted] to increase the tax imposition on transportation at the rate of 3%. After LTFT attempted to push hard through negotiation and back-door liaison, the rate was just recently announced to be imposed at 1%. I could say, during my presidency, the total logistics costs of our member dropped about 10%.

While focusing on the joint “voluntary” operating agreement and ability to stay committed to the mission of LTFT, the Federation had provided its members access to new opportunities, new markets, capabilities, knowledge, and capital, along with the ability to share development and operation costs. Frequent formal and informal acts of communication among member organizations were regularly promoted through meetings, newsletters, telephone calls, or various activities. Thonyoo asserted, *“We promote the constructive abrasion among members. We must talk over several issues, especially business benefits. [There] should be no more price cut[ting] among us”*.

Concerning the benefits of joining LTFT, Sirapop Phichairattanaphong^{vii}, a member of the committee of the Professional Crane Association, and also a member of the LTFT committee, asserted, *“It is beneficial [to form] alliance with LTFT. Not only [do] we learn new knowledge, but the most important thing I learn from LTFT is about how to strategically and tactically deal with the government”*.

In the case of negotiation, which was normal to emerge politically, member organizations of LTFT would oftentimes bow to the relationship and forgo their negotiating positions. The LTFT philosophy emphasized an organizational model that was flatter, more flexible, team-oriented, and more reliant on knowledge assets drawn from each member. Along with having more organic and network-like structures came a need for the Federation to understand these structures and learn how to manage them technically and relationally. In Chairman Yoo’s words, *“Any glory is in that fact that we [have] . . . served our members well. Open lines of Communication and good climate is the key to our existence”*.

There were many more challenges awaiting LTFT, e.g., bolstering the ability to

promote understanding and dialogues within and among their member organizations and across the organization. However, the big thing awaiting LTFT was to be the spearhead in pressuring the government -- while simultaneously maintaining “back-door talks” -- in paving the path towards the establishment of a Thailand Logistics Council.

On the Path toward the Establishment of the Thailand Logistics Council: The True Challenge

One of the superordinate goals within the LTFT mission involved attempts to establish a Thailand Logistics Council to help overcome the erstwhile narrow view of logistics as a “supportive industry,” rather than as a critical factor of competitive advantage and a strategic industry in its own right. That logistics had grown to become a top revenue generator could be seen in statistics cited by Thongyoo, who pointed out that logistics was third only to tourism and the industrial sector in revenue generation, at 800,000 million baht, 2 million million baht, and 1.7 million millions, respectively. Within the LTFT, there had been an increasing conviction that the logistics sector should have been more promoted as an important growth sector of the country, as it had been in neighbouring countries like Singapore.

In fact, countries such as Malaysia and Australia had already launched national logistics councils to strengthen and promote their logistics services. Thongyoo cited the case of the Malaysia Logistics Council (MLC) that was established to provide leadership for the overall coordination of strategies, policies, regulations, and rules associated with the development of the industry. Looking back at Thailand, Thongyoo had identified the fragmented development of the logistics industry as the cause of various problems facing the industry. A particularly big problem was the fact there was no central organizational entity like a logistics council to strategically and holistically manage and coordinate the sector in Thailand. Thongyoo stated that:

Logistics coordination should take place within the national framework. Where possible, there should be a single logistics organization working as coordinator, heading working groups and its steering committee. This organization should draw on technical and advisory resources from both members and other logistics organizations, while also motivate[ing] the government and policymakers to strengthen law enforcement mechanisms in favour of the whole industry.

LTFT had then resolved to strive to move towards the launch of the Thailand Logistic Council (TLC) to enhance the positioning of the logistics sector as a whole and to increase leverage among LTFT member organizations, both existing and future ones. Various priority issues were widely discussed among LTFT members concerning such establishment. According to Chairman Yoo, LTFT, under the name of TTLA, one of the key constituent LTFT organizations, submitted the proposal, “Thailand Blueprint on Strategic Planning Scheme for the Logistics Development 2013-2016,” and the establishment of TLC to the government in 2012. Simultaneously, LTFT began working as joint committee with the Ministry of Transport in drafting the vision, mission, goals and objectives of the new TLC.

Pointing out that rapid growth in close cooperative relationships across

organizational boundaries had become increasingly evident in today's world, Chairman Yoo, at the outset of the TLC, envisioned the building of a strategic partnership with the private sector which would create a platform for private- and public-sector agencies to work together in addressing challenges facing the industry amidst increased regional and global competition. With such a partnership, the logistics industry's impact on Thailand would be more considerable, more timely, more efficient and more administratively collaborative.

In terms of task force selection, fourteen names of the LTFT constituent organizations were identified by the Chairman Yoo as LTFT's strategic alliances in joining forces to establish TLC. The list included Thailand Shipping Council, Thai National Shipper's Council, The Thai Airfreight Forwarders Association (TAFA), Thai Freight-Forwarder Association (TIFFA), The Industrial Council of Thailand, Thai Council of Chamber of Commerce, Association of Port Operators, TTLA, Thai Logistics Federation, The Business Association of Air Transportation, Association of Ship Owners and Ship Representatives, Association of Transport Truck throughout Thailand, Association of Thai Actuary, and Warehouses.

Each party was recognized with dignity and respect. With the practice of appreciative moves, LTFT focused upon the importance of collaborative alliances and partnerships towards the future possibility of becoming TLC. This was key to increase LTFT's leverage in the eyes of other relevant multi-stakeholders. Chairman Yoo stated that:

We perform as [a] gateway to the building of strategic alliance[s] with these key organizations towards the establishment of TLC in the not-too-distant future, hopefully. Our members include the leading industry figures, academics, and technocrats whose expertise combined to contribute to the development of logistics sector of the country. It was a real challenge to work with multi-stakeholders which come with diverse interests. This has proved to be [an] indicator of organizational performance. Our leverage as LTFT then increases.

This leverage acquisition was critical, particularly in dealing with the government which, according to Thongyoo, still perceived logistic operators as having the "Old Boss Styles of Management". Hence, the establishment of TLC would promote the credibility of the logistics sector through the enhancement of logistics operators' professionalism, operational efficiency, and good business practices in compliance with international standards, codes of conducts and ethics. Of the challenges facing TLC and the emerging popularity of Public Private Partnerships (PPP), Thongyoo offered that:

"The real challenges of TLC are dualistic in nature. First and foremost, it involves the fact that TLC must deal with the government, . . . which in some cases are watchdogs, and they are still the game makers in others. They might not want to shift the power dynamics if TLC becomes stronger in the future. Second, we must work with multi-stakeholders. In the future, market access will be determined by stricter regulations, and business relations are likely to be based more firmly on contracts, rather than dependent upon personal contacts as previously prevail[ed]. The form of Public Private Partnership (PPP) and MOU-driven relationships among

parties would be more practiced”.

Skills at inventing options could be one of LTFT's strengths and useful assets. Both Chairman Yoo and Thongyoo shared common perspectives towards the relative role of TLC in proposing and creating “better” options for the country. It should learn to work and “negotiate smart” with the government, as well as apply pressure by “putting a price on the status quo” if the government were to become reluctant to approve implementation of projects that would benefit the logistics industry – e.g., relaxing law enforcement in ways that could reduce the logistics costs significantly without jeopardizing public safety.

One major option under consideration by the LTFT concerned the use of Public-Private Participation (PPP) tools to develop more infrastructure projects. The idea was that TLC would take a lead in promoting a detailed understanding of the vulnerability of the country's logistics infrastructure among all stakeholders, especially the national authorities. Development initiatives in the transport and related sectors would be designed to protect and enhance logistics capabilities, and in any event would not contribute to increased vulnerability of transport infrastructure. Another mega-plan involved the push for the creation of new transport corridors called “Logistics Parks” throughout Thailand, especially in major cities and provinces. Thongyoo stated that these logistics parks would be designed to facilitate and support export and import activities, as well as perform as distribution parks for goods and products, and of course as service parks or rest areas for trucks and containers.

The need for such facilities was well established since, as Thongyoo explained, “. . . we don't have rest areas for trucks and containers, today they have used gas station as their rest areas”. Further, chimed in Songpol Malanon^{viii}, Human Resources & Administration Manager of LTFT constituent member TIFFA ICD Co., Ltd., “We have problem in both geographical and physical locations of warehouses. The sites had been inappropriately designed for transportation. Every day we have witnessed the traffic congestions in the Depot domains. This affects our operation[s]”.

Additionally, Chairman Yoo, explaining that LTFT planned to work with its strategic partners to facilitate the development of these needed facilities, stated:

We would work closely together in order to shape these new transport corridors, i.e., identify future transport corridors, seek ways to build up required infrastructures, proactively contribute to the establishment and develop the systems of products and services which are optimized for transportation activities taking place in these corridor.

Moreover, emphasized the chairman, learning to consolidate properly and to make the best use of the existing resources were essential. TLC would be wise to learn from their member counterparts' experiences -- for example, Thailand Industrial Council and their successes in the consolidation process, in securing more budget allocation from the government (at the rate of 20% subsidized once become a Council), and in launching 47 industrial zones around Thailand. Chairman added that: “On becoming TLC, we must learn from them. The logistics sector should be prepared to see more consolidation in [the] road transport sector that will benefit [us all in tapping] hidden market opportunities”

Dr. Suratin acknowledged several impediments to the establishment of TLC: the

problems with information technology (IT), technology systems, and the lack of sophisticated management techniques among the logistics service operators. Information was the engine that drove the logistics cycles; without information, the logistics system would not run smoothly. Normatively, managers would gather information about each activity in the system and analyse that information to make decisions and coordinate future actions. However, in reality, a number of logistics operators in Thailand offered simple and “low-tech” logistics services and low-tech logistics solutions to customers. Although the service fees were relatively inexpensive, serving the local market niches was thought to be only marginally profitable.

Suratin averred that to bring the logistic industry of the country upfront, it was important to make logistics service operators aware of sophisticated logistics management. In strengthening integration and linkages among the transport and logistics networks to disseminate efficient logistics development and practices, the future establishment of e-logistics would be crucial. Dr. Suratin continued:

The market for logistics services in Thailand has long been somewhat fragmented, [mostly] lacking in transparency and [filled with] inefficiency . . . Online platforms may be an option to better coordinate logistics services. These platforms include relevant information about logistics service providers in the market. An online platform which integrates comprehensive information would facilitate the rapid identification of optimal providers for required services.

From the outset, TLC also had resolved that conflict management would be a policy priority. It would aim to perform as conflict mediator to provide alternative dispute resolution to the conflicting parties. However, there was a danger in entering conflict management or negotiations before all concerned parties agreed in both principle and practice, and committed to achieve the common interests of becoming TLC.

Thongyoo stated that modern logisticians not only need to create logistics management information system, but that other activities help drive or support the well-functioning logistics systems -- including organization, budget, supervision, monitoring and evaluation, and staffing. LTFT also took the lead in accentuating the critical shortage of labour, especially the lack of trained and skilled manpower serving the logistics sector. He stated that:

We must become fully aware of this labour shortage. Why [do] we face this shortage? Because of low wages. Because the society [sees] them, the truck drivers, as culprits who cause bad conditions of the road surface in Thailand, . . . [so] they switch to do other jobs available to them. LTFT then must learn to cooperate and negotiate with the government bodies. We the logistics industry need more [than] 600,000 labourers to serve us. We must negotiate with the Ministry of Labour in training and upgrading our skilled labours working in the logistics industry. We must talk with the Ministry of Education in launching the vocational curriculum to answer our calls [concerning] labour issues. We must take a lead in collective bargaining with the government in increasing [the] minimum wage . . . for these blue-collar workers. What we need is the development of professionalism for upgrading their skills. We must negotiate with the

government to acknowledge our crisis.

Beginning in 2008, LTFT had begun chairing the regular meetings and keeping the communication lines open among 14 selected partners in the advancement of TLC's future. Although the allies agreed on the missions of TLC, which laid out the essential elements of tasks of stabilizing and rebuilding the logistics sector of the country, they had differed on how to accomplish it in practice. Most of the committee of LTFT were of the view that efforts to stabilize Thailand's logistics sector would require a long-term commitment from all allies. Integration and collaboration had to be promoted, instead of so-called arm's-length agreement among members. The virtues of close ties and close cooperative relationships among key members had to be maintained. Truly, there were many challenges facing LTFT in championing the launch of TLC. Overshadowing all was the approaching operationalization of the ASEAN Economic Community in 2016 – an event that portended both opportunities and threats for logistics service operators in Thailand.

Towards the Opening Up of the Association of South East Asian Nations Economic Community (AEC): The Collision between Opportunities and Threats

As he continued reminiscing about the highlights of LTFT's developmental history and accomplishments to date, Chairman Yoo was very much aware that the year 2016 would mark a major watershed for LTFT, as it was to be the year in which an operationalized ASEAN Economic Community (AEC) would embark upon the priority effort to enhance the integration of the Community's logistics service sector. Built upon the ASEAN existing frameworks, specific measures and timelines for integration and liberalization of the logistics sector had already been outlined in the *Roadmap for Integration of the Logistics Sector* – including issues related to trade and custom facilitation, expansion of the capability of logistics service providers within the region, human resources development, and enhancement of multi-modal transport infrastructure investment.

Moreover, according to Chinachart Vatanasuchart^{ix}, law specialist at Tilleke& Gibbins International Ltd., in Thailand, domestic transportation and other services businesses had been among the activities restricted by the Foreign Business Act B.E. 2542 (1999), under which foreign shareholding could not heretofore exceed 49% of the total shareholding in an entity. However, the logistics industry was one of the services in which equity participation in ASEAN countries was set to change under the AEC. The AEC Blueprint allowed equity participation of 51%, which was to increase to 70% in 2016. As other ASEAN members states increased their equity participation in Thai business to up to 70%, local players would need to develop their capacity in order to compete effectively.

According to Visoot Srikajorn^x, Editor of the *Carriers, Bus & Truck, Transport Moving* magazine, a firm that had worked closely with LTFT for several years, whereas opportunities assuredly existed, far-ranging threats loomed larger. In his view, with which Chairman Yoo concurred, the Thai government should have been more aware of the necessity of setting up a government agency to assist local logistics business operators. Such assistance could have included providing cross-benchmarking information on logistics business operators of other ASEAN countries, updating laws and regulations that had long negatively affected the whole logistics sector, or at least facilitating the near-term establishment of TLC, as proposed by LTFT.

Structurally, although the logistics market in Thailand had not been saturated, the majority of players in the market were small and medium sized or SMEs. The consequent pyramid-shaped structure of the Thai logistics and transportation industry reflected the fact that the market had been dominated by two major groups: foreign companies and a few Thai “Super Powers.” This meant, Visoot noted, that once AEC came into being, the domestic Thai market would be even more influenced by large multinational and local Super Power companies because of their significant competitive advantages in comparison with the local Thai SME, particularly in terms of access to financing and technological know-how.

Visoot also talked about the flaws of logistics-related litigation and laws enforcement, in addition to the problems of the pyramid-shaped structure of the logistics sector in Thailand:

[By comparison to Taiwan and Korea, [where] there are effective logistics laws imposed [to the effect] that “If your business operates in dealing with sea transport, you could not operate land transport”, . . . Thailand . . . [had nothing] like that. The 24 foreign logistics companies currently operate in Thailand are very powerful -- for instance, NYK, K Line, Mitsui from Japan, and for the CEP (Couriers, Express, Parcels), are DHL, Federal Express, UPS, etcetera. The local Super Powers are [the] Wangkanai Group, Mitrepol Group, SCG Logistics, and Thai Beverage Group. Once AEC arrived, there would be no space for the Thai SME to stand unless more consolidation . . . and more integration among local logistics operators were allowed. What we [LTFT] could do is . . . promote more talks with these Thai Super Powers to brainstorm about how to help our SMEs.

Further, since government regulations and procedures affected all elements of the logistics system, it would be incumbent on LTFT to take the lead in pushing the government to stay more strategic and up-to-date in its policies. From the perspective of Visoot, the government should also take the lead in the facilitation of, and contribution to, the empowerment among local logistics players. They must be allowed to voice their concerns, to be more autonomous and more adaptable. Since adaptability was a key characteristic of all successful logistics systems, the systems must be designed to be flexible and adaptable to constantly changing circumstances, such as changes in demand for a product or changes in funding policy for logistics activities. To function well, both government and the LTFT-led logistics operators would have to design the logistics system to be more strategic and adaptable.

Due to the inefficient interconnection among transportation modes problems facing Thailand, LTFT attempted to “send the message” to the government that multimodal transport infrastructure must be improved. Since 80% of transport in Thailand was road transport, LTFT had long commented on the infrastructural constraints of roads that stymied effective logistics. Thus, LTFT, which had been working hard to become TLC in the future, aimed to work collaboratively with the government in designing and revitalizing the land and transport routes in Thailand. In the view of LTFT officers, in anticipating AEC, the Thai government should facilitate international road transportation between AEC member states, and also with China which was interested in using land routes to accelerate

regional exports. The continuing work of China, under ASEAN Plus Three Scheme (China, Japan, and South Korea) aimed to develop international transportation and simplify border crossing procedures in the ASEAN region.

Moreover, Dr. Suratin stated that, to cooperate and yet compete with the neighbouring countries, LFTF had strived to lead in educating their alliances and the government about the need to establish a research culture. Logistics research and research-oriented cultures were critically needed for the whole logistics industry. As research was a driver for sustainable development and innovation, ways to promote research in existing and emerging logistics markets had to be made more central in order to increase the knowledge level and credibility. In this connection, it was thought that LTFT could be instrumental, in that it could design programs to enhance organizational learning, knowledge transfer and/or technological innovation. Explained Dr. Suratin:

How can we make our alliances, as well as government, to embrace new concepts and practices, for example, sustainable logistics management via research cultures? A significant, yet often overlooked, component of people's information environments are composed of the relationships that they use for information and knowledge creation and capture. We must provide the opportunities for creating hybrid managers – [who are] both practitioners and academics -- to pursue critical issues in logistics management related to customer satisfaction and operation excellence. The development of a competitive logistics businesses in Thailand requires not only financial capability, but definitely also technological know-how. What we need is a stronger research culture.

Thongyoo also mentioned that Thai logistics operators needed to expand their knowledge from logistics to the more modern concept of supply chain management (SCM), which incorporated logistics and viewed logistics activities as the operational component of supply chain management. According to Thongyoo, SCM encompassed the planning and management of all activities involved in sourcing and procurement and all logistics management activities -- including quantification, procurement, inventory management, transportation and fleet management, and data collection and reporting. This called for coordination and collaboration with channel partners, who could be suppliers, intermediaries, third and fourth party service providers, and customers.

Most of them don't understand, or [haven't] even heard about the concept of SCM. We as a country could not make a progress or integrate systematically without opening up to acquire this knowledge. Our businesses cannot succeed unless the supply chain delivers a reliable and continuous supply of commodities to our customers. Most of them are still practicing the business legacy of the old days of doing business.

Dr. Siddhi Pittayachawan^{xi} -- Program Director, Bachelor of Business Program at RMIT University, Australia – argued that Thai operators had to become more aware of the innovative concepts of Reverse Logistics that had been practiced in more advanced countries. This concept of Reverse Logistics not only encompassed the return of goods from customers to producers, but could also include the handling of recycling and waste-management activities. Thai Logistics providers who offered effective reverse logistics could profit from new business opportunities, particularly if environmental regulations and

legislation became more stringent in the future with the launch of the AEC.

Broadening the concept of logistics even further, Thongyoo spoke about the notion of “humanitarian logistics” by which professional logistics services were needed to minimise the incurrence of negative consequences. LTFT should negotiate with the Thai logistics providers, in his view, to see their support as not only necessary to maintain economic stabilities, but also to enhance social welfare, especially in circumstances when the country faced crisis. Disaster response teams, for example, should be established based on more comprehensive and professional management. The institutionalization of such humanitarian logistics efforts would be made more strategically. He elaborated:

LTFT had played an important role in helping Thai people during the great flood situation in 2011. We could recruit help from our member organizations. But we all in the logistics industry have to learn a lot more together about the practice of Relief Logistics. LTFT [by itself] is not enough. Everyone who works in logistics must remember that they select, procure, store or distribute products to meet societal needs. We must negotiate with them to be more socially responsible in the future.

From the Chairman Yoo’s point of view, LTFT could take justifiable pride in having mobilized the logistics movement in Thailand into an increasingly effective economic force for change, largely by demonstrating the importance of building networks among key organizations in the logistics industry. As LTFT’s chairman, Yoo had recently been invited to be a member of the committee of the Greater Mekong Sub-Region, in which China, Myanmar, Laos, Vietnam, Cambodia, and Thailand worked collaboratively for the development of the South-east Asian region. Mindful of the fact that a central goal of all negotiation was that of reaching agreement among members, Chairman Yoo, in his invited speech on the logistics industry and how to promote strategic partnership in the future, reminded his audience that *“Your chances of a good outcome are often better if all parties agree to play by the same rule and to play the same game”*.

The New Paradigm of Designing a Value-Added System of Logistics Management: Green, Sustainable, Professional, and Strategic

From Chairman Yoo’s perspective, the transformation of the Thai economy from agricultural-based to agro-agricultural-based and trade-driven based over the past few decades had stimulated awareness that the transport and logistics sector had a crucial role to play in facilitating the growth of the country’s economy. To this end, he was satisfied that LTFT had moved “the ball” quite a distance toward the goal line. However, a number of challenges awaited LTFT’s accomplishment in the near future. As far as Chairman Yoo was concerned, the overarching challenge – the next milestone to reach -- was to ensure that the Thai logistics industry would be able to hold its own against the onslaught of competition that would accompany the launch of the AEC.

Recounting the organization’s strengths, the chairman took satisfaction in the fact that part of LTFT’s organizational success lay in its attention to the human element in the management of conflicts, as well as to improving collaboration and creating and transferring knowledge throughout in LTFT’s organizational network. Adherence to an informal structure within and among organizations through the practice of strategic communication in

the shadow negotiation that coexisted with the formal structure of these organizations had also been instrumental in LTFT's accomplishments to date. Further, LTFT had learnt to establish metrics that measure not only the business results of alliance, but also the quality and strength of the relationships that were always essential in the Thai socio-cultural context. How to build on these to ensure their efficacy for the challenges ahead – particularly the challenge of the AEC -- was now the key question.

Endnotes

ⁱ Interviewed on February 14th, 2014 at KNR Group, Bangkok

ⁱⁱ Interviewed on January 20th, 2014 at Primary Coffee House, Bangkok

ⁱⁱⁱ According to Thongyoo, the phrase “domesticated ways of doing things around here” meant that in the logistics sector in Thailand, the prevailing and preferred mode of business operation among most of the local service providers was still typically Thai, and it had been widely accepted as business legacy being practiced for decades.

^{iv} Interviewed on February 12th, 2014 at Big C Super Store, Ratburana, Bangkok

^v These 11 organizations were composed of: 1) The Land Transport Association of Thailand, 2) Imports-Exports Transport Association, 3) North-eastern Transport Association, 4) Thai Transportation & Logistics Association, 5) Eastern Transportation Association, 6) Professional Crane Association, 7) Association of Southern Logistics and Transportation, 8) Laemchanang-Chonburi Transport Association, 9) Petroleum Truck Hanlier Association of Thailand, 10) Association of Trucks Nakorn Pathom, and 11) Association of Agricultural and Industrial Products Operators.

^{vi} The Southern Association of Logistics had recently joined the LTFT in 2012

^{vii} Interviewed on February 27th, 2014 at U&T Motor Works, Bangkok

^{viii} Interviewed on January 15th, 2014 at TIFFA ICD., Co.,Ltd, Bangkok

^{ix} Chinachart Vatanasuchart, Partner to Tilleke & Gibbins International Ltd. (2012), cited from www.tilleke.com

^x Interviewed on December 19th, 2013 at U&T Motor Works, Bangkok

^{xi} Interviewed on January 18th, 2014 at Mae Fah Luang University, Chiang Rai, Thailand

Addendum of Exhibits

Exhibit One: Thailand Logistics Council

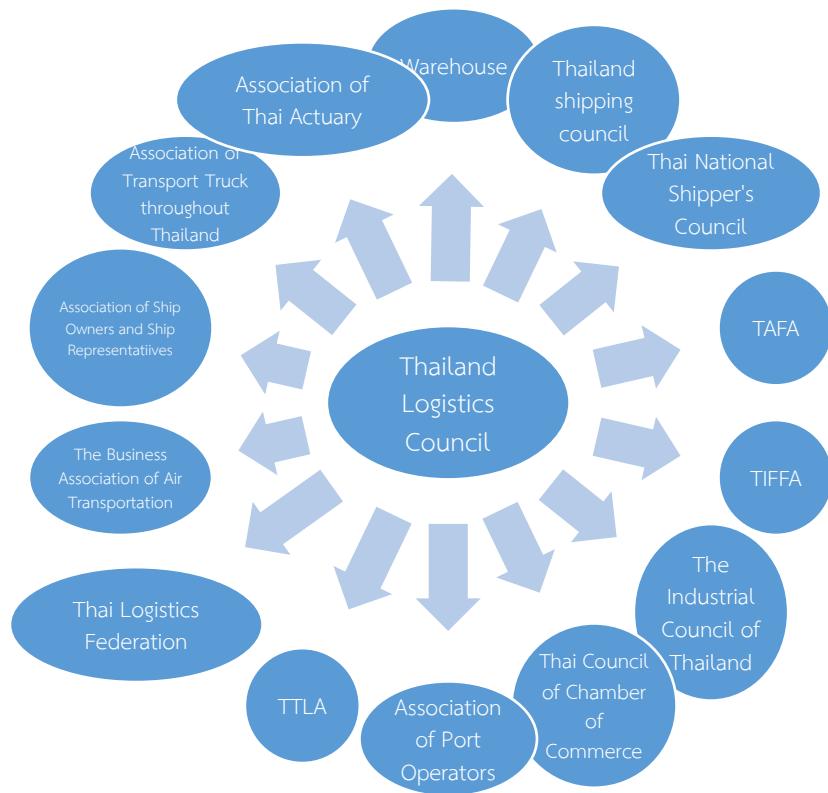


Exhibit Two: Thailand's National Strategies in Logistics Development Plan 2008-2012

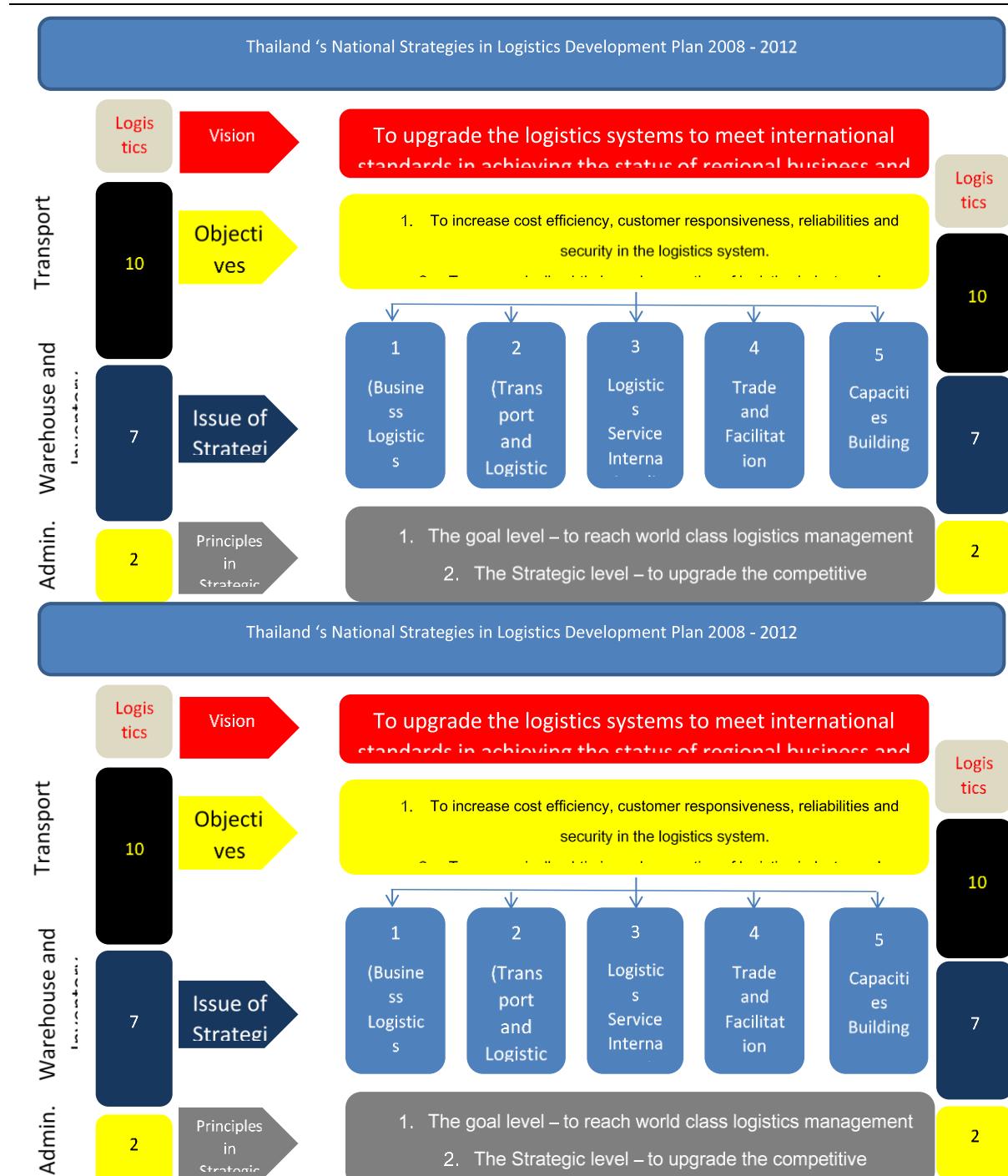
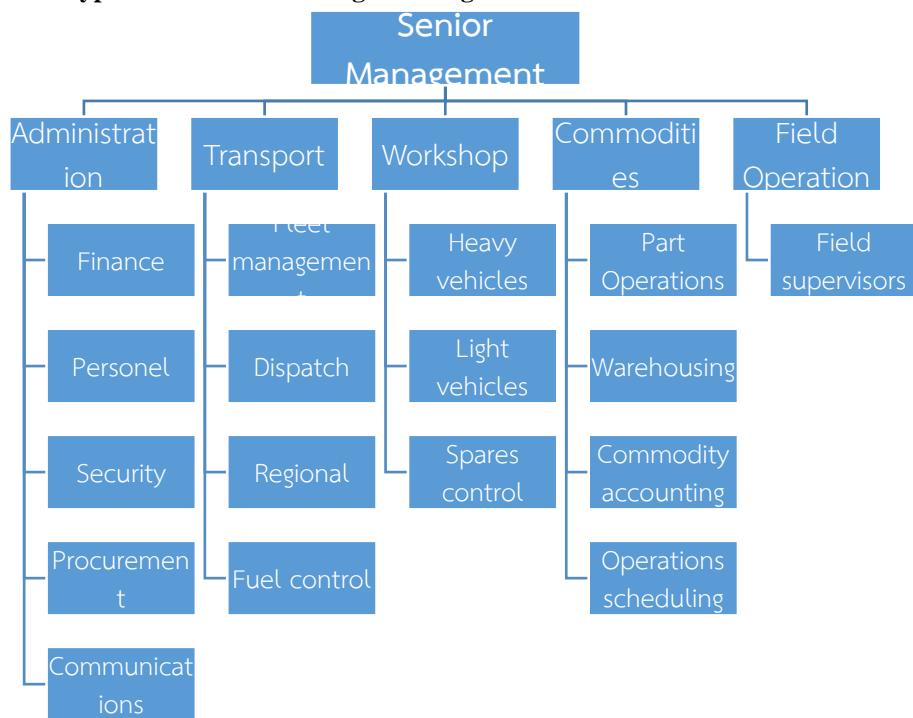


Exhibit Three: A Typical Structure of a Logistics Organization**References:**

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THE EFFECT OF ETHICAL DISPOSITION ON PURCHASE INTENTION OF COUNTERFEIT LUXURY BRANDS

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ABSTRACT

Previous studies in marketing literature have found ethics as an irrelevant factor in making consumer decisions to purchase luxury counterfeits or genuine items. This study aims to investigate the situations that make ethics take a significant role. The outcome of this study confirms that ethics alone does not explain the purchase intention but it finds that ethical disposition will influence purchase intention of counterfeits if it was stimulated with collectivistic orientation. On the other hand, self image will enhance purchase intention of genuine items. In brief, ethically-minded consumers do not buy counterfeits if they are highly collectivistic, while unethically-minded consumers will do so if they are highly collectivistic. Ethically-minded consumers do not buy genuine items if they have high self image, whereas unethically-minded consumers will do so if they have high self image.

KEYWORDS

Counterfeit luxury brands, purchase intention, ethical disposition

INTRODUCTION

In marketing, luxury goods are defined as “goods such that the mere use or display of a particular branded product brings the owner prestige apart from any functional utility” (Mason 2001). On the other hand, counterfeits are defined as “copies of products that are identically packaged, including their trademarks and labeling, to seem to consumers as though they are the genuine article.” (Chiou et al. 2005). Previous studies have examined various types of consumer characteristics on luxury and counterfeit buying behaviors to develop effective ways to discourage counterfeit purchases and encourage genuine brand purchases. Among various consumer characteristics, consumer ethics or morality is assumed to have an important role on luxury counterfeit purchases (Yoo and Lee 2009). However, contradictory to such a commonsense as well as theoretical assumption, consumers are not seriously concerned with the ethical issues related to counterfeits. They do not seem to apply any ethical standards when buying fake products. For example, two thirds of counterfeit buyers are proud to buy fake goods and have no problem admitting it to friends and even wealthier shoppers are proud of these purchases. Renee Zellweger, a renowned actress, openly admitted to buying counterfeit handbag while in Hong Kong. Both qualitative and quantitative research fail to find ethical differences between counterfeit buyers and genuine item buyers (Yoo and Lee 2004; 2009).

Two theories could explain this interesting phenomenon. First, counterfeit buying behavior is a pure economic activity, making ethics irrelevant (Staake et al. 2009). From an economic viewpoint, counterfeits provide beneficial consumer welfare for the affordable price.

Second, consumers do not follow ethics in an absolute sense but in a relative sense. In other words, depending on situations (only when combined with situations), ethics becomes influential. Therefore, the primary purpose of this study is to investigate those situations that, when present, make ethics take a significant role in counterfeit buying behavior whereas they, when absent, make ethics appear unimportant. As a result, the conditions under which consumer ethics affect counterfeit purchases negatively would be identified.

HYPOTHESES DEVELOPMENT

Ethical Disposition

Many researchers have explained why consumers like to buy such counterfeit goods in terms of ethical, cultural, economic, and legal rationales (Higgins and Rubin 1986; Eisend and Schuchert-Guler 2006; Yoo and Lee 2009; Staake et al. 2009, Trinh and Phau 2012). However, it still remains unaddressed how ethics influences consumer intentions to buy counterfeits. The Theory of Planned Behavior expects that purchasing intention can be predicted by morality, values, and ethics (Ajzen 1985; Vermeir and Verbeke 2007). But empirical studies show that only 10 percent of those who promise buying ethically actually do so (Futerra 2005). The reason that ethics is not literally translated into actual buying behavior must be that consumers go through a highly complex process (Carrington et al. 2009). Previous studies report a significant, insignificant, and mixed effect of consumer ethics on luxury counterfeit purchases. It is noteworthy that a lot of researchers find ethics not play a significant role with consumer decisions to purchase luxury counterfeits.

After comparing Eastern and Western cultures, Kwong et al. (2003) conclude that the two groups have no significant difference on ethical belief and in both groups ethics does not affect attitude toward counterfeits or predict the purchase of counterfeits. Consumers seem to disregard ethics on counterfeit buying behavior for some reasons. First, counterfeits offer the buyer with a similar feel or illusion of wealth and prestige while saving a lot of money (Chiou et al. 2005). Second, the quality of counterfeits is quickly improving and undistinguishable from genuine brands (Mason 2001, Trinh 2014). And worse, luxury manufacturers move their plants to counterfeit producing countries to cut costs, which gives a higher technology and design edge to counterfeiters (Mason 2001, Trinh and Phau 2012). Third, counterfeits make consumers think they get benefits passively because they are not actively involved with any illegal activity (Phau et al. 2009, Vitell 2003). Fourth, in most countries, consumers have few norms that teach buying or consuming luxury counterfeits is wrong. Unlike stealing or shoplifting, counterfeits do not necessarily harm the original products, and the damage to the manufacturer is not obvious (Vitell 2003). Fifth, the real worth of luxury brands is based on what other people perceive it to be. As a result, consumers are willing to buy counterfeits to feel like they are living the life they desire to (Phau et al. 2009, Yoo and Lee 2009). Sixth, despite poor quality, the brand name and the identical design characteristics (logo, color, pattern, and accessories) that counterfeits convey are themselves valuable. When consumers pursue such benefits, they will accept counterfeits over

genuine items, ignoring ethics (Yoo and Lee 2009). Similar to the case of counterfeits, buying genuine items is not necessarily linked to ethics.

Generally speaking, luxury brands are not a type of products satisfying morality or ethical values because they are primarily related to materialism and social status demonstration (Yoo and Lee 2009). Therefore, we propose the following hypothesis:

H1: Ethics does not affect intention to buy luxury products, counterfeit or genuine.

Ethical Disposition versus Collectivism

Phau et al. (2009) and Trinh (2014) argue that consumers go through the three distinct stages of moral reasoning when they decide to buy a counterfeit: namely, the expected personal consequences, positive or negative; the social influence and conformity to the traditional values of the society; and the desire to differentiate moral values from referent groups and authorities. Therefore, the ethical judgment is a complex process and produces very different decisions, depending on situations. Nia and Zaichkowsky (2000), based on consumer surveys, find that certain cultural, social, and market contexts influence demand for counterfeits and the real brands. An example supporting this argument is Phau and Teah's (2009) study of Chinese consumers, in which collectivism, one of representative constructs of culture, is found not to influence attitudes or purchase intentions towards counterfeits. This demonstrates that culture alone is not much explanatory, but that when combined with other factors it could become influential.

Culture, especially collectivism, would be meaningful when combined with ethics. Staake et al. (2009) predict that culture seems a promising factor when researching determinants of counterfeiting. Chaudhry and Stumpf (2011) specifically suggest that collectivism is likely to be related to counterfeit purchases. Collectivism values face saving because it is closely linked to interdependence and the desire to get the in-group's approval and acceptance. So, it results in higher level of susceptibility to normative interpersonal influences. Collectivistic consumers feel obliged to in-group pressure and norms, either favorable or unfavorable. When a consumer is highly ethical and accordingly perceives buying counterfeits to be unethical, he/she would be very unlikely to buy counterfeits especially when her cultural orientation is collectivistic. It is because her collectivism makes her think that her in-group must possess a similar level of ethics like her and buying counterfeits would increase her anxiety that her in-group members could reject her due to the conduct contradictory to the in-group norms. However, if he/she is less collectivistic, that is, individualistic, he/she worries not much about how her in-group members would perceive her, so he/she is more likely to buy counterfeits. On the other hand, when a consumer is unethical and accordingly considers buying counterfeits not to be unethical. He/she would be more likely to buy counterfeits when he/she is highly collectivistic than when he/she is less collectivistic. It is because a collectivistic person, with the impression that her in-group is also as unethical as he/she is (e.g., mentality such as "Everybody does it- so do I"), would think counterfeits could be an effective instrument to acquire acceptance by her unethical fellows. In

fact, in a corrupted collectivistic mind, sharing creative work is not a copyright infringement, but rather an acceptable way of benefiting the entire society (Chiou et al. 2005). Albers-Miller (1999) finds that a consumer is more willing to buy an illicit good like counterfeits when he/she perceives others also do so. Therefore, we propose the following interactive hypothesis:

H2: Ethically-minded consumers are less likely to buy counterfeits when they are more collectivistic than when they are less collectivistic. In contrast, unethically-minded consumers are more likely to buy counterfeits when they are more collectivistic than when they are less collectivistic.

Ethical Disposition versus Self Image

Self image, which refers to "how I am seen by others" (Sirgy and Danes 1982), positively affects purchase intention of genuine items because they deliver the image of wealth and social class (Wee et al. 1995). Consumers purchase luxury brand goods surely because they can be distinguished by prestige, high levels of wealth, and a more elite social position signaled by luxury products (Chiu et al. 2009; Penz and Stöttinger 2005). According to Phau et al. (2008), individuals of high self image are especially concerned about the impression they make on others.

They would feel positive, confident, and secure about genuine items because genuine items would arouse positive responses from others. This attitude is expected to be much stronger among unethically-minded consumers than among ethically-minded consumers. The reason is that ethical values do not support external desires such as acquiring status through possessions of luxury goods. Ethical consumers abhor maintaining self-esteem, personality, and status by luxuries. According to Wilcox et al. (2009), ethical consumers' behaviors are likely to be driven by value expressive motivation (i.e., focusing on own need for self-expression, interested in actual intrinsic aspect of product such as quality and reliability), whereas unethical consumers are affected by social-adjustive motivation (i.e., motivated by the need to be accepted in social situations, interested in brand names). The nature of a product is a central determinant of purchase intention because consumers link the product with their ideal self image (Bian and Moutinho 2009). Therefore, we conclude:

H3: Ethically-minded consumers are less likely to buy genuine items when they have higher self image than when they have lower self image. In contrast, unethically-minded consumers are more likely to buy genuine items when they have higher self image than when they have lower self image.

Other Factors

We also incorporate other variables into this study that influence purchase intention of counterfeits and genuine items. These variables are positive thoughts towards buying counterfeits, materialism, and past experiences with counterfeits and genuine items. Among

other studies, Yoo and Lee (2009) find that all of the variables are major determinants of the purchase intention of counterfeits and originals.

At first glance, it seems that consumers purchase counterfeit products primarily because of the low price. This would imply that counterfeits are primarily attractive to low-income consumers. However, although they can afford the genuine brands, high-income consumers in well-developed countries also buy counterfeits (Gentry et al. 2006; Prendergast et al. 2002). Staake et al.'s (2009) empirical research finds other antecedents than the financial motive as possible explanations for the conscious purchase of counterfeits. In summary, consumers buy counterfeits not merely because of price advantages but mainly because of very different, non price benefits. Therefore, it is expected that consumers' income is not related to purchase intention of counterfeits and genuine items (H4).

According to the Theory of Planned Behavior, attitudes toward an act influence behavioral intentions (Ajzen 1991; Ajzen and Fishbein 1980). Therefore, positive thoughts towards buying counterfeits would positively affect purchase intention of counterfeits, but negatively affect purchase intention of genuine items, which is the opposite act (H5). Materialistic consumers put possessions and their acquisition at the center of their lives, finding satisfaction and well-being in life through them (Richins and Dawson 1992, Trinh 2012) and distinctiveness (Trinh 2012). As the objective of possessions of luxuries is to impress others rather than themselves, both counterfeits and genuine items that provide identical appearances would fit it well although genuine items would do so better. Therefore, it is expected that materialism positively affects purchase intention of both counterfeits and genuine items (H6). Past behavior is known to be a more significant predictor of later behavior than cognitive and affective consideration as it drives a consumer to repeat the same behavior (Bagozzi et al. 2002; Bamberg et al. 2003). So, it is predicted that past experiences with counterfeits would positively affect purchase intention of both counterfeits and genuine items (H7). Inertial behavior would make consumers keep buying counterfeits but simultaneously dissatisfaction in counterfeit experiences due to poor product quality and potential guilt feelings leads to realization of the value of genuine items. Past experiences with genuine items would positively affect purchase intention of genuine items, but not counterfeits (H8). Experiences with genuine items would lead to loss of interest in counterfeits due to their social risks, which does not serve the purpose of conspicuous behavior attempting to achieve social standing.

RESEARCH METHODS

Sample

Undergraduate students from an Australian University campus in Hong Kong, Malaysia and Singapore voluntarily participated in the survey. Hong Kong, Malaysia and Singapore were selected because it is known to be a major consumption center of luxury fashion brand counterfeits and it is quite easy to gain access to counterfeit luxury brands in these markets. A total of 184 responses were obtained for this study.

Measures

All items were measured in seven-point Likert scale except for past experiences measured in a set of binary responses. Intention to buy counterfeits (genuine items) was measured by five items which assessed the purchase intention of counterfeits (genuine items) of luxury handbags, shoes, apparels, sunglasses, and accessories. The reliability of purchase intention of counterfeits and genuine items was 0.88 and 0.92, respectively. Past experiences with counterfeits (genuine items) was measured by the sum of responses to ten binary questions each of whom assessed whether or not the respondent purchased or owned the counterfeits (genuine items) of luxury handbags, shoes, apparels, sunglasses, and accessories. We developed a scale of counterfeit-related consumer ethics by three items which assessed how illegal the respondent views the act of buying, selling, and manufacturing of counterfeits to be. Its reliability was 0.82. As for collectivism, we used Yoo, Donthu, and Lenartowicz's (2011) six-item scale of collectivism. Its reliability was 0.90. As for self image, we used the 19-item scale developed by Ahn et al's (2001). Its reliability was 0.84. To measure materialism, this research used the new 16-item materialism scale which can measure four components of materialism – namely success, happiness, essentiality and distinctiveness (Trinh, 2012). Its reliability was 0.82. We measured discretionary income by one item: I freely spend \$ ____ per month after I have paid off all of my bills. Table 1 reports the descriptive statistics and correlations of the scales.

Analysis and Results

To examine the impact of consumer ethics further and test the research hypotheses, we ran regression analysis in which two dependent variables, purchase intention of counterfeits and genuine items, were regressed to the selected independent variables. Table 2 summarizes the results of the analysis. No serious multicollinearity was detected in Models 1 and 3 as witnessed in the low condition index and variance inflation. However, as our main hypotheses require cross-product terms, before analysis, we centered all means to reduce the potential threat of multicollinearity and improve the ability to distinguish the effect of changes in each element of the cross-product term from changes in the cross-product term. Mean-centering reduces the covariance between the linear and the interaction terms, resulting in the reduced collinearity and the computational precision of parameters (see Aiken and West 1991). As a result, all four regression models of Table 1 report the parameters based on mean centering.

Models 1 and 3 predict purchase intention of counterfeits and genuine items, respectively, by selected variables without interaction terms, whereas Models 2 and 4 do so with interaction terms. They show that consumer ethics has no significant role in both cases of intention (0.04 and 0.02, respectively, $p > 0.10$), which confirms H1 (no impact of consumer ethics). However, Model 2 shows that the interaction term of consumer ethics and collectivism has a negative impact on purchase intention of counterfeits (-0.06, $p < 0.10$). When the two variables only are considered, purchase intention of counterfeits is computed as $(0.03 - 0.06 \times \text{Collectivism}) \times \text{Consumer ethics} + 0.03 \times \text{Collectivism}$: this suggests that in the case of low level of ethics, purchase intention of counterfeits would increase when collectivism increases, whereas, in the

case of high level of ethics, it would decrease when collectivism increases. Therefore, H2 is supported. Model 4 shows that the interaction term of consumer ethics and self image has a negative impact on purchase intention of genuine items (-0.17, $p < 0.05$). When taking the two variables only into consideration, purchase intention of genuine items is computed as $(0.08 - 0.17 \times \text{Self image}) \times \text{Consumer ethics} + 0.28 * \text{Self image}$, which predicts that in the case of low level of ethics, purchase intention of genuine items would increase when self image increases, whereas, in the case of high level of ethics, it would decrease when self image increases. Therefore, H3 is supported.

Table 1. Construct Correlations

Variables	1	2	3	4	5	6	7	8	9	10
1. Intention to buy counterfeits	1									
2. Intention to buy genuine items	0.08	1								
3. Discretionary income	0.00	0.30	1							
4. Positive attitudes towards buying counterfeits	0.45	-0.21	-0.11	1						
5. Materialism	0.19	0.46	0.18	0.00	1					
6. Past experiences with counterfeits	0.59	0.20	0.13	0.28	0.19	1				
7. Past experiences with genuine items	0.03	0.44	0.39	-0.16	0.28	0.21	1			
8. Counterfeit-related consumer ethics	-0.09	0.17	0.18	-0.21	0.08	-0.09	0.17	1		
9. Collectivism	0.07	-0.02	0.10	0.11	-0.04	0.04	-0.01	-0.02	1	
10. Self image	0.10	0.23	0.21	0.02	0.12	0.12	0.23	-0.01	0.04	1
Mean	2.85	4.49	31.72	2.52	3.99	2.72	3.08	4.46	2.91	4.30
Standard deviation	1.47	1.70	13.84	0.90	0.71	2.47	2.97	1.44	1.17	0.72
Minimum	1	1	0.70	1.00	1.85	0	0	1	1	2.37
Maximum	7	7	90	5.17	6.55	10	10	7	7	6.68

$p < 0.05$ for correlation of 0.11 or greater.

Table 2. Regression Results

Variables (and Hypotheses)	Intention to buy			
	Counterfeits		Genuine Items	
	Model 1	Model 2	Model 3	Model 4
Intercept	0.03	0.02	-0.02	-0.02
Discretionary Income (H4)	-0.00	-0.01	0.01	0.01
Positive Thoughts towards Buying Counterfeits (H5)	0.48*****	0.50*****	-0.33****	-0.34****
Materialism (H6)	0.24***	0.24***	0.80*****	0.78*****
Past Experiences with Counterfeits (H7)	0.30*****	0.30*****	0.08**	0.07**
with Genuine Items (H8)	-0.04	0.04	0.13*****	0.14*****
Consumer Ethics (H1)	0.03	0.03	0.07	0.08
Collectivism	0.04	0.03	0.02	0.04
Self Image	0.08	0.10	0.28***	0.28***
Consumer Ethics x Collectivism (H2)		-0.06*		0.01
Consumer Ethics x Self Image (H3)		0.05		-0.17**
F-value	32.27*****	26.40*****	23.25*****	19.42*****
R-square	0.45	0.46	0.38	0.39
Adjusted R-square	0.44	0.44	0.36	0.37

* p < .10; ** p < .05; *** p < .01; **** p < .001; and ***** p < .0001.

Discretionary income was not a significant predictor of either purchase intention of counterfeits or genuine items across regression models. This result shows consumers buy luxury products, fake or real, for different reasons rather than by income, supporting H4. Positive attitudes toward buying counterfeits had a strong positive impact on purchase intention of counterfeits in Models 1 and 2 ($p < 0.0001$), but a strong negative impact on purchase intention of genuine items in Models 3 and 4 ($p < 0.001$), supporting H5. Materialism was a significantly positive predictor of both purchase intention of both counterfeits ($p < 0.01$) and genuine items ($p < 0.0001$), but its impact was stronger on purchase intention of genuine items, which supports H6. Past experiences with counterfeits had a positive impact on both purchase intention of counterfeits ($p < 0.0001$) and genuine items ($p < 0.05$), supporting H7, although its impact was stronger on purchase intention of counterfeits. In contrast, past experiences with genuine items showed a significantly positive impact on purchase intention of genuine items ($p < 0.0001$), but no significant impact on purchase intention of counterfeits, whose result supports H8.

DISCUSSION

This study primarily examined the role of ethics in purchase intention of luxury brand counterfeits and genuine items. It was found that ethics alone does not explain the purchase intention but it does when combined with certain consumer characteristics. Specifically, collectivism works together with ethics to influence purchase intention of counterfeits, whereas self image joins ethics to impact purchase intention of genuine items. Ethically-minded consumers do not buy counterfeits if they are highly collectivistic, whereas unethically-minded consumers do so if they are highly collectivistic. Ethically-minded consumers do not buy genuine items if they have high self image, whereas unethically-minded consumers do so if they have high self image.

Future research can be extended in three major directions. First, as the findings are based on surveys, they need to be validated in more rigorous methods such as experiments. For example, when a consumer is manipulated to be put under a higher versus lower social pressure situation or a higher versus lower self image situation, how differently does an ethic show its role on purchase intention of counterfeits and genuine items? Social and policy experiments could identify the conditions under which consumers will opt for counterfeit or pirated products in lieu of genuine items. Controlled experiments would provide useful insights under what ethical conditions individuals and groups would purchase luxuries. Second, collectivism and self image are examined to explain the moderating role of ethics, but they must be a mere example of many other personal and situational factors. Researchers need to investigate other and more significant determinants at the individual, societal, or national level. The effective degree of preventing the consumption of counterfeits depends on social characteristics and community behavior. Purchase intention of counterfeits might be lower at the places where more neighbors interact closely and are likely to intervene in incivilities. Third, the sample was college students. Thus, there is a certain limitation to generalizability of the empirical findings across other demographic groups. The relationship between ethics and counterfeit behaviors may vary across social cultures and contexts. Other countries and sample types need to be studied. In particular, it is highly recommended to compare developed versus developing countries, luxury brand versus counterfeit producing countries, genuine item versus counterfeit heavy buyers, and high versus low income consumers in future study.

Implications

Despite the significant moderating role of ethics, the main effect of ethics was insignificant with or without being combined with other factors. Our findings suggest that consumers are not likely to have a desire for greater personal responsibility in rejecting the consumption of the counterfeits. They appear to take less social responsibility and government intervention to the purchase of counterfeits. This raises a very serious policy question: To which method among ethics, education, or law should we primarily rely on to discourage consumers to buy counterfeits? The answer is law, which seems the most effective choice than ethics or education because ethics is not working at all in influencing purchase intention of counterfeits as this and

previous research confirm. When people are allowed to buy counterfeits, people develop lower morality and higher dishonesty (Gino et al. 2010) and try to justify their behavior even when they admit the act is wrong (Staake et al. 2009). Such consequences are not beneficial to the society, industry, and national economy, so counterfeit buying behavior needs to be regulated by laws.

Another issue is that counterfeits are now available in online shopping sites where consumers enjoy convenience, privacy, and global reach. For example, Tiffany and Co. found 73 per cent of randomly bought Tiffany jewelry through eBay was fakes. The U.S. Departments of Justice and Homeland Security together seized 82 websites in 2010 for selling counterfeits. However, unfortunately, in most countries, laws state no clear liability for internet service and content providers if they host online vendors of counterfeits. Counterfeiting is a threat to the world economy. But it is surprising that consumers, that is, the demand side of counterfeiting and the real drive of the supply side, face no legal penalty in most countries (Staake et al. 2009). Studies show that consumers perceive their behavior to be wrong if it is illegal (Vitell 2003) and that willingness to buy illicit goods is negatively associated with the level of perceived criminal risk (Albers-Miller 1999). Therefore, buying, consuming, and owning behavior of counterfeits needs to be treated as being really illegal if countries really want to stop the demand of counterfeits.

It is a dilemma to policy makers, however, that producers and consumers, particularly, in luxury fashion brand industry and design sector tend to accept the idea that pirates and counterfeits are not that harmful. For instance, the theological ethics model justifies the counterfeiting activities by the rationale that they have no harmful effects on fashion industries(e.g. Al-Khatib et al. 1997). Some consumers also legitimize their counterfeit consumption for the reason that it makes no damage on the fashion industries, and even feel that their buying behaviors may contribute to the industry. On the other hand, studies have emphasized that the consumption of counterfeits is not just an ethical problem but a social issue and becomes a widespread and everyday practice (Rutter and Bryce 2005). Many consumers enjoy counterfeits as a kind of harmless fun, rather than a serious ethical problem (Phau and Cheah 2009, Trinh 2014). Moreover, fashion sector has ignored legal prohibitions against copying (Maldonado and Hume 2005).

While strengthening legal frameworks and enforcement efforts, a new social consensus against purchasing counterfeits needs to be nurtured to discourage counterfeit purchases. Public policy instruments such as public information and communications campaigns can contribute to reducing the purchase of the counterfeits. The growing knowledge about how counterfeits seriously distort normal economic activities and social ethics can change public understanding and attitudes regarding the consumption of the counterfeits. The active roles from both NGOs and media are also important to reduce the purchase of counterfeit goods associated with everyday routines. They can undertake a campaign, such as those successful advertisement based, to re-educate consumers.

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CUSTOMER KNOWLEDGE CREATION THROUGH KNOWLEDGE SHARING: MODEL DEVELOPMENT AND CROSS CULTURAL INVESTIGATION

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ABSTRACT

This study therefore investigates and develops a customer knowledge creation model using part of Nonaka's concept of Ba (place) together with other supporting literatures. The model was further compared across two cultures (Gambia & Taiwan) to investigate if cultural differences will impact on the model fit. The results of the Gambian study showed that customer knowledge can actually be created by adopting the concept of Ba. This means that individual face to face knowledge sharing, group face to face knowledge sharing & virtual knowledge sharing are 3(three) Ba's thus leading to customer knowledge creation and hence proved to be the platforms through which customer knowledge can be created. Though great model fit was achieved for Gambia but not for Taiwan. This further proved our research hypothesis that the structural models between these two countries are significantly different thereby highlighting culture differences and questioning standardization strategy. This model can be beneficial to any company that depends on customers to increase sales and survive in the competitive market of today.

KEYWORDS

Customer Knowledge Creation, Customer Interaction, Cultural Differences

INTRODUCTION

We are currently witnessing a transformation of the business environment from product-centric to being customer-centric. Companies are now seeking to gain competitive advantage from the knowledge of customers about the company's products and services. With the passing of time, customer's trends and preferences changes which is the more reason why companies need to constantly keep customers in the loop of their business activities.

To begin with, knowledge management and knowledge creation are two facets of knowledge being identified by (Bajaria, 2000). While Knowledge management emphasizes

efficiency in using what we know, knowledge creation focuses on generating a new knowledge. This new knowledge that is being referred to in this study is the knowledge from customers about the products and services of a company. It is also concerned with the knowledge of how these products can be improved to suit the preference of customers. However, organizations need to foremost know how they can create the knowledge from their customers before managing it. Thus, creation comes before management. The systems in the organization need to support and build the place for it because the knowledge of customers is being characterized as part of the firm's knowledge in turn leading to competitive advantage (Sanayei, 2011).

It is rare to come across a research which looks at customer knowledge creation as a whole. Most researches only looked into customer knowledge management, knowledge creation or knowledge management within the organization. Researchers like (Choi & Lee, 2002; García-Murillo & Annabi, 2002; Schumann, Wunderlich, & Zimmer, 2012) and others are some of the researchers that looked into customer knowledge management within the organization. Other researchers such as (Akhavan, 2008) explained how knowledge management and Customer relationship management can be combined to lift the status of customers from mere recipients of information, products and services and empowering them as fully fledged knowledge partners.

However, one most interesting contribution pertaining to knowledge creation is that of Nonaka who introduced the SECI model (Nonaka & Konno, 1998; Nonaka, Reinmoeller, & Senoo, 1998). This is a model of knowledge creation which was developed based on the Japanese organizational culture. It shows the different Ba's (place) through which knowledge is converted from Tacit to explicit visa vis. Knowledge is created through interactions between tacit and explicit knowledge, rather than from tacit or explicit knowledge alone (Nonaka, Toyama, & Konno, 2000). For example in the case of customers, they can exchange tacit knowledge through votes by raising their hands on a particular product or service. Likewise in terms of explicit, they can simply voice out or write down what they think of a product or service. The idea of Ba was originally introduced by the Japanese philosopher Kitaro Nishida and further developed by Shimizu (Nonaka et al., 2000). Nonaka's model seemed like the perfect tool that can be used in the creation of customer knowledge. In this study, the idea of the research model was based on Nonaka's concept of knowledge creation. His model was modified to suit the purpose of this study thus adapting it in view of customers.

Another important thing that came to mind looking at Nonaka's model is the issue of culture difference. Nonaka's model of knowledge creation was solely created to suit the Japanese system of organization. A concern was that if his model is adapted in view of

customers, will it still be applicable in another culture or country? This concern brought to mind that the adoption of a particular model will be influenced by the unique culture of the country which it was tailored to suit. It will be necessary and be of interest to also do a comparison with another country subsequent to testing the default model in the first choice of geographical space (The Gambia).

At present, many companies have to face high competition. Some struggle to implement corporate strategies to response to existing markets and their customer base. To gain high benefit, some companies use knowledge to compete with others. Customer Knowledge gained through their participation proved to help the companies improve their service, increase quality of product, reduce cost and faster response to their customers (García-Murillo & Annabi, 2002). With this research, organizations will be able to more appreciate and value the concept of customer knowledge and how they can be created.

Based on the above mentioned, this research aims to answer the following questions.

1. Can Nonaka's concept of knowledge creation be applied in the context of customers by focusing on the Ba (place)?
2. What are the Ba's (place) needed for customer knowledge to be created?
3. Will cultural differences have an impact on the model?
4. What will be the implications for companies if model fit for customer knowledge creation is achieved?

This study is organized as the following sections. First, we review the past literatures related to knowledge creation. Second, we go through the methodology and explain the method to collect data. Third, we analyze the data and present the results. Last, we provide discussions and conclusions.

LITERATURE REVIEW

Understanding Nonaka's Model of Knowledge Creation

According to Nonaka et al. (2000), Knowledge is context-specific, as it depends on a particular time and place. Without being put into a context, it is just information, not knowledge. By Nonaka's definition, one can clearly distinguish between information and knowledge. Without the place, we are just dealing with information and not knowledge as Knowledge requires the context of an intelligent Medium (Blumentritt & Johnston, 1999). This brings us to Nonaka's concept of Ba. Nonaka defines Ba "as a context in which knowledge is shared, created, and utilized, in recognition of the fact that knowledge needs a context in order to exist.

Since some parts of Nonaka's model will be adopted to formulate a new model for this research, it is important to understand what the concept of Ba is all about. Though his model

was formulated to fit the Japanese system of organization, (Weir & Hutchings, 2005) believe that the model can be applied in the Non-Japanese context. The model consists of four modes of knowledge conversion known as SECI. These are; socialization (originating Ba), externalization (dialoguing Ba), combination (systemizing/cyber Ba) and internalization (exercising Ba).

The originating Ba (socialization) is the place where a sales agent interacts face to face with a customer. Nonaka describes this as a transfer of tacit knowledge because the customer displays his emotions, feelings and experiences to the sales agent or customer relationship manager. In dialoguing Ba (externalization), the sales agent shares the tacit knowledge received from the customer to explicit knowledge within working groups inside organization. It is defined by collective and face-to-face interactions. In this stage, constant dialogues are made or negotiated based on the knowledge received from the customer at the socialization stage. The combination or cyber Ba as the name implies refers to collective and virtual interactions between working groups using the internet, emails etc. The interaction is done solely with the use of technology through explicit to explicit means. The final process of conversion is the exercising Ba (internalization) which is defined by individual and virtual interactions. This is the stage where the knowledge is put into practice or exercised.

Nonaka's model clearly shows how knowledge is converted and transferred from the customer down to the organization via Ba's otherwise known as place. His model clearly shows the importance of place to create knowledge. However we could notice that in his model, the customer takes part in the process only in the socialization stage. The other conversion stages are mainly done within the organization. So, how about picturing this framework with customers as the key actors or players? We will see to the possibility of that as we progress further in subsequent paragraphs and chapters.

Individual and face-to-face knowledge sharing Ba

Individual and face to face knowledge sharing is adopted from Nonaka's originating Ba as shown in his model (Nonaka & Konno, 1998). It emphasizes person to person interaction between two people (Choi & Lee, 2002). In this medium, a customer can interact with a sales representative or relationship manager. It is imperative in this instance to mention the concept of "Guanxi" which describes a form of personal connection between two people of which one of them provides a favor or service to the other (Park & Luo, 2001; Xin & Pearce, 1996). This is a concept of Chinese social hierarchy and does not necessary have to be between equals. The concept of "Guanxi" makes it easy for smooth interaction not only for individuals but this can also rise to group or more parties (Davies, Leung, Luk, & Wong, 1995; Fan, 2002). This medium of knowledge sharing also includes sharing of one's experience with one individual

at a time (Nonaka & Konno, 1998; Nonaka et al., 2000). Most service companies fail to make use of the opportunity to interact with their customers during sales transactions; one might be amazed at how much knowledge of the product or service the customer will reveal. Through the revealed knowledge of the customers, the service personnel gets to know the kind of product or service the customer is searching for (García-Murillo & Annabi, 2002). When two individuals or more come into interaction or collaboration, the communication between them is more fluid, because they share experiences which arise to a new perspective or concept (Gulati, 1995). This new perspective or concept stated by Gulati refers to new knowledge. Most customers feel more at ease when sharing their knowledge with a service representative or customer relationship manager and will tend to reveal more. This makes the sales site a base point for interaction and the first hypothesis.

H1: *Individual knowledge sharing will significantly lead to the process of customer knowledge creation (a) perceived importance and (b) willingness to share.*

Group face-to-face knowledge sharing Ba

Group face to face knowledge sharing involves the exchange of idea, dialogues with many customers at the same time and corresponds to the Dialoging Ba of Nonaka (Choi & Lee, 2002; Nonaka & Konno, 1998). While some customers feel more comfortable sharing their knowledge one-on-one, others might feel face-to-face group discussion is the best way to share their knowledge about the company's product or service. This type of discussion can involve the use of focus groups which has been suggested to refine new product or service functions rather than selecting random customers (Leahy, 2013). Moreover, focus groups involve a collective activity which involves exploration of different views and experiences (Kitzinger, 1994). The concept of "Guanxi" can also help in determining the targeted people for focused groups. A lot of ideas can be presented on different angles which will be beneficial and a great input for a company. According to (Lin & Wu 2005), tacit knowledge about concept creation of new product is made explicit and participants can interact collectively and also virtually (systemizing ba) for reviewing, verifying and validating in accordance with planned arrangements. In addition to this, dialogues have proved to be an opportunity and effective way of generating new business knowledge (Ballantyne, 2004). However some people's willingness to participate in group discussion depends on how much they know about the firm's product or service (Nonaka et al., 2000). To achieve knowledge creation, group discussions and interactions along with designs of a series of creative products are requested (Yeh et al., 2012). As a result, we therefore present our second hypothesis;

H2: *Group knowledge sharing will significantly lead to the process of customer knowledge creation (a) perceived importance and (b) willingness to share.*

Virtual knowledge sharing Ba

Virtual knowledge sharing corresponds to systemizing or cyber Ba (Nonaka & Konno, 1998). It refers to knowledge sharing on the internet or virtual community including emails, social network sites like face book, twitter etc (Koh & Kim, 2004). More over ICT use have been proven to be of significant contribution in knowledge collecting (Lin, 2007). At this day and age on the internet, most people prefer to use social websites and blogs to share knowledge because of social identification and also to gain online reputation (Hsu & Lin, 2008). New technologies, such as the internet, allow broad communities of interest (e.g., customers) to coalesce around specific products and services (Nambisan, 2002). Service companies can make use of this opportunity to engage customers through online websites especially face book which has become popular today. This takes us to our third hypothesis thus;

H3: *Virtual knowledge sharing will significantly lead to the process of customer knowledge creation (a) perceived importance and (b) willingness to share.*

Relationship Trust and commitment

In the same concept of (Nonaka et al., 1998), they made mention that, care, love, and trust emerge from the originating Ba. This idea made me had a re-think that the three medium of knowledge sharing (individual, Group and virtual) are not independent. But rather they depend on something to make it possible. This idea gave rise to a new theory to include in the model relating to customer relationship “(Relationship, trust and commitment)” (Morgan & Hunt, 1994; von Krogh, 1998).

This new concept of Relationship, trust and commitment means that an existing smooth relationship must have been established based on trustworthiness, reliability, and integrity of an individual before there can be any opportunity for knowledge sharing and interaction (Crosby, Evans, & Cowles, 1990; Garbarino & Johnson, 1999; Morgan & Hunt, 1994; Ridings, Gefen, & Arinze, 2002; Usoro et al., 2007). This perfectly makes sense because customer knowledge sharing cannot begin without the commitment or established relationship. According to (Garbarino & Johnson, 1999), people need to share knowledge with someone who they are psychologically attached to. Care, love and trust support all Ba because security and emotional stability are important for human beings to become creative (von Krogh, 1998). This brings us to other hypothesis from four to six.

H4: *When there is Relationship, Trust, and Commitment, it increases the chances of Individual knowledge sharing.*

H5: *When there is Relationship, Trust, and Commitment, it increases the chances of Group knowledge sharing.*

H6: When there is Relationship, Trust, and Commitment, it increases the chances of Virtual knowledge sharing.

Based on the literature review of this study, the research model for customer knowledge creation is illustrated in Figure 1.

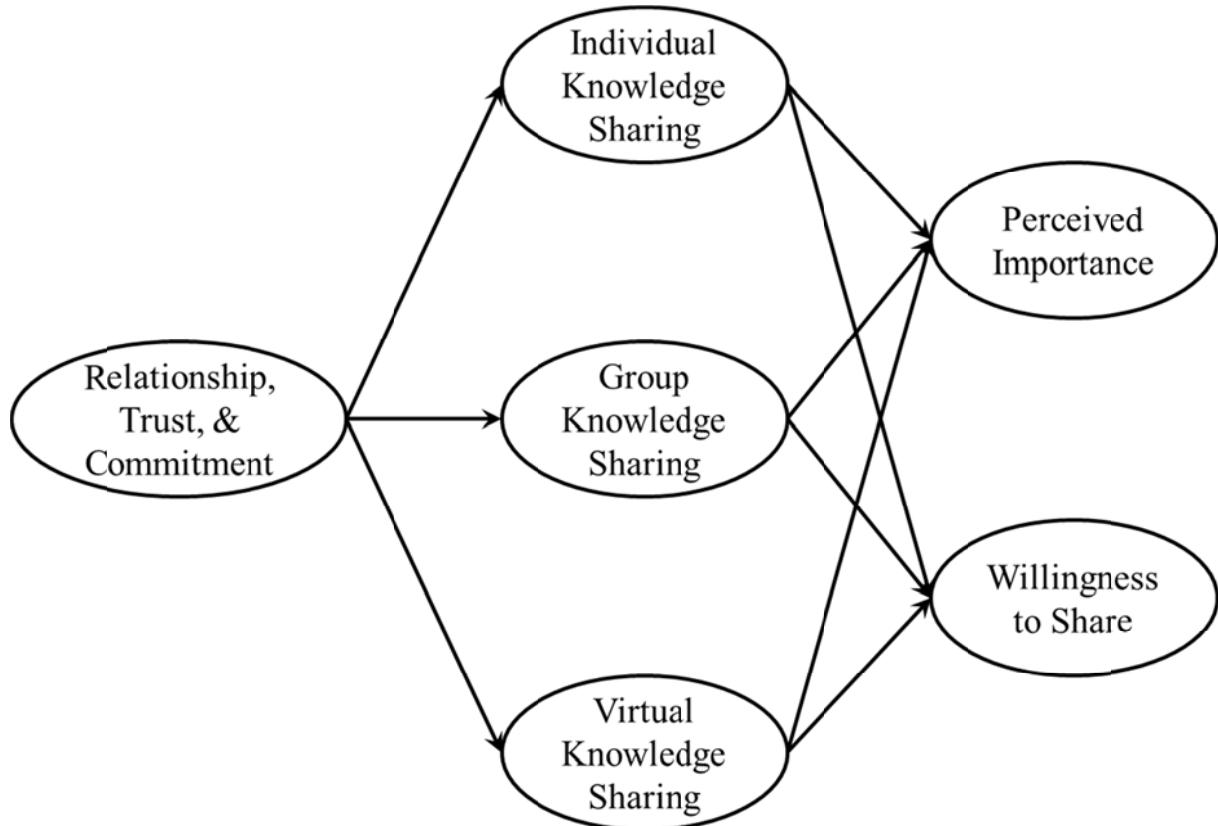


Figure 1 Customer Knowledge Creation Model

Cross Culture Dimensions of Gambia & Taiwan

Culture is being defined as the collective programming of the mind which distinguishes the members of one group from another (Hofstede & Hofstede, 2005, p. 4). Our day to day business activities are being influenced by culture differences especially across nations. A particular product, service or business concept might work in a particular country while it is doomed to fail in another. It is necessary to conduct a cross culture comparison between two different countries (Taiwan and the Gambia) to find out whether similarities or differences with regards to the culture dimensions will reflect on the research model. One of the reasons why so many solutions do not work or cannot be implemented is because differences in thinking among the partners have been ignored (Hofstede & Hofstede, 2005, p. 2).

Before getting acquainted with each country's ranking and score with regards to the dimensions of culture, I wish to highlight some other social differences between these two countries. Gambia is a small West African country with a population of about 1.8 million which is dominated by 90% Muslims, 8 % Christians and 2% other beliefs. Their official language is English with about 8 to 9 other local languages. Taiwan on the other hand is from an Asian origin with a population of about 23 million and mandarin Chinese used as an official language. 24% of the population follows Buddhism, 20% follows Taoism and the rest follows Yi Guan Dao, Protestantism, Catholicism and Lord of Universe Church.

When it comes to punctuality there is huge difference between the two countries. In Gambian society, conferences may start about two hours after the announced time. But in Taiwan culture, events start on spot as stated even if not all guests are seated. The concept of "Guanxi" can also be addressed here again which is important for business successes in Taiwan (Davies et al., 1995). Though Gambia too value the concept of personal relations in business but this concept seem to be more accepted or transparent in Chinese culture. In light of this, differences in culture have an influence on behavior (Berrell, 1999).

The Hofstede dimensions of Power distance, individualism/collectivism, masculinity/femininity, and uncertainty avoidance are offered as a framework for developing hypotheses in cross-cultural studies (Hofstede, 1983). It should be noted that Gambia is not directly listed as a country among the index but is well represented by West Africa since Gambia is located in the west coast of Africa. Firstly looking at power distance, it means that all individuals in society are not equal. Taiwan ranks 43 to 44 on the PDI index while West Africa (Gambia) ranks 17-18. For Taiwan, this means that people accept a hierarchical order in which everybody has a place and which needs no further justification. Gambia on the other hand scores highest on this index which means that Gambia's hierachal order is much more transparent. According to Schumann (Schumann et al., 2012), power distance has no substantial impact on the customers' motivation to provide personal information but on the other hand, research has mentioned that culture differences in power distance may have a moderating effects on voice (Brockner et al., 2001). Social relationships should be handled with care if there is small power distance while in large power distance, status should be balanced with restraint (Hofstede & Hofstede, 2005).

In terms of individualism and collectivism (IDV), both countries are a bit close but with different figure ranking of 64 for Taiwan and 56-61 for West Africa. Based on this Taiwan, is more collective than Gambian. People living in a high individualist country or society might prefer knowledge sharing through individual face to face interaction while those scoring low might prefer group or virtual knowledge sharing. Customers in individualist cultures have less motivation to provide personal information than customers in collectivist cultures. People in

individualist cultures have a greater sense of privacy (Schumann et al., 2012). In addition, collectivist cultures respect the in-group authorities and are willing to do anything to maintain the integrity of the in-group while they distrust and are unwilling to cooperate with members of out-groups (Ardichvili , Maurer, Li, Wentling, & Stuedemann, 2006; Triandis, 1989).

Taiwan and West Africa are similar in terms of masculinity and femininity (MAS). These two countries live in a more masculine society. In a masculine society, challenge, earnings, recognition and advancement are important while relationships and quality of life are important for feminine societies. Customers in feminine cultures accept more active roles in the service provision process, but those in more masculine cultures prefer to remain passive (Schumann et al., 2012).

In terms of uncertainty avoidance, Taiwan has a higher score than Gambia which means Taiwanese believes in risk avoidance than Gambian. The cultural value with the strongest effect on the motivation to provide information is uncertainty avoidance (Schumann et al., 2012). Based on the above analysis of Gambia & Taiwan, we could see differences in their culture and culture dimensions and based on that, national cultures can influence a person's actions through perhaps in built values towards those actions (Berrell, 1999; Triandis, 1989). This takes us to the seventh and final hypothesis which is;

H7: The structural model for customer knowledge creation is significantly different for Taiwan and Gambia.

METHODOLOGY

After the pilot study, the official questionnaire was set up. The survey was posted online via survey monkey for easy distribution to Gambian and Taiwanese students. The Gambian and Taiwanese demographics include both Gambian and Taiwanese currently home and away, enrolled in a university or under employment.

The method used to send the survey was via face book. Personal messages with the survey link were sent to Gambians through face book as well as the face book page of Gambian students in Taiwan in order to keep track of links sent. The total number of respondents that the link was sent to is 496. The data collection period for Gambians range from 1st February 2013 to 26th February 2013 and the number of responses collected within that period excluding the incomplete responses is 206 with a response rate of 41.53%. The survey was downloaded in to excel format for analysis.

For the Taiwanese survey, two separate links were created of which one of them was for undergraduate student respondents from Yuan Ze University and the other were respondents via face book. The undergraduate students were students being lectured by my thesis adviser who were asked to respond to the survey in exchange for course credits. The total number of

responses for Taiwan is 166. The data collection period was from May 27th 2013 to June 14th 2013.

Descriptive statistics were done to show us a profile of the respondents with regards to their age, gender, education level, service working experience and geographical location. An exploratory factor analysis was conducted using SPSS to summarize and reduce our data set. This analysis will help us to know which variables are significant and to be retained for further analysis. Confirmatory techniques provide global tests of ‘fit’ of a well-specified theoretical model to the observed data. Structural equation models are statistical procedures for testing measurement, functional, predictive, and causal hypotheses and may be used to build or test a theory (Bagozzi & Yi, 2012) (Roberts, Thatcher, & Grover, 2010).

Reliability was conducted after the factor analysis to examine the reliability of each factor in this study. Reliability is based on the Cronbach’s alpha and a Cronbach alpha greater than 0.7 means that the construct has high reliability. Our items have content validity because most of the questionnaire items were based on past literatures. The AVE (average variance extracted) was done for convergent and discriminant validity among constructs. Structural equation model was done using Amos18 to asses model fit and test our research hypothesis.

RESULTS & DISCUSSION

This chapter presents the results of the study and examines the hypothesis. The first part presents the results of data collected from Gambian respondents, the second will be the results of the Taiwanese respondents and the final part will be on the comparison between the results of Gambian and Taiwanese respondents.

Results for Gambia

The demographic information includes gender, age, education level, service working experience and geographical location. The total number of responses analysed is 206. The majority of respondents include Male who account for 62.14%. Respondent between ages 26 to 30 account for the highest which is 36.89% while the lowest are those 45 years of age (1.94%). Undergraduates account for half of respondents (50.49) while graduates are the second majority (30.58%). In terms of their experience working in a service industry, the numbers seems to appear almost even with 106 respondents with service working experience and 100 respondents without service working experience. Finally most of the respondents include Gambians who are away with a percentage of 63.11% while the remain percentage are Gambian respondents who are home based.

Confirmatory techniques provide global tests of ‘fit’ of a well-specified theoretical model to the observed data. Structural equation models are statistical procedures for testing

measurement, functional, predictive, and causal hypotheses. SEM may be used to build or test theory (Bagozzi & Yi, 2012; Roberts et al., 2010). Amos 18 was used for this analysis.

During the reliability tests, variable SC23 and GRP10 were deleted in the analysis because they didn't meet the standardized factor loading >0.5 (Hair et al., 2010, p. 695). After their deletion, remaining variables met the criteria for factor loadings above the 0.5 acceptable limits. The Cronbach alpha of the factors also fall above the acceptable level >0.7 which means that the data is reliable (Hair et al., 2010, p. 695). The values of Cronbach alpha after all criteria are met range from 0.754 to 0.892.

The questionnaire items used in this study were based on previous literatures and the scales were being modified to suit the purpose of this study. Based on this, the measurement of the study has content validity. There are no convergent validity concerns because our AVE is greater than 0.5 and meet the requirements (Hair et al., 2010, p. 695). However before the assumptions were met, variable IND1 was deleted during the AVE extraction because the factor of individual knowledge sharing did not initially meet the accepted level of 0.5. In order to ensure convergent validity and to meet the assumptions, the lowest loading variable on Individual knowledge sharing factor which is IND1 with a value of 0.512 was deleted. IND3 and IND4 had loadings of 0.796 and 0.679 respectively.

Discriminant validity is the extent to which a construct is truly distinct from other constructs. High discriminant validity provides evidence that a construct is unique and captures some phenomena that other measures do not (Hair et al., 2010, p. 710). The examination of discriminant validity in this study was by identifying the square root value of AVE and correlations among constructs. Correlation of constructs matrix are the square root of the average variance extracted. For adequate discriminant validity, diagonal elements should be greater than corresponding off-diagonal elements. As per Table 1, the diagonal elements are greater than the off-diagonal elements or correlations. This means that we have discriminant validity among our constructs. The table below also provides the mean and standard deviation of each factor.

Table 1 Discriminant Validity, Mean & Standard Deviation – Gambia

	Mean	Standard Deviation	RTC	IND	GRP	VIR	PE	WILL
Relationship, Trust and commitment (RTC)	20.23	5.145	0.764					
Individual knowledge sharing	7.34	1.939	0.387	0.738				

(IND)								
Group knowledge sharing (GRP)	12.45	2.174	0.064	0.217	0.766			
Virtual knowledge sharing (VIR)	9.32	2.396	0.130	0.131	0.209	0.720		
Perceived importance (PE)	22.07	2.796	0.105	0.332	0.460	0.170	0.762	
Willingness to share (WILL)	14.79	2.731	0.028	0.249	0.271	0.303	0.333	0.746

After conducting our EFA & CFA and all criteria being met, we then move on to the structural equation Model analysis. Goodness of fit indicates how well the specified model reproduces the observed covariance matrix among the indicator items (i.e. the similarity of the observed and estimated covariance matrices) (Hair et al., 2010). The Chi-Square value is the traditional measure for evaluating overall model fit and, assesses the magnitude of discrepancy between the sample and fitted covariances matrices (Hu & Bentler, 1999). The normed χ^2 of 1.59 suggests an acceptable fit for the CFA model because it falls within the recommended threshold of 1 to 3, a value up to 5 is also considered acceptable (Hair et al., 2010, p. 721). The value 0.000 is the approximate probability of getting a chi-square statistic as large as the chi-square statistic obtained from the current set of data. It is significant at the 0.05 level. In addition to the chi-square/df, incremental fit index (IFI) 0.937, comparative fit index (CFI) 0.936 and root mean square error of approximation (RMSEA) 0.054 are used to judge the fitness of the data for structural equation modeling. Our values meet the criteria acceptable for our data based on recommendations by (Browne, Cudeck, Bollen, & Long, 1993; Hair et al., 2010; Hooper, Coughlan, & Mullen, 2008). RMSEA better represents how well a model fits a population, not just a sample used for estimation (Hair et al., 2010). A value of 0.05 for RMSEA may be a close fit of the model in relation to the degrees of freedom and a value of 0.08 or less would indicate a reasonable error of approximation (Browne et al., 1993, p. 142; Hooper et al., 2008). Figure 2 shows the results of the structural model for Gambia based of the estimates.

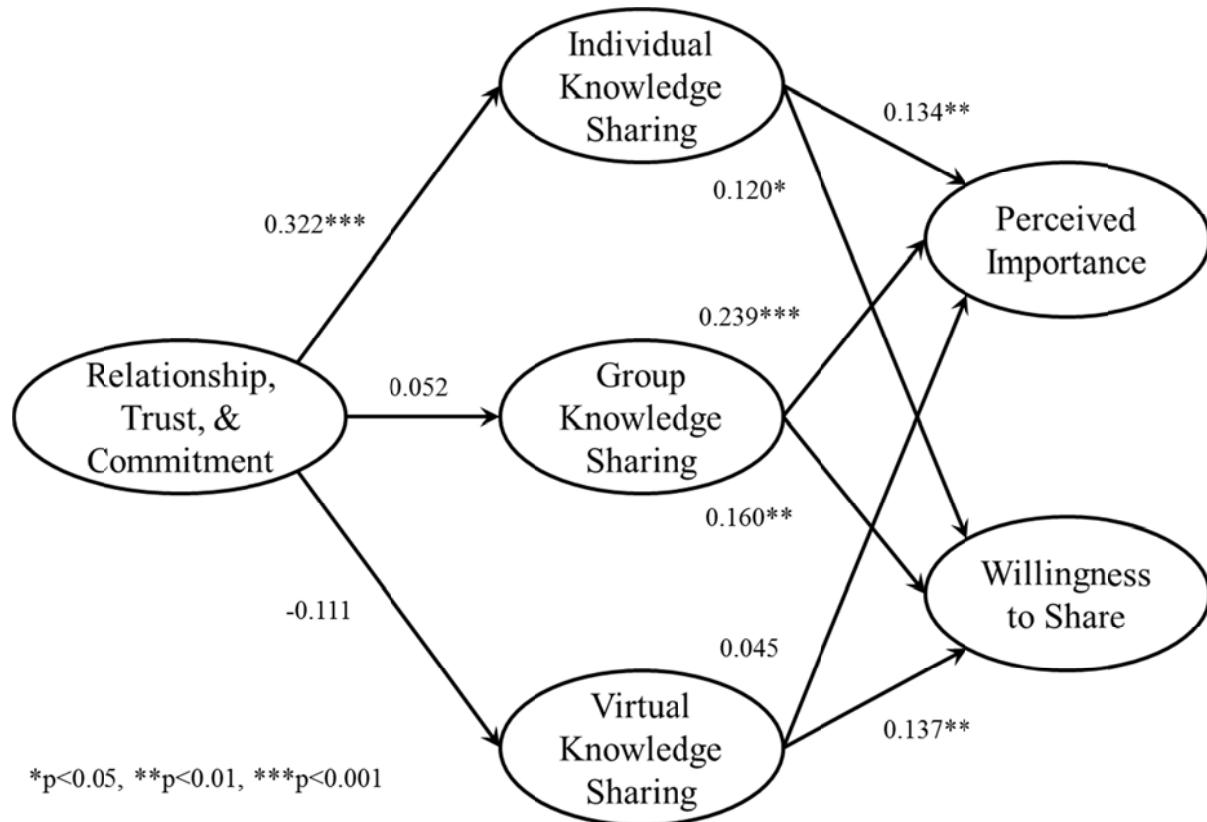


Figure 2 Structural Model Results for Gambia

In the results for hypothesis testing, all the hypotheses are significant at the 0.05 level except H3a, H5 and H6 which fall above the significant level of 0.05. The hypothesis for H1a and H1b proves that Individual knowledge sharing has significant impact on customer knowledge creation. This also means that respondents perceive that their individual knowledge interaction with the service company is important and that they are willing to share their knowledge. This hypothesis is in line with the literatures of (Nonaka & Konno, 1998) and (Gulati, 1995). The hypothesis for H2a and H2b also proved that group knowledge sharing have significant impact on customer knowledge creation both in terms of ‘perceived importance’ and ‘willingness to share’ in line with literatures of (Choi & Lee, 2002; Nonaka & Konno, 1998). However hypothesis H3a ‘perceived importance’ of virtual knowledge sharing of customer knowledge is not significant while H3b ‘willingness to share’ through virtual is significant. This reason can be explained thus; though customers may be willing to share their knowledge through virtual medium but they may feel their knowledge will be of no use to share through Virtual means. This point is even proved and supported by (Ardichvili, Page, & Wentling, 2003)’s research that in many cases, people are afraid that what they post may not be important or may not be completely accurate, or may not be relevant to a specific

discussion. Another reason for this insignificance can be in the form of perceived social presence of customers in virtual interaction thus resulting to issues or concerns relating to perceived security or privacy (Shin & Shin, 2011). The concept of privacy and security concerns in virtual knowledge sharing is further proved by the research of (Chai & Kim, 2010) who mentioned that security and privacy functions of service providers of blogs will positively influence online knowledge sharing behavior. On our hypothesis of H4, Relationship, trust and commitment have significant impact on individual knowledge sharing just as the literature of (Nonaka et al., 1998) revealed. Though H5, Relationship, trust and commitment is not significant to group knowledge sharing. This means that a commitment, trust or existing relationship need not be established before group knowledge sharing can take place. However, (Nonaka et al., 2000) mentioned in the dialoguing Ba that selecting individuals with the right mix of specific knowledge and capabilities is the key to managing knowledge creation in this Ba and hence it can be understood why relationship, trust and commitment does not matter in group based knowledge sharing compared to individual face to face knowledge sharing. On H6, the insignificance of Relationship, trust and commitment to virtual knowledge sharing may also mean that virtual knowledge sharing does not need any relationship commitment before sharing customer knowledge. In this regard, (Hendriks, 1999) proves that motivation is a key factor that influences knowledge sharing in ICT(virtual). In line with this, other researchers like (Bartol & Srivastava, 2002; Matthew et al., 2006) also proved the same point that customer knowledge sharing through virtual is determined by the motivation or reward they receive from it. Therefore customers need to be motivated in order for them to share their knowledge about a product or service online and not necessarily based on the relationship or commitment they have with the service provider.

Results for Taiwan

The total number of responses from Taiwan was 166. The majority of respondents include male who constitute 65.45%. 45.78% of the respondents were also between the ages of 21 to 25. Undergraduate students constitute 60% of respondents. 58.79% have service working experiences while 41.21 have no working experience in service industries. 96.36% percent of the Taiwanese respondents are residing in taiwan.

In terms of reliability, the construct of individual knowledge sharing was weak and did not meet the recommended Cronbach alpha >0.7 . But however, a further proof was needed before this construct can be deleted, so it was retained for further analysis in terms of validity using the average variance extracted. Apart from the construct of individual knowledge sharing, all the other constructs with their corresponding variables meet the required factor loading >0.5 and have Cronbach alpha greater than 0.7.

During the validity analysis of the constructs, the first output of individual knowledge sharing produced an average variance less than the minimum threshold of 0.5. Hence, the variable with the lowest factor loading which is IND3 with a loading of 0.5 was deleted and the AVE conducted again with the remaining two variables of the construct of Individual knowledge sharing (IND1 & IND 4). Even after the second AVE output after deletion of IND3, the factor of IND (individual face to face knowledge sharing) still could not meet the minimum 0.5 threshold. At this point, there is nothing that can be done again about this construct because if the lowest variable loading IND4 is deleted, the measurement model in Amos will not be able to run with a construct with only one variable IND1. This construct was then deleted completely because it neither met the requirement for reliability nor that of validity. However, a possible explanation can derive for this case. To recall back Hofstede dimension of cultures based on individualism and collectivism, Taiwan have a low index score (17) with regards to individualism (IDV). This means that Taiwan is more of a collective society than individualistic. That being the case, collective societies prefers working and doing things together as a group rather than based on personal and individual goals. This brings us back to our study to explain why individual knowledge sharing might not be preferable for Taiwanese respondents.

To further enable us to make a comparison between Taiwanese and Gambian respondents, the structural model with the remaining 5 constructs was conducted. The normed chi square provided a good fit with a value of 2.5 at a probability level significant at 0.05. The CFI 0.852, IFI 0.853 and RMSEA 0.094 did not actually perform good enough but provided only a fair and moderate fit (Hooper et al., 2008).

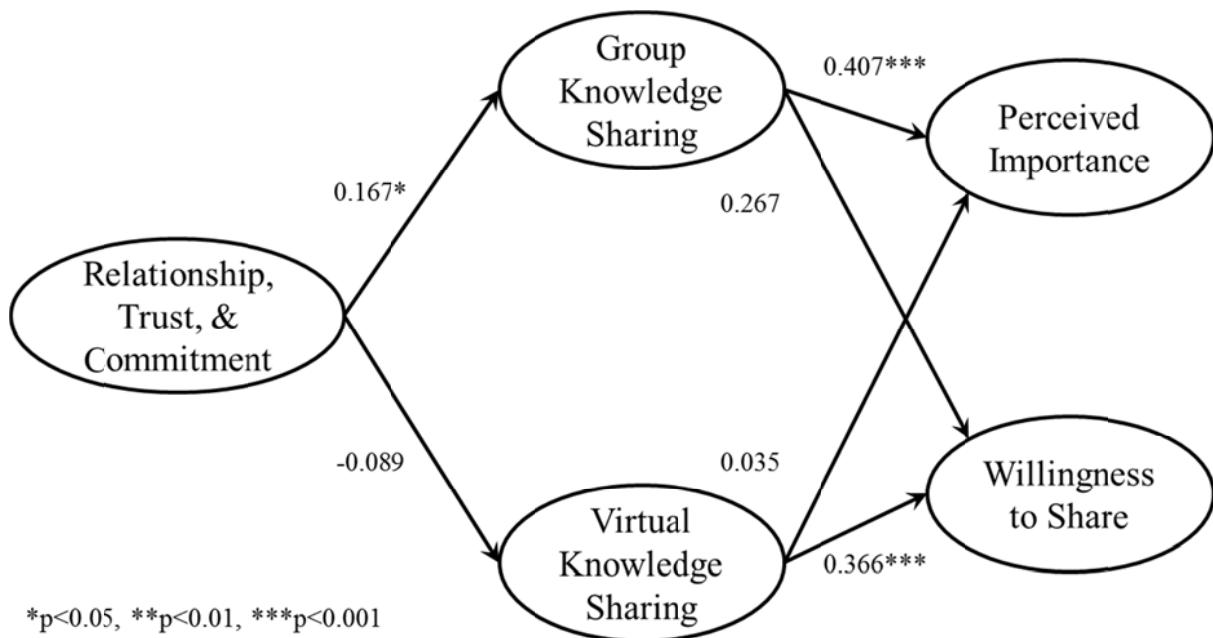


Figure 3 Structural Model Results for Taiwan

Based on these results shown in Figure 3, only 3 hypothesis were supported which are H2a, H3b and H5. In H2a and H2b, Taiwanese respondents perceive group knowledge sharing to be of importance but are less willing to participate in group discussion. However H2b though insignificant in value but has a weak support because the P value is less than 1. In (Hofstede & Hofstede, 2005, p. 97), they mentioned that students in a collectivist culture will hesitate to speak up in larger groups especially if members in the group are partly composed of relative strangers. Since Taiwan is more of a collectivist culture, it explains the fact that respondents are less willing to share their knowledge through group based knowledge sharing. Another reason for this can be seen in the form of social hierarchies' i.e. knowing your place in society and therefore knowing when to speak and when not to speak. This happens especially in cross class encounters (Gray & Kish-Gephart, 2013). Moreover, there is this role that age and generation plays in deeply rooted Chinese culture of which respect for the elderly is deeply embedded in patterns of deference in Taiwan and, ideally, age has been associated with greater authority and greater control over decisions (Beckett, Goldman, Weinstein, Lin, & Chuang, 2002). In H3a and H3b, Taiwanese respondents do not perceive virtual knowledge sharing to be of importance but are willing to participate in virtual based knowledge sharing backed with the same reasons as the results for Gambian. On H5, Relationship, trust and commitment is significant to group based knowledge sharing. Since Taiwanese will be less hesitant to talk to strangers, it makes sense that they find relationship, trust and commitment to influence their knowledge sharing activities through group

discussions. This is where the concept of relationship management comes in wherein relationship managers' needs to build very close relations with their customers as this tend to make it easy for them to share knowledge (Mithas, Krishnan, & Fornell, 2005). However in H6, relationship trust and commitment need not necessarily be established before engaging in virtual knowledge sharing also backed with the same explanation as that of Gambian respondents.

Comparison between Taiwan and Gambian

The fit indices and hypothesis testing from the structural model were used as the basis for comparison between Taiwan and Gambia. The structural model for Gambia achieved a great fit both in terms of the normed chi square and the fit indexes. All passed the suggested threshold values. For Taiwan, the normed chi square was able to achieve 2.5 which is within the threshold <3. In terms of the IFI, CFI and RMSEA, they only generated a moderate and fair value though not with the recommend thresholds. Looking at the fit indices, it can be agreed upon that the structural model for customer knowledge creation achieved a greater fit and support for Gambia than for Taiwan. Furthermore, the Model for Gambia included all 6 constructs while that of Taiwan only supported 5 constructs since individual knowledge sharing was found to be unreliable and have validity concerns. Table 2 shows the different values of the fit indices for Gambia and Taiwan.

Table 2 Comparison of Fit Indices

Fit index	Gambia (6 constructs)	Taiwan (5 constructs)
Normed chi square	1.59	2.5
IFI	0.944	0.853
CFI	0.943	0.852
RMSEA	0.052	0.094
Probability level	0.000	0.000

In terms of the hypothesis, it can be noticed that some of the results of the hypothesis testing for Taiwan are the same as that of Gambia while others were significantly different. The hypothesis for individual knowledge sharing for Gambia was supported while it was not supported for Taiwan. As mentioned earlier from Hofstede's cultural dimensions, Taiwan ranks low in individualism which means that the concept of individual knowledge sharing cannot be applied. Though Gambia also ranks low in terms of individualism but tend to be a bit more accommodating of individual knowledge sharing than Taiwan. Respondents from both countries perceive Group based knowledge sharing to be of importance to customer

knowledge creation for the service company but when it comes to willingness to participate in group discussions, Taiwanese are less willing to share while Gambians are more willing to participate in group discussions.

In terms of virtual knowledge sharing, respondents from both countries do not perceive virtual knowledge sharing to be of importance but are readily willing to share their knowledge in virtual based discussions. For Gambians, Relationship, trust and commitment are not needed before group knowledge sharing can take place but Taiwanese deem it important to share their knowledge with people they are relatively familiar with and can trust only. At the same time, both countries do not need an established relationship before virtual knowledge sharing can take place.

After the analysis of both results of Gambia and Taiwan, it brings us to support our hypothesis 7 that the structural model for Taiwan and Gambia is significantly different. These countries though share similarities in some aspects, but still encompass differences in other areas and hence the same concept cannot be fully adapted in both countries. Table 3 provides a summary of the comparison of hypothesis from both countries.

Table 3 Comparison of Hypothesis

	Hypothesis	Gambia	Taiwan
H1a	Individual knowledge sharing is perceived to be of importance for customer knowledge creation.	Supported	Not Applicable
H1b	Customers are willing to share their knowledge through Individual face to face interaction.	Supported	Not Applicable
H2a	Group knowledge sharing is perceived to be of importance for customer knowledge creation.	Supported	Supported
H2b	Customers are willing to share their knowledge through group face to face interaction.	Supported	Not Supported
H3a	Virtual knowledge sharing is perceived to be of importance for customer knowledge creation.	Not Supported	Not Supported
H3b	Customers are willing to share their knowledge through virtual interaction.	Supported	Supported
H4	When there is Relationship trust and commitment, it increases the chances of individual knowledge sharing.	Supported	Not Applicable
H5	When there is Relationship trust and commitment, it increases the chances of Group knowledge sharing.	Not Supported	Supported
H6	When there is Relationship trust and commitment, it increases the chances of Virtual knowledge sharing.	Not Supported	Not Supported
H7	The structural model of customer knowledge creation is significantly different for Taiwan and Gambia	Supported	

CONCLUSIONS

Research Conclusions

In the beginning, Nonaka's knowledge creation model was adopted and modified to a customer knowledge creation model based on past literatures. In terms of model fit, it was discovered after the confirmatory and exploratory factor analysis that there is a good model fit for Gambia. Individual face-to-face knowledge sharing, group face-to-face knowledge sharing and virtual knowledge sharing are not only mediums through which customers can engage in knowledge exchange of a product or service but also discovered from this study that these knowledge sharing Ba's lead to the process of creation of customer knowledge as well. This study brought to light the importance of relationship, trust and commitment between a service company and a customer most especially when dealing one on one with an individual customer. Knowledge sharing between individuals is a means to creating of customer knowledge. Individual or face to face interactions are normally perceived by customers to be of significant importance and they are readily willing to share their knowledge of the company's product or service with the service provider.

The study also brought to attention that group based interaction or dialogues play an important role in creating customer knowledge. Customers express their willingness to share their knowledge in group discussion and believe that it will add significant value for the service provider including creating room for innovation etc. Virtual based knowledge sharing does not seem to be of importance as perceived by customers but customers however expressed their willingness to participate in virtual discussion.

Based on the measurement items, customers perceived that their knowledge will form a good knowledge base of a service company, create innovation, value, avenue for firm productivity, and most importantly that good IT systems are required to support the knowledge interaction.

Contributions and implications

One of the theoretical contributions of this study is the empirical investigation and creation of a customer knowledge creation model. Previous researches on knowledge creation were based solely within the organization setting. Even though the activities that take place within the organization are important but, we need to understand that we are moving towards a customer focused era where in service companies needs to gain a competitive advantage by constantly interacting and engaging in dialogues with their customers. This study applied Nonaka's knowledge creation model based on his idea of Ba 'place' thereby coming up with the medium or place through which customers are likely to be engaged in knowledge sharing interaction with the service provider. These Ba of individual knowledge sharing (originating),

group knowledge sharing (dialoging) and virtual knowledge sharing (cyber) all together eventually lay the foundation for customer knowledge creation for a service company. The study also highlighted the role of relationship, trust and commitment when interacting with customers on the front line or sales site.

This study provides a lot of implications for managers and organizations of today. First and foremost, managers need to understand that they should not wait for an opportunity to come by itself before interacting with their customers; they instead need to create the place that will encourage the mutual interaction and dialogues between the company and their customers. The customer should be the primary focus of most organizations (SWIFT, 2001). That being said, managers should train their staff to spend more time to interact with their customers face to face at sales points since the study proved that customers especially in Gambia are more comfortable and willing to share their product and service knowledge and experiences individually.

Managers or organizations should also create discussion forums where in their most valued top customers need to participate. However, this group based discussion needs individuals with the right mix of knowledge capabilities (Nonaka et al., 2000) which managers needs to identify. According to (Nambisan, Agarwal, & Tanniru, 1999), organizations can enhance their customer's ability to participate in knowledge creation by increasing their awareness about a product or technology and its potential use as well as about complementary products or technology. These may trigger innovative ideas from the customer. Since the internet has become so popular, the model proved that managers need to create virtual space as most people have become so technology sophisticated. We are quickly moving from information technology to relationship technology (SWIFT, 2001). Most business have even acknowledged this fact which is why so many pages or blogs of companies can be found through social networks especially face book which has become the most popular. To support virtual knowledge interaction, managers also need to develop and manage good IT support systems and inbuilt IT team with customer experience to manage these customer blogs or pages.

Another important factor to be noted is the emphasis of relationship management. This forms the basis of all customer interactions. Service companies need to have good relationship rapport with their customers. Once there is an existing relation, it becomes easier to interact and share ideas with the customer since he/she would have been familiar with the relationship manager and will enhance free flow knowledge. (Mithas et al., 2005) mentioned in their research that Customer relationship management applications facilitate organizational learning about customers by enabling firms to analyze purchase behavior across transactions through different channels and customer touch point. In addition, research has suggested that

CRM systems should enhance not only an organization's ability to interact, attract and build one-to-one relationships with customers but also the ability to gain customer knowledge (Xu, 2005).

This study proved that different cultures exist in different countries. Each country has its set of unique values, beliefs or way of thinking. A particular business strategy employed in one country cannot be employed in another; an adjustment of business strategy is needed based on the different value systems of customers in that country. This issue takes us to whether a country should adopt localization or standardized strategy. Based on the result of the comparisons between Taiwan and Gambia, it can be noticed that a standardization strategy is not likely to work even though there might be some bit of similarities between countries. Not only applicable to services companies but all other companies should take note of the unique needs or preferences of their customers in different countries and should not assume that all their customers in different countries are the same. A model will fit a particular country but when transferred to another, it turns out to mean something totally different. Culture values affect the practice and theory of organizations (Hofstede & Hofstede, 2005, p. 368).

Limitations and Future Research Directions

A limitation is that the cross cultural comparison may have been a bit biased since the sample sizes of respondents in both countries are unequal. Measurement equivalence was not being able to be achieved since Gambia had 6 constructs while Taiwan had 5 (individual excluded). In light of this method of comparison used may be biased. Another thing to be pointed out in terms of drawbacks was that questionnaire items were not being provided for Hofstede's culture dimensions to have a more explicit validity of the cross culture impact. However, since Hofstede's research contains many items for each of the dimensions, matching each dimension of culture to our questionnaire would have generated very low response rates and probably inaccurate as the questionnaire would have been too cumbersome for respondents.

Further research could do a study of this model in other geographical spaces or of other nationalities and also try to include few questions on each culture dimensions. A comparison can also be done between male and female respondents to know if there are any differences of opinions between genders based on the model. Other research could also focus on a detailed customer knowledge sharing implementation plan for each medium especially on how to select the right mix of customers for group based knowledge sharing so as to guide managers.

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APOLOGIES IN HEALTHCARE DISPUTES AND RISK MANAGEMENT

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ABSTRACT:

Conflicts and disputes are unavoidable in any sector of the society, and the healthcare sector is no exception. Apart from compensation in various forms, patients/relatives may want to have a chance to vent their grievances, receive explanations, assurances and a simple apology. Overseas experience has demonstrated the benefits of sincere apologies to both parties, such as healing humiliation, freeing the mind from guilt, removing the desire for vengeance and ultimately mend, even enhance the relationship between healthcare providers (HCPs) and patients/relatives. Overseas studies have demonstrated that after a medical injury, there are more patients who want an apology or explanation than those who want financial compensation. The trend of using apology is rising. If given at an early stage, an apology can promote early resolution of a dispute and result in significant savings. However, there are risks with apologies, and that is why traditionally many HCPs have been advised by their lawyers not to apologize. The question is, "When will it be safe for anybody to apologize?" At present, apologizing in mediation is relatively safe because of the observance of confidentiality. It will be safer when there is a legislation that would prevent liability being based on an apology, by making the apology inadmissible for purposes of proving liability and by not construing the apology as an admission of liability. Apology Legislation was first enacted in the State of Massachusetts, U.S.A. back in 1986. Experience from overseas has indicated that such legislation is particularly useful in healthcare-related disputes. James Chiu was the first person to talk about legislating apology in Hong Kong in 2008. The Department of Justice sees the advantages and is actively studying whether an Apology Ordinance should be enacted in Hong Kong. If passed, it may be the first one in Asia.

KEY WORDS: Apologies Healthcare Disputes

"What we call experience is often a dreadful list of ghastly mistakes."

J Chalmers Da Costa, 1863- 1933

INTRODUCTION

Conflicts and disputes are facts of life. They happen every day to almost everybody and in all kinds of scenarios. The health care sector is no exception. Health care providers (HCPs) consist of medical doctors, dental surgeons, nurses, physiotherapists, and pharmacists etc. In this sector, there are many situations in which disputes may arise. The one which has the largest impact on HCPs, whether in terms of numbers or in terms of monetary and non-monetary loss, has to be disputes between them and their patients/relatives.

Patients and the society have higher and higher expectation of the HCPs in recent years. At the same time, it is easier and easier for the patients/relatives to complain as there are more channels available to them than before. In Hong Kong, when a patient has a complaint against

a HCP, he may choose one or more of the following routes. He may complain directly to the HCP, the employer of the HCP, the regulatory body of the HCP, the District Councillors, the Legislative Councillors, the Consumer Council, the media or go to the Courts. (Chiu, 2014)

Traditionally, seeking help from lawyers and going to Courts is the usual course taken if the two parties cannot resolve the dispute themselves. However, it is well known that the process of litigation can be extremely lengthy, costly and stressful, so much so that the judiciary in many countries all over the world has advised litigants to seek alternative forms of dispute resolution.

The Hong Kong Hospital Authority (HA) is the largest health management organisation in Hong Kong. It employs nearly 35,000 medical, nursing and allied health practitioners, and provides more than 90% of in-patient services in Hong Kong. Each year, it receives about 2,000 complaints against its medical services and staff attitude. (Hospital Authority Annual Report 2013-2014) When a complaint has been received by the HA and, if no claims have been made at the same time, it will be directed to the Public Relations Office (“the PRO”) first. Staff members of the PRO have undergone training in mediation, conflict resolution and communication skills. This arrangement proves to be very successful, as nearly 90% of these complaints are resolved after explanation and apology made by staff members of the PRO. If this form of risk management works for the HA, will it be equally effective in resolving disputes in other health care settings, thereby cutting down the number of litigation and complaints?

The former Ombudsman, Mr. Alan Lai, opined that “While apologies are not magic potions that work in every case, they can be quite effective in addressing the key needs of complainants. In some cases, an appropriate apology is in fact the main thing that they are after”. (The 25th Annual Report of the Ombudsman) Mr. Lai aptly sums up the benefits of apology in a press conference and said, ”even when the complainant has not explicitly demanded it , a sincere and timely apology was often what he/she deserved to get. When the apologising party takes responsibility for the action in question and shows commitment towards preventing similar mistakes, saying 'I am sorry' often allows the aggrieved person to forgive and move on. There are numerous studies that have identified the power of apology in settling disputes and restoring social cohesion. Contrary to conventional wisdom, the act of apologising enhances rather than undermines images and esteem. Instead of being seen as proof of weakness, it demonstrates the moral strength of the individual and the organisation, and their ability to deal with the aftermath. It rebuilds trust.” (Office of the Ombudsman, 2013)

WHAT IS AN APOLOGY?

So, what is an apology which appears to be an efficient way of risk management and resolving health care disputes?

To the patients, an apology is a “word or statement saying sorry for something that has been done wrong or that causes a problem”. (Oxford Advanced Learner's English-Chinese Dictionary) Dr. Aaron Lazare, author of the book “On Apology”, a psychiatrist and the retired Chancellor and Dean at the University of Massachusetts Medical School, in U.S.A. states that “apology” refers to an encounter between two parties in which one party, the offender, acknowledges responsibility for an offence or grievance and expresses regret or remorse to a second party, the aggrieved. Some scholars suggest additional criteria for apology, such as an explanation for the offence, an expression of shame and/or guilt, the intention not to commit the offence again, and reparations to the offended party. (Lazare, 2004) These different aspects of apology will be discussed in more details in later sections.

HOW DO APOLOGIES WORK?

One of the most important questions we can ask about the apology process is how do apologies heal damaged relationships? Another way to approach this question is to ask what psychological needs do successful apologies satisfy, and, conversely, what psychological needs do unsuccessful apologies fail to meet for the offended parties? After studying a wide range of apologies drawn from both personal and public contexts, Dr. Aaron Lazare proposes that successful apologies heal because they satisfy at least one – and sometimes several – distinct psychological needs of the offended party. These needs are:

- restoration of self-respect and dignity
- assurance that both parties have shared values
- assurance that the offences were not their fault
- assurance of safety in their relationships
- seeing the offender suffer
- reparation for the harm caused by the offence
- having meaningful dialogues with the offenders (Lazare, 2004).

Basically, if the physician does not apologize, the patient will hold a grudge and may sue out of anger and out of a desire to find out what the physician is with-holding. The physicians will suffer guilt and shame if he/she does not apologise. Despite it all, however, the offering of an apology can be a powerful, profound interaction between a patient and the physician. A sincere apology has power to heal humiliations, free the mind from guilt, remove the desire for vengeance, and ultimately mend, even enhance, the physician-patient relationship. (College of Physicians and Surgeons of Ontario, 2007)

TRENDS IN APOLOGIES.

There are some important trends occurring in regard to apologies. Apologizing appears to be a growth phenomenon. Research on the subject demonstrates that apology is no longer limited to academic journals and conferences. Apology is the topic of newpapers, magazines, television and radio shows, cartoons, self-help books and other commonly available sources of information. More and more people are exposed to thinking on the subject. Sport heroes, actors, and other celebrities regularly take to the media to offer public apologies for their own wrongdoing. There appears to be an increasing trend for public apologies to be communicated through broadcast media. High profile individuals, commercial ventures, religious institutions and other organizations offer apologies for actions that may be perceived to damage their reputations. Government apologies are provided by politicians and prominent public figures for a wide variety of circumstances. An example is the oft-quoted apology message delivered by President Bill Clinton to the survivors of the Tuskegee experiments in 1997. (Van Dusen and Spies, 2003) This will be discussed in more details under the section on “Elements common to successful apologies”.

SUCCESSFUL EXAMPLES

Empirical evidence has emerged in the United States in the area of medical malpractice litigation that supports the view that offers of apologies and compensation can reduce litigation costs and promote the early resolution of disputes.

In 1987, after losing two medical malpractice cases that cost a total of \$1.5 million US, the Veterans Affairs Medical Centre in Lexington, Kentucky (the “Lexington VA”), a 400 bed hospital, changed its approach to medical mistakes. It adopted a policy of full disclosure

(which will be discussed further in the section “How to apologise?”) and apology. (Ministry of Attorney General, British Columbia, 2006) Their policy encourages employees to report all mistakes and to immediately investigate the incident. The hospital contacts the patient and informs him or her of the error regardless of whether the patient is aware of the error. Hospital personnel then meet with the patient, encouraging him or her to bring counsel and anyone else he or she wishes to the meeting. The patient receives a verbal apology at the meeting and, if desired, a written apology. The hospital also discusses with the patient the steps it intends to take to ensure the incident does not occur in the future. Hospital personnel assist the patient in obtaining further medical care and benefits. Furthermore, when the risk management committee determines the hospital to be at fault, hospital personnel offer a settlement. (Van Dusen and Spies, 2003) This daring and novice approach is credited with reducing lawsuits, settlement costs and defence costs. Seventeen years later, only three cases have gone to trial and the average settlement is US\$16,000, as compared to the national average for veterans' affairs facilities of US\$98,000. In addition, cases closed in two to four months, significantly below the average of two to four years. (Ministry of Attorney General, British Columbia, 2006)

The Catholic Healthcare West system of 41 hospitals and medical centers in California, Nevada, and Arizona, is also taking this approach. COPIC Insurance, a Denver-based medical liability insurer, has gotten into the act with a program called the 3Rs – Recognize, Respond, and Resolve – for unexpected medical outcomes. Patients can receive up to US\$25,000 for additional medical care and up to US\$5,000 to compensate for “loss of time” while still retaining the right to file suit later on. In all of these three programmes, while physicians may offer a personal apology, the organization takes responsibility for making restitution. (Lowes, 2009)

However, one has to study these reports carefully and see whether their findings are applicable to local settings. As Jonathan Cohen points out, not all organisations can adopt the approach of assuming responsibility for injuries, including apology, with (beneficial) financial consequences similar to the Lexington VA (even in the U.S.A.). This is because the legal and economic arguments governing VA hospitals and their employees, as well as the VA's historical relationship with its members, differ from those typical in the private sector. Further, the medical setting has features, such as pre-existing relationships between doctors and patients and an ethic of care, not found in many other contexts. (Cohen, 1999)

Another example in the United States is the hospitals in the University of Michigan's Health System. Since 2002, they have been encouraging doctors to apologize for mistakes. Malpractice lawsuits and notices of intent to sue have fallen from 262 filed in 2001 to about 130 a year. (Ministry of Attorney General, British Columbia, 2006)

DO PATIENTS WANT APOLOGIES?

In a submission to the Select Committee on Health of the UK House of Commons (the DoH submission), the Department of Health stated that those patients involved in clinical negligence disputes had several desires by way of process and outcome: a speedy, fair and cost-effective process that will resolve their disputes effectively, a process that deals with the legal issues and also encompasses their emotional grievances, a chance to meet with the clinician(s) involved, and not just with their legal and executive personnel, a process that can enable them to retain (if desired) a relationship with the perceived 'negligent' clinician and/or hospital, compensation at a 'fair' level, if the claim justifies it, and a chance to 'vent' their grievances, receive explanations, assurances, and even a simple apology. (Procedures relating to adverse clinical incidents and outcome in medical cases, 1999)

In a survey in England, 94 (41.4%) of the 227 patients and relatives who were taking legal action replied yes to the question “once the original incident had occurred could anything have been done which would have meant you did not feel the need to take legal action?” The 94 persons who replied yes gave nine different reasons that might have prevented litigation. Some of them gave two reasons. The number of people who cited explanation and apology as the reason (37) more than doubled those who cited pay compensation (17). (Vincent, Young, and Phillips, 1994)

Similar findings were identified in a survey carried out in 2002 on behalf of the Department of Health in the UK. Patients who had been affected by medical injury were asked what they wanted from the NHS. The response showed that 34% wanted an apology or explanation, and only 11% wanted financial compensation. (Dental Protection Limited, 2011)

In the United States, medical malpractice cases are prevalent and often result in extremely high damages. Apologies have been promoted and supported in many jurisdictions as a way to reduce the suffering of patients and to facilitate conflict resolution. Studies have shown that a significant portion of actions would not have gone to court if the physicians had apologised. (MacLeod, 2008)

Such is also the experience in Hong Kong. To avoid unnecessary legal costs and to save time and frustration for all parties concerned, the Hong Kong Dental Association formed a Patient Complaints Mediation Committee (PCMC) in 2002 to mediate complaints initiated by patients against their dentists. (Hong Kong Dental Association, 2007) The Founding Chairman of PCMC found that patients may make a complaint for a variety of reasons: they may want their dissatisfaction to be heard, want to be taken seriously, want an explanation, want to see action (preferably immediately), want to teach the practitioner/staff a lesson, want compensation or want an apology. (Cheung, 2008) In the experience of the PCMC, while most of the cases are rooted on misunderstanding or miscommunication which gave rise to the first place, others arose from patient dissatisfaction with various aspects of treatment and/or practice management, or from unsatisfactory and failed treatment outcomes. Some patients are happy with simple apologies or clarifications, while others want refunds of paid fees. Most cases result in monetary settlement to the patient to enable them to seek out other options. (Hong Kong Dental Association, 2006)

DO HCPs WANT TO APOLOGISE?

When we were young, we were told by our parents and teachers to say “sorry” if we have done something wrong, especially if we had caused damages, pain or even mere inconvenience to others. Is this still the culture today? It appears so, as this is still the teaching in schools and youth groups such as among boy scouts and girl guides. However, when Mr. Tang King Shing, the former Commissioner of the Hong Kong Police Force, apologised publicly on behalf of the police force a few times when he was in office, he was ridiculed in the internet as ‘Sorry Sir’! One often hear the saying “*To err is human.*” It may be said with equal conviction when error leads to injury that *to apologize is also human.* Certainly, this is true in healthcare, in which the problems of an illness or the complications of a procedure are often unanticipated because our (*medical*) knowledge is always incomplete, and our human imperfections are inescapable. When, in the course of medical treatment, a patient suffers harm, apologizing would seem natural. However, because not all disagreements are capable of an easy solution that comes with saying “I’m sorry,” and because legal confrontation becomes the final avenue for resolving many of these disputes, the legal implication become critically relevant. (Block, 2007)

Virgil Van Dusen and Alan Spies from two different schools of pharmacy believe that ultimately, it boils down to this: if an apology is right for the patient, an apology should be pursued. In applying this standard, the pharmacist maintains the highest professional code of ethics. When faced with this difficult decision (of whether to apologize), pharmacists must look deep within themselves to determine the *right* thing to do. Pharmacy has long been viewed as an ethical, honest, and compassionate profession whose members see those in need and respond appropriately. Offering an apology, when needed, can strengthen this high ethical standard. They also think that the ability to provide an effective apology really separates the master pharmacist from the average pharmacist. (Van Dusen and Spies, 2003)

This author believes that one of the reasons why physicians are reluctant to apologise is because they were not taught the skills of apologizing in medical schools. In the 'good old days', doctors were treated as demi-gods, and patients never challenged what their doctors said or did. Apologies were rare, if any. In the authoritative textbook, Clinical Communication Skills, written by Richard Fielding in 1995, which is still referred to in teaching medical students on the topic, there is no mention of 'apology'. (Fielding, 1995) Even nowadays, when the importance of communication with patients and relatives is fully recognised, apology is not taught in the Clinical Interpersonal Skills Course for medical students. Dr. Mark O'Brien also points out that most doctors lack comprehensive training in recognising the key elements of, and designing effective strategies to work with, patient disappointment. (O'Brien, 2008) This idea of incorporating apology in the curriculum of professional education is shared by academics in two schools of pharmacy in the States. In the introduction section of their Statements entitled "Professional Apology: Dilemma or Opportunity?", Virgil Van Dusen and Alan Spies stated that "Offering a sincere, effective apology at the appropriate time should be the goal of both the legal system and of pharmacy education. With this in mind, the future pharmacist should expect to deal with both a legal and a moral dilemma: wanting to offer an apology but fearing the possible legal repercussions. This article affirms the position that pharmaceutical education should encourage and teach students that attitudes of sympathy and remorse need to be incorporated into the professional life as it relates to patients." (Van Dusen and Spies, 2003)

According to Dr. Aaron Lazare, there are several reasons why physicians are less likely to admit that an apology needs to be (or should be) offered: (a) physicians are apt to be perfectionists who do not like to admit mistakes, (b) many physicians are told by many hospital lawyers never to apologise because that would be an acknowledgment of guilt and enhance the chances of being sued, (c) many physicians were trained in atmospheres in which their personal offences (not medical mistakes) towards patients, nurses, and various students were acceptable as part of the culture. Besides, shame, fear of a lawsuit and isolation from colleagues, are all reasons why doctors avoid apologizing to patients after adverse events. (College of Physicians and Surgeons of Ontario, 2007)

In Malaysia, the Medical Council has a statement that advise doctors to apologise. Although this is not a legal requirement, it is a recognition that it is alright, and actively encouraged, to apologise to patients without fear of legal liabilities. (Teoh, 2013) Perhaps, this kind of practice will help physicians to apologise more freely.

Traditionally, lawyers for both plaintiffs and defendants in civil cases have been resistant to apologies because they perceive that apologies may result in monetary settlements unfavourable to their clients. Furthermore, lawyers tend to focus on economic and legal issues rather than emotional and intangible ones. However, as the advantages of apologies – to both parties – have become more apparent in recent years, lawyers have recognized the need to

work with apologies in appropriate cases and have supported legislation which encourages apologies and limits liability. There is reason to expect that lawyers' receptivity to apologies will increase. (MacLeod, 2008)

In general, lawyers in Hong Kong are still reluctant to advise the accused HCPs to apologise.

VIEWS OF THE PROFESSIONAL INDEMNITY INSURANCE ORGANISATION

For the HCPs, there is also a risk that an apology will have negative legal consequences such as voiding an insurance policy or being taken as evidence of liability. In Hong Kong, most private practitioners who have taken out professional indemnity insurance subscribe to the Medical Protection Society from England (MPS). In a Special Feature article, Dr. Ming Keng Teoh, the Head of Medical Services (Asia) of the MPS, reassures members that saying sorry is not an admission of guilt but is the first step to healing the doctor-patient relationship and preventing the patient from wanting to litigate. Patients expect doctors to be honest and sincere and provide information about what happened to them. It is important that doctors learn from adverse events and show what they have changed in order to reduce the chance of it happening again to another patient. Also, patients are often looking for an expression of regret or sorrow and information on how similar outcomes could be prevented in the future. He further advises that an apology or expression of regret is part of explaining an adverse outcome to the patient or the family. If done with sincerity and in a timely manner it conveys care and humility, and would not be construed as an admission of liability. The focus should be on doing the right thing, which will reduce the risk of a complaint or claim, rather than the feared risk of an apology damaging the chances in defending a claim. (Teoh, 2013) A common concern expressed by doctors about discussing an adverse outcome with a patient, particularly where an expression of regret is considered, is that this may harm their chances of successfully defending any action taken against them by a patient, or that MPS may take a negative view of undertaking such a conversation. Dr. Mark O'Brien of MPS's Educational Services advises that full explanation and showing empathy to a patient after a serious adverse outcome is fully supported by MPS. It is, however, important to highlight the importance of discussing facts – not speculation which should be avoided. Questions should be answered honestly, including an acknowledgment that a question cannot be answered with the current available information if this is the case. (O'Brien, 2010)

HOW TO APOLOGISE?

Dr. Aaron Lazare proposes a four-part apology process which he believes is necessary to meet the needs of the offended party: **acknowledging** the offence; communicating certain attitudes and behaviours (**remorse**, shame, humility, sincerity), offering an **explanation**; and offering **reparations**, using proper timing, and negotiating differences between parties. He considers the most essential part of an effective apology is acknowledging the offense and, without such a foundation, the apology process cannot even begin. He explains that the reason that this part of the apology can be so challenging is that the acknowledgment may involve as many as four parts: 1) correctly identifying the party or parties responsible for the grievance, as well as the party or parties to whom the apology is owed; 2) acknowledging the offending behaviours in adequate detail; 3) recognizing the impact these behaviours had on the victim(s); and 4) confirming that the grievance was a violation of the social or moral contract between the parties. An effective apology requires that the parties reach agreement on all four parts,

although it is common for one or more of the parts to be implicit – that is, not verbally stated. (Lazare, 2004)

The TLC Laser Eye Centers in Dallas, U.S.A. use a five-step process in making a meaningful apology to a patient. The five steps are all 'r-words' and in order they are (1) recognition; (2) regret; (3) responsibility; (4) remedy; and (5) re-alignment. **Recognition** means knowing when to express **regret**. The latter differs in different situations. A basic approach often used is, 'I regret that you have had a bad experience with your surgery. Neither one of us expected you to have these problems. I am very sorry this has happened.'

Responsibility is the most difficult aspect of an apology. It is most important that the doctors be straightforward and completely honest with patients. Their experience has shown that patients expect their doctors to tell them the truth, even if they have to say that they may have done something that caused the patient harm. In fact, it is their experience that a sincere expression of regret and complete assumption of responsibility is the best policy in every instance. Immediately following acceptance of responsibility, they move to offering a precise and clearly stated **remedy** for the patient's problem, and a statement that they will do what they can to use what they learn from the patient's experience to try to prevent others from having the same or a similar problem in the future. If they do not have a remedy yet, they will say so and then clearly state when they will. One final step in the expression of regret is **re-alignment**. The doctor needs to state directly that anything that is learned from the patient, or from what happened, will be used by to try to prevent other patients from having the same or a similar problem in the future. The implementation of this five-step process for expressing regret quickly and sincerely with complete disclosure became the most important step in the beginning of their dispute resolution and conflict management effort. (Potter, 2008)

Also in 2008, Leslie Macleod in Canada identifies seven core elements of apology from the literature. He feels that an effective and authentic apology requires a combination of some or all of these core elements, depending upon the circumstances. These seven core elements are: **recognition** which involves identification of the wrong, acknowledgment of the violation of a norm, and appreciation of the extent of the harm done to the victim; **remorse** which includes genuine expressions relating to regret for the harm that occurred; **repentance** which includes attitudes and behaviours including regret, shame, humility and sincerity and which affirms that the wrongdoer understands and acknowledges the moral wrong that has been committed; **responsibility** which acknowledges that the wrongdoer did harm to the victim; **reparation** or restitution that is often offered as part of the apology to make the victim whole and/or restore the relationship; **reform** which includes personal promises by the transgressor to change behaviour and actions by an individual, organization, or government to prevent future harm or to commemorate the harm; and **reasons** which are explanations to the victim including the circumstances that led to the wrongdoer's actions and/or why victims were harmed. (MacLeod, 2008)

The core elements in common are: recognition (acknowledgment), remorse, repentance (including regret), responsibility, reparation (remedy), reform (re-alignment) and reasons (explanation). To these seven 'r-word' core elements, this author would like to add four more. The first one is '**recount**'. The HCP will ask the patient to give an account of what happened to him and how he feels. The HCP will perform active listening. The second one is '**request**'. The HCP will invite the patient to ask questions on what he wants to know in order to clarify any misunderstanding and doubts in his mind. The third one is '**repeat**'. If the error is a minor one, a single expression of regret from the HCP may be enough. If the damage is more severe, then genuine regret should be expressed more than once at the appropriate time. The HCP will

also try his best to see the patient himself on follow up visits. This gesture will show the patient that he continues to shoulder his responsibility and is keen to maintain and value the professional relationship with the patient. The fourth one is '**reassurance**'. On follow up visits, the HCP will check the progress of the patient, record any measurable improvement and reassure the patient that he is on his way to recovery through the joint efforts of both parties.

ELEMENTS COMMON TO SUCCESSFUL APOLOGIES

Leslie MacLeod also lists the following questions which should be asked when formulating an apology:

Who are the givers of apologies? Apologies have the greatest potential impact if they are delivered by the actual wrongdoer or wrongdoers.

What are the actual circumstances surrounding the harm? The apology must articulate these clearly.

Why is the apology being offered? The reasons must be clearly articulated.

When is the best time to apologise? Apologies offered within a reasonable time have the best chance of meaningful impact.

Where should an apology be offered – in private or in a public forum? Survivors usually call for two kinds of apologies: a personal, private apology, and/or an official, public apology.

How should an apology be offered? Whether it is oral or a written statement should be determined by the needs of the victim.(MacLeod, 2008)

Dr. Alvin Block also identifies several elements which are common to successful apologies. The first one is **who** should apologise, e.g. the attorney (lawyer) or the physician? The former is likely to be more circumspect in choosing proper words but unfortunately often has the undesired effect of spawning victim suspicion. The latter's appearance is far more likely to be viewed as caring and genuine, thereby refocusing attention to reconciliation rather than legal defense. Strangely, even though physicians deal regularly with patients on a close, personal basis, many of them are deficient in communication skills and can unwittingly exacerbate the patient's misgivings in the setting of an adverse event. The second element is **how** the apology should be transmitted. Written apologies generate a needed paper trail and certainly allow a cautious position, but the spoken word is far more powerful and influential. However, emphasis must be placed on sincerity. Any appearance of attempted manipulation can be terribly inflammatory. The third element is **when** the apology should be made. The sooner it comes after the injury, the more satisfying to most patients (in general). When a medical mishap occurs, most physicians ordinarily examine or visit a patient shortly afterwards. If an apology is forthcoming, that moment is a natural one for it. (Block, 2007) As stated above, John Potter's group also found that it was essential to express regret as quickly and sincerely as possible. (Potter, 2008) Dr. Aaron Lazare holds the opinion that it is never too late to apologize. Interestingly, he also described an unhappy experience of a "premature apology" from his 30-year-old nephew who had played a practical joke on him. When he exploded, his nephew interrupted him with profuse apologies after only 10 seconds. This annoyed him because he wanted his nephew to be quiet while he expressed his anger. He thought that if his nephew had the forbearance to allow him to vent his anger and then apologize, they could have had a civil conversation afterwards. (Lazare, 2004) Dr. Alvin Block's fourth element is the **wording** of an apology, which he thinks is a critically important ingredient. It is important to appreciate the fact that at least two people are involved in these matters – the physician, who presumably knows his or her own feelings, and the patient, who

is forming impressions from both the words and demeanor of the physician. There is a lot of room for misunderstanding. Finally, **genuineness** is important too. An apology that bears the trace marks of insincerity, by word or manner, is a drawn bow, almost certain to provoke distrust and anger. Not everyone is adept at communication. In the potentially explosive situation of harm having been done to a patient, such things as tone of voice, speed of words, appearing distracted or uninterested, and failing to look directly at the injured party receiving the apology can all convey the wrong message and, in doing so, impair or nullify the apology. (Block, 2007)

An oft-quoted example of a successful apology was the one delivered by President Bill Clinton to the survivors of the Tuskegee experiments in 1997. The “Tuskegee Study of Untreated Syphilis in the Negro Male” occurred in 1932, with 399 indigent Southern black men who were recruited by health researchers to chart the progress of the disease. The study's purpose was to withhold treatment and compare the health of those individuals with syphilis to the health of those without the disease. Because government health workers recruited them, the participants believed they received free medical treatment. At the conclusion of the study in the 1940's, 100 men had died of syphilis, 40 wives had been infected, and 19 children had contracted the disease at birth. In the 1970s, the US Government began compensating participants with a US\$10 million out-of-court settlement and provision of free medical care. However, the government never admitted any prior wrongdoing until 1997 when President Clinton, at a White House ceremony said, “....The American people are sorry – for the loss, for the years of hurt. You did nothing wrong, but you were grievously wronged. I apologise and I am sorry that this apology has been so long in coming.....” Though nearly 65 years had passed since the beginning of the study, response to the apology by the survivors of Tuskegee was one of relief and gratitude. (Van Dusen and Spies, 2003) This is also an example of a formal public apology offered by the government referred to in an earlier section on “Trends in apologies”.

Of equal importance is to avoid treacherous expressions. In apologizing, it is essential to shun unnecessarily incriminating expressions such as “I regret that we didn't anticipate” or “I wish that we had done ...”. Also in the category of risky disclosures are “My weekend coverage didn't know that you had been taking blah, blah” or “My nurse didn't understand that you had been told ...”. Especially incendiary are expressions that sound like an admonishment, such as “Why didn't you let us know”. To patients, these sound accusatory and tend to be interpreted as the physician's ploy to shift blame away from himself or herself on to the patient, inciting anger and resentment. (Block, 2007)

THE USE OF APOLOGIES IN MEDIATION

Mediation as a form of alternative dispute resolution has gained much popularity in recent years in Hong Kong. With the introduction of Civil Justice Reform in 2008, implementation of the Practice Direction 31 on mediation in 2009 and the enactment of Mediation Ordinance in 2013, mediation has been used increasingly in health care disputes with success.

Mediation can be defined as a structured process comprising one or more sessions in which one or more impartial individuals, without adjudicating a dispute or any aspect of it, assist the parties to the dispute to do any or all of the following – (a) identify the issues in dispute; (b) explore and generate options; (c) communicate with one another and (d) reach an agreement regarding the resolution of the whole, or part, of the dispute. (Mediation Ordinance, 2013)

In terms of using apologies to facilitate resolution, mediation offers a number of advantages over litigation. Firstly, apologies (in mediation) are typically protected from being used as an

admission of liability. Secondly, apologies may direct parties to innovative remedies that a court would not order. Thirdly, parties are at the centre of mediation and are encouraged to interact in a non-adversarial way. Fourthly, mediators can assist the parties in crafting apologies and statements of forgiveness that are responsive to the needs and expectations of the parties. Lastly, mediation is a flexible process that can be tailored to give sufficient time and attention to the potential of apologies. (MacLeod, 2008)

This author believes that, because of the assurance of confidentiality in mediation, the HCPs can apologise more freely with sincerity in the course of mediation, which helps the patients and relatives to heal their emotion wound and thus make it easier to accept the offer made by the HCPs and reach a settlement agreement.

An exemplary illustration is found in the scandal of Alder Hey Children Hospital and the University of Liverpool in England. In September 1999, over 1,100 parents accidentally discovered that organs of their children who passed away in the Children Hospital were removed and kept by the hospital without their consents. Law suits were filed and the disputes were finally settled out of court by mediation. The settlement terms included payment of five thousand pounds for each deceased child, the hospital trust also agreed to send out personal letters of apology and regret to parents, put up a commemorative plaque at the hospital, make a five thousand pounds contribution to a memorial to be located in Liverpool, and arrange a future meeting with parents to discuss changes in practice and procedure at the hospital. The university agreed to donate to charities nominated by the parents' trust. In a press conference, formal and public apologies were made by the chairperson of the hospital trust, the vice-chancellor of the University and the health minister. The solicitor for the majority of parents remarked that the apologies made on that day were a crucial factor in settling the litigation and allowing parents to move on. He said: "Had it not been for today's press conference, the letters of apology and the plaque to be erected at Alder Hey, the litigation would have continued for the simple reason that no amount of money could ever compensate the parents for the trauma which they have had to endure during the course of the last three and a half years." (The Guardian, 1 February and 27 February 2003)

Prof. Robyn Carroll also points that, in many instances, mediation provides a broader safe harbour for apologies because it protects apologies that include an admission of fault or wrongdoing (full apologies) as well as statements of regret and sympathy that are not a full apology. In contrast, apology legislation in many jurisdictions does not offer protection to all types of apologies (only to partial apologies) or apply as broadly to civil disputes. (Carroll, 2014) The privilege conferred on mediation communications in some circumstances is wider than common law privilege. However, she also cautions that there are limits to the protection provided by confidentiality agreements. The remedies available against a person who breaches confidentiality are limited in scope and effectiveness. Even if damages can be shown to result from a breach of confidentiality, a damages remedy may fall short of compensating from the harm resulting from the breach. (Carroll, 2005) Mediation and apology legislation may be used together to complement each other, and the combined beneficial effects will be much greater.

APOLOGY LEGISLATIONS

Apologies are important to civil society. Protecting apologies is important as a way of increasing civil behaviour. (Vines, 2008) As discussed above, there are legal and insurance implications which deter the accused in civil litigation from making apologies other than in a 'safe' setting such as in mediation.

Lawyers are bound to make sure they protect their clients from adverse consequences in case the matter ends up before a judge. This is why lawyers are careful to protect their client from making statements that could later come back to haunt them if the matter does not settle before trial as everyone hopes. Lawyers are interested in protecting the interests of their *particular* client who is not a statistic or someone else's happy-ending story. (Morris, 2003)

To overcome this, many jurisdictions in the world have enacted apology legislation to address these concerns. In essence, such legislation will provide that an apology does not constitute an express or implied admission of fault or liability in connection with that incident or void an insurance policy.

State of Massachusetts in the United States enacted the world's first apology legislation designed to enhance settlement way back in 1986. (Massachusetts General Laws, 1986) After that many States have followed. As of January 2009, 36 States (including Massachusetts and Washington, DC) have enacted various forms of apology laws between 1999 and 2008 (except for Massachusetts, whose law dates back to 1986). Massachusetts, Texas, California, Florida, Washington and Tennessee, have general apology statutes that apply across all industries while the other 30 States have specific laws that only protect the statements of apology made by health care providers. (Ho and Liu, 2011a) It is interesting to note that those six States which have general apology statutes that apply across all industries are also the first six States which enacted apology legislation in the United States.

In general, there are two forms of apology legislation. A limited form provides that an expression of sympathy or regret is not admissible to establish liability; however, that part of an apology that contains an admission of fault or liability is either not specifically protected or is specifically excluded. This type of legislation is in place in a number of U.S. States, (such as Massachusetts, Texas, California and Florida). A more robust form protects both an expression of sympathy or regret and apologies that contain admissions of fault or liability. For example, the U.S. States of Colorado and Oregon have enacted this kind of legislation. (MacLeod, 2008) In other words, the limited form will only protect 'partial' apologies whereas the robust form will protect 'full' apologies.

Other common law jurisdictions also followed the United States and passed apology legislation in one form or another. The Australian state of New South Wales enacted the Civil Liability Act in 2002. Then came the Apology Act in British Columbia, in May 2006, which was the first one in Canada. This was followed by the English Compensation Act in July 2006.

Jonathan Cohen identified four broad (and) overlapping reasons to support these laws., a) they encourage settlement and avoid needless litigation; b) they promote natural, open and direct dialogue between people after injuries; c) they express the culmination of the logic already implicit in the evidence codes; and, perhaps most basically; d) they encourage people to engage in the moral and humane act of apologizing after they have injured another. (Cohen, 2002)

Experience from overseas has indicated that apology legislation is particularly useful in medical-related disputes. Using a difference-in-differences estimation (a novel mathematical model), Benjamin Ho and Elaine Liu find that apology laws, which exclude apologies from being used as evidence in medical malpractice litigation, expedite the speed of resolution. They also find that apologies are most effective in cases involving obstetrics and anaesthesia, in cases involving improper management or a failure to diagnose, and in cases involving infants and small children. (Ho and Liu, 2011b)

SCENARIO IN HONG KONG

This author was the first person to speak publicly about legislating apology in Hong Kong to an audience of international and Hong Kong surgeons as well as judges and lawyers on 16 May 2008. The Civil Liability Act 2002 of New South Wales, the Apology Act 2006 of British Columbia and the Compensation Act 2006 in the UK were quoted. The definition of 'apology', its effect on liability and the ways to determine damages for non-economic loss were also presented. It was explained to the audience that "such an Act helps to ease the mind of the surgeon, who can express themselves more freely and apologises without fear of interpreted by others as being at fault." The legislative body was urged to pass a similar law in Hong Kong. (Chiu, 2008 a) The presentation was subsequently published in the same month in a journal. (Chiu, 2008 b) This was the first publication on the topic of apology legislation from Hong Kong.

Almost two years later, a Report of the Working Group on Mediation was published by the Department of Justice. In the section on "Apology", it was pointed out that experience in other common law jurisdictions has demonstrated the benefits that could be brought about by legislation on apology. Although experience in other jurisdictions would have to be considered with care, it is generally accepted (especially amongst mediators) that apologies are particularly relevant in disputes that have a personal element (such as employment disputes, personal injuries and especially medical malpractice) as they can change the dynamics between the parties. In principle, the Working Group saw the advantage of introducing legislative provisions to deal with apologies in the context of mediation. (Department of Justice, the Government of the HKSAR, 2010)

In November 2012, in a speech made at the Joint Conferment Ceremony of the Royal College of Surgeons of Edinburgh and the Hong Kong College of Otorhinolaryngologists, the Hon Mr Rimsky Yuen SC, the Secretary for Justice, informed the audience that "a new Steering Committee on Mediation, together with its three Sub-Committees, are in the process of being established. Members will include representatives of all the key stakeholders including the medical profession. One area of work which will be undertaken by the Steering Committee and which is particularly relevant to medical disputes is the intended study on whether Hong Kong should have an Apology Ordinance or legislative provision dealing with the making of apologies for the purpose of enhancing settlement. It is a form of corrective justice which plays an important role in dispute resolution." He then quoted the Irish Law Reform Commission which recommended that "a statutory provision be considered which would allow medical practitioners to make an apology and explanation without these being considered as an admission of liability in a medical negligence claim". Mr. Yuen went on to say that "In short, experiences and studies in other jurisdictions show that the offer of an apology may have an important effect and may even be instrumental in achieving a settlement, and legislation dealing with the making and effect of apology can be particularly useful in promoting the use of mediation to resolve medical disputes." (Yuen, 2012)

Three days later, the Steering Committee and its three Sub-Committees were established. One of the Sub-Committees was the Regulatory Framework Sub-Committee. Among other tasks, it was assigned to study whether there should be an Apology Ordinance in Hong Kong. A Working Group on Apology Legislation was then formed under this Sub-Committee for that purpose in 2013. A Consultation Paper has been published and general consultation has been launched.

The idea of enacting an apology legislation is welcomed by the media. In an editorial entitled "Making 'sorry' far easier to say", the editor of a newspaper quoted statistics from the

former Ombudsman Mr. Alan Lai and concluded that “Generally, we can do without more laws and regulations to govern our lives. But, given figures like that, a sorry law makes sense.” (Sunday Morning Post, 2013) The response from the Chinese language newspaper is also positive (Hong Kong Economic Times, 2013)

If enacted, it may be the first one in Asia.

IS APOLOGY LEGISLATION WELCOMED BY ALL?

Not all academics are in favour of Apology Legislation. There are compelling arguments in support of apology legislation (some of them have been discussed) and arguments against it. Some of the arguments against apology legislation include; a) it might encourage insincere and strategic apologies by sophisticated defendants who may thus take advantage of less sophisticated plaintiffs; b) it might preclude evidence of admissions that some plaintiffs might need to prove their case; and c) apologies encouraged by such legislation might create an emotional vulnerability in plaintiffs who might accept low and unfair settlements. (Morris, 2003)

The evident trend towards the enactment of apology legislation demonstrates that the arguments in favour of such legislation outweigh the arguments against. Legislatures throughout the world have embraced the potential for apology legislation to support moral, social and legal justifications for apologies. (MacLeod, 2008)

It must be pointed that the purpose of introducing apology legislation is not to replace the civil law court system, but to offer an alternative way of resolving disputes which will be beneficial to both parties.

CONCLUSIONS

Overseas experience has demonstrated the benefits of sincere apologies to both parties, such as healing humiliations, freeing the mind from guilt, removing the desire for vengeance and ultimately mend, even enhance, the relationship between HCPs and patients/relatives. From the perspective of risk management, if an apology is given at an early stage, it can promote early resolution of a dispute and result in significant savings. An apology legislation is particularly useful in medical-related disputes. Although not all academics are in favour of the enactment of apology legislation, the evident trend demonstrates that the arguments in its favour outweigh those against it. Apologies will also enhance the chances of successful mediation. An Apology Ordinance will facilitate dispute resolution and also enhance the scope of risk management in Hong Kong. If enacted, this may be the first one in Asia.

However, until then, it is advisable to consult the lawyers, the professional indemnity insurance organisations or senior colleagues before a HCP makes an apology to a patient or relative, whether verbally or in writing, unless the error is a minor one.

It must be pointed out that the purpose of introducing apology legislation is not to replace the civil law court system, but to offer an alternative way of resolving disputes which will be beneficial to both parties.

Looking ahead, it will also be beneficial to everybody if the medical and health-related professional schools will consider providing lectures and training on 'apology' in the curriculum of their students.

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DETERMINANTS OF CONTINUANCE INTENTION TOWARD LOCATION INFORMATION DISCLOSURE IN SOCIAL NETWORKING SITES: THE PERSPECTIVES OF PRIVACY CALCULUS, TRUST, AND PERSONAL INNOVATIVENESS

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ABSTRACT

By integrating the literature of privacy calculus and trust, this study develops a theoretical model to examine the factors affecting continuance intention of location information disclosure in the social networking sites context. Data collected from 302 users of Facebook were used to test the proposed model. The results show that perceived value and trust are the key predictors of continuance intention toward location information disclosure. The results also reveal that perceived benefits have positive effects on perceived value, whereas perceived risk exerts significant influences on perceived concerns and trust. The results, on the hand, self-regulation and government regulation has significant effects on trust as well. Finally, the results show that perceived value and trust exert stronger effects on continuance intention of location information disclosure for high-innovativeness users, while perceived concerns have stronger effect on continuance intention of location information disclosure for low-innovativeness users. The implications for theory and practice and suggestions for future research are also discussed.

KEYWORDS: Social networking sites, Privacy calculus, Trust

INTRODUCTION

Social networking sites (SNS) have attracted millions of Internet user to create their profile and interact with others by sharing texts, photos, and videos (Chen, 2013; Lin and Lu, 2011). Recently, the popularity of GPS-enabled mobile devices also enables users to employ SNS (e.g., Facebook) to disclose their location information on the Internet. Disclosing location information via SNS has become a popular activity in some countries, such as the United States and Taiwan (Central News Agency, 2013). However, disclosing location information often reveals a person's real time position and it generally can be considered as a kind of

potential intrusion of privacy (Xu et al., 2010). Researchers agree that concern about information privacy is a vital factor inhibiting personal information disclosure (Culnan and Bies, 2003). This raises an interesting question: why users use SNS to disclose location information continuously?

The issue of information privacy has drawn considerable attention among researchers during the past decade. However, much of the literature has addressed information privacy in the context of e-commerce (e.g., Dinev and Hart, 2006; Liao et al., 2011). Less is known about self-disclosure behavior, such as location information disclosure, in SNS (Chen, 2013). In this study, we develop and test a theoretical model empirically to explore the factors related to users' continuance intention of location information disclosure in SNS. Generally, an individuals' decision for disclosing privacy information is often determined by the analysis of costs and benefits (i.e., privacy calculus) (Culnan and Bies, 2003; Li, 2012), since people will perform a specific behavior only when benefits exceed costs (Dinev and Hart, 2006; Li, 2012). In this sense, we argue that perceived value and perceived concerns are the factors that will determine of continuance intention of location information disclosure, according to the previous literature on privacy calculus (Dinev and Hart, 2006; Xu et al., 2011). We then theoretically propose that perceived benefits and perceived risk may exert direct effects on perceived value, while perceived risk will have positive influence on privacy concerns.

On the other hand, previous literature argues that trust is a vital factors that affecting behavioral intention in the stage of continuance usage (Xu et al. 2010). Thus, we consider that trust is the predictor of continuance intention of location information disclosure. This is consistent with Culnan and Bies (2003) and Dinev and Hart (2006). Furthermore, according to the perspective of institution-based trust (Pavlou, 2002; Zucker, 1986), we postulate that self-regulation and government regulation are the two institutional factors that will affect trust development. In addition, researchers argue that individual differences such as personal innovativeness would moderate the link between behavioral intention and its antecedents, since an individual with higher personal innovativeness is more prone to take risk (Yi et al., 2006). Thus, in this study, personal innovativeness is included to test its moderating effects on the linkages between continuance intention of location information disclosure and its determinants (i.e., perceived value, trust, and privacy concerns).

Overall, the objective of this study is to examine the antecedent factors of continuance intention of location information disclosure by integrating the literature of privacy calculus and trust. While some recent studies have revealed that perceived value, privacy concerns, and trust are the factors affecting users' willingness to disclose privacy information, few studies have been done to test the inter-twined effect of perceived value, privacy concerns, and trust on continuance intention of location information disclosure. Few studies, on the

other hand, have been conducted to test the moderating effects of personal innovativeness on the relationships between continuance intention and its antecedents as well. The findings may help both academics and practitioners gain insights into how to promote users' continued usage behavior in SNS.

THEORETICAL BACKGROUND AND RESEARCH MODEL

Figure 1 presents the research model of this study. The model illustrates that perceived value, privacy concerns, and trust are the determinants of continuance intention of location information disclosure. The model also asserts that perceived benefits and perceived risk will influence perceived value, while perceived risk has positive impact on privacy concerns. The model, on the other hand, posits that perceived risk, self-regulation, and government regulation will impact trust. The following sections elaborate on the construct in the model and the proposed relationships among them.

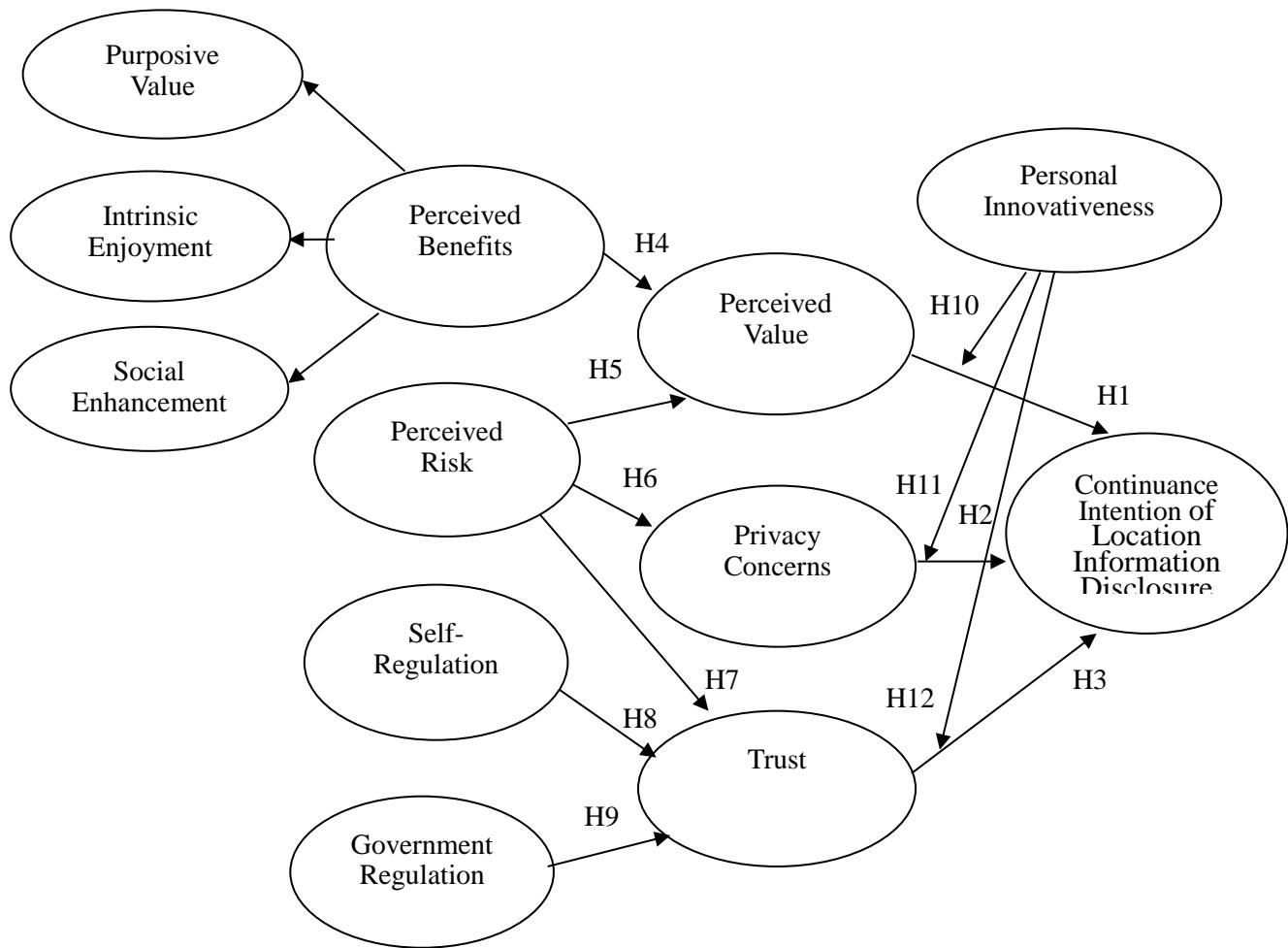


Figure 1 Research Model

Determinants of continuance intention of location information disclosure

Privacy refers to the capability how one to control his/her personal information is used and acquired (Liao et al., 2011; Westin, 1967). Generally, privacy is highly value and people tend to disclose their privacy information by performing risk-benefits analysis (Dinev and Hart, 2006), or what we refer to as the “privacy calculus” (Culnan and Bies, 2003). That is, people are more likely to accept the loss of privacy if they can receive a positive net outcome based on the risk-benefits calculus (Culnan and Bies, 2003).

The perspective of privacy calculus has been widely used to explore the antecedents of privacy information disclosure (e.g., Dinev and Hart, 2006; Xu et al., 2011; Xu et al., 2012). In the recent studies, perceived value and perceived concerns are considered as the factor that can present the outcomes of privacy calculus, which in turn affect a person’s intention to disclose privacy information (Dinev and Hart, 2006; Xu et al., 2011). Accordingly, perceived value and perceived concerns are considered as the determinants of continuance intention of location information disclosure in this study. In addition, trust is treated as a contextual factor that may impact privacy disclosure intention (Malhotra et al., 2004). In this sense, trust is used as the antecedent of continuance intention of location information disclosure, following Dinev and Hart (2006) and Liao et al. (2011).

Perceived value refers to an individual’s overall assessment of the utility of product based on what is received and what is given (Lin et al., 2012; Zeithaml, 1988). In this study, perceived value is defined as the benefits received from personal information disclosure, considering the time and effort spent (Chiu et al., 2012). In general, an individual tends to use a information technology (IT) continuously when he/her perceives that the value of IT usage is high (Lin et al., 2012). Based on the utility maximization theory, Li (2012) also assert that perceived value determines the personal information disclosure. Some empirical studies also find that perceived value is closely related to continuance intention towards information technologies usage (e.g., Lin et al., 2012, Lin and Wang, 2006) and personal information disclosure (Xu et al., 2011). Thus,

H1: Perceived value will have a positive effect on continuance intention of location information disclosure.

In the online context, activities on information access from others may potentially threaten an individual’s ability to control how others can use his/her personal information (Xu et al., 2012). As a result, concerns about how much individuals can protect their information may arise (Liao et al., 2011). Privacy concerns are defined as one’s concerns that who has access to the information disclosed in the Internet and how it is used (Lowry et al., 2011). Privacy concerns are the vital factor that will inhibit one’s willingness to disclose personal information on the Internet (Dinev and Hart, 2006). Prior literature suggests that users who

express their concerns about their privacy are likely less willing to share personal information (Awad and Krishnan, 2006; Stone et al., 1983). Similarly, according to the utility theory, researchers argue that privacy concern increase disutility and thus impact users' willingness to disclose personal information (Bansal et al., 2010). Many studies have provided empirical evidences to support the link between privacy concerns and personal information disclosure (e.g., Bansal et al., 2010; Dinev and Hart, 2006; Liao et al., 2011). Thus, we may expect that privacy concerns may mitigate users' intention to disclose location information via SNS continuously.

H2: Privacy concerns will have an negative effect on continence intention of location information disclosure.

Trust, on the other hand, refers to an individual's subjective belief that other people will perform expected behaviors and will not act opportunistically by taking advantage of the situation (Qureshi et al. 2009). Trust is an important factor that may facilitate an individual's behavior because trust could reduce social complexity by ruling out undesired, yet possible, future behavior of others and thus increases one's belief that their expected benefits can be fulfilled (Gefen et al. 2005; Hsu et al., 2011). That is, trust reflects an individual's willingness to assume the risks of information disclosure (Culnan and Bies, 2003; Mayer et al. 1995). Trust has been found to be a strong predictor of personal information disclosure in the prior literature (e.g., Dinev and Hart, 2006; Liao et al., 2011). Therefore,

H3: Trust will have a positive effect on continence intention of location information disclosure.

Antecedents of perceived value

Xu et al. (2011) argue that perceived benefits and perceived risk are the factors that will affect perceived value. Perceived benefits refer to the advantages resulted from IT usage (Lin et al., 2012). Past studies provide three important benefits for SNS usage: purposive value, intrinsic enjoyment, and social enhancement (Dholakia et al, 2004; Okazaki, 2009). Purposive value refers to the value derived from accomplishing some pre-determined instrumental purpose, such as information exchange (Dholakia et al, 2004; Okazaki, 2009), while intrinsic enjoyment reflects the benefit received from the multisensory, fantasy and emotive aspects of SNS use (Chiu et al., 2012). Social enhancement, on the other hand, is the benefits derived from establishing and maintaining contact with others (Dholakia et al, 2004; Okazaki, 2009). In this study, perceived benefits could be conceptualized as a second-order latent construct with purposive value, intrinsic enjoyment, and social enhancement components.

According to the viewpoint of privacy calculus, users will continue to disclose personal information when they perceive that the receive benefits they receive could exceed the current or future risks of disclosure (Culnan and Bies, 2003). Generally, a higher benefits will

enhance the overall assessment of the value of information disclosure (Xu et al., 2011), because users may perceive that adequate benefits will be received (Culnan and Bies, 2003). Recent empirical studies have highlighted that perceived benefits will facilitate users' value perception (e.g., Lin et al., 2012; Xu et al., 2011). Therefore,

H4: Perceived benefits will have a positive effect on perceived value.

In this study, perceived risk is defined as the extent to which a user believes that the release of location information will lead to the high potential of loss (Featherman and Pavlou, 2003; Malhotra et al., 2004; Xu et al., 2011). According to prior studies, the location information submitted to SNS may be used opportunistically, such as selling personal data to or sharing information with third parties (Xu et al., 2011), and improper handling information will result in the visibility of personal behavior (Beinat, 2001; Clarke, 2001; Xu et al., 2011). Such privacy invasion will lower the value of information disclosure (Xu et al., 2011). Xu et al.'s (2011) study also provides empirical evidence to support that perceived risk will mitigate users' value perception. Thus,

H5: Perceived risk will have a negative effect on perceived value.

Antecedents of perceived concerns

Perceived risk should be related to the privacy concerns, as depicted by Dinev and Hart (2006). As mentioned earlier, privacy concerns are the beliefs that who has access to the information disclosed in the Internet and how it can be used (Dinev and Hart, 2006). In general, disclosing information over the Internet may increase privacy concerns (Dinev and Hart, 2006). This is because technology tools will allow people to collect and utilize others' personal information easily. This may lead to a greater risk about who has access to the information disclosed on the Internet and how it is used (Dinev and Hart, 2006; Liao et al., 2011). That implies that users will have greater concerns about who has access to the personal information they disclose when they perceive the higher privacy risk due to the lack of control of individuals (Dinev and Hart, 2006; Liao et al., 2011; Xu et al., 2008). Empirical studies have revealed that perceived risk has a positive effect on perceived concerns (e.g., Dinev and Hart, 2006; Liao et al., 2011). Thus,

H6: Perceived risk will have a positive effect on privacy concerns.

Antecedents of trust

Prior studies argue that perceived risk will impact the development of trust (Dinev and Hart, 2006; Liao et al., 2011). According to Mayer et al. (1995), trust is "the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor" (p. 712). This implies that trusting beliefs are based on some level of risk (Dinev and Hart, 2006; Jarvenpaa et al., 2000; Tan and Thoen 2001). Hence, the greater level of perceived risk will lead to lower degree of trust. Empirical

evidence from prior literature has supported that perceived risk will exert negative influence on trust (e.g., Dinev and Hart, 2006). Thus,

H7: Perceived risk will have a negative effect on trust.

In the literature of information privacy, researchers agree that self-regulation and government regulation could be considered as the factors related procedural fairness that can have major effect on trust (Culnan and Armstrong, 1999). Similarly, the viewpoint of institution-based trust (Pavlou, 2002; Zucker, 1986) suggests that institutional factors such as regulations and laws will impact the development of trust. In this study, we treat self-regulation and government regulation as the antecedent factors of trust.

Self-regulation is a commonly used approach for protecting users' information privacy (Xu et al., 2010). Self-regulation ensures that service providers commit to use users data responsibly and keep the information safe and privacy (Hui et al., 2007; Xu et al., 2010). In general, the principles of fair information practice (FIP), such as privacy statement, policies regarding consumer information collection, and security for the personal information, could be the useful self-regulation mechanisms for service providers to protect privacy information (Hui et al., 2007; Xu et al., 2010). These self-regulatory efforts will enable users to believe that service providers will act fairly in the process of collecting and using user information (Xu et al., 2010) and thereby help users make a more accurate assessment of the risks of personal information disclosure (Hui et al., 2007) and enhance trust (Tang et al., 2008). Therefore, we propose the following hypothesis.

H8: Self-regulation will have a positive effect on trust.

Government regulation is another commonly approach used for protecting personal information (Xu et al., 2010; Xu et al., 2012). Government regulation embodies strong institutional structural assurances provided by government agencies (Gibson and Caldeira, 1996; Xu et al., 2010; Zucker, 1986). With government regulation, users will believe that personal information disclosed on the Internet could be against misuse and breach (Swire 1997; Xu et al., 2012). As such, government regulation is likely to enhance users' procedural justice perceptions toward service providers' privacy practices (Xu et al., 2010). Past literature reveals that procedure fairness is a vital determinant of trust (Turel et al., 2008). Therefore, we may expect that government regulation will facilitate the development of trust.

H9: Government regulation will have a positive effect on trust.

The moderating effect of personal innovativeness

Personal innovativeness refers to the willingness of an individual to try out new technology (Agarwal and Prasad, 1998; Xu et al., 2011; Yi et al., 2006). Personal innovativeness has been considered as the factors that will moderate the behavioral intention and its antecedents (Yi et al., 2006). Thus, we may expect that personal innovativeness will exert moderating influence

on the link between continuance intention to disclose location information and its determinants.

According to innovation diffusion theory (IDT) (Rogers, 2003), users' tendency toward adopting a technology in different stages due to their difference in innovativeness (Yi et al., 2006). Accordingly, users can be classified into one of five categories: early adopters, early majority, late majority, and laggards (Yi et al., 2006). In general, related to users with lower level of innovativeness (later adopters), users with higher level of innovativeness (earlier adopters) involved in more interpersonal communication (Brancheau and Wetherbe, 1990; Yi et al., 2006). They are also engage in advice giving and seeking activities more frequently than users with lower level of innovativeness (Yi et al., 2006). In addition, users with higher level of innovativeness will feel that they are respected by their peers due to the first-hand knowledge of innovation (Yi et al., 2006). By synthesizing the above arguments, we may recognize that users with higher level of innovativeness will be more confident that they can obtain the advantages associated with a technology usage than those with lower level of innovativeness (Yi et al., 2006). Therefore, we may propose the following hypothesis.

H10: The link between perceived value and continuance intention of location information disclosure will be stronger for high-innovativeness users than that for low-innovativeness users.

On the other hand, the relationship between privacy concerns and continuance intention of location information disclosure may be moderated by personal innovativeness as well. Generally, innovation of technology involves greater risk and uncertainty (Thiesse, 2007; Xu et al., 2011). According to IDT, users with higher level of innovativeness are more likely take risk of using a new technology (Roger, 2003). This implies that a more innovative individual should be more likely to cope with higher risks about personal information misuse and thus should develop more positive attitude toward the location information disclosure (Xu et al., 2011). Therefore, we may expect that privacy concerns will exert stronger effect on continuance intention of location information disclosure for users with lower level of personal innovativeness.

H11: The link between privacy concerns and continuance intention of location information disclosure will be stronger for low-innovativeness users than that for high-innovativeness users.

IDT also suggest that a more innovative individual believes that he/she possesses the ability to control his/her future and to perform the behavior successfully (Yi et al., 2006). As such, highly innovative individuals may consider that the new technology is easy to use (Yi et al., 2006 decision science). Previous literature finds that perceived ease of use impacts trust significantly (Gefen et al., 2003). Accordingly, we may expect that trust will exert stronger

effect on continuance intention to disclose location information for user with higher level of innovativeness. Thus,

H12: The link between trust and continuance intention of location information disclosure will be stronger for high-innovativeness users than that for low-innovativeness users.

RESEARCH METHODOLOGY

Survey administration

The proposed model was tested using the data collected from the users of Facebook in Taiwan, since it is a well-known SNS in Taiwan. According to a recent survey, international airports are the popular places where users will disclose their current positions (Central News Agency, 2013), since users tend to enhance their identity and satisfy social interactive needs by disclosing their location information. In this study, users who have disclosed their location at international airports in Taiwan were invited to support this survey. In order to target respondents, a banner with a hyperlink connecting to the Web survey was posted on a number of bulletin board systems (BBS) and Facebook of Groupon. The respondents were instructed to answer all of the questions based on their usage experience with location information disclosure in the Facebook. The first page of Web questionnaire stated the purpose of this study and assured the confidentiality. At the end of data collection, a total of 302 questionnaires were collected for further data analysis.

Measurement Development

The questionnaire was developed by adapting measures had been validated by prior literature. Two experts in the IS field were invited to support the pre-test of the survey to improve the face validity of the instrument. Furthermore, an online pilot test was carried out using 25 undergraduate students with location information disclosure experience. The instrument was then modified slightly in accordance with their comments. For all measures, a five-point Likert scale was used with anchors ranging from strongly disagree (1) to strongly agree (5).

DATA ANALYSIS

Partial least square (PLS) was employed for data analysis since PLS is well suited for highly complex predictive models, such as the current research (Xu et al., 2011). Following Anderson and Gerbing (1988), we utilized a two-step approach to conduct data analysis. The measurement model was assessed first, and then the structural model was examined to test the relationships among the latent constructs. In this study, SmartPLS 2.0 M3 (Ringle et al., 2005) was used in our data analysis.

Measurement Model

The criteria of reliability, convergent validity, and discriminant validity were used to assess

the adequacy of measurement model. First, Table 1 shows that all of the composite reliability (CR) values ranged from 0.87 to 0.95, indicating the accepted reliability. Second, all values of factor loading exceed the criteria 0.7 and the average variance extracted (AVE) are above 0.5. The results support the adequate convergent validity (Fornell and Larcker, 1981) Finally, as shown in Table 2, the square root of the AVE exceeds the correlation shared between the construct and other constructs in the model (Fornell and Larcker, 1981), confirming the adequate discriminant validity (Fornell and Larcker, 1981).

Table 1. The results of reliability and convergent validity testing

Constructs	Factor Loading	CR	AVE
Purposive Value (PP)	0.92	0.95	0.85
	0.93		
	0.93		
Intrinsic Enjoyment (IE)	0.88	0.93	0.2
	0.90		
	0.93		
Social Enhancement (SE)	0.88	0.93	0.72
	0.89		
	0.87		
Perceived Risk (PR)	0.74	0.93	0.82
	0.85		
	0.91		
Self-Regulation (SR)	0.91	0.93	0.82
	0.89		
	0.91		
Government Regulation (GR)	0.92	0.94	0.86
	0.88		
	0.94		
Perceived Value (PV)	0.95	0.94	0.79
	0.91		
	0.92		
Privacy Concerns (PC)	0.84	0.94	0.79
	0.88		
	0.88		

	0.91			
	0.90			
	0.93			
Trust (TR)	0.94	0.94		0.84
	0.88			
	0.89			
Personal Innovativeness (PN)	0.77	0.87		0.69
	0.84			
	0.89			
Continuance Intention (CI)	0.95	0.94		0.83
	0.89			

Table 2. The results of all latent variable correlations

Construct	PP	IE	SE	PR	SR	GR	PV	PC	TR	PN	CI
PP	0.92										
IE	0.60	0.90									
SE	0.60	0.73	0.85								
PR	0.11	0.18	0.18	0.90							
SR	0.29	0.35	0.37	0.15	0.90						
GR	0.12	0.26	0.29	0.28	0.29	0.94					
PV	0.44	0.58	0.63	0.22	0.42	0.40	0.89				
PC	-0.01	0.12	0.16	0.66	0.22	0.26	0.18	0.89			
TR	0.41	0.60	0.56	0.04	0.49	0.41	0.64	0.04	0.92		
PN	0.28	0.40	0.36	0.22	0.31	0.22	0.48	0.15	0.42	0.83	
CI	0.46	0.62	0.60	0.11	0.36	0.31	0.68	0.03	0.58	0.47	0.91

Notes: 1. Diagonal: Square Root of AVEs report along diagonal in bold. 2. Off-diagonals: Correlation between latent variables. 3. PP: purposive value; IE: intrinsic enjoyment; SE: social enhancement; PR: private risk; SR: self-regulation GR: government regulation PV: perceived value; PC: privacy concern; TR: Trust; PN: personal innovativeness; CI: continuance intention.

Structural Model

The theoretical model and hypothesized relationships were evaluated using the bootstrap technique in SmartPLS with a sample size of 500 to generate t-values and standard errors for determining the significance of path coefficients in the structural model. In order to test moderating effect of personal innovativeness, the subgroup analysis approach was used to test the model in full and each subgroup (Ahuja and Thatcher, 2005; Chang et al., 2014). In this

study, the groups were divided into high-personal innovativeness ($N= 144$) and low-personal innovativeness ($N= 158$) using the median (Baron and Kenny, 1986; Chiu et al., 2012). We employed the formula proposed by Chin et al. (1996) (see Appendix A) to evaluate the differences in path coefficients of models of high personal innovativeness and of low personal innovativeness by calculating t-statistics (Ahuja and Thatcher, 2005; Chang et al., 2014).

Figure 2 and Table 3 summary the results of structural model and moderating effect tests. As shown in Figure 2, perceived value and trust exert strong effects on continuance intention ($\beta= 0.54, 0.25$; $t= 9.00, 3.76$, respectively), indicating H1 and H3 are supported. However, privacy concerns have insignificant influence on continuance intention ($\beta= -0.08$, $t= 1.64$), meaning that H2 is not supported. Also, perceived benefits have positive effects on perceived value ($\beta= 0.63$, $t= 17.39$), thus supporting H4. Privacy risk exerts significant influences on privacy concerns and trust ($\beta= 0.66, -0.12$; $t= 18.44, 2.24$), while it does not have significant impact on perceived value ($\beta= 0.10$, $t= 1.83$). Thus, H6 and H7 are supported, whereas H5 is not supported. Self-regulation and government regulation, on the other hand, have positive effects on trust ($\beta= 0.42, 0.16$; $t= 6.40, 2.36$, respectively), validating H8 and H9. In addition, Table 3 shows that perceived value and trust exert stronger effects on continuance intention for users with higher level of personal innovativeness and privacy concern has higher influence on continuance intention with users with lower level of personal innovativeness. Hence, H10, H11 and H12 are supported.

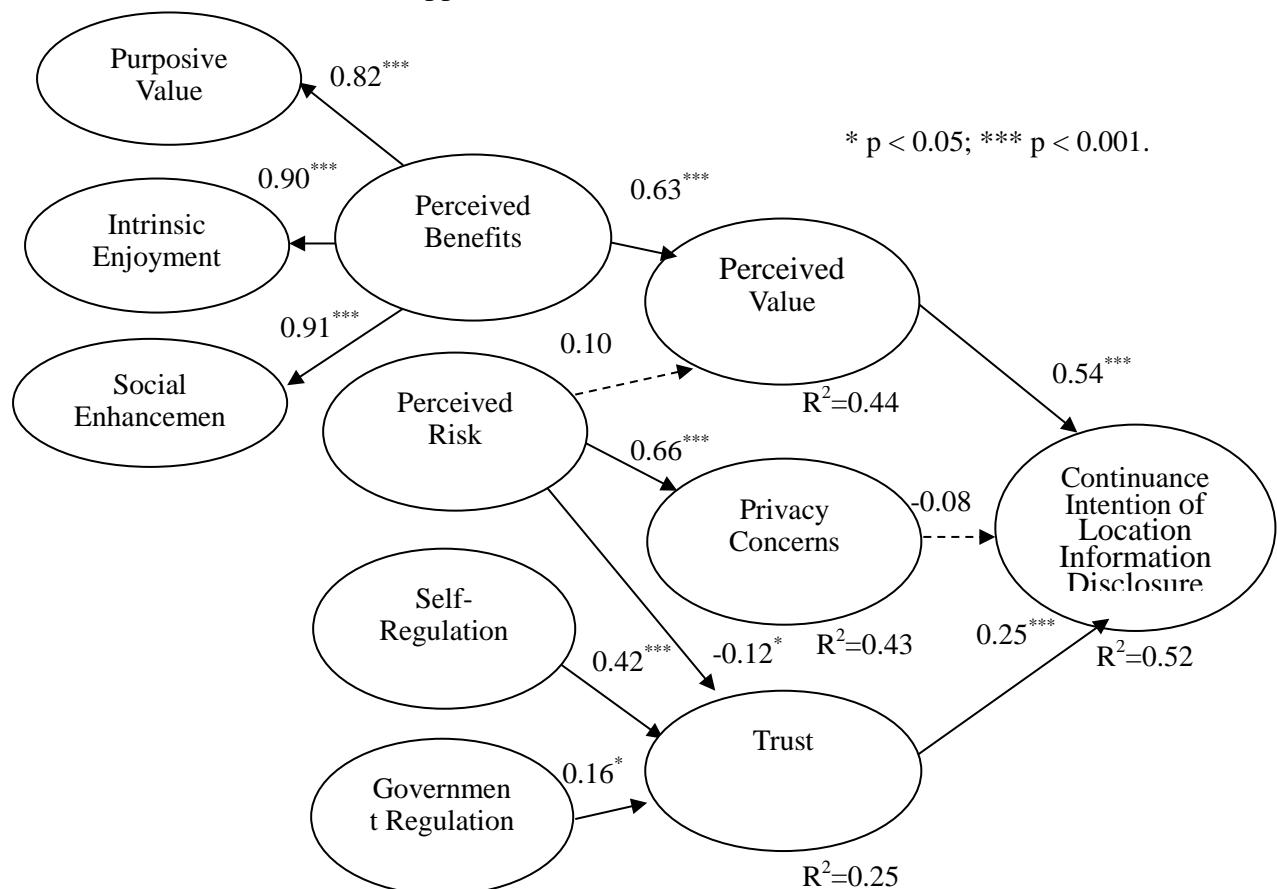


Figure 2 SEM analysis of the research model (full sample)

Table 3. Statistical comparison of paths

Paths	Low-innovativeness		High-innovativeness		Statistical comparison of paths
	Standardized path coefficient	t-value	Standardized path coefficient	t-value	
Perceive value → continuance intention	0.402	4.44***	0.520	5.27***	3.36***
Privacy concerns → continuance intention	-0.188	2.27*	-0.039	0.56	4.71***
Trust→ continuance intention	0.182	2.07*	0.276	2.63**	2.65**

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

DISCUSSION

The goal of this study is to integrate the perspectives of privacy calculus and trust to identify the factors affecting continuance intention of location information disclosure in SNS. The results of this study provide overall support for the research model, yet the results also reveal that some relationships are not in line with what we hypothesized. As expected, the results show that perceived value and trust have significant impacts on continuance intention of location information disclosure. The findings are in line with prior studies that trust and perceived value would impact users' willingness to disclose privacy information (Dinev and Hart, 2006; Liao et al., 2011; Xu et al., 2010). However, privacy concerns do not exert significant effect on continuance intention of location information disclosure. According to Lowery et al. (2011), personal innovativeness may impact the link between privacy concerns and behavioral intention. The results of this study reveal that privacy concerns have negative and significant effect on continuance intention of location information disclosure for low-innovativeness users, while perceived concerns exert insignificant influence on continuance intention of location information disclosure for high-innovativeness users. The results that provide an possible explanation for the insignificant relationship between perceived concerns and continuance intention of location information disclosure and confirm the assertion of Lowery et al. (2011).

In addition, the results also reveal that that perceived value and trust have stronger influences on continuance intention for high-innovativeness users. The findings are in line with Yi et al. (2006) that personal innovativeness is a moderator that will impact the link

between behavioral intention and its antecedents. The findings imply that users with higher level of personal innovativeness are more likely to trust service providers and may perceive higher value, which in turn may enhance users' intention to continue disclosing location information via SNS. Moreover, our results show that perceived benefits are positively associated with perceived value. The finding is consistent with prior literature (Xu et al., 2011), providing additional evidence to support the viewpoint that a higher expectation of benefits should amplify the overall assessment of the utility of information disclosure.

In line with prior literature (Liao et al., 2011), perceived risk exhibits the most significant impact on privacy concerns. This implies that technologies may not fully alleviate users' risk concerns in the online context. This is because users may be aware that a stranger can collect their personal information without permission (Liao et al., 2011). Perceived risk is also negatively associated with trust. This is in line with prior literature (Dinev and Hart, 2006; Liao et al., 2011) and provides additional evidence to support the link between risk and trust. However, perceived risk does not exert significant influence on perceived value. An plausible explanation for this insignificant relationship is that users' privacy risk in this study is associated with the release of location information only. Although the third parties could collect the location data to identify users' behavior, users will not suffer the possible losses derived from technology uncertainty such as theft of credit card information and breach of private information that may occur in the e-commerce context. Thus, users' value perception will not be affected by risk perception. Finally, the results show that self-regulation and government regulation have positive effects on trust. The findings are consistent with the standpoint of institution-based trust (e.g., Pavlou, 2002; Zucker, 1986) that self-regulation and government regulation can be seen as the institutional factors that can facilitate trust development.

Overall, this study provides some implications for management of SNS to increase users' intention to disclose location information continuously. First, management of SNS should reduce the concerns of privacy for low-innovativeness users by deploying privacy control mechanisms. They also should use several trust-building strategies to facilitate trust for high-innovativeness users. For example, they could invite third-party organizations to evaluate the practice of protecting privacy and upload the guidelines and standard of privacy protection (Tang et al., 2008). Finally, managers of SNS could facilitate perceived value by providing well-designed interfaces and useful applications (e.g., finding friends around you right now), since users, especially for users with high-innovativeness, need to be aware that privacy concerns can be traded off against benefits.

Although this study provides some interesting findings, several limitations of this study should be acknowledged. First, the data of this study were collected from users of Facebook

in Taiwan. Future research should test the findings of our study in the different countries to test the generalizability of this study. In addition, further studies could test the generalizability of this study by using experimental design method, since such method is considered as a proper method for studying ubiquitous computing applications (Xu et al., 2010). Second, there are other factors, such as website quality and social influence, that will influence users' intention to disclose location information in the continuance usage stage (Xu et al., 2010). Further research could be done by extending this proposed model to include other possible factors. Finally, the experience bias may impact the results of this study, since an inexperienced user may perceive a privacy threat simply due to a lack of knowledge (Lowry et al., 2011). Further studies should be conducted to test whether significant discrepancies are found among users with differing levels of usage experience (Lowry et al., 2011).

APPENDIX A

$$\text{Spooled} = \sqrt{[(N1 - 1)/(N1 + N2 + 2)] \times SE12 + [(N2 - 1)/(N1 + N2 + 2)] \times SE22}$$

$$t = (PC1 - PC2) / [\text{spooled} \times \sqrt{1/N1 + 1/N2}]$$

where spooled = pooled estimator for the variance

t = t-statistic with $N1 + N2 + 2$ degrees of freedom

N_i = sample size of dataset for subgroup i

SE_i = standard error of path in structural model for subgroup i

P_{ci} = path coefficient in structural model of subgroup i

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UNDERSTANDING THE IMPACT OF GREEN INITIATIVES AND GREEN PERFORMANCE ON FINANCIAL PERFORMANCE IN THE US

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ABSTRACT

We study the influence of green initiatives and green performance on financial performance for the top 500 publicly traded companies in the US between the manufacturing and service industries. Green initiatives are measured by Green Pay Link, Sustainability Themed Committee and Audit. Green performance is measured by Energy Productivity, Carbon Productivity, Water Productivity, Waste Productivity and Green Reputation. The results show that green initiatives have a negative impact on Energy Productivity and Green Reputation whereas green initiatives and green performance does have a significant impact on financial performance. These results are mixed and vary by industry sector. Both energy productivity and pay link have a positive impact on debit ratio, whereas carbon and water productivity have a negative impact on financial performance. The impact of green initiatives and green performance on financial performance is greater in Consumer Discretionary and Consumer Staples sectors than other sectors.

Keywords: Green operations, Environmental impact, Green policies and performance, Green reputation

INTRODUCTION

Over the past few years, environmental concerns have led organizations to wide-spread interest in sustainable initiatives and their relationships to business performance. This is reflected in a growing number of recent papers which explore the relationship between environmental initiatives, environmental performance, and business performance [3] [32] [55] [44]. The literature in this area contains some empirical evidence suggesting a positive relationship between “green” initiatives and business performance [23]. However, more empirical work is needed to clarify the nature of this relationship [24] [29].

Research on environmental initiatives for the most part has focused on the areas of green product and process development, lean and green operations management, and remanufacturing and closed-loop supply chains [2] [32]. Only a few studies have looked at the relationship between green initiatives, green performance, and a firm’s financial performance on a comparative basis between the manufacturing and service industries. Existing empirical evidence so far is limited to few studies that focus on the manufacturing sector [23] [29] [31] and others on the service sector [17] [19] [223]. Very few of these studies found scientific evidence that green practices have important effect on firm’s financial performance. For instance, Enz and Siguaw [12] and Schendler [59] argue that environmental practices can improve customer loyalty and employee satisfaction, reduce costs, and enhance competitiveness. In their review of the literature on papers which explore the link between green operations and firm’s financial performance in the

service industry, Kassinis and Soteriou [23] found most researches to be manufacturing based case studies in which the authors predominantly identified opportunities for future research.

Historically, numerous environmental frameworks, cases and concepts have evolved around the manufacturing industry. Today, we are in the midst of a service revolution that is rapidly transforming industries and changing some fundamental assumptions we have about business and economics. Increasingly, the size of the service economy's contribution to gross domestic product is more than 70% in the U.S. and other developed countries, while the share of employment in services exceeds 80% in the U.S. and continue to rise [15] [45] [57]. These trends imply that further research and discovery is needed to gain an enhanced perspective and insight into these issues as they are becoming increasing relevant to almost any organizational stakeholder. Environmental issues and their implications for business performance therefore present tremendous research opportunities for traversing the growing and changing gap in how environment issues uniquely and collectively impact the value adding process in manufacturing firms and service firms [57]. This gap has been acknowledged by Kassinis and Soteriou [23]. These authors conclude that "In practice, we know little about the environmental impacts of most service operations, how they can be managed, and what impact the environmental practices service firms adopt have on performance". The identification of this gap prompts us to investigate the relationship between green initiative, green performance and firm's financial performance in each sector that covers manufacturing and service industry and thus providing a deeper understanding of impact of green operations.

The paper is organized as follows. In the next section, we review the literature about green initiatives, green performance as well as firm-level performance. We then raise our research questions and put forward a theoretical framework to explain the relationship between green initiative, green performance and firm's performance. Empirical data for theory testing is collected from Compustat, a database of financial, statistical and market information on active and inactive global companies throughout the world, and Newsweek, an information gatekeeper that enables consumers to access a list of environmental friendly companies. Following the presentation of the methodology and the analysis used in our study we interpret our findings, present conclusions and outline implications and future research.

THEORETICAL FOUNDATION AND HYPOTHESES DEVELOPMENT

Green Initiatives

Environmental issues have attracted the attention of researchers in various disciplines. The scope of research ranges from studying operational problems such as green product and process development, lean and green operations management, to remanufacturing and closed-loop supply chains [4] [7] [29]. Environmental initiatives by firms and by the research community lead to different terminologies with varying scope. One term emerging from the literature is "green initiatives". This term is used to describe a set of actions undertaken by a firm with aim to minimize negative environmental effects associated with the entire life cycle of its products or services starting from design of the product, acquisition of raw materials, product use, up to the final disposal of the product [43] [65]. Research on green metrics is evolving and is playing an important role among practitioners. It provides managers with useful metrics that can be used to

monitor their firms' environmental efforts as well as to support decision making process related to green initiatives [18]. In the research community, MSCI ESG Research, a leading source of environmental, social, and governance ratings collaborated with NEWSWEEK to develop green metrics. Trucost, a firm that Specializes in quantitative environmental performance measurement; and CorporateRegister.com, the world's largest online directory of social responsibility, sustainability and environmental reporting also worked toward the same goal as the previous two firms. All these companies have adopted terms such as "Pay Link", "Sustainability Themed Committee", and "Audit" in their assessments of environmentally responsible (green) practices among 500 publicly traded U.S. companies.

A sustainability pay link is a "mechanism to link the remuneration of any member of a company's senior executive team with the achievement of environmental performance targets." A score of 100% is awarded when such link exists and a score of 0% is attributed if there is no such link is in place.

A Sustainability Themed Committee refers to the existence of a committee at the Board of Directors level whose mandate is related to the sustainability of the company, including but not limited to environmental matters. The existence of such a committee is awarded a score of 100%. A score of 0% is attributed if there is no such committee in place.

The term Audit refers to the case where a company provides evidence that the latest reported environmental metrics are audited by a third party. A score of 100% is awarded if such an audit has been performed, and a score of 0% is given in cases where such an audit was not performed.

Green Performance

Green Performance is defined as positive consequences of green productivity initiatives on the natural environment inside and outside the firm [64]. Green Performance includes Energy Productivity, Carbon Productivity, Water Productivity, Waste Productivity and Green Reputation (Corporate Knights Capital).

Energy Productivity is defined as Revenue (\$US) / Total Energy Consumption (GJ). Carbon Productivity or Greenhouse Gas (GHG) Productivity is defined as Revenue (\$US) / Total Greenhouse gas (GHG) Emissions (CO₂e). The term Water Productivity is defined as Revenue (\$US) / Total water (m³). Waste Productivity is defined as Revenue (\$US) / [Total waste generated (metric tonnes) – waste recycled/reused (tones)]. Finally, the term Green Reputation is used to reflect the public image of the firm in relation to its attitude and actions toward environmental issues when managing its operations and product lines.

The Reputation score is made up of two components: (1) The RepRisk Index, which is a quantitative measure that captures criticism and quantifies a company exposure to ESG risks. It ranges from zero (lowest) to 100 (highest); the higher the value, the higher the ESG risks exposure. The RepRisk Index value is percent-ranked against all companies in the ranking and multiplied by 0.5. (2) The second component is based on the number of environmental issues that were identified by RepRisk for each company. The environmental issues are: global pollution and climate change, local pollution, impacts on ecosystems and landscapes, overuse and wasting of resources and waste issues; the total number of environmental issues for each

company is percent-ranked against all Industry Group peers in the ranking and multiplied by 0.5. The Reputation Score is the sum of the scores from the two above components. Companies whose sub-industry group is “tobacco” and which are deriving the majority of their revenue from weapons manufacturing and related products/services automatically get a zero for the Reputation Score. 20%

A number of authors have proposed research frameworks to assess the business performance of environmental responsible firms. Beamon [5] described performance measures appropriate for the extended supply chain. Labuschagne and van Erck [35] and Chinander [6] also contributed frameworks and methods by which a firm can incorporate environmental objectives into their operations. Building on these environmental score and concepts from Trucost, Corporate Knights Capital, and CorporateRegister.com, we study the relationship between green initiatives (measured by Pay Link, “Sustainability Themed Committee, and Audit), green performance and firm performance in both the manufacturing and service industry.

Organizational financial Performance

Historically, financial measures such as return on sales (ROS), return on assets (ROA), return on equity (ROE), and return on invested capital (ROIC) have been used in the literature to evaluate the interests of various stakeholders in the market place [20] [21] [33] [58]. In modeling capital borrowed by stockholders from creditors and investors as well as their equity capital contribution, Konar and Cohen [34], Russo and Fouts [56], Elsayed and Paton [13], Nakao et al. [44], and King and Lenox [25] have used ROA, Tobin’s $q-1$, ROS, ROE, and return on capital employed (ROCE) to measure firm financial performance. Using the argument that managers are more open in offering their perceptions rather than offering precise quantitative data, other scholars use subjective perceptions of managers to assess firm financial performance [8] [22] [60].

The study herein is concerned with a firm’s financial performance relative to the market and its competition. Debt ratio (DR), profit margin (PM), return on total assets (RTA), market to book ratio (MBR), and Inventory Turnover (ITO) are recognized as important dimensions to firm’s financial performance [61]. DR is defined as the total debt over total assets. PM, a primary variable most investors examine when analyzing a company’s performance, measures the profitability of a company and represents the net income over the sales. The RTA represents the net income over the total assets, and the MBR represents the market price over the book value. Inventory Turnover is a measure of how often the company sells and replaces its inventory and is the ratio of cost of goods sold to average inventory.

Linking Green initiatives to Green Performance

The literature documents a number of studies on green initiatives adoption as well as on the relationship between green initiatives and green performance. According to Peglau [47], since 1996, more than 88,800 facilities worldwide have adopted green initiatives; including environmental management systems that are certified to ISO 14001. Previous studies on green initiatives can be found in Potoski & Prakash [51]; King, et al. [28], Darnall [10]; Melnyk, et al. [38], Nicholls & Kang [43]; and Anton, et al. [1]. Other research scholars found a positive relationship between green initiatives and environmental performance [24] [50] [28].

Linking Green Performance to Financial Performance

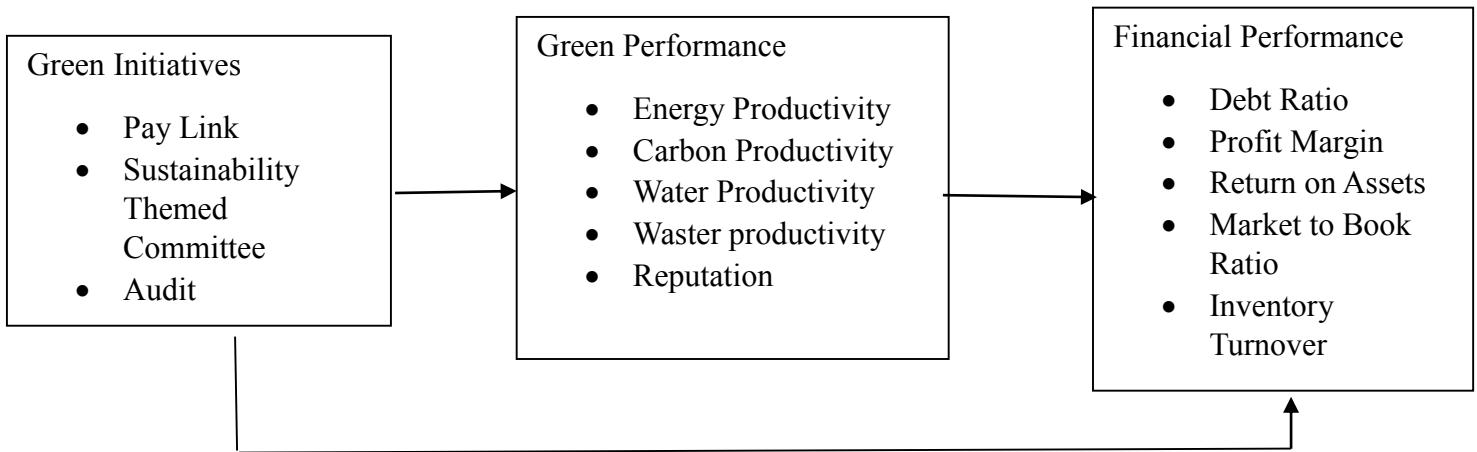
Research on environmental issues links green performance to corporate profitability. However, results from these studies are mixed [10] [24]. Some findings indicate that a profitable correlation exists between green performance and business performance [56] [20] [54] [62] [37] [44] [45] [46]. Other results indicate that companies having higher scores on environmental performance realize stronger financial returns than the overall market, whereas companies with poor scores have weaker returns [8] [14] [39] [41]. Most of these studies suggest that environmental performance is positively correlated with the intangible asset value of S&P 500 firms as well as firm market value [11] [30] [25] [34]. A study by Nakao et al. [42] reveals that for the particular case of Japanese manufacturing sector, environmental performance improves ROA and Tobin's $q - 1$. From a competitive perspective, Porter and van der Linde [48], Rao and Holt [52], Dao et al. [9], and Reinhardt [53] suggest that environmental operations can improve firm-level financial performance and overall competitiveness through green products or services.

On the other hand, other studies findings indicate either insignificant relationship exists between the two variables (e.g., [36] [37] [44] [45]) or varied findings (e.g., [24]). Therefore, further studies are needed to assess the relationship between green performance and firm financial performance. Because the literature suggests a direct relationship between green initiatives and a firm's financial performance, understanding the link between these two variables is important to practitioners.

In addition, research on environmental issues in the context of services industry is limited. Kassinis and Soteriou [23] argue that the results found in this literature is "limited by the case study or anecdotal nature of the evidence they are based on" and acknowledge the need for further empirical work to assess the relationship between environmental practices and firm-level performance in the service industry. The relative scarcity of research examining these two variables and the fact that prior approaches do not report consistent findings with regard to explaining how green initiatives and green performance impact firm-level performance in both the manufacturing and the service industry [11] [25] [30] motivates the need for the study conducted herein. It is our contention that by jointly examining the impact of environmental initiatives to green performance and firm-level performance in each sector of manufacturing and service industry, we can substantially contribute toward the findings of earlier studies.

RESEARCH FRAMEWORK

The research framework guiding our investigation is illustrated in Figure 1. We draw on concepts from the interrelated literature streams of environmental initiatives and corporate growth to propose a research model that indicates that green initiatives have a positive impact on green performance that in turn leads to improved financial performance. The model also shows a direct impact of green initiatives on financial performance. Other potential factors that may impact firm-level performance are not included in his study due to the limitation of the data.

FIGURE 1: Research Framework

RESEARCH METHODOLOGY

The focus of this research is on the top 500 publicly traded companies as identified by their levels of revenue, market capitalization and number of employees. The score of green initiatives for each company was obtained from Newsweek (Oct 5, 2014). Newsweek also classify each company into 10 industry sectors (Consumer Discretionary, Consumer Staples, Energy, Financials, Health Care, Industrials, Information Technology, Materials, Telecommunication Services and Utilities). Even though the green metrics were published in 2014, each company is evaluated based on the data in the year 2012 and therefore represent their green initiatives and green performance in that year. Therefore, the financial performance of each company in 2012 and 2013 will be used in this study and was obtained from Compustat. 66 companies were dropped because of missing data either in Newsweek or in Compustat and the sample size is reduced to 434.

Data Analysis and Discussion

In this section, an overview of green initiatives, green performance and financial performance in each industry sector is discussed first, followed by t-tests on the impact of each green initiative (Pay Link, Sustainability Themed Committee, and Audit) on green performance. A regression analysis is then used to test the impact of green initiatives and green performance on financial performance.

Green Initiatives of Top 500 US Companies by Industry Sector

Table 1 shows that nearly half of top 500 companies (49%) have a sustainability themed committee, about one third (34%) of the companies have linked their senior executives pay to the environmental performance targets. In addition, about 44% have their environmental metrics audited by a third party.

For Green Pay link, top 3 industry sectors are Materials (52%), Consumer Staples (51%), and Utilities (48%), bottom 3 sectors are Health Care (27%), Consumer Discretionary (26%), and Financial (25%). For Sustainability Themed Committee, top 3 sectors are the same as in Pay

Link, they are Materials (85%), Consumer Staples (71%), and Utilities (60%). Telecommunication Services (60%) is tied with Utilities. The bottom 3 sectors are Industrials (40%), Financials (38%) and Health Care (33%). For Audit, the top 3 are Consumer Staples (66%), Telecommunication Services (60%) and Utilities (52%) and the bottom 3 are Consumer Discretionary (37%), Health Care (36%) and Energy (27%).

In Sum, Materials, Consumer Staples, Telecommunication Services and Utilities are leading industry sectors that are implementing green initiatives. In contact, Health Care and Consumer Discretionary are lagging behind in green initiatives (See Chart 1).

Green Performance of Top 500 US Companies by Industry Sector

Table 2 shows green performance metrics of top 500 US companies by industry sector. Overall, the results indicate that the top 500 companies has the highest score on Green Reputation (0.56), followed by Waster Productivity (.45) and Water Productivity (.44). Carbon productivity received the lowest score (.39) compared to other performance scores.

For Energy Productivity, the top 3 sectors are Health Care (0.52), Materials (0.47), Consumer Staples (0.45) and Information Technology (0.45); for Carbon Productivity, the top 3 sectors are Health Care (0.49), Information Technology (0.47), and Consumer Staples (0.45); for Water Productivity, the top 3 sectors are Information Technology (0.57), Industrial (0.53), Health Care (0.47) and Materials (0.47); for Waster Productivity, top 3 are Information Technology (0.56), Industrials (0.55) and Materials (0.52); finally, for Green Reputation, top 3 are Information Technology (0.56), Financials (0.55) and Health Care (0.52). The results show that Information Technology and Health Care have better green performance than other sectors as Information Technology sector belong to one of the top 3 for each green performance metrics, and health care belong to one of the top 3 for 4 metrics out of 5.

Looking at the bottom 3 sectors for each performance indicator, for Energy Productivity, they are Financials (0.33), Utilities (0.34), and Telecommunication Services (0.35); for Carbon Productivity, they are Telecommunication Services (0.28), Utilities (0.29), and Financials (0.33); for Water Productivity, they are Utilities (0.25), Financials (0.29), and Telecommunication Services (0.38); for Waster Productivity, they are Energy (0.32), Financials (0.33) and Telecommunication Services (0.33), and for Green Reputation, they are Consumer Staples (0.44), Telecommunication Services (0.49) and Energy (0.50). In sum, Telecommunication Services, Financials and Utilities have lower green performance than other sectors as Telecommunication Services sector belong to the bottom 3 for each performance metrics, Financials belong to the bottom 3 for the 4 metrics out of 5, and Utilities belong to the bottom 3 for the 3 metrics out of 5. (See Chart 2 also).

Based on the above results, it can be inferred that Green Initiatives maybe do not have a positive relationship with green performance. For example, Telecommunication Services and Utilities have higher scores in green initiatives and lower scores in green performance compared to other sectors; in contrast, Health care has lower scores in green initiatives in contrastof having higher scores in green performance.

Financial Performance of Top 500 US Companies by Industry Sector in 2012 and 2013

Table 3 shows that the sectors of Financials, Health Care and Information Technology have higher profit margin than other sectors in both 2012 and 2013. In contrast, Energy and Telecommunication Services have lower profit margin than other sectors. For Return on Assets, Consumer Staples and Information Technology have higher scores than other sectors, and Financials, Utilities and Telecommunication Services have lower scores than other sectors. In addition, Consumer Discretionary and Telecommunication Services have higher Inventory Turnover than other sectors, while Materials and Consumer Staples have lower Inventory Turnover than other sectors.

Table 3 also shows that Consumer Discretionary and Consumer Staples have higher Market to Book Ratio; while Utilities and Financials have lower scores on this metrics. In addition, For Debit Ratio, Utilities, Telecommunication Services and Consumer Staples have higher scores than other sectors, while Information Technology, Financials and Energy have lower scores.

In sum, Information Technology has higher score on Profit Margin and Return on Assets, while Consumer Staple has higher Market to Book Ratio and Debit Ratio. For all Top 500 companies from 2012 to 2013, Profit Margin increased 20.0%, Inventory Turnover increased 35.6%, Debit Ratio increased 3.8% and Market to Book Ratio dropped 38.3%. There is no change in Return on Assets from 2012 to 2013.

The Impact of Green Initiatives on Green Performance

A series of T-tests are used to investigate the impact of each green initiative (Pay Link, Sustainability Themed Committee, and Audit) on Green Performance. The results are shown in Table 4.1, Table 4.2 and Table 4.3 respectively. Table 4.1 shows that Pay link has a significant negative impact on Energy Productivity and Reputation. The companies that do not have their Top Executive Pay linking to Green Performance have better performance on energy productivity and green reputation.

Table 4.2 shows the impact of Sustainability Themed Committee on Green Performance. The results show a significant negative relationship between Sustainability Themed Committee and Green Reputation. Again, the companies that do not have sustainability themed committee have a higher green reputation than those companies that have such committees. Table 4.3 shows that Audit have a negative impact on Energy Productivity and Green Reputation.

In sum, it can be inferred that Green reputation is negatively impacted by each of green initiatives metric (Pay link, Sustainability Themed Committee and Audit), this is in contrast with our initial assumptions. These results may imply that companies take a reactive, not proactive approach in the implementation of green initiatives. Companies that have poor green reputation are under more public pressure. These types of companies are more likely to adopt various green initiatives, maybe in the hope of improving their image (i.e. green reputation). Similarly, Energy Productivity is negatively impacted by Pay link and Audit, reflecting a reactive approach companies are taking in dealing with their environmental issues. These findings are in consistent with our earlier observation, indicating that green initiatives maybe do not have a positive relationship with green performance.

The Impact of Green initiatives and Green Performance on Financial Performance

Five regression analysis were conducted to see how green initiatives and green performance impact financial performance using Energy Productivity, Carbon Productivity, Water Productivity, Waster Productivity, Green Reputation, Pay Link, Sustainability Themed Committee and Audit as independent variables, and each financial indicator (Debt Ratio, Profit Margin, Return on Total Assets, Market to Book Ratio and Inventory Turnover) as dependent variable. The results are depicted in Table 5.

The results show that debt ratio is positively impacted by Energy Productivity and Pay Link, and negatively impacted by Caron Productivity in both 2012 and 2013. However, the impact is stronger in 2013 than in 2012 based on regression coefficient. The results show that there is no significant relationship between green performance and Inventory Turnover in 2012. However in 2013, Inventory Turnover is positively impacted by Energy Productivity, Carbon Productivity and Water Productivity. This result may suggest that the impact of green performance on financial performance is not immediate and it may take more than one year for companies to see the impact.

It can be observed that the impact of green initiatives and green performance on financial performance is limited. Out of all financial performance indicators, only debt ratio and inventory turnover are impacted by green initiatives and green performance. In addition, it can be inferred that the impact of green initiatives and green performance on financial performance is long-term oriented. Company may not be able to see an immediate impact of green initiatives.

The Impact of Green initiatives and Green Performance on Financial Performance by Industry Section

To investigate the impact of green initiatives and green performance on financial performance in each industry sector, a series of regression analysis were conducted for each sector. Out of 10 industry sectors, only four sectors (Consumer Discretionary, Consumer Staples, Energy and Health Care) show significant relationships. These results appear in Table 6.

In Consumer Discretionary sector, Debt ratio is positively impacted by green reputation, pay link, and sustainability committee, and is negatively impacted by audited environmental metrics in both year 2012 and 2013.

In Consumer Staples, Inventory turnover is positively impacted by Carbon Productivity and Water Productivity, and is negatively impacted by Energy Productivity and Pay link in the year 2012, those relationship still exists in 2013 with a higher regression coefficient. The results also reveal that Waster Productivity has no significant relationship with Inventory Turnover in the year 2012, however, this relationship become positive in the year 2013. In addition, there is no significant relationship between any green indicator and profit margin in the year 2012, however, in the year 2013, profit margin is found to be positively related to energy productivity and negatively related to water productivity.

In Energy, no significant relationship exists in the year 2012. In the year 2013, Debt Ratio is positively impacted by energy productivity, and is negatively impacted by carbon productivity, waster productivity, and audited environmental metrics.

In Health Care, Inventory Turnover is positively impacted by green reputation and negatively impacted by water productivity and sustainability themed committee in the year 2012. No significant relationships are found in the year 2013.

It can be seen that the impact of green initiatives and green performance on financial performance is greater for Consumer Discretionary and Consumer Staples based on the number of significant impacts in those two sectors. In addition, Debt Ratio and Inventory Turnover are two financial measurements that are likely influenced by a company's green initiatives.

It can be also concluded that green initiatives and green performance have a significant impact on financial performance. However, this impact is mixed and varies by industry sector. In addition, the results also indicate that a firm's green performance in one year not only impact an organization's financial performance in that particular year but also impact the year that follows. However, the impact is stronger for Consumer Staples and Energy, and is degraded for Health Care sector.

CONCLUSION AND IMPLICATION

This study investigates the influence of green initiatives and green performance on financial performance by industry sector for the top 500 publicly traded companies in the US. Green initiatives are measured by Green Pay Link, Sustainability Themed Committee and Audit. Green performance is measured by Energy Productivity, Carbon Productivity, Water Productivity, Waste Productivity and Green Reputation. Financial performance was measured by Debt Ratio, Profit Margin, Return on Assets, Market to Book Ratio and Inventory Turnover.

The results show that green reputation is negatively impacted by each of green initiatives (Pay link, Sustainability Themed Committee and Audit), this is in contrast with our initial assumptions. The results may imply that companies take a reactive, not proactive approach in the implementation of green initiative. The results show that debt ratio is positively impacted by Energy Productivity and Pay Link, and negatively impacted by Caron Productivity in both 2012 and 2013. However, the impact is stronger in 2013 than in 2012. This result may suggest that the impact of green performance on financial performance is not immediate and it may take more than one year for companies to see the impact.

The results also show that the impact of green initiatives and green performance is mixed and varies by industry sector. The impact of green initiatives and green performance on financial performance is greater in Consumer Discretionary and Consumer Staples sectors. In addition, Debt Ratio and Inventory Turnover are two financial measurements that are most likely impacted by a company's green initiatives and performance.

One limitation of this study is the small sample size in each section which may impact the validity of the results. Future studies can be conducted to extend this study by increasing the sample size in each industry sector. Other research endeavors may also incorporate other contextual variables (such as firm size, organizational culture, environmental pressure, and nature of industry) so that the variation among industry sectors can be explained in further detail.

A longitudinal study may be conducted also to investigate how the changes in green initiatives affect the changes in financial performance.

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Table 1: Green Initiatives of Top 500 US Companies by Industry Sector

Industry Sector	# of Firms (Numer)	# of Firms (%)	Pay Link (Number)	Pay Link (%)	Sustainability Themed Committee (Number)	Sustainability Themed Committee (%)	Audit (number)	Audit (%)
Consumer Discretionary	68	15.67%	18	26.47%	28	41.18%	25	36.76%
Consumer Staples	41	9.45%	21	51.22%	29	70.73%	27	65.85%
Energy	45	10.37%	13	28.89%	19	42.22%	12	26.67%
Financials	79	18.20%	20	25.32%	30	37.97%	34	43.04%
Health Care	45	10.37%	12	26.67%	15	33.33%	16	35.56%
Industrials	45	10.37%	18	40.00%	26	40.00%	25	40.00%
Information Technology	54	12.44%	17	31.48%	25	46.30%	24	44.44%
Materials	27	6.22%	14	51.85%	23	85.19%	12	44.44%
Telecommunication Services	5	1.15%	2	40.00%	3	60.00%	3	60.00%
Utilities	25	5.76%	12	48.00%	15	60.00%	13	52.00%
Total	434	100.00%	147	33.87%	213	49.08%	191	44.01%

CHART 1. GREEN INITIATIVE OF TOP 500 COMPANIES

Consumer Discretionary Consumer Staples Energy Financials
Health Care Industrials Information Technology Materials
Telecommunication Services Utilities

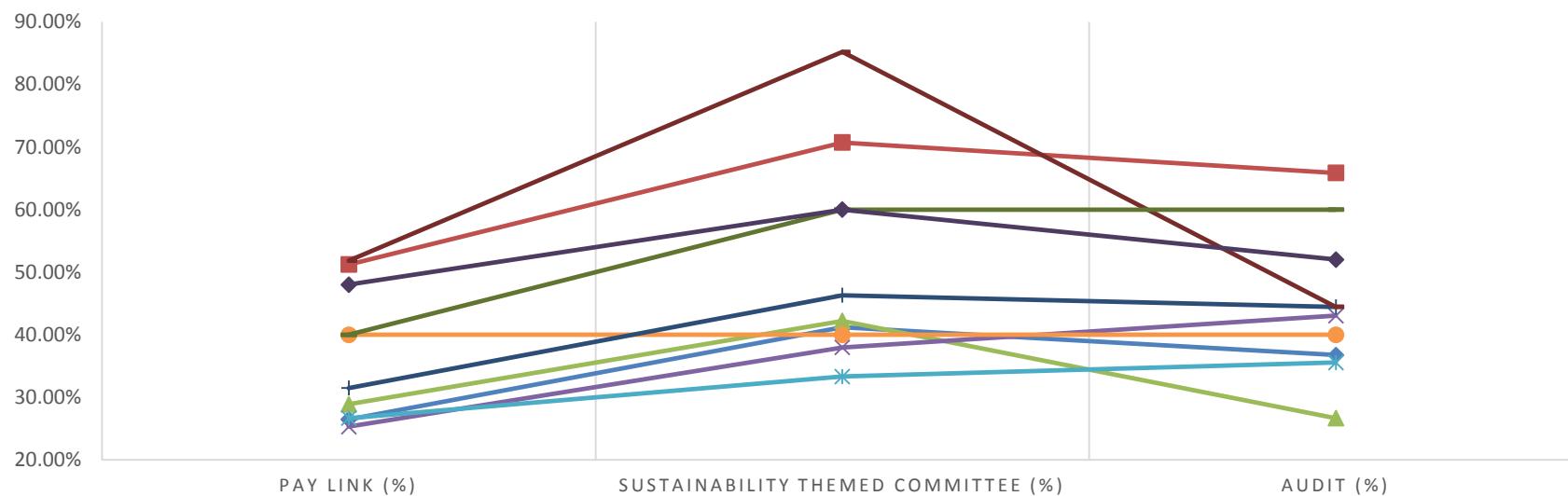


Table 2: Green Performance of Top 500 US Companies by Industry Sector

Industry Sector	# of Firms	Green Score	Energy Productivity	Carbon Productivity	Water Productivity	Waste Productivity	Green Reputation
Consumer Discretionary	68	0.28	0.38	0.33	0.43	0.39	0.51
Consumer Staples	41	0.41	0.45	0.43	0.45	0.42	0.44
Energy	45	0.24	0.41	0.34	0.44	0.32	0.50
Financials	79	0.28	0.33	0.33	0.29	0.33	0.63
Health Care	45	0.35	0.52	0.49	0.47	0.44	0.58
Industrials	45	0.39	0.42	0.42	0.53	0.55	0.54
Information Technology	54	0.40	0.45	0.47	0.57	0.56	0.64
Materials	27	0.41	0.47	0.41	0.47	0.52	0.55
Telecommunication Services	5	0.33	0.35	0.28	0.38	0.33	0.49
Utilities	25	0.33	0.34	0.29	0.25	0.51	0.52
Total	434	0.33	0.42	0.39	0.44	0.45	0.56

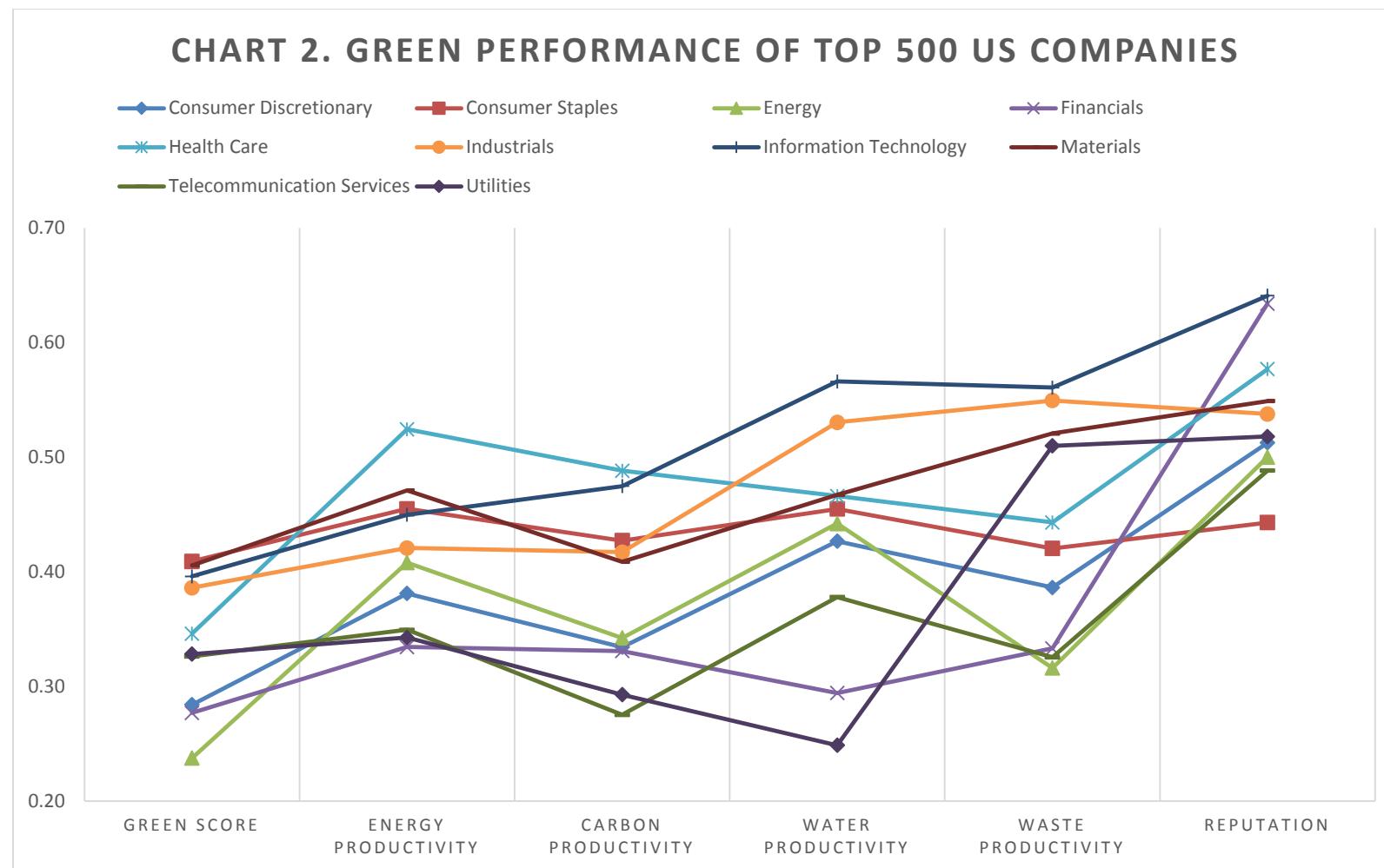


Table 3. Organizational Performance of Top 500 US Companies by Industry Sector in 2012 and 2013

	Year 2012					Year 2013				
	Debt Ratio	Profit Margin	Return on Assets	Market to Book Ratio	Inventory Turnover	Debt Ratio	Profit Margin	Return on Assets	Market to Book Ratio	Inventory Turnover
Consumer Discretionary	0.28	0.05	0.07	7.24	41.41	0.29	0.11	0.08	3.94	63.95
Consumer Staples	0.32	0.10	0.10	19.57	7.36	0.32	0.11	0.11	5.91	7.25
Energy	0.25	0.04	0.05	1.92	17.41	0.25	0.06	0.05	2.40	17.26
Financials	0.25	0.15	0.03	1.84	11.55	0.24	0.19	0.03	2.06	21.38
Health Care	0.28	0.11	0.07	2.52	9.65	0.28	0.11	0.06	2.63	36.68
Industrials	0.26	0.09	0.07	19.04	25.85	0.26	0.10	0.08	3.16	24.92
Information Technology	0.16	0.14	0.08	-8.92	23.21	0.17	0.14	0.08	2.82	12.47
Materials	0.26	0.10	0.07	3.01	5.87	0.27	0.09	0.07	3.25	5.72
Telecommunication Services	0.34	0.00	-0.01	2.19	38.30	0.37	0.03	0.01	1.74	39.77
Utilities	0.37	0.07	0.02	1.48	13.81	0.37	0.08	0.02	1.49	14.59
Total	0.26	0.10	0.06	4.96	19.43	0.27	0.12	0.06	3.06	26.35

Table 4.1 T-tests- The Impact of Pay link on Green Performance (Top 500 US Companies)

Pay Link		N	Mean	T value	Significance Level
Energy Productivity	Yes	136	.37	-2.92	.00**
	No	160	.46		
Carbon Productivity	Yes	140	.38	-0.87	.39
	No	170	.40		
Water Productivity	Yes	109	.43	-0.75	.46
	No	95	.46		
Waste Productivity	Yes	96	.43	-1.35	.18
	No	74	.48		
Green Reputation	Yes	141	.43	-6.35	.00**
	No	282	.62		

Table 4.2 T-tests- The Impact of Sustainability Themed Committee on Green Performance (Top 500 US Companies)

Sustainability Themed Committee		N	Mean	T value	Significance Level
Energy Productivity	Yes	193	.42	.29	.77
	No	103	.41		
Carbon Productivity	Yes	199	.40	.63	.53
	No	111	.38		
Water Productivity	Yes	140	.45	.69	.49
	No	64	.43		
Waste Productivity	Yes	118	.47	1.02	.31
	No	52	.42		
Green Reputation	Yes	207	.50	-3.67	.00**
	No	216	.61		

Table 4.3T-tests- The Impact of Audit on Green Performance (Top 500 US Companies)

Audit		N	Mean	T value	Significance Level
Energy Productivity	Yes	182	.39	-2.05	.042**
	No	114	.45		
Carbon Productivity	Yes	187	.39	0.16	.871
	No	123	.39		
Water Productivity	Yes	134	.46	0.86	.392
	No	70	.42		
Waste Productivity	Yes	116	.48	1.78	.077
	No	54	.40		
Green Reputation	Yes	182	.50	-3.34	.001**
	No	241	.60		

TABLE 5. Regression Analysis of Impact of Green Initiative and Green Performance on Financial Performance in All Sections in 2012 and 2013

	Year 2012					Year 2013				
	Debt Ratio	Profit Margin	Return on Assets	Market to Book Ratio	Inventory Turnover	Debt Ratio	Profit Margin	Return on Assets	Market to Book Ratio	Inventory Turnover
Energy Productivity	.24*					.26*				.40**
Carbon Productivity	-.30**					-.29**				.35**
Water Productivity						-.20*				.23*
Waste Productivity										
Green Reputation										
Pay Link	.20**					.21**				
Sustainability Themed Committee										
Audit						-.16*				

((Note: ** indicates a significant level at 0.05, * indicates a significant level at 0.10.

INNOVATIVE EDUCATION: A STUDENT'S PERSPECTIVE

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ABSTRACT

Innovative education has different points of views. Usually we see it from the point of view of schools and professors. Traditionally the pros have been used by professors in the field of education in order to persuade future students to enroll in a particular program. Since each student faces different sets of circumstances the different types of educational programs mean different things to each student. In the discussion that follows we explored three various types of educational programs. The programs include the traditional classroom setting, distance education courses and online learning courses. The discussion looked at every program from the point of view of a student, who has been through the three distinct programs. The hope is to help students better understand how innovative education through these three different education programs can better suit students' lives both inside and outside of the classroom.

KEYWORDS: Innovative Education, Student View, Distance Education

INTRODUCTION

Innovation is the introduction of something new such as an idea, method or device. In order for something to be considered innovative it must radically change the way things were previously done; additionally it must also improve the current method of doing things. Therefore, innovation must not merely change things, it must also enhance them. Innovation takes time, and it requires taking risks. An idea needs to be tested in order to prove that it is superior to the current process. The risk presents itself when the idea is tested because not every idea tested will become an innovation within its field. Innovation has happened overtime in many fields and education is no exception. Education has become innovative on many levels over the past years. Innovation within education is no different than innovation within other fields. Real educational

innovations are those products, procedures, strategies and methods improving significantly upon the status quo and reaching higher scales (Shelton, 2011). According to Shelton there are three pathways for educational innovation; these include field scans, basic and applied research and directed development.

RATIONAL OF THE STUDY

Before proceeding with this discussion, one may want to delve into the motive behind a discourse of this nature. Accounts have been written about the benefits of innovative education, but these benefits were set forth by university and education professionals. Innovative education, on the other side, has two aspects: The educator's side and the student's side. One cannot but wonder whether university's officials really hold an objective view when trying to persuade students to enroll in these learning programs. To rephrase, often students are swayed into these learning programs without understanding what these curricula entail for the students. However, accepting information offered by biased individuals can impair students and lead them towards making faulty decisions. Therefore, an objective view is often needed, yet can sometimes be hard to come across. Thus this case study will address the student side of innovative education, from the learner's point of view. Coming from a student whom has gone through various types of learning programs the discussion plans to offer an objective view of a student's needs when researching these programs. The review will look at both the positive and negative points of a learning program and those important aspects one should consider when making these types of life altering decisions.

RESEARCH QUESTION

The call for this discussion derives from the reality that as in any innovative method, there needs to be a genuine conversation from the consumer or user point of view in order to discuss whether the purpose of the methods used address the concerns of the stakeholders served, or whether there may be better results than the original methods. In other words, are students being served effectively by these new methods of teaching, or, could there be better, improved ways of delivering these services to students? The really thought provoking questions the current discussion seeks to assess are the following: Just how do students fare with the usage of these innovative ways of teaching, and which methods are likely preferred by the students?

PURPOSE OF THE STUDY

In Achieving Development Goals Innovation in Education and Development Technology Kuboni et al., n.d. underscored that Technology created a push for change within education. This is because technology changed the way education can be delivered to students. It is not to be said new technology and educational design can fully replace old technology and design; however, technology may improve educational design and delivery. This improvement can be in the form of learner support, interactivity and access to education. Technology can, in effect, help students enrolled in various types of learning programs; furthermore, and it can help move education programs to a more learner-centered approach. Thus, the purpose of this discussion is to show educators and students alike that they need to become familiar with the different tools Technology males available to them, in order to improve the students' learning experience out of the traditional classroom.

INNOVATIVE EDUCATION: LEARNING OUT OF THE TRADITIONAL CLASSROOM

However, with the increase in technology availability to students and educators, it is important to keep in mind education innovation is about the design of education and not simply about introducing new technology into the education process (Kuboni et al., n.d.). Educators have the challenge of monitoring changes in technologies, determining if these apply to learners living in the real world, while also seeking ways to use technologies to complement and support instructional methodologies and practices (Kuboni et al., n.d.). As technologies changes a push for change in education also happens; however as more technology becomes available it is increasingly important to use it as a support and not allow it to take over education programs.

*Technologies for use in and out of the classroom**YouTube*

Different technologies have become available in recent years. Improvements in the internet and digital communication have made the use of technology in education an everyday thing. Other digital media are also becoming a part of many education programs. For instance, YouTube is one of these other forms of digital media that has worked its way into current education programs. YouTube can be used as a way to inspire and engage students (Burke & Snyder, 2008). It allows students to take an active versus passive attitude in their education. This resource is open and free to both students and instructors making it ideal for use as a supplement in the classroom. However, students and instructors need to become familiar with YouTube features in order to use it efficiently and effectively. Therefore, an orientation on YouTube's features may be helpful before using this tool (Burke & Snyder, 2008).

Ubiquitous computing

Another technology advancement that has come along to help educators is ubiquitous computing. Ubiquitous computing is the use of interfaces other than desktop computers. The use of ubiquitous computing in the learning process is referred to as ubiquitous learning. Ubiquitous computing is being used in educational activities both indoors and outdoors. Through the use of ubiquitous computing students can access learning related activity from laptops, tables, and mobile devices (Kurti, Milrad & Spikol, 2007). This allows students to have access to their school activity from different devices, making them available virtually anywhere. However, it is important that students not become overwhelmed with all the technology available to them. Therefore, keeping a balance is important when it comes to ubiquitous computing. Kurti, Milrad and Spikol's study found that Innovative learning activities improved by mobile technologies should not be considered as standalone activities; these should be part of a well-built educational movement that is also combined, with traditional ways of succeeding and learning (Kurti, Milrad & Spikol, 2007).

Traditional education programs often require students to meet in a classroom at a set time. Students meet in order to interact with each other, and listen to the professor's lecture. Traditionally, students read the textbook that contains information about the topic the professor will be lecturing on, during class. After class students go home and work on homework that is related to the lessons they learned about during class time. Students spend time reinforcing what they learned in class by doing homework.

Distance learning is somewhat a bit different. Students are almost required to teach themselves the material in the curriculum. They spend their time learning with minimal oversight in comparison to what takes place in traditional classroom programs. Some professors help more than others, by offering worksheets and outlines pertaining to what students need to learn; however, truth be told, this is not always the case.

Online learning combines a little of both worlds. It is the latest innovation in education which has been introduced to improve distance learning. Online learning includes various technologies. Traditional face to face courses that are blended with learning technologies have recently received very good reviews from students. Blended courses are also referred to as hybrid course. This is because they are a hybrid of the traditional and distance learning education programs (Hiltz & Turoff, 2005). Professors who deliver courses in both distance and face to face sections of courses are blending or mixing the separate sections so that as far as the instructors are concerned there is no separation in the material, assignments and participation for either type of student (Hiltz & Turoff, 2005). This allows both categories of students to receive the same education whether in the class or online settings. Online learning is a novel social process which is starting to act as a total substitute for both distance learning and the traditional face to face classroom (Hiltz & Turoff, 2005).

In the article ‘Multiplicity in Learning and Teaching,’ the authors conducted a case study on online education. In their study they discovered that several factors played a significant part in online courses. They included multiple contexts for learning, multiple instructional media, multiple instructional formats, multiple learning activities and multiple assessment techniques. Under the multiple contexts for learning they found out four different contexts. (1) The first is that learning in online classes helps students acquire the material studied because they work on their coursework when they find bits of time. (2) Also, learning by implementing the coursework in their classroom is the second context through which learning occurs. This means that students learn by using what they are taught in online courses. (3) Other contexts in which students learn were found to be through simulations and informal groups. (4) The last multiplicity in learning was found to be multiple instructional media. Currently, professors use various media form in order to integrate distance learning into traditional face to face courses. Instructional format is another area in which multiplicity can be found. Different formats for online course include the following: (i.) Project groups, (ii.) real time interactions, (iii.) simulations, (iv.) electronic field trips, and (v.) lectures, among many others.

Learning activates an additional area in which the authors found multiplicity. Online learning also allows for multiple assessment techniques. It permits students to be assessed not only by the traditional means such as by the professor but also by other means such as their classmates through discussion boards. Other ways students are assessed in online learning includes through self-assessment and other audiences that may see their work. In online learning there are a lot of multiplicities, and many are addressed in James Levin, Sandra Levin and Gregory Waddoups’s article (1999).

Even though there are many advantages to online learning, this avenue is still may not be the best option for all students. Drennan & Pisarski (2005) dealt with student satisfaction with usefulness of flexible and the learner’s locus of control. These authors tested several different hypotheses in their study. The first hypothesized test was whether the “ease of using flexible learning would have a direct relationship with course satisfaction” (Drennan, Kennedy &

Pisarski, 2005). However, it was found that ease of use had an indirect relationship with the satisfaction of students with the course. Another hypothesized test in that study was related to the direct relationship existing between locus of control and students' satisfaction. It was found that students who had a high locus of control reported to also have a high level of satisfaction in the online learning course. Still, the same study showed that online learning courses may not be for everyone. There were other factors which were found to affect or not affect the reasons students were completely satisfied or dissatisfied with their course.

CONCLUSION

Whether it be traditional courses, distance education, or online learning, these all present advantages and shortcomings. As a student one may simply have preferences; what is right for one person may not be fully advantageous for everyone or for other individuals. As educators it is important to remember that not everyone learns in the same way or has the same lifestyle outside of the classroom. To reiterate the same notion, what may be good for one student may not satisfy the needs of another student. Additionally, it is important to understand even with all the technology advancements taking place no one education program can completely replace an existing program. Students have different needs; educators do well not to forget this fact.

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THE PERFORMANCE IMPACT OF PROCESS MANAGEMENT

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ABSTRACT

As the adoption of process management (PM) is deemed mainly driven by customer pressure, it is remained unclear that how customer satisfaction is fostered via PM. Previous studies also perceived PM as a single construct mainly control-oriented but without considering its multi-dimensional nature. Failing to do so has led to its inconclusive performance effect as reported in the literature. To make contribution to this line of research, we evaluate how the effect of process management (PM) on customer satisfaction is mediated by operational performances including quality, delivery, flexibility, production cost and R&D. We model PM as a multidimensional construct composing of control, incremental and radical improvement. Based on the data collected from 330 manufacturing firms in Pearl River Delta China, we find that the effect of PM on customer satisfaction is mediated to different extent by different operational performances. In other words, institutional perspective is partially supported as PM is found not only directly influential to customer satisfaction.

KEYWORDS: process management, operational performances, customer satisfaction

INTRODUCTION

Numerous QM studies have revealed that organizational performances is hinged upon how well process management (PM) transmits its antecedents' effect on organization (e.g., Anderson et al., 1995; Flynn et al., 1995, 2001; Wilson & Collier, 2000). The literature suggests that PM helps to remove non-value-added activities and results in cost reduction and efficiency improvement. (Benner & Tushman, 2003; Dean & Snell, 1996; Garvin, 1995). However, the impact of PM on operational performance is nevertheless equivocal and controversial in the literature (Benner & Tushman, 2003).

A number of studies have directly or indirectly revealed the performance effect of PM (Sarah, et al. 1989; Anderson, et al. 1995; Choi & Eboch, 1998; Wilson & Collier, 2000). Table 1 summarizes the findings. Though past studies have indicated that PM has significant relationship with operational performances, several issues have yet to draw sufficient attention. First, the performance effect of PM is still inconclusive (Benner and Tushman, 2002; Ittner and Larcker, 1997). In fact, two of the seven reviewed studies in Table 1 show insignificance of the relationship between PM and firm performances (Powell, 1995; Samson & Terziovski, 1999). The controversy may be due to the fact that past studies used different measures to represent PM, evaluated its effect on different operational performance or examined its performance in different contextual settings.

Second, as shown in Table 1, quality, customer satisfaction and financial performance are always the take-for-granted measures of performance. However, little is known about PM's relationship with delivery, cost and flexibility, which are regarded as the basic competitive capability of organizations in Operations Strategy literature (Adam & Swamidass,

1989; Boyer & Lewis, 2002; Boyer & McDermott, 1999; Boyer & Pagell, 2000; Joshi et al., 2003; Swamidass & Newell, 1987; Ward & colleagues 1995, 1996, 1998, 2000).

Table 1 Association between process management and performance measures

Literature	Relationship		Performance measures
	Significantly associated	Insignificantly associated	
Saraph et al. (1989)	✓		Quality performance, Customer Satisfaction
Flynn et al. (1995)	✓		Perceived quality market outcomes % passed final inspection with no rework
Powell (1995)		✓	TQM performance, Total performance
Choi & Eboch (1998)	✓		Plant performance, Customer Satisfaction
Wilson & Collier (2000)	✓		Financial results, Customer Satisfaction
Anderson et al. (1995)	✓		Employee fulfillment, Customer Satisfaction
Flynn et al. (2001)	✓		Business results
Samson & Terziovski (1999)		✓	Customer Satisfaction, Employee productivity, Operational performances
Yeung, Cheng, & Chan (2004)	✓		Time-based efficiency, cost-related efficiency, marketing performance, financial performance
Yeung, Cheng, & Lai (2006)	✓		Time-based efficiency, cost-related efficiency, marketing performance, financial performance

Third, since PM is always perceived as one of the components in the TQM framework, its impact on organizations are always mingled with those of other components of TQM (e.g., Flynn et al., 2001; Wilson & Collier, 2000). Therefore, it may be difficult to identify and understand its unique contributions to organizations.

Finally, PM is usually framed as unidimensional in the QM literature. But increasing studies have revealed that PM is actually a multidimensional construct. However, little is known about the internal dynamics and performance effect when PM is perceived as multidimensional. The literature has further suggested that PM dimensions are complementary to each other and that synergy would exist when they are implemented simultaneously (Al-Mashari et al., 2001; Collins and Hill, 1998; Grover, 1999; Hill & Collins, 1999; Jha et al., 1996; Ng et al., 2015; Sutcliffe et al., 2000). The claim is still awaiting empirical validation.

Acknowledging the above controversies, this study aims at investigating the performance effect of PM. The rest of this chapter is organized as follows: We first discusses the proposed performance effect of PM and delineates the associated hypotheses, control variables and performance measures to be investigated. Then we provide evidence of reliability and validity of the variables used. We also juxtapose the data analysis methods and reports the analysis results. We further discuss the results and highlight the theoretical contributions and managerial implications. Finally, we highlight the limitations, the future research directions and conclude the contribution of this chapter to advance the knowledge of PM.

THEORETICAL BACKGROUND AND HYPOTHESIS DEVELOPMENT

“Process management and its associated set of managerial practices and programs are perhaps the most important managerial innovations of the last 20 years.” (Benner and Tushman, 2002:676) In the literature, while some definitions of process management exclusively focus on stability by putting emphasis on process control (e.g., Anderson et al., 1995; Flynn et al.,

1995; Saraph et al., 1989; Sutcliffe et al., 2000), others address the need for change through process improvement but in a narrow focus on incremental approach (e.g., Benner and Tushman, 2002, 2003; Yeung et al., 2004). In spite of its varied notions, there is considerable agreement in the literature that process management, as a set of routines and practices, demonstrates a capability of exploiting existing processes comprising process control and incremental process improvement for the pursuit of efficiency and stability (Benner and Tushman, 2002; Benner & Tushman, 2003; Benner and Veloso, 2008; Garvin, 1988; Clark & Fujimoto, 1991; Harry & Schroeder, 2000).

However, the fact that organizations have to deal with the simultaneous need for being reliable and adaptable (Sutcliffe et al., 2000) has toppled the traditional thought of PM that focus on exploitation (Ng et al., 2015). Organizations should have dual goals of change with the support of the capability of incremental reliability-focused exploitation and the capability of radical learning-focused exploration (Damanpour, 1991; Damanpour & Evan, 1984; Sutcliffe et al., 2000). Even though the dual capabilities of change are different in orientation, their coexistence can lead to resilience and long-term capabilities (Sutcliffe et al., 2000) and can achieve responsive and flexible adaptation particularly when the environment is increasingly dynamic (e.g., Cardinal, 1995; Eisenhardt & Tabrizi, 1995; Henderson & Clark, 1990; Olson and Savory, 1999; Simon, 1995; Sutcliffe et al., 2000). Therefore, organizations should possess capability of both exploitation and exploration, including not only process control (PC) and incremental process improvement (IPI) but also radical process improvement (RPI). In this study, we define that PM is manifested via the three dimensions.

In spite of the continuous debate over the performance effect of PM, many studies support that implementation of individual PM dimensions can lead to positive organizational performances (e.g., Bossert, 1994; Bounds et al., 1994; Dale and Oakland, 1994; Gilbert, 1995; Juran and Gryna, 1993). We subscribe to this view but argue that the effect will be different for different performance (cf., Ng et al., 2015). Quality performance is for sure when PC is perceived as principles and practices aiming at maintaining process performances to the expected performance level and minimizing the undesired process variation. The increase implementation of PC can improve the quality performance and reduce the cost due to nonconformity. Because of the consistent quality performance, the dependability of delivery performance is guaranteed as well. However, the argument of whether process control can lead to flexibility is mixed. On one hand, PC increases the extent of formalization in terms of documentation and standardization. These efforts to maintain the consistency of process performance may paralyze the process capability of handling demand uncertainty because of the rigidity built. On the other hand, the implementation of process control may contribute to the flexibility performance. Studies have suggested that process variability affects flexibility (Pentland, 2003; Zantek, Wright, & Plante, 2002). Flexibility means organizations need to responsively handle frequent demand change, product design change, and product mix change. Without well-controlled processes as back up, the frequent changes will definitely elicit undesirable variations in manufacturing operations. Therefore, the following hypothesis is established:

H₁: the effect of PC on customer satisfaction is mediated by operational performances

Incremental process improvement (IPI) aims at improving existing process gradually. Jha et al. (1996) notice that process simplification lies at the very heart of IPI. Specifically in the course of IPI, front-line employees are usually encouraged to participate in work improvement teams (e.g., Quality Control Circle) when IPI is launched (Chang & Cheng, 1999; Johnston et al., 2001; Stoddard & Jarvenpaa, 1995; Yoram, Shani, & Meiri, 1997).

Therefore, IPI helps to identify and eliminate the non-value-added activities that may not be easily detected by management who are usually remote from the frontline operations. The process can thus achieve better delivery performance because of the detection and improvement of small quality and cost problems. For example, the improvement can be the change of inspection method, better design of jig and fixtures, or technical training provided for the operators. IPI can also contribute to the process's flexibility performance. For instance, when front-line employees are trained to be multi-skilled as in the case of work cell (Heizer & Render, 2006), it is much easier for production plant to respond to the change of production volume and product mix. Customer Satisfaction can also be improved. To this end, the follow hypothesis is proposed:

H₂: the effect of IPI is mediated by operational performances

The implementation of radical process improvement (RPI) always leads to the fundamental change of existing processes or the emergence of newly designed processes. It can be the redesigning and reconfiguring equipment to reduce set-up time (Koufteros et al., 1998). To this end, it is reasonable to link RPI with delivery and flexibility performance that are commonly characterized by the requirement of high responsiveness. Since it is always driven by a strong desire to a new status (Dervitsiotis, 1998), RPI is deemed to be a strategy-driven organizational initiative to improve quality, responsiveness, cost, flexibility, customer satisfaction and shareholder value (Kettinger & Grover, 1995). Therefore, the following hypothesis is proposed:

H₃: the effect of RPI is mediated by operational performances

DATA COLLECTION, MEASUREMENT QUALITY OF VARIABLES

We have administered a survey questionnaire to the manufacturing firms in Pearl River Delta, China. Totally, 330 usable questionnaires have been collected and accounted for around 10% response rate. Unidimensionality of each construct in the measurement model is demonstrated by the acceptable fitness of the model reflected from various fit indices. As shown in Table 2, items uniquely load on their corresponding factor but not the others. Therefore, undimensionality is achieved.

Reliability of the various factors is reflected from the composite reliability with criteria > 0.6 (Bagozzi & Yi, 1988; Nunnally, 1978; Stratman & Roth, 2002). Table 2 (see Appendix) shows that all reliability values exceed this threshold. Convergent Validity is demonstrated if each item's factor loading on its posited underlying construct > 0.40 and is significantly greater than twice its standard error of estimate (Anderson & Gerbing, 1988). That is, all λ s of the same construct should be greater than twice their standard error of estimate (SE_r). For instance, λ of item CUST2 (0.588) in Customer Satisfaction is greater than twice of its SE_r ($2 \times 0.101 = 0.202$). Since all items in Customer Satisfaction have their loadings greater than 0.40 and is also greater than twice of their SE_r's, the convergent validity of Customer Satisfaction is demonstrated. Therefore Convergent Validity of the constructs used in this study is assured. Discriminant validity is demonstrated if correlation between the two constructs $= 1.000$ lies outside the range of correlation coefficient of two constructs (r) $\pm 2SE_r$. If it is true then discriminant validity is achieved (Anderson and Gerbing, 1988). We have followed the procedure of Cohen et al. (2003) to estimate the Standard Error of Estimate (SE_r) of each correlation coefficient. The result shows that no correlation coefficient has range of $\pm 2SE_r$ with 1.000 inclusive. Therefore, discriminant validity is achieved.

RESULTS AND DISCUSSION

To test H_1 , H_2 , and H_3 , we have adopted Structural Equation Modeling (SEM) to evaluate the performance contribution of individual PM dimensions and the associated mediated effects as shown in Figure 1.

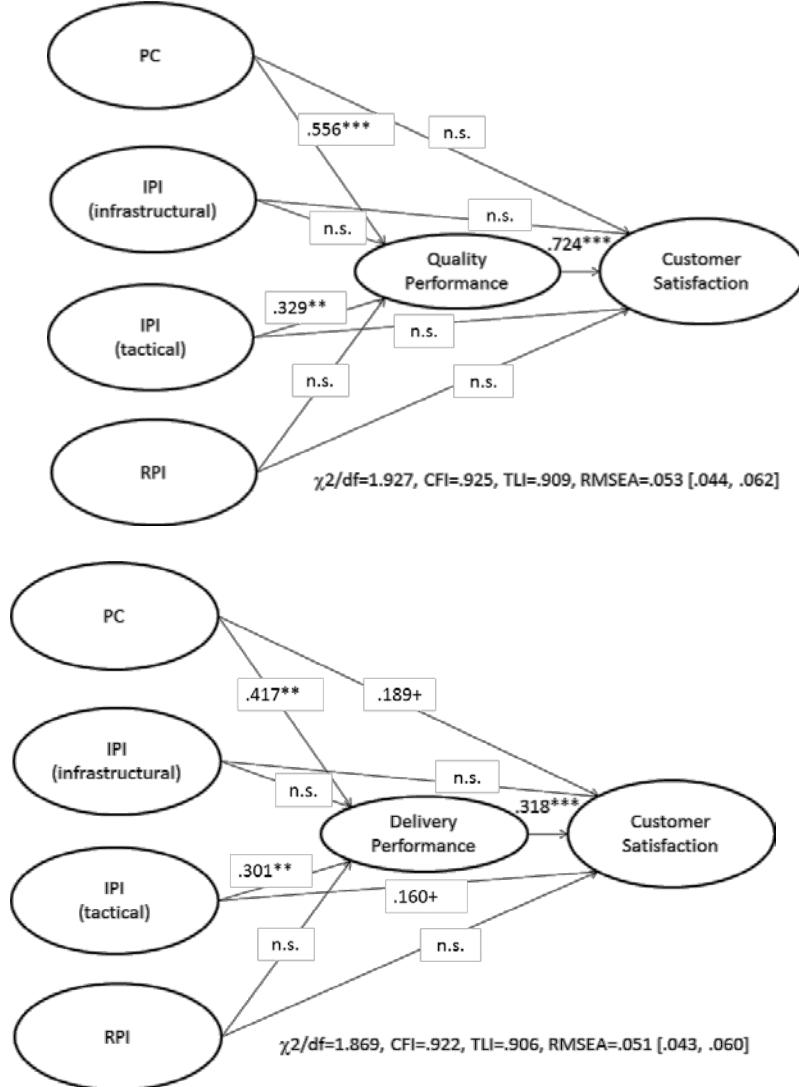




Figure 1 Effects of process management on customer satisfaction

The result sheds light on the details of PM's effect on customer satisfaction via various

operational performances. The above diagrams reveal that achievement of Customer Satisfaction is greatly hinged on an integrated PM composing of process control, incremental process improvement and radical process improvement. Customers are heightening their requirements not only in product quality, but also in process control and improvement nowadays. Literature has revealed that process management practices have significantly positive effect on Customer Satisfaction (Saraph, et al. 1989; Anderson, et al. 1995; Choi & Eboch, 1998; Wilson & Collier, 2000). Currently, there are two school of thoughts postulating the relationship between PM and Customer Satisfaction. The first thought suggests that Customer Satisfaction is caused by the achievement of operational performances (e.g., Parasuraman et al., 1990; Tsikritsis & Heineke, 2004; Yeung et al., 2004). Thinking along this line, PM affects Customer Satisfaction through operational performances. The second thought stresses that adoption of QM practices is driven by coercive pressure such as customer preference (Choi & Eboch, 1998; Ketokivi & Schroeder, 2004). Therefore, satisfied customers may not be due to the suppliers' superior operational performance but their image of modernization when an integrated PM is implemented. From this view, PM should directly affect Customer Satisfaction. This assertion is in congruence with the neo-institutional perspective (Choi & Eboch, 1998; DiMaggio & Powell, 1983; Westphal et al., 1997) that organizations conform to adopting certain OM practices is driven by the coercive pressure from resources holders. Particularly, when Choi & Eboch (1998) find that QM practices directly affect Customer Satisfaction but not plant performance, the researchers postulate that managers perceive the purpose of QM practices is to entertain customers. Nevertheless, the findings from Yeung and colleagues (2004, 2005) reveal that both lines of thought exist. That is, PM indirectly influences Customer Satisfaction through operational performances but also directly affects Customer Satisfaction.

Our study results drive us to cast doubt on the institutional perspective which asserts that adoption of QM practices is mainly driven by customer pressures (Choi & Eboch, 1998). As their findings reveal that QM practices directly influence Customer Satisfaction but not plant performance, Choi & Eboch (1998) postulated that managers might perceive the primary objective of implementing the requested QM practices was to satisfy customers. Our finding is exactly opposite to that of Choi & Eboch (1998) and partially agreeable with Yeung and colleagues (2004, 2005) who find that some of the PM dimensions (PC and IPI tactics) directly affect Customer Satisfaction. In sum, this study tends to support the mediation thought rather than the institutional thought about the effect of PM on Customer Satisfaction. It also reveals that not all operational performances are mediating the effect of PM onto Customer Satisfaction.

CONCLUSION

Theoretical Contributions

This study specifically advances the knowledge of PM's performance effect in the following aspects. First, the complexity of PM implementation and its positive impact on operational performance is conceptually beyond doubt but empirically inconclusive. Systematic effort to explore and examine the details is hitherto unseen. This study strives to bridge this gap and reveals PM's performance when it is perceived as a set of integrated principles and practices. Second, this study makes a significant contribution in operationalizing and testifying the existence of integrative effect of PM, which is always rhetorically declared in literature but with little empirical support. This study shows that PM dimensions complement each other to generate integrative effect that is positively associated

with operational performances. Finally, this study reveals that the proposed PM performs differently in progression of customer satisfaction when different operational performance is pursued.

Managerial Implications

This study bears profound implications to managers. Managers should acknowledge that firstly, PM has differential performance on operational performances and impact on customer satisfaction. Whether PM can make significant contributions to organizations is hinged on which operational performance is being pursued. Secondly, managers should acknowledge that implementing an integrated PM is much better than basing on a piecemeal approach. Managers should not solely rely on PC to manage their processes but also integrate with IPI and RPI. In same vein, managers should also not improve processes all the time but overlook the foundational role of PC. Fourthly, managers should be aware that satisfied customers are hinged on acceptable operations performances. In this connection, implementing PM solely based on customer pressure would be inadequate for satisfying customers.

Finally, managers should acknowledge their own influence on PM. For instance, their aggressiveness (Bateman & Crant 1993; Crant, 2000; Miles and Snow 1978; Langer, 1983; Venkatraman 1989; White, 1959) and knowledge about PM and QM (Benson, Saraph, & Schroeder, 1991; Crosby, 1979; Daft 1978; Damancpour 1991; Deming, 1986; Dewar & Dutton 1986; Ettlie et al. 1984; Grover et al. 1999; Guimaraes 1999; Hill & Collins 1999; Juran, 1986; Mezias & Glynn 1993) are pivotal to the effectiveness of PM.

LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

This study is limited by its cross-sectional nature of data. Therefore, the question of whether a specific order is observed in PM implementation cannot be statistically tested. Besides, the sample used is characterized by a majority of small and medium sized manufacturers. Therefore, the conclusions drawn from this study should be interpreted with caution.

Several research avenues are yet worthy for consideration. First, as Pettigrew et al. (2001) notice, longitudinal attempts to link change process and firm performances are still sparse. This is particularly true in PM and QM studies as most of them are cross-sectional in nature. Since the implementation of PM is always triggered by the initiation of some higher profile change programs such as ISO9000, TQM and Six Sigma, the only way researchers can observe the implementation details is to engage with organizations planning to embark these programs. Besides, case studies based on archives should also be considered to uncover the complexity of interactions among PM dimensions. Above all, several research questions remain unanswered if longitudinal or case study is not conducted. As Westphal et al (1998) notice, early adopters pursue QM/PM for efficiency while late adopters pursue the program for social acceptance. In other words, late adopters do not matter whether PM can bring performance effect. Therefore, it makes sense to ask would there be any conceptual shifts of PM over time and what would be the associated performance effect because of the conceptual shifts? In addition, would the performance effect of PM also change over time? Lawrence et al. (2001)'s postulation shows that any innovative practices will go through a life cycle characterized by the last stage of deinstitutionalization.

Second, contingency studies should be conducted to examine if the simultaneous effect is valid across different settings. Though PM has been commented as contextual dependent (Powell, 1995; Dow et al., 1999), little is known about its performance under

different contexts. Besides, as this study uses samples from manufacturing sectors, organizations from service sectors should also be considered. Past study has shown that PC may be less paramount to service industry (Zhao et al., 2004). Future works should focus on the differentiated application of PM in different service settings including mass service, professional service, service industry, and service shop (Heizer and Render, 2006).

Finally, this study assumes the recursive relationship between PM and operational performances. However, non-recursive relationship always exists between change processes and performance outcomes (Pettigrew et al., 2001). For instance, the operational outcomes may in return reinforce or discourage the efforts in PM. Therefore, how and to what extent will such effect evolve over time? To answer this question, more sophisticated theories and analysis methods should be developed.

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APPENDIX*Table 2 Assessment of Uni-dimensionality, Reliability and Convergent Validity*

N=330	Standardized Factor Loading λ (SEr)	t-value	Is $\lambda > 2SE_r$?	Composite reliability	Is Convergent Validity supported?
<i>Process Control</i>				0.8513	Yes
PC ₁ : we have established methods to measure and analyze quality of our products and service	0.667	N/A ^a	N/A ^a		
PC ₂ : we have site-wide standardized and documented operating procedures	0.762 (0.084)	11.890	Yes		
PC ₃ : housekeeping is maintained to ensure the plant is neat and tidy, and tools/materials can be easily accessible	0.730 (0.115)	11.474	Yes		
PC ₄ : most of the core processes have had clear and measurable performance indicators	0.724 (0.105)	11.397	Yes		
PC ₅ : adequate training is provided to those perform the tasks	0.756 (0.120)	11.815	Yes		
<i>Incremental Process Improvement</i>				0.8031	Yes
IPI ₁ : we run improvement projects on a continuous basis	0.824	N/A ^a	N/A ^a		
IPI ₂ : front-line employees are encouraged to participate in process improvement teams	0.848 (0.065)	15.448	Yes		
IPI ₃ : we implement the improvement in a gradual way	0.597 (0.109)	10.776	Yes		
<i>Radical Process Improvement</i>				0.7698	Yes
RPI ₁ : we seldom design and implement a totally new process	0.730	N/A ^a	N/A ^a		
RPI ₂ : we seldom use IT as enabler in process redesign	0.715 (0.094)	11.138	Yes		
RPI ₃ : we implement the newly designed process radically	0.538 (0.064)	8.637	Yes		
RPI ₄ : “think out of the box” is encouraged by top/senior management	0.484 (0.087)	7.818	Yes		
RPI ₅ : we form task force to implement process improvement projects	0.683 (0.115)	10.747	Yes		
<i>Quality Performance</i>				0.7346	Yes
QP ₁ : We have longer production down time*	0.492	N/A ^a	N/A ^a		
QP ₂ : We have less external product rejects	0.680 (0.137)	8.366	Yes		
QP ₃ : We have more internal WIP/product rejects*	0.710 (0.098)	8.543	Yes		
QP ₄ : Our products are relatively less reliable*	0.664 (0.277)	8.826	Yes		
<i>Delivery Performance</i>				0.7455	Yes
DP ₁ : We have better on-time delivery performance	0.759	N/A ^a	N/A ^a		
DP ₂ : We have longer process flow time*	0.587 (0.060)	9.985	Yes		
DP ₃ : We have shorter machining cycle time	0.570 (0.069)	9.611	Yes		
DP ₄ : We have shorter delivery lead time	0.649 (0.069)	10.940	Yes		
<i>Flexibility Performance</i>				0.8256	Yes
FP ₁ : We are more capable of handling rapid product design changes	0.651	N/A ^a	N/A ^a		
FP ₂ : We are more capable of handling rapid volume changes	0.890 (0.078)	12.407	Yes		
FP ₃ : We are more capable of handling rapid change of product mix	0.784 (0.074)	11.744	Yes		
<i>Production Cost Performance</i>				N/A ^b	N/A ^b
CP ₁ : We have higher unit production cost*	0.845	N/A ^b	N/A ^b		
<i>Customer Satisfaction</i>				0.6929	Yes
CS ₁ : We have more customer complaints*	0.717	N/A ^a	N/A ^a		
CS ₂ : We have higher customer retention rate	0.588 (0.101)	10.004	Yes		
CS ₃ : We have higher warranty costs*	0.458 (0.109)	7.089	Yes		
CS ₄ : We have more misShipments*	0.622 (0.109)	10.577	Yes		

* items with negative word

INNOVATIVE EDUCATION: NEW WAYS OF LEARNING AND A NEW ORIENTATION FOR THE EDUCATIONAL SYSTEM – WHAT CAN WE LEARN FROM MEDICINE?

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ABSTRACT

In this discussion, the authors used the unusual but ground-breaking approach of medicine to discuss innovative education. The study of the cell as well of motivation served as the background for this discussion. Motivation-Medicine was also used to show remote education that which takes place in a way not to permit close proximity between the observer and that which is studied; but also education happening out of the individual, may not bear the fruits expected. There is a call for the education system to innovate lest it wants to lead today's students to complete chaos.

KEYWORDS: Innovative Education, Motivation-Medicine, Cell.

INTRODUCTION

Seldom would anyone risk examining educational problems from a medical point of view; hence, one would readily admit threading on uncharted territory. Yet in an increasingly complex world, innovation in education is necessary in order to meet modern requirements (Avvisati et al., 2013). The transition from the industrial age to the information age has not made our lives any simpler. Instead, our everyday lives have become increasingly complex and challenging (Franklin Covey, 2004). We have been experiencing greater degrees of uncertainty, and are increasingly afraid of the future. As a result, many people fear losing their jobs and fear no longer being able to provide for their families. In this fast-paced age, we are continuously confronted with change: In fact, just when we think we have achieved “stability” in any given field, changes are already underway. That which is deemed “progress” here is actually a frightening, unstable type of development.

In fact, this situation has a medical parallel: That of a patient in an intensive care unit whose general condition cannot be stabilized over the long term, despite state-of-the-art therapeutic measures, and for whom there is no good prognosis. The way our world has developed is a result of our modern educational systems, which are diverse throughout the world but have not been adequately reformed to meet the prevailing new circumstances.

PURPOSE OF THE STUDY

The goal of the present article is not to introduce new ways of learning into the educational system, but to also create a critical analysis of the perception of the environment in school and everyday life. The way in which humans perceive their environment is conditioned not only by their way of thinking and the organization of their educational systems, but likewise by their capacity to cope with difficult life situations. The working basis of the concept for

Motivational-Medicine[©], which was introduced during a business forum in the United States in the state of New Hampshire in November 2013, is to outline the contributions the medical field can make to innovations in the educational system. In order to formulate responses to the above-mentioned issues, this discussion critically investigates innovative educational systems of the 21st century. The concept behind Motivational-Medicine and its implication for the educational system will be described within this context.

WHAT IS THE FOCUS OF INNOVATIVE EDUCATIONAL SYSTEMS IN THE 21ST CENTURY?

It is easy to ascertain the number of global challenges presented by the 21st century is on the rise. These challenges include economic and social problems, competition for resources, international terrorism, climate change, and environmental pollution, just to name a few. The central question today is the following: What skills and abilities does society need to survive the 21st century? Without effective education and sustainable development, life as we know it will be threatened. Therefore, the educational system warrants special attention as a precondition for sustainable development. Without education and innovation, it will not be possible to shape a viable future society.

For this reason, the United Nations declared the years 2005 to 2014 to be the decade of "Education for Sustainable Development" around the world. This global educational campaign sought to incorporate sustainable development thought and action into kindergartens, schools, universities, and educational organizations. Another goal was expanding education in early childhood and making it a continuous process throughout people's lives (A recommendation from the European Parliament and the Council of Key Competences for Lifelong Learning, 18 December 2006, 2006/962/EC, OECD 2010, OECD 2011, OECD 2012). Currently, there is still disagreement as to which skills and abilities should be taught or studied in order to master the challenges of today and tomorrow. The following three concepts have been gathered from discussions in recent years and provide an overview of the critical needs of 21st century educational systems.

The said concepts are the following: (1) A framework for learning in the 21st century (The Partnership for 21st Century Skills 03/2013); (2) Four keys to college and career readiness (David T. Conley 2011); and (3) seven survival skills (Tony Wagner 2010). This is a list of various skills and abilities that guarantee success in the new global economy. These skills include (i.) critical thinking, (ii.) communication, (iii.) collaboration, (iv.) creativity, (v.) problem solving, (vi.) flexibility and adaptability; also (vii.) agility, (viii) initiative and self-direction, (ix.) social and cross-cultural skills, (x.) productivity and accountability; and lastly, (xi.) leadership and responsibility. They also include skills such as the following: (i.) collaboration across networks and (ii.) leading by influence; (iii.) initiative and entrepreneurship; (iv.) effective oral and written communication; (v.) accessing and analyzing information; (vi.) curiosity and imagination; (vii.) problem formulation; (viii.) research; (ix.) interpretation; (x.) precision, and (xi.) accuracy; (xii.) goal-setting; (xiii.) self-awareness; (xiv) persistence, (xv.) collaborative learning; and (xvi.) student ownership of his or her learning among other skills.

These are only some of the necessary abilities or skills society will need in order to face new challenges; the list can still be expanded, attesting to the complexity of the world in which we live today. In effect, innovative educational systems of the 21st century also naturally contend with the problem of the learning environment, and how it should be arranged in order to make learning an enjoyable and creative process (Dumont & Istance,

2010; William, 2010; Slavin, 2010; Mayer, Cheng & Ling 2013; Sheridan et al., 2014; Noonan, 2014). An additional factor is the optimization of instructor training in order to increase learning effectiveness and to ensure a successful transition to the job market (Zitter et al. 2009; Zitter, 2010; Zitter et al., 2011; Zitter & Hoeve, 2012).

Last but not least, art plays an increasingly important role in supporting some of these skill sets – whether in the form of theater or music (Clapp & Edward 2013; Groff 2013; Nathan, 2013; Hetland, et al. 2013; NCES 2012; Vuust, et al., 2012; Winner, Goldenstein & Vincent-Lancrin, 2013). Likewise, emotional skills are important, core issues that should not be ignored in terms of problem-solving in the 21st century. (Miners, 2006; Ayiro, 2009; Mulla 2010). Furthermore, searching for solutions to the challenges of our time requires not only certain abilities and skills, but also integrative thinking that can transcend technical disciplines. The next sections comprise a critical analysis of innovative educational concepts, the concept of motivational medicine, and its implications for the educational system.

CRITICAL ANALYSIS OF INNOVATIVE EDUCATIONAL SYSTEMS

Effective skills and abilities as an “emergency solution”

As previously mentioned, the main objectives addressed by innovative educational systems are these: Which effective skills do we now need to better address the current “imbalance” in the world? The questions of how we arrived at this point, and what caused this development, do not seem to be germane to our discussion. This approach is similar to an emergency medical situation or the use of a second medication to combat the side effects of a first. In a life-threatening medical emergency, the physician often does not know how the patient reached his or her current state. In such acute situations, the primary concern is to alleviate the life-threatening situation and stabilize the patient. Only afterwards is the reason for the decline in the patient's condition investigated so that adequate therapeutic measures or adjustments can be introduced. In cases of medical emergencies, symptom-oriented treatments usually take priority.

A critical examination of innovative educational systems suggests that proposed solutions should be understood as “therapeutic measures” designed to present challenges. The “underlying illness” or the fundamental issue behind the situation is, however, not immediately specified. Therefore, the skills and abilities we need to teach with the goal of stabilizing the situation serve as “the antidote,” which helps us overcome challenges. This is similar to the patient in the emergency situation who receives appropriate medication for his or her physical illness to better control the unstable condition. The cause of the physical pain or, in our case, the cause of the societal challenges, is yet to be determined.

Alternatively, imagine you were a medication manufacturer, and you wanted to help a doctor treat his or her patients. Taking the underlying illness into consideration, you provide him or her with an appropriate medication. At first, the medication helps the patient quite a bit. However, over time, this medication proves to cause significant side effects for the patient. In light of this new challenge, you successfully develop a new preparation to combat these side effects. Despite good initial results, over time, this new medication also causes side effects. This new challenge also calls for a solution. Even though you have made real progress with each new challenge, you do not fully succeed in stabilizing the patient in the long run. Instead, you transition from one “unstable” situation to the next. How can you succeed in treating this patient without creating side effects?

If you really want to help this patient over the long term and prevent him or her from experiencing further side effects, you would need to change the concept of your medication or

the way you think. The side effects of the medication are only a reflection of your train of thought, because a medication does not just appear out of a vacuum: A pharmaceutical company is its manufacturer. In other words the medication proceeds from the manner in which you organize your thoughts to manufacture the medication. This means your concept of the medication or your thinking itself may contain side effects, which the medication may only reflect. If the initial idea is free of side effects, the medication will also be free of these. A medication can have only side effects if side effects are somehow inherent to the process that created them.

All things being kept equal, a similar problem lies behind the challenges of the 21st century. Similar to this example of medication, something in society's way of thinking and point of view needs to change. Society must now confront the perceptions and ways of thinking that have led us to today's conflicted circumstances. This means that today's challenges are only a reflection of society's way of thinking. In trying to solve problems in everyday life, society's thought processes produced future challenges that are comparable to the side effects of the medication in our metaphoric account. Therefore, acquiring skills (the new medication that is supposed to combat the side effects) does not dramatically help to solve the underlying problem. From a Motivational-Medicine perspective, the main problem of the 21st century relates to our perception and thinking. The human sensory system can provide an illustrative reference in analyzing the problem more closely.

THE SENSORY ORGANS AND THE SENSORY SYSTEM

The don-bosco gymnasium experiment: the sensory organs and the sensory system

In December 2014, the center for Motivational-Medicine[©] and the Promotion of Life conducted the following experiment with 31 pupils from the 5th grade at the Don- Bosco Gymnasium in Essen [*The Don-Bosco Gymnasium Essen is a private Catholic school founded in 1966. Its supporting organizers are the Salesians of Don Bosco.*]: The students were separated from one another and asked to describe everything they saw and perceived in their environment. These students described all the objects in their surroundings, such as trees, cars, and other students. Surprisingly, none of the students included themselves in their descriptions. When asked whether they were part of their environment, the students were speechless. They could not understand how they could have "forgotten" themselves in their descriptions of the environment. This experiment begs the following question: Why did the participants not see themselves in the experiment as part of their environment? Did they not assume they were part of it? When asked why they did not include themselves as part of their surroundings, their responses indicated it had simply not occurred to them to include themselves. This, again, raises the following question: How do we perceive our environment? The answer to this question requires a short discussion of our sensory organs.

Individuals perceive the world and their environments to be "outside of them," not "inside of them"

What are sensory organs and how are sensory organs defined? Generally, all individuals differentiate between five sensory organs (taste, touch, smell, sight, hearing). Neuroscientists describe five additional senses that supplement the five classical senses for a total of ten. These include the following:

- a) Sense of balance, which is responsible for spatial orientation and physical balance.
- b) Kinesthetic sense (proprioception), or the awareness of one's own body; the perception of the body's physical movement. Kinesthetic sense is further divided into the visceral sense,

the perception of one's internal organs. This also includes the perception of hunger, the perception of temperature by the thermal receptors, and the nociceptors, which permits us to react appropriately to threatening injuries. There are probably more sensory organs than one thinks.

"Sense organs are the instruments by which the mind is brought into relation with the external world." Stimuli from the environment are converted into electrical impulses, which are conveyed to the brain through nerve fibers. In the brain, they are processed in certain regions, allowing us to perceive them. (Hans-Werner Hunziker 2011).

According to Ulrich H. Rose [*Ulrich H. Rose is a natural philosopher. Though he has not completed any courses in philosophical study, his analytical powers with regard to various topics are very impressive*] the brain represents the only sensory organ. He assumes, without central processing in the brain, sensory organs would be useless. Only in the brain are the impulses from the sensory organs interpreted. In other words, only within the mechanisms of the brain do the impressions from the sensory organs take on meaning, not before. From this fact, Ulrich H. Rose concludes there is only one sensory organ: The brain. A schematic representation of this idea is represented in Figure 1 available in the fuller version of this discussion.

Even though this is not the position of this article, it can still be seen as a very critical confrontation with the issue of sensory organs and their definition. Instead, this article will represent the view that the sensory organs (in their classical understanding) and the brain work together to form a sensory system. The brain can only make evaluations if it receives impulses from the sensory organs. Without the brain, information from the sensory organs does not take on meaning and significance. As it is in all biological processes, this situation involves interdependence. This interdependence comprises participating structures that are neither superior nor inferior to one another. They are of equal value. The important factor here is only their optimal interworking.

The brain as a 'unified' sense; According to Ulrich H. Rose, the brain represents the only sensory organ. Only the brain brings meaning into the impressions collected by the mouth (Mund), nose (Nase), eye (Auge), ear (Ohr), and skin (Haut). Therefore, it is not logical to say our sensory organs include the mouth, the nose, the eyes, the ears, or the skin. This definition of sensory organs emphasizes the perception of conditions and processes taking place in the external world, or the world "outside" of humans. Humans trivialize themselves with this definition, functioning only as observers, even though they are also part of this world. This type of perception of one's environment makes one not an "insider" but an "outsider" with regard to one's environment. As an "outsider," one does not have access to "insider" knowledge. Instead, their main focus is on the "external world," which they analyze and evaluate continuously. All their knowledge and the knowledge that is taught in schools, universities, and training facilities is based on these assumptions. As "outsiders", how can humans attain knowledge that is withheld from "insiders"? Therefore, the idea behind Motivational-Medicine[©] suggests that in order to solve a problem, the first step should be a basis of integrative work with oneself as well as in relation to the environment. This is the precondition for the emergence of a new consciousness, which makes possible new orientations and effective response strategies. This was documented in the context of a non-randomized study discussed in earlier discussions pertaining to the concept of Motivational-Medicine[©] (Etoung, 2015).

MEDICINE AND INNOVATIVE EDUCATION

The concept of motivational medicine[©]

What is motivation?

Psychologically speaking, the concept of motivation concerns factors that predispose people to a particular course of conduct. From this point of view, motivation can be seen as goal-directed behavior (Zimbardo and Gerig, 2002). Motivationally based approaches can no longer be dismissed in modern management theory. Increased motivation is helpful not only in terms of performance, but also in terms of loyalty and forging bonds between key personnel and the company. One can distinguish between intrinsic and extrinsic motivation based on whether the factors that motivate people to display a desired behavior are self-determined (e.g. important activities, interesting work content) or are determined by third parties (e.g. supervisors, and human resource departments for instance). Every well-known motivational theory is rooted in psychology and neuroscience (Berridge, 2004; Adler & Chen, 2011). Accordingly, motivation assumes either the existence of a psyche or that of a nervous system or both. This example shows the psyche and the nervous system are not ubiquitous preconditions for motivation.

Motivational Medicine[©] is a theory of success and drive whose working basis is not rooted in psychology, but rather in medicine, and in the science of the human cell. The concept is derived from Virchow's cellular pathology, the basis of today's modern medicine.

A doctor's day-to-day activity in his or her practice and clinics focuses on disease. Generally, people visit the doctor not for enjoyment, but because they require urgent medical attention. Patients expect adequate care and sympathy from the entire medical staff. While any responsible physician strives toward this ethical and humanitarian ideal, unfortunately it often falls by the wayside. Though the reasons for this vary, in many cases, it is due to excessive workload. If the cell is the basis of medicine and life, this means the person should also be the focus of the medical trade and life itself. Working with cells therefore, one should focus less on investigating pathology than on the characteristics or basic functions of the organism that serves to preserve human life. The question Motivational Medicine[©] poses is the following: How can one apply medical or general knowledge of the cell to help people meet the demands of their everyday lives? Motivational Medicine[©] seeks to build a concept of success based on the answer to this question.

Understanding the cell as a source of motivation or inspiration for everyday life lends medicine and its representatives greater importance than simply the treatment or prevention of disease. Before grappling with the terminology involved in cellular pathology, we must establish a definition of the constituent terms, cell and pathology.

Introduction to "cell motivation theory"

Definition of terms

What is a cell?

A cell is defined as the smallest unit of life able to complete the basic functions of an organism, such as metabolism, growth, movement, and heredity.

What does the term pathology mean?

Pathology is defined as the study of disease processes within the human organism. Usually a distinction is drawn between general and special pathology. General pathology is concerned with the general laws of diseases. This includes aetiology, or the origin of diseases and pathogenesis. It concerns the emergence and development of a disease. Special pathology is

the study of disease patterns within individual organs. This part of pathology occupies an important place in medical diagnostics.

What is cellular pathology?

Cellular pathology is a theory according to which diseases are based on disturbances to the cells in the body or their function. In other words, every disease is linked to the cell, to changes within the cell, and the resulting effects. This also means all health derives from cells.

The concept of “cellular pathology”: Learning based on cellular pathology and the cell, and the cell as a basis for “motivational theory”

In 1858 the pathologist Virchow first put forth the notion of “cellular pathology.” Unlike his predecessors, Virchow understood the cell as a vital unit and accordingly the site of pathogenesis, again, the study of disease processes within the human organism. Even today, Virchow’s concept remains the basis for the model of pathology taught in medical schools. Along with microbiology – the study of microorganisms such as bacteria, viruses, fungi, etc. – it provides the foundation for contemporary medical education. Today, we know we are sick because our cells are sick. Virchow’s cell theory also brought about a decisive change in the medical world. Virchow saw in cells “the vital elements from which tissue, organs, systems, the entire individual is composed” (Virchow, 1966, p.3). In his main work on cellular pathology, Virchow wrote the following:

“Every animal appears as a sum of vital units, each of which bears the full nature of life itself. The character and unity of life cannot be found at any particular point on a higher organizational level, in a person’s brain for example, but rather only in the fixed, constantly recurring organization that contains each individual element in itself. From this it appears that the composition of a larger body always derives from a type of social organization, a social sort of organization, whereby a number of individual existences are dependent upon one another. Each element has its own particular activity and even though it receives stimulus from other elements for its activity, the actual accomplishment is self-propelled” (Virchow, 1966, p.12).

Today, it is accepted that cells emit light (biophotons) and the light emitted from living cells coordinates all the biochemical processes in cells, and controls their communication (Popp, 1995). Biophotons are “light quanta,” that is the smallest physical elements of light released by living cells. In cellular pathology it becomes clear that the cell’s central role in all beings extends beyond pathology itself. The idea behind Motivational Medicine[®] holds the human body to be the highest-performing and most successful system of all time. The cell, the most important structure in the human body and the basis for all human activity, provides the foundation for that system. This simple idea led to the development of a motivational concept inspired by the cell (Etoung, 2015).

IMPLICATION FOR EDUCATION

Implication for education: “perception and ability to achieve harmony,” self-awareness in educational systems and in society.

“Perception ability”: I am the environment; I am part of my surroundings

The Don-Bosco experiment, the non-randomized study, and the definition of sensory organs show us that our senses are primarily directed toward the “external world.” The sense organs are primarily used to perceive other things, not themselves.

Mathematicians and physicists perceive their subject, their work, before they perceive themselves, if they perceive themselves at all. Conversely, students think of their various subjects of study as distinct and separate from themselves. The positive results from the non-randomized study can be traced back to three reasons: the skills of the attending team, the change in the patients’ own perception, and their perception of their environment. Perceptual ability comprises two facets: self-perception, and the perception of one’s environment. However, these two forms can be consolidated into one form of perception: self-perception. The reason for this is, if one changes one’s perception of oneself, one also perceives one’s environment differently. With this ability, people begin to see themselves as part of their environment: “I am the environment.” There is neither an “external world” nor an “I.” I am also the “external world.” I have at my disposal all the abilities of my sensory organs and am not separate from the external world. Now one can create a new learning environment in which one has the possibility of becoming better acquainted with oneself, opening the way for one to learn to experience one’s environment more deeply, thus optimizing one’s personal performance.

“Ability to achieve harmony”

We can observe our environment, although we are part of it. The basis of our knowledge is rooted in our observations. We consciously or unconsciously avoid contact with ourselves. This condition is like an inner conflict, because in perceiving oneself and one’s environment, one regards the environment as “other” and thus takes the role of the observer. In our modern “un-unified” condition, the desired abilities for the 21st century – such as communication, collaboration, creativity, critical thinking, effectiveness, personal growth, etc. – create conflict instead of unification. Every environment influences and supports the elements or the characteristics that are present and dominant within it. This means that in a setting where, for example, hatred is advocated, communication, collaboration, creativity, critical thinking, and effectiveness will all be in the service of hatred, and any personal growth will be shaped by hatred. If, however, people’s surroundings are shaped by tolerance, then their way of communicating, collaborating, expressing creativity will all foster tolerance, because tolerance is the basic element shaping their environment.

Equally, the human body functions according to this same principle. For example, the muscle of the heart is a contractile organ that supplies the whole body with blood. All the cells in this tissue are developed in such a way that they support the contraction of the heart. They collaborate and communicate in order to keep this vital function of contraction working. The liver represents another bodily environment, and the cells in this region of the body are oriented toward the basic characteristics of the liver tissue, using their effectiveness and “creativity” for its purposes. In contrast, unless it is treated, a healthy cell that has mutated into a cancer cell will employ its communicative, collaborative, and creative abilities to destroy itself and the whole organism. In all of these examples, cells communicate, cooperate, and act creatively, but depending upon the nature of their environment, different results are attained. What are the implications of this fact?

The terms communication, critical thinking, effectiveness, and creativity are neither good nor bad; they have neither positive nor negative connotations unless we know the context in which they are used. Only when the environment and its basic characteristics have

been defined can we ascertain whether these skills will thrive. Thus, skills and abilities are not the center of our attention, but rather the environment in which the abilities are employed. If the environment is “malign,” then the abilities will facilitate malignancy. Conversely, if the environment is “good-natured,” the abilities will promote health. Therefore, we should always ask the question: Which abilities should we promote in our environment? Love? Hatred? Envy? Or Peace? In a conflict situation, the abilities specified above serve to promote conflict. Therefore, it is critical that we leave this stressful environment for a harmonious one. Our communication, collaboration, creativity, and critical thinking will foster unity between our environment and ourselves because the basic element of our new environment is unity. In this context, the ability to achieve harmony is one of the most important -if not the singular important- ability in the 21st century.

Educational systems as platforms that foster self-awareness

As observers, we need a certain distance from the object or condition we want to know more about. This distance can be a physical or mental separation from the object or circumstance under examination. This means any insight that comes from observation is relative knowledge rooted in the specific perspective of the observer. It is limited knowledge that cannot claim universal validity. One could call this “observer’s knowledge” or “removed knowledge”.

Strictly speaking, the things that we examine from an outside perspective remain distant and unknown. Why would one make such a claim? From our experiences in everyday life, we know we cannot have a deep understanding of anything from which we are separated by distance. Distance prevents us from making optimal contact with the object or circumstance and learning from it. It is precisely this distance we need in order to be observers and make analysis that simultaneously prevents us from truly encountering the things we want to observe.

Many are familiar with prejudice; all may have made judgments about other people before getting to know them. In other words, from a distance, we may make judgments. However, the more one becomes acquainted with a person, the more one reserves his or her prejudices. The reason is the individual usually sees that the other person is not at all the way he or she thought him or her to be. In this case, proximity helps one to revise his or her prejudices and even to dismantle them completely. This observation, then, shows that “knowledge” requires a certain proximity. If it were possible to become one with this person, to *be* him or her for a moment, one would even understand him or her better still. This also means the shorter the distance (physical or mental) between the observers and the observed, the more one can learn about what the person observes. The smallest distance possible between observer and observed occurs when the two are one and the same person, i.e. ourselves. Here, the distance is zero. Thus, we can learn the most from ourselves. We are closer to ourselves than to any other being. The caveat is that at any distance more than zero we enter into uncertain terrain [An oral testimony by J. Mbok from Cameroon, attorney and minister. The basic ideas behind these assertions come from him.]

The second obstacle to comprehending things in an all-encompassing way is the way they change constantly over time, since nothing can remain static in a dynamic world. This means we could examine a given structure for its entire life without understanding it completely. This also explains why generations of scientists spend their entire lives researching the same subject without arriving at any final conclusions. It amounts to a journey that never leads one

to the intended destination, though anyone who plans a trip is pleased to one day arrive at the destination. As observers, we have set out on a “journey” – no one knows where it is leading and when the “travelers” will arrive. This is a situation that we can classify as “unstable” or even dangerous. What implications, then, do these observations have for innovative educational systems?

As previously mentioned, current educational systems convey knowledge based on observation, or “*knowledge at a remote*,” knowledge that is not universal since according to the above analysis, the distance between the observer and the observed represents a limiting factor on the path to understanding. Since this obstacle is not present in self-awareness, one can imagine educational systems as platforms for personal growth and development, platforms that not only convey ‘knowledge at a remote’ but also allow students and trainees to learn in a way that is similar to becoming acquainted with themselves.

What does this means concretely? This means that teaching programs in the schools and universities would not only be focused on acquiring “knowledge at a remote,” but would also work to foster self-awareness. This goal responds to the question: How do biology, mathematics, geology, or physics help me increase my understanding of self? These subjects then become more than theoretical constructs with practical applications in certain technical areas outside of us. They become subjects that can be used in the service of personal development and self-awareness, self-growth, even. This means that one no longer becomes a mathematician, physicist, geologist, or biologist. In effect, these choices of names emphasize our roles as observers and outsiders in the environment, separating us from our own identities, from our ability to understand ourselves, our abilities to achieve harmony and self-awareness. I am not a biologist, but I am myself. I use biology, physics, and geology as a means to experience more about myself. This entails using my ability to understand myself as a form of communication with myself, strengthening awareness.

SUMMARY AND PERSPECTIVES

In this work, the challenges of the 21st century have been presented as the product of our current perception of the world. As our perception of the world and our environment determine our behavior and way of thinking, which in turn delimit future challenges, it can be assumed that without a change in this perception, there can be no important progress made in resolving the problems humans face. It is beyond question that humans require definite skills and abilities in order to confront the challenges of their time. As a consequence of human perceptions and actions, our fast-paced age is characterized by constant change. This means new challenges continually arise and we must continually develop new skills. If we extrapolate, it becomes clear with increasing progress, the number of challenges will not grow smaller, but rather larger. The number of skills humans must possess in order to effectively master these challenges will increase likewise. In the course of time, there will only be a “chosen few” capable of developing all the necessary survival skills. In a worst-case scenario, nobody will possess all of the skills necessary to survive.

The relative speed at which such a scenario may arise probably depends on whether our skills develop in a linear or exponential manner in response to the challenges of our age. Our perception of the world may be guiding us towards “self-destruction.” From this perspective, the most pressing problem is not so much how to continuously develop our skills but rather how to change our perception of our environment. Medicine’s role in resolving this problem cannot be underestimated. Whoever finds him or herself in conflict with their environment and themselves can never develop a reasonable solution for him or herself and

the surrounding environment. It is not the problem itself that stands at the center of attention, but rather the person who wants to solve the problem. It is therefore a matter of the highest priority to perform integrative work with oneself and one's environment before taking action, in order to solve any potential conflicts on the one hand, and any actual problems on the other.

Educational systems should therefore first carry out reconciliation work within their own institutions and their environments, before working on skill development. Skills – whether in communicating or critical thinking – can lead to both “bad” and “good” developments. Their final effect depends on the composition and basic characteristic of the environment, a point which is emphasized here. Finally, schools and universities of the future should provide a platform focused on developing the skill of self-awareness. The sole accumulation of remote knowledge increases conflict among ourselves as well as between us and our environment. “I” am not an academic field, i.e. I am not a biologist or geologist. I am myself. Accordingly, the academic world should help me to discover myself. The final bell has tolled for the current educational system. A radical re-orientation of the educational system is unavoidable.

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RESEARCH IN PROGRESS: WHAT STRATEGIES ARE SENIORS USING TO REDUCE LONELINESS?

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ABSTRACT

In common with other countries that have an aging population, Australia has a looming problem in the forecasted growth of older citizens. Currently there is a sharp increase in public expenditure on care for people past the age of 80 and we can expect that to climb with continued improvements in medical care and other technologies to assist individuals live longer. Currently in Australia the policy is to keep seniors living independently in their own home for as long as possible. The area we are investigating is how can we support and teach skills to older people to live independently through the use of enabling technologies such as information technology. This support can be in the form of the provision of assistive tools to provide an environment for seniors that improves their quality of life in conjunction with reducing the demand on social services.

INTRODUCTION

In common with other countries that have an aging population, Australia has a looming problem in the forecasted growth of older citizens. Currently there is a sharp increase in public expenditure on care for people past the age of 80 and we can expect that to climb with continued improvements in medical care and other technologies to assist individuals live longer. Currently in Australia the policy is to keep seniors living independently in their own home for as long as possible. The area we are investigating is how can we support and teach skills to older people to live independently through the use of enabling technologies such as information technology. This support can be in the form of the provision of assistive tools to provide an environment for seniors that improves their quality of life in conjunction with reducing the demand on social services.

In this paper we further categorize older people into young-old (65 to 85 years) and older-old (over 85 years). The interventions we are discussing here are targeted at the young-old as they will provide these people with the skills to be able to live more independently when they reach the older-old category. As a demographic, people over 85 years old currently comprise 2% of the population in Australia however the current intergenerational report (Intergeneration report 2015) extrapolates that by 2054-55 this figure will rise to 4.9%. While the young-old currently comprise 13% of Australia's population, in the next 40 years this will increase to 17.7%. It is predicted that this increase in life expectancy will be accompanied by an increase in healthy life expectancy as since 1998 any increase in reported life expectancy has been within the years that a person could expect to live without a disability. This means that we can assume that as a population we will be active and able to live independently longer. Currently there is a sharp increase in the consumption of public spending on aged care past the age of 80 with the spending on health for a person over 85 being four times the spending on an

average person, hence the predicted 2.45 times increase in this demographic will impact on public spending in health and social services (Intergeneration report 2015).

Approximately 36% of older Australians (65 or older) live in rural/ regional Australia and this represents some challenges for rural communities (Davis & Bartlett, 2008). Regional areas also have a higher proportion of seniors than urban areas. The move from active paid work into retirement is a time of transition for people and the skills, knowledge and experience gathered through active participation in the work force and community can be lost resulting in a loss in community social and human capital. With the transition to retirement comes a reduction in the number of social connections as the connections made through work are lost. In regional and rural Australia many seniors have had their identity as a primary producer or primary producer's helpmate stripped away by a loss of physical ability or a move to a larger regional centre to be nearer to health services. This move shatters their strong ties to their communities, disrupting social networks and their preferred informal support network (Davis & Bartlett, 2008). Even those who are able to stay in the rural community have their social network fractured by their peers moving (Franklin & Tranter, 2008). This is at a time where they have an increased amount of time on their hands and an increased need for social connections outside the home (Felmlee 2009). The common move into larger regional centres also brings the challenge of forging new social connections, this process is critical as loneliness can easily be a common theme in this situation.

In Australia loneliness is a large problem as 50% of people over 61 experience loneliness, 26 to 29% are chronically lonely with men experiencing more extreme forms of loneliness (Franklin & Tranter 2008, p. 10). Loneliness is associated with higher stress ratings, an increased risk of heart attacks and cardiac deaths (Hawley et al. 2003), depression (Cacioppo et al. 2006), other psychiatric disorders such as schizophrenia (House, Landis & Umberson 1988), reduced physical activity (Hawley, Thisted & Cacioppo 2009) and acts as a risk factor for increased morbidity and mortality (Hawley et al. 2003). Depression alone results in up to a 50% increase in general medical expenses (Druss, Rohrbaugh & Rosenheck 1999) with the lonely reporting their health as twice as bad as those who are not lonely (Easton 2011). Inversely an increase in social relationships is associated with significant benefits to behaviour, mental and physical health with people with good social connections being healthier and living longer (Umberson & Montez 2010). Loneliness cannot be cured by placing seniors in proximity to community centres, they need to form meaningful relationships in order to build social networks (Easton 2011). The conundrum for older rural citizens here is a need to access the medical and transport infrastructure associated with urban communities with the loss of community ties and social networks that have been developed over many years. This is of course is also exacerbated by the death of close friends and relatives as people get older.

IMPLICATIONS OF LONELINESS

In Australia, around 45% of adults (7.3 million between the ages of 16 – 85 years) experience a mental disorder in their lifetime with the prevalence in older people over the

age of 65 years increasing in recent times (AIHW 2014). Indeed, more than half of those seniors (52%) who are permanent aged care residents have symptoms of depression (AIHW 2013). Depression is a common mental disorder that, worldwide, affects 350 million people of all ages and is the leading cause of disability globally (WHO, 2012). Depression is on the rise and can vary in intensity, at worst leading to suicide. Despite there being known effective treatments, fewer than half of those individuals living with depression receive treatment (WHO, 2012). Late-life depression is defined as the suffering of people over the age of 65 from depression (Alexopoulos, 2005) with the causes being i) social isolation and loneliness; ii) physical ill health; and iii) loss of a partner (Black Dog Institute, 2012). Furthermore, being a non-physical issue, depression is often overlooked by health practitioners in favour of physical ailments (Snowdon 2001) with a lack of resources and the stigma associated with mental health issues also providing major barriers to effective treatment (WHO, 2012)

The consequences of depression for older people are different to that for younger people (Yesavage et al., 1983; Schoevers, et al., 2000; Licht-Strunk et al., 2009; Verhaak et al., 2014). While late-life depression does not necessarily lead to suicide, it is a contributing factor (Australian.gov ref: <http://www.mindhealthconnect.org.au/depression>; Bamonti, Price and Fiske, 2013). The mortality rate of older people who attempt suicide is greater than that of younger people (Nock, 2014). There are a number of factors known to contribute to the development of late life depression and they are: loneliness (Theeke, 2009), living alone (Victor et al., 2000), marital status (Savikko et al., 2005), the lack of social networks (Cutrona, Russell & Rose, 1986), poor quality connections with others (Holmen & Furukawa, 2002), cognitive decline (Dejernes, 2006); and low income (Aylaz, et al., 2012). These factors are interconnected, with the role of social connections and are the core theme that is strongly related to late-life depression (Verhaak et al, 2014). Loneliness, be it perceived or experienced, was evident in a large number of studies and is identified as the strongest predictor of late-life depression (Theeke, 2009). Loneliness predominantly results from living alone which reflects marital status with either the death of a spouse leading to living alone (Aylaz et al., 2012) or the lack of family to socialise with for those who have never married (Vink et al., 2008).

The lack of a social network, which occurs in part due to family members moving to other cities (Aylaz et al., 2012), is detrimental to people's sense of worth and self-esteem as they do not feel respected and needed (George et al. 1989; Cutrona, Russell & Rose, 1986). Furthermore, with age the number of friends tends to decreases due to death and illness leading to less social interaction (Holmen & Furukawa, 2002). Cognitive decline resulting in confusion, decreased coordination and speech and memory loss lead to negative feeling in individuals about their condition and they reduce their social interaction (van't Veer-Tazelaar et al., 2008). Finally, low incomes limit the ability of older people to pay for social activities which constrains social interaction (Aylaz, et al., 2012)

Loneliness begets loneliness. Loneliness and isolation (physical and/or mental) are known to lead to anxiety, shyness, anger, tension and late-life depression. As a consequence of these factors, sufferers feel even more isolated and alienated (Aylaz, et al., 2012). Mehta et al (2008) classified older-old differently to our current category, namely over 80 instead of 85, however in their research they reported at a more nuanced level, the antecedents of depression are known to vary between the 'young-old' (65-80 years) and the old-old (>80 years) (Mehta et al., 2008)

Community

Throughout the research, there is a strong indicator that community is a very important factor. There is the plurality of definitions for a community. Should we define a community as a geographical area or a social network of people with shared experiences, interests, tastes and values who may reside in geographically diverse locations Piselli's (2007). A definition of community based on social networks rather than geographical places adds to the complexity of funding of social services. Hillery Jr's (1955) work looked at commonalities in the definition of a community for rural people and found that for the majority of people a location is capable of furnishing a common bond. A minimum definition was "an area in which social interaction and one or more common bonds are to be found". Piselli (2007) adding that a physical location can help drive how social events are organised and a feeling of local identity can help to drive shared experiences and therefore increase social connections. MacQueen et al. (2001, p. 1929) offers an alternative definition of an urban community from a public health perspective "as a group of people with diverse characteristics who are linked by social ties, share common perspectives, and engage in joint action in geographical locations or settings". These two definitions of community across a range of time periods and locations show that an argument can be built to use a geographical location to set community parameters. So as Piselli (2007) states social connections cannot be driven by proximity therefore rather than clustering seniors together, do we need to provide other mechanisms for seniors to avoid social isolation? However Felmlee (2009) states that friends are more important than family for seniors confidence and self-esteem.

Social marketing

In this paper, we are suggesting that social marketing has a role in defining the factors associated with loneliness amongst older people. Social marketing addresses public health and social issues in ways that enhance peoples' quality of life (Hastings *et al.*, 2012) with the principle remit to enhance the well-being of individuals and society at large (Hastings *et al.*, 2012). It can be seen from the growing number of social marketing case studies, successful outcomes result from a precise and nuanced understanding of the cause, its antecedents, enablers, barriers and consequences. It is this foundation knowledge that leads to the careful design and operationalization of appropriate interventions, be they 'downstream' interventions to individuals, 'upstream' interventions to authorities, 'midstream' interventions targeted at other stakeholders or hybrids of these (Hastings *et al.*, 2012; Hoek and Jones, 2011).

Recently there has been a growing interest among social marketers about the use of social media to effectively engender behaviour change for the social good (Gordon, 2012). The capability of social media to build social connections and create communities is increasingly seen as a potential remedy to address social loneliness, a key precursor to late-life depression among seniors (WHO, 2012). Mental health is important to healthy ageing (WHO, 2013). Interventions that enable the maintaining and building of social connections and a sense of community among seniors have the potential to reverse or stem the onset of late-life depression; the consequences of which are considerable for the individuals, their family and friends and society at large.

It can be seen that social marketing interventions to address depression in older people could not only improve the quality of life of older people, but potentially reduce

suicide attempts and unnecessary deaths. Social marketing interventions that seek to encourage older people to be socially active and enables them to have and maintain a good support network with family, friends and carers are recommended (Victor, et al., 2000; Verhaak et al., 2014). Social marketing also provides an opportunity to situate the community health initiatives within the community, so that the community is in partnership with the community health providers

A RESEARCH APPROACH USING SOCIAL MARKETING AND SOCIAL NETWORKING TOOLS

Virtual social connections can be made through social networks such as "Facebook" as they have the ability to increase bonding between "friends" and increase a person's social capital by lowering the barriers to communication (Burke, Kraut & Marlow 2011). People may use social networks to cope with a feeling of disconnection and because they find their use rewarding and providing a positive substitute for face-to-face contact (Sheldon, Abad & Hinsch 2011). Burke et al. (2011) found that positive benefits were increased by using directed communication with a friend rather than broadcasting a message or passively consuming others news. Directed communication acts to keep a channel of communication open even when in-person contact is not possible making maintaining friendships over geographical distance possible. Ease of communication in social networks having the ability to increase the value of a friendship, or deepen a casual friendship. Two studies conducted by Nimrod (2010) found that online social networks had the ability to enhance social structures and provide an enjoyable leisure activities in seniors. Chen (2009) states that the current mainstream social networks such as "Facebook" are aimed toward their younger primary audience and the services and facilities do not meet senior's requirements. So it is not possible to merely suggest to seniors that they use an existing social networking medium such as FaceBook but an online social network still has the potential to assist in increasing social connections. Heo 2010 found that seniors who used the Internet as a leisure activity were highly satisfied with the activity in the dimensions of entertainment, relaxation and social information. Gatto and Tak found that seniors using a computer reported the feeling of being connected, a feeling of satisfaction with the information found and increased self-esteem from the learning process. However some seniors reported that they were frustrated with the amount of time it took them to learn computer skills and a concern with privacy and a concern that they might become addicted to the internet.

Access issues

A Queensland 2009 study of home computer use found that 87.88% of 55-64 year olds and 61.1% of 65 years and older Queenslanders had access to a computer, with both the sectors growing strongly from 2008. Internet use was 83% in the 55-64 sector and 53.3% in the over 65 year olds. The yearly growth rate was 7.8% for the 55-64 year olds and 4.8% for the over 65 year olds. The lower growth rate in the over 65 year old sector might be explained by the wider age range in this sector. These statistics demonstrate that the majority of over 55 year olds have access to computers and Internet use so that this does not form a barrier to the adoption of an online system.

The role of social marketing

While social networks for seniors (Chen 2009; Nimrod 2010, 2011) and the information technology education needs for seniors (Sayago et al. 2007) have been previously explored, the use of social marketing techniques in this space has not been done and an education component to build social skills has not been embedded in within a social network. However Leist 2013 states that online communities provide a suitable tool for social support and that social media also offers an opportunity to include educational materials. This research will endeavour to use marketing techniques to increase social connections in seniors to increase the knowledge base of how to actively engage a growing sector of the community, seniors in community capacity building strengthening the ability of the community to solve social problems internally. This research also has the capacity to leverage the higher Internet speeds predicted to be available by training a group of people not previously exposed to information technology. This sector of the community has the potential to be one of the biggest consumers of e-services facilitated by these higher speeds such as e-health and e-government so that a group of trained people who are already actively engaged in community service have the ability to disseminate learnt skills through the community.

THE RESEARCH QUESTIONS

In order to investigate loneliness among older people, we will be looking at the factors associated with loneliness and determining if a social marketing approach can assist in reducing a person's loneliness. In addition we wish to determine if ICT can be used as an enabling technology to utilize contextually relevant social marketing approaches to reduce the level of loneliness. Therefore our research questions are as below;

RQ 1 What are the factors that cause loneliness amongst seniors?

RQ 2 Can social marketing approaches assist in reducing loneliness?

RO 3- Does ICT have a role in providing an enabling technology to help people overcome loneliness?

RQ 4- What ICT approaches can be deployed?

The research approach

We will be using a mixed methods approach in researching this problem. Firstly we will conduct a qualitative investigation to discover the factors that trigger loneliness among older people living in regional areas. Secondly we will be looking at the acceptability of a social marketing approaches and whether they can reduce loneliness. Here we will be using focus groups and interviews from seniors across our target region, namely the Sunshine Coast in Queensland, Australia. These qualitative approaches will inform the construction of a quantitative research instrument that will be distributed more widely. This survey will be designed to allow older people to provide input into suggestions on what social marketing approaches will be used and how we could use ICT to enable the use of such approaches across a wide area.

CONCLUSIONS

The approach undertaken here needs the co-operation of members of the senior's community. We are fortunate in this case as the targeted area has a great number of

retirees from all walks of life and from all states of Australia. This is because the environment (sub-tropical) is very conducive to retirement living. In addition the University of the Third Age has a strong base of willing people who are happy to be involved with the research. The university of the third age is described as a “worldwide self-help organisation promoting learning for personal enjoyment and satisfaction” (<http://www.u3abrisbane.org.au/>)

This research has significance for future generations as any reduction in the cost of healthcare for the elderly will help balance future government budgets. These savings stretch well beyond the direct aged care considerations such as housing etc. This is because reducing loneliness can also reduce other medical conditions such as depression and other situations associated with loneliness including possible suicide.

It is also hoped that once the relevant social marketing approaches have been identified that apps can be developed for tablets or smartphones that will allow ICT technology to become an enabler for older people to communicate with newly acquired friends. This approach will be different to the traditional social media approaches such as Facebook etc. as it will be targeted to older people and will be contextually appropriate to this older group who in many cases are not as computer literate as others.

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SUPPLY CHAIN INFORMATION SHARING (SCIS): A PRELIMINARY LITERATURE REVIEW

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ABSTRACT

Information sharing is to make operational, tactical, and strategic information available to business partners in supply chains. Supply chain information sharing (SCIS) has been a well-established research area in supply chain management since 1990s. In the beginning, a vast number of modeling studies endeavored to investigate information sharing issues. Gradually, more empirical studies on SCIS were conducted. It is necessary to review relevant literature on these two streams. In this paper, we attempt to summarize our observations on the development of SCIS research area and to explore the future research direction.

Keywords: supply chain information sharing, modeling studies, empirical studies

INTRODUCTION

Fierce business competition forces enterprises to pay more attention to the coordination with their suppliers and customers. Information sharing is a prerequisite for coordinated supply chain operations. It is impossible to coordinate supply chain activities without appropriate information sharing among supply chain partners (Choi, 2010). Mentzer et al. (2001, p.8) defined information sharing as “the willingness to make strategic and tactical data available to other members of the

supply chain." More specifically, information sharing is the real-time information exchange on material flow, order entry, shipping and billing, forecasts, and plans with supply chain partners (Marquez, Bianchi, and Gupta, 2004).

Information sharing has been an important theme in supply chain research (Frohlich and Westbrook, 2001; Sahin and Robinson, 2002). A wide range of literature emphasizes the importance of information sharing to supply chain management. Lee, Padmanabhan, and Whang (1997) claimed that one important mechanism for coordination in a supply chain is the information flow among supply chain members. Kanji and Wong (1999) indicated that information exchange between different supply chain members is necessary for better coordination of work among members, which may also lead to improvements in the supply chain operation. Cooper, Lambert, and Pagh (1997) emphasized the benefit of frequent information updating among the chain members for effective supply chain management. Lee and Whang (2000) pointed out that the integration and optimization of information flow in the supply chain is as important a core concern as that of material flow and financial flow.

Traditionally, most of SCIS studies explored benefits of information sharing through modeling approach and focused on only one or two types of information shared in simple supply chain structures. Since Li and Lin (2006) and Zhou and Benton (2007), more empirical studies on SCIS have been conducted. There are three literature reviews for modeling and simulation studies (i.e., Sahin and Robinson, 2002; Huang, Lau, and Mak, et al., 2003; Choi, 2010). Five years has passed since the most recent literature review on modeling approach. It is necessary to have a literature review on supply chain information sharing research from the perspectives of both modeling and empirical approaches. The objective of this literature review is to summarize our observations on the development of supply chain information sharing research area and to explore the future research direction.

REVIEW METHODOLOGY

The review is based on about 60 academic articles between 1996 and 2015. The following keywords, information sharing, information flow, information exchange, supply chain visibility, supply chain ordination, supply chain integration, were searched at ProQuest, ABI, and EBSCO. Particular attention is paid to top-tier journals in information system and operations management,

and supply chain management, such as, MIS Quarterly, Journal of Management Information Systems, Information & Management, Decision Support Systems, Information Systems Research, Information Systems Journal, Journal of Enterprise Information Management, Journal of Information Systems, European Journal of Information Systems, Management Science, Decision Sciences, Operations Research, European Journal of Operational Research, IIE Transactions, International Journal of Production Research, Journal of Operations Management, International Journal of Operations & Production Management, Industrial Management & Data Systems, Manufacturing & Service Operations Management, Production and Operations Management, Supply Chain Management: An International Journal. Then, a content analysis was conducted to ensure the appropriateness of the literature searched. These previous studies in the literature review were organized based on research methods used.

RESEARCH ON SUPPLY CHAIN INFORMATION SHARING

Modeling Approach

Supply chain modeling is the process of constructing a supply chain structure (SCS) and characterizing relationships between SCS and various parameters and relationships among these parameters. The modeling approaches have basically fell into three categories: analytical models, mathematical programming models, and simulation models. Table 1 summarizes the SCIS studies by modeling approaches and specifies authors, supply chain structure, types of information sharing, and methodologies.

Analytical models, quite popular in supply chain management field, are effective in providing important insights into information sharing issues. This line of research analytically proved the existence of four sources of the bullwhip effect (Lee et al., 1997) and demonstrated the benefits of information sharing (e.g. Bourland, Powell, and Pyke, 1996; Gavirneni, Kapuscinski, and Tayur, 1999; Yu, Yan, and Cheng, 2001; Chen, Drezner, Ryan, and Simchi-Levi, 2000; and Chen, Ryan, and Simchi-Levi, 2000) and even found that upstream partners can get more benefits from information sharing than downstream partners (Lee et al., 2000). Because the benefit of information sharing is not evenly distributed among supply chain partners, a more recent study by Ding, Guo, and Liu (2011) attempted to design a benefit allocation scheme in a three-level supply chain to motivate retailers to share demand information. A similar study by Leng and Parlar (2009) analyzed how cost savings from demand information sharing can be allocated fairly

in a three-level supply chain. Information sharing is an indispensable ingredient of some supply chain management practices, such as, vendor-managed inventory (VMI) and continuous replenishment programs (CRP). A study found that downstream partners have received more benefits of VMI than upstream partners (Dong and Xu, 2002). In addition, Yao and Dresner (2008) investigated the interaction among information sharing, continuous replenishment programs, and VMI in a two-level supply chain.

The earlier analytical SCIS studies were primarily conducted under simple two-level supply chain structures. Gradually, more analytical models have been extended to more complex supply chain structures, such as, Iyer and Ye (2000) and Munson and Rosenblatt (2001). With increasingly complex supply chain structures under consideration, SCIS studies turned to use simulation approach. For example, Lau, Huang, and Mak (2004) conducted a multi-agent based simulation research to explore the impact of information sharing on inventory replenishment in a three-level supply chain structure. Huang and Gangopadhyay (2004) conducted a simulation study to examine the efficacy of demand information sharing under several operating scenarios within a four-level divergent supply chain structure. Another stream of simulation study is the discrete event simulation on SCIS including Zhao et al. (2001), Zhao and Xie (2002), Zhao, Xie, and Leung (2002), Zhao, Xie, and Wei (2002), Zhao, Xie, and Zhang (2002), and Abuhilal, Rabadi, and Sousa-Poza (2006). The research findings from these simulation studies are quite similar to those from analytical studies.

Because information sharing provides more information for supply chain planning process, some studies explore the effect of information sharing in supply chain planning process by employing mathematical programming models. For example, Gaonkar and Viswanadham (2001) constructed a linear programming model to study schedule and demand information sharing in a supply chain. Kim, Leung, Park, Zhang, and Lee (2002) developed a mathematical programming model that considers a supply network consisting of a manufacturer and multiple suppliers to answer the question of how much of each raw material is to be ordered from each supplier under the constraints of capacities of suppliers as well as the manufacturer.

Basically, by using modeling approach, the content of supply chain information sharing extends from forecasting, inventory, demand, and order status information to production, capacity information (Lee & Whang, 2000). Demand-side information sharing has been intensively

explored, such as, inventory information sharing (Dong & Xu, 2002; Gavirneni, 2006), demand information sharing (Leng and Parlar, 2009), forecasting information sharing (Cachon & Lariviere, 2001), and order information sharing (Lau, Huang, & Mak et al., 2004; Zhu, Gavirneni, & Kapuscinski, 2010). Some other studies also explore supply-side information sharing, such as, production, capacity, and supply quantity information (e.g. Jain & Moinzadeh, 2005; Chen, Yang, & Yen, 2007; Xue, Shen, Tan, Zhang, and Fan, 2011). Actually, demand-side information sharing has driven the analytical studies on information sharing (Choi, 2010).

Table 1 Summary of Studies on Supply Chain Information Sharing by Modeling Approaches

Authors	Supply Chain Structure	Type of Information Sharing	Modeling Approaches
Bourland et al. (1996)	Two-stage (a supplier and a customer)	Demand information	Analytical model
Güllü (1997)	Two-stage (one supplier and several retailers)	Inventory status and forecasting information	Analytical model
Mason-Jones and Towill (1997)	Two-stage (one factory and several customers)	Sales information	Discrete event simulation
Swaminathan et al. (1997)	Two-stage (a manufacturer and two suppliers)	Capacity information	Analytical model
Chen (1998)	A serial inventory system with N stages	Centralized demand information and local inventory information	Analytical model with numerical examples
Cheung and Lee (1998)	Two-stage (a supplier and multiple retailers)	Inventory information	Analytical model
Gavirneni et al. (1999)	Two-stage (a capacitated supplier and a retailer)	Demand information	Analytical model with numerical experiment
Gavirneni and Tayur (1999)	Two-stage (a customer and a supplier)	Inventory policy and demand distribution	Discrete event simulation
Gilbert and Ballou (1999)	Two-stage	Advanced order commitment	Analytical model
Strader et al. (1999)	5-tier divergent differentiation supply chain	Demand information	Multi-agent simulation

Waller et al. (1999)	Three-stage (one manufacturer, several distribution centers and retailers)	Inventory information	Discrete event simulation
Cachon and Fisher (2000)	Two-stage (a supplier and N identical retailers)	Order and inventory information	Analytical model with numerical experiment
Cetinkaya and Lee (2000)	Two-stage (a vendor and multiple retailers)	Inventory information	Analytical model
Chen, Drezner, et al. (2000)	Two-stage (a retailer and a manufacturer)	Demand information	Analytical model
Chen, Ryan, et al. (2000)	Two-stage (a retailer and a manufacturer)	Demand information	Analytical model
Iyer and Ye (2000)	Three-stage (customer, retailer, warehouse)	Price and inventory	Analytical model
Lee et al. (2000)	Two-stage (a retailer and a manufacturer)	Order information	Analytical model
Aviv (2001)	Two-stage (a retailer and a supplier)	Forecasting information	Analytical model with numerical study
Cachon and Lariviere (2001)	Two-stage (a manufacturer and a supplier)	Forecasting information	Analytical model
Gallego and Ozer (2001)	Two-stage	Advance demand information	Analytical model
Ganeshan et al. (2001)	Three-stage (a plant, a distributor and a supplier)	Inventory information	Discrete event simulation
Gaonkar and Viswanadham (2001)	Three-stage	Demand information	Mathematical programming model
Gavirneni (2001)	Two-stage (a capacitated supplier and N retailer)	Demand information	Analytical model with numerical experiment
Li et al. (2001)	A serial structure with N stages	Order, demand, inventory, and shipment information	Analytical model
Munson and Rosenblatt (2001)	Three-stage (supplier-manufacturer-retailer)	Price discount information	Analytical model

Ng et al. (2001)	Two-stage supply chain with two warehouses and two retailers	Order information	Analytical model
Yu et al. (2001)	Two-stage (a manufacturer and a retailer)	Order, demand and inventory information	Analytical model
Zhang (2001)	Two-stage (a manufacturer and two retailers)	Demand information	Analytical model
Zhao et al. (2001)	Two-stage (a capacitated supplier and four retailers)	Early order commitment	Discrete event Simulation
Zimmer (2002)	Two-stage (a supplier and a producer)	Demand information	Analytical model
Dong and Xu (2002)	Two-stage (a supplier and a buyer)	Inventory information	Analytical model
Kim et al. (2002)	Two-stage (a manufacturer and multiple suppliers)	Capacity information	Mathematical programming model
Zhao, Xie, & Leung (2002)	Two-stage (a capacitated supplier and four retailers)	Net requirement and order plan	Discrete event Simulation
Zhao, Xie, & Wei (2002)	Two-stage (a capacitated supplier and four retailers)	Early order commitment	Discrete event Simulation
Zhao, Xie, & Zhang (2002)	Two-stage (a capacitated supplier and four retailers)	Net requirement and order plan, and Early order commitment	Discrete event Simulation
Zhao and Xie (2002)	Two-stage (a capacitated supplier and four retailers)	Net requirement and order plan	Discrete event Simulation
Lau et al. (2004)	Three-stage structure	Order and demand information	Multi-agent simulation
Jain & Moinzadeh (2005)	Two-stage (a retailer and a manufacturer)	Supply information	Analytical model
Gavirneni (2006)	Two-stage (a retailer and a supplier)	Inventory information	Analytical model
Chen, Yang, & Yen (2007)	Multi-stage	Inventory, demand, and capacity information	simulation

Leng and Parlar (2009)	Three-stage (a manufacturer, a distributor, and a retailer)	Demand information	Analytical model
Zhu, Gavirneni, & Kapuscinski (2010)	Two-stage (a retailer and a supplier)	Order information	Analytical model
Xue, Shen, Tan, Zhang, & Fan (2011)	Two-stage	Supply quantity	Analytical model

Empirical Approach

Information sharing is not only an operational issue, but also a strategic issue. To explore SCIS strategically, it is inevitable to consider the influence of decision makers' behavior. SCIS research by modeling approaches are incapable of capturing the influence of human intervention. In addition, these studies did not consider the influence of competitive environment on the adoption of SCIS. Therefore, it is necessary to examine the driving forces behind information sharing adoption. According to Roth (2007) and Fisher (2007), empirical studies using survey method can greatly contribute to this important research area.

Empirical studies on SCIS are started from Li and Lin (2006) and Zhou and Benton (2007). Information sharing, as a capability, subjects to the influence of a lot of factors. Some studies, therefore, explored antecedents of information sharing. Li and Lin (2006) indicated that supplier uncertainty is the only environmental uncertainty influencing information sharing. Madlberger (2009) scrutinized the effect of internal factors (commitment, information policy, and technical readiness), inter-organizational factors (relationship, trust, power, and business partners' technical readiness) and economic factors (perceived benefits and costs) on information sharing behavior. Arnold, Benford, Hampton, and Sutton (2010) demonstrated that B2B E-Commerce risk negatively influence information sharing, but absorptive capacity have positive influence on information sharing. Further, organizational commitment mediates these relationships. Cai, Jun and Yang (2010) investigated the effects of trust and a series of institutional factors including legal protection, government support and importance of guanxi on SCIS in China. They find that trust mediates the influence of government support and importance of guanxi on SCIS. Cheng (2011) studied how relational benefits, relational proclivity, connectedness, power symmetry, and dysfunctional conflict affect information sharing. Du, Lai, Cheung, and Cui (2012) identified partnership extent, data dynamism and process complexity as antecedents to information sharing.

In addition, a wide variety of empirical studies examined the effects of information sharing on organizations. Zhou and Benton (2007) showed that information sharing and supply chain practice mutually reinforce each other to improve supply chain performance. Premus and Sanders (2008) explored the role of information sharing on forming supply chain alliances. Information sharing may increase supply chain agility and flexibility (Swafford, 2008). Sezen (2008) inspected the relative effects of supply chain integration, information sharing, and supply chain design on supply chain performance. Schloetzer (2012) found that information sharing directly contributes to financial performance of the focal firm in supply chains. Liu, Huo, Liu, and Zhao (2015) tested how information sharing and process coordination influence logistics outsourcing.

Some empirical studies examined both the antecedents and consequences of information sharing. Fawcett et al. (2007) noted that technological connectivity, as one of antecedents of information sharing, is positively related to operational performance. Hsu, Chiu, Chen, and Liu (2009) found that some contingency factors, organizational structure, organizational climate, environmental uncertainty, and technology dynamics, contribute to information sharing, and information sharing increases supply chain integrated performance. Schloetzer (2012) found that asymmetry of interdependence and magnitude of interdependence affect information sharing and further information sharing contributes to financial performance. Ye and Wang (2013) discovered that IT alignment increases cost efficiency of a supply chain through information sharing. Wang, Ye, and Tan (2014) revealed that managerial ties and trust positively affect information sharing extent and quality, whereas information sharing quality reduces supplier opportunism. Huo, Zhao and Zhou (2014) revealed that international competition stimulates firms to share information both internally and externally, which in turn enhance supply chain performance.

Table 2 summarize the empirical SCIS studies we reviewed and specify authors, antecedents, consequences of information sharing, theories used, and data analysis methods.

Table 2. Summary of Empirical Studies on Supply Chain Information Sharing

Authors	Antecedents	Consequences	Theories	Data Analysis Method
Arnold, Benford, Hampton, & Sutton (2010)	B2B E-Commerce risk, absorptive capacity, organizational commitment	Not applicable	Resource advantage theory	SEM
Cai, Jun &	legal protection,	Not applicable	Institutional	SEM

Yang (2010)	government support, importance of guanxi, trust		theory, TCT	
Cheng (2011)	relational benefits, relational proclivity, connectedness, power symmetry, dysfunctional conflict	Not applicable	RBV, Political economy perspective	SEM
Du, Lai, Cheung, & Cui (2012)	partnership extent, data dynamism, process complexity	Not applicable	Partnership-data -process perspective	SEM
Fawcett et al. (2007)	technological connectivity	operational performance	No	regression
Huo, Zhao & Zhou (2014)	Competitive environment	supply chain performance	No	SEM
Hsu, Chiu, Chen, & Liu (2009)	organizational structure, organizational climate, environmental uncertainty, technology dynamics	supply chain integrated performance	Contingency theory	Factor analysis
Li & Lin (2006)	environmental uncertainty, intra-organizational facilitators, inter-organizational relationship	Not applicable	No	regression
Liu, Huo, Liu, & Zhao (2015)	Not applicable	logistics outsourcing	RBV	SEM
Madlberger (2009)	internal factors, inter-organizational factors, and economic factors	Not applicable	RBV, TCT, SET, theory of embeddedness	Partial least squares (PLS)
Premus & Sanders (2008)	Not applicable	supply chain alliances	No	Correlation analysis
Schloetzer (2012)	asymmetry of interdependence, magnitude of interdependence	Financial performance	TCT	regression
Sezen	Not applicable	supply chain	No	regression

(2008)		performance		
Swafford (2008)	Not applicable	supply chain agility and flexibility	No	SEM
Wang, Ye, & Tan (2014)	managerial ties, trust	supplier opportunism	SCT, TCT	SEM
Ye and Wang (2013)	IT alignment	Cost efficiency, customer responsiveness	RBV	SEM
Zhou & Benton (2007)	Not applicable	supply chain performance	No	SEM

DISCUSSION AND CONCLUSION

The purpose of this paper is to review the most updated and important development of supply chain information sharing research. Through the literature review of 60 studies on SCIS for the past 20 years, it is found that most of the previous SCIS studies use mathematical modeling or simulation research methods. Only less than one-third studies use empirical methods.

Among the modeling studies on SCIS, simple two-level supply chain structure were frequently used to gain insight into the effect of information sharing. Under the two-level structure, researchers also identified the existence of the bullwhip effect in supply chain operation, quantifies its influence, and explore ways to alleviate it. More complex, three-level or multi-level, supply chain structures have been adopted to be approximate supply chain reality. This stream of studies started from exploring the effect of demand-side information sharing, such as, forecasting, inventory, demand, and order status information sharing, to supply-side information sharing, such as, production schedule, capacity, and supply quantity.

The first empirical study on SCIS was published in 2006 almost ten years after the first modeling study on SCIS. Among these empirical studies, regression analysis, path analysis or structural equation modeling (SEM) were employed to analyze the survey data. Actually, SEM is the dominant data analysis method. The research models in earlier studies were established without theoretical support. This line of studies on SCIS gradually seek theoretical support in economics, organization, and strategic management, such as, contingency theory, resource-based view (RBV), social capital theory (SCT), and transaction cost theory (TCT). It seems that RBV

and TCT were most frequently quoted theories. However, there might not have a “one-size-for-all” theory for supply chain phenomena (Halldorsson et al., 2007). Different theories may complement each other to provide more appropriate explanation for supply chain information sharing. More granular understanding of information sharing should be provided in the future empirical research. Because information sharing needs be explored quantitatively and behaviorally, modeling studies and empirical studies on SCIS will coexist in the long run. Empirical studies will be increasingly important.

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INNOVATIVE EDUCATION: THE CHALLENGE OF A 21ST CENTURY EDUCATION

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ABSTRACT

The authors discussed the changing nature of education, some reasons why individuals though in need of higher education may not always be able to take advantage of this opportunity. Distance Learning may be the answer for many individuals today in that category. In this discussion, the authors extolled the virtue of higher education in the United States, a place where many dream to come and attend college, while Americans themselves sometimes lack the means or desire to do so. The discussion showed innovative education could offer a path to those willing to still avail themselves of the benefits of a higher education.

KEYWORDS: Higher Education, Distance Learning, 21st Century.

INTRODUCTION

The US census still asserts that “for many people, education is a sure path to a prosperous life, the more education people have the more likely they are to have a job and earn more money, particularly for individuals who hold a bachelor's degree” (Census.gov). Noticeably, the New York Times reported recently more than 30 percent of American adults held bachelor's degrees, a first in the nation's history (Eacute, 2012). However, although the number of degree holding adults has increased, there is still a vast amount of the population who do not have an education due to certain challenges or barriers, such as not having the time, money, or not just having any interest in pursuing a higher level of education.

RATIONAL OF THE STUDY

Since the U.S. possesses a vast multitude of colleges and universities, and is a country known for its impeccable higher education institutions it just is sad, not many individuals within the US take advantage of these institutions; especially given many come from all around the world to attend

these higher institutions of learning. However, this situation springs from several factors. The top five reasons (Faubert, n.d.), why people do not attend college in the United States are the following: (1) They cannot afford it; (2) nobody in their family has ever attended college; (3) they do not know what to do with their life; (4) they think college is too hard; and lastly, (5) they think they just will not fit in (CollegeAtlas.org).

According to a survey reported in the Huffington Post (i.) 23% of people investigated indicated they did not go to college because they could not afford it; (ii.) 20% declared they were undetermined; (iii.) 16% stated they already had a good job; (iv.) another 16% confirmed they would rather work and make money than go to college; (v.) 11% alleged they needed to support their family; (vi.) 3% specified their grades were not high enough for them to qualify for college acceptance; and lastly (vii.) 2% believed their job did not require a higher education (“*Top excuses people use to not attend college*,” n.d.). In order to best analyze the success or benefits of innovative education, one ought to explore these various groups of stakeholders, the true beneficiaries from technology and today’s innovative education.

RESEARCH QUESTION

People have changed the way they think and operate in the 21st century. Additionally, more people today are choosing to either go straight into the workforce, the military, or to do nothing at all, instead of getting an education. How can society still address the needs of these different categories of individuals? This discussion addresses a few of the challenges with getting an education in the 21st century, while juggling career and multiple other demands, and how innovative education, more specifically distance learning can just be the answer to many of these questions (Goldberg, 2009).

PURPOSE

Online education has gained in popularity over recent years. Although the concept of distance learning is not new, innovations in technology have made it easier to pursue classes online. According to an article from U.S. News, approximately 6.1 million students took at least one course online in 2011. As hinted already, not having enough time is one of the reasons that prevents people from obtaining a higher education. Some start families sooner, and parents need to be home to ensure things run smoothly. The average age for a woman who had her first child in 2009 was as young as 15 (*Surprising facts about birth in the United States*, 2015). With the rising occurrence of young teenage mothers and families, people are being forced to stay at home to take care of their families (Klein, n.d.).

Another challenge of getting an education in the 21st century is being able to balance out school and work. People have decided to go straight to work, instead of going to school. Many individuals believe that they can make more money by entering straight into the workforce. Since many choose to start their family earlier than in previous years, men and women have to work to take care of themselves and their children. Being able to prioritize your child’s homework, making sure that one’s family eats, getting the children to bathe, picking out school clothes, and getting ready for one’s workday can be challenging, especially when one has to attend classes and get work done. Besides, attending school can be a lengthy process that takes commitment, focus, and dedication to complete. Sometimes, individuals avoid an education because of how long it will take to get their degree. The average Associate’s degree takes over a

year and a Bachelor's degree takes over three years. That can be perplexing for someone who still have to take care of their priorities at home.

THE BEAUTY OF DISTANCE LEARNING

Thus, distance learning is the solution to many of the challenges just mentioned. Getting an education online allows people the opportunity to get the knowledge they seek, at their convenience. Online classes give students the control to plan their days so they can get their assignments completed around their own time. The convenience distance learning provides is what helps make it the best choice in getting an education in the 21st century. We live in a knowledge society, an era in which time is fluid; nothing lasts and everything changes or is unstable. The new millennium was led by a dramatic technological revolution. The society we live in is increasingly diverse, globalized, complex and heavily saturated by the media. One observer stated this technological revolution would have a greater impact on society than did the transition from an oral to a print culture. Our diverse society is characterized by a series of internal, social, and environmental crisis.

THE NEED FOR A NEW EDUCATION

In the beginning, education and the ideals it embodied aspired to create a “perfect” citizenry. Later, the objective shifted to ensuring that citizens were well-trained, and more recently it shifted once again to the awakening of critical thinking. Today, the ideal is creativity: the capacity to learn and a lifelong willingness to face new things and modify learned expectations accordingly. In a knowledge society, education aims to provide the capacity to be creative in an environment of uncertainty, the capacity to properly manage the mental conflict that gives rise to humans’ failure to comprehend reality (Innerarity, 2010). Therefore, society must move away from sporadic education towards lifelong learning. Conventionally, education has been understood as preparation for life, as personal awareness, and as an essential element in progress and social change, in accordance with changing needs (Chitty, 2002). Orr (2004) warned if certain precautions were not taken, education may equip people to become “more effective vandals of the earth.” He described education as appearing as far as a possible problem, and argued for a new type of education.

Therefore, education must lead to empowerment. Individuals should acquire, through education, the capacity to make decisions and act effectively in accordance with those decisions. Consequently, education should consist of developing not only personal but social skills as well. It is the development of humans’ awareness of how society works, as well as their knowledge of how it is structured. While education alone does not create employment, it is essential to keeping workers on the job. Therefore, it is not sufficient just to ensure the expansion of the educational system. It is necessary to generate an enhancement in the quality of the teaching offered, in order to meet the demand for increasingly qualified human resources to accompany the changes presently under way.

REFORMULATION OF HIGHER EDUCATION

Einstein once said, no problem could be solved from the same level of consciousness having created it. Current needs suggest we must learn to view the world as well as education in a new way. In the past, higher education has demonstrated a critical role in introducing change and

progress in society and today, it is considered a key agent in educating new generations to build the future. The *World Declaration on Higher Education for the 21st Century* (1998), pointed out that higher education was facing a number of important challenges at the international, national and institutional levels.

At the international level, one of the challenges consists in encouraging international cooperation between institutions, in order to share knowledge across borders and facilitate collaboration. States need to provide the necessary financing enabling universities to carry out public-service functions (Bauman, 2007). States may also enact laws to ensure equality of access and strengthen the role of women in higher education and in society. The following are the challenges faced by universities and other institutions of higher learning:

Changes in the educational model.

New teaching and learning approaches should be integrated. This will enable the development of critical and creative thinking. In the knowledge society in which we live, higher education should transform society from disoriented projectiles into guided missiles: rockets capable of changing direction in flight, adapting to variable circumstances, and constantly changing course (Morin, 2009). Teachers must teach students to learn quickly as they go along, with the capacity to change their mind and even repudiate previous decisions if necessary, without over-thinking or having regrets. Teaching and learning must be more active, connected to real life, and designed with students and their unique qualities in mind (Sterling, 2001).

Changes should aim at tapping the potential of information and communication technologies in the creation and dissemination of knowledge. Furthermore, changes should prepare students for social responsibility and the transfer of knowledge (Dobson & Bell, 2006). The work of higher-education institutions must be relevant. What they do, and what is expected of them, must be seen as a service to society. Research must anticipate social needs; and the products of research must be shared effectively with society through appropriate knowledge-transfer mechanisms.

ONLINE LEARNING

Data from Project Tomorrow News report the following (1) 47% of students in grades 9–12 pursue online learning to secure courses not offered at school and (2) 43% of these students work at their own pace. The primary reason 42% of students in grades 6–8 take these online classes is to receive extra help with their studies. (3) 77% of teachers believe technology makes a difference in learning, and (4) 28% of teachers want online courses to be offered as an alternative in their district. Lastly, (5) 42% of parents believe online classes are a good investment to improve student achievement because of the following reasons from a Gallup poll:

(i.) Lessons taught in high schools often lack 21st century skills such as collaboration and real-world problem solving; (ii.) a research organization, working with Microsoft Partners in Learning and the Pearson Foundation interviewed 1,014 people ages 18-35 with varying levels of education, asking them to recall their last year of school: The result revealed only 22% of students with a high school education or less said teachers encouraged them to apply what they learned to a real-world problem; (iii.) additionally, approximately one-third of the students reported learning about other cultures and teaming up with classmates on projects, while working online. Still, though technology use was common among these students, only 3 percent said they

used video conferencing, discussion boards or resources such as Skype. (“*Trends in global higher education: Tracking an academic revolution*”, 2009)

The same Gallup survey report suggested students tasked with regularly deploying these 21st century skills deemed these critical in the workplace, stating they were more likely to help them excel at their jobs (Cachia, Anusca, Ala-Mutka, & Punie, 2010). Experts suggested to look at what dominated the news cycle and think about how it applied to lessons. Teachers could use severe weather outbreaks and environmental disasters to illustrate everything from climate patterns to the logistics of coordinating relief efforts. Educators could also capitalize on the seemingly never-ending political campaign season to teach students about everything from statistics to finance and big data (Bauman, 2007; Innerarity, 2010). They could tap industry experts; granted, getting a CEO into your classroom could be a logistical nightmare. However, getting the same CEO on a Skype call could be quite feasible (Chitty 2002).

In effect, free online tools open up an array of opportunity for getting experts in front of students. Educators could set up a call or join one hosted by someone else, using such tools as Skype in the Classroom. The White House, media outlets and other organizations also regularly host Twitter chats and Google Hangouts with top minds in the industry within nearly every field imaginable. Teachers can also turn the tables and have students present a project or pitch an idea to industry leaders (Orr, 2004).

HOW DISTANCE LEARNING PREPARES STUDENTS FOR THE WORKFORCE

Students understandably are different, with different learning styles, work schedules, and childcare needs (Bertman, 1998; Belasco, 1991). One size does not fit all and everyone does not learn the same way. A lecture or chalkboard approach will not produce the results one desires with technology savvy students. “If we always do what we’ve always done, we’ll always get what we’ve always gotten.”

Distance Learning can help bring education into the 21st century. By nature GED students want to be in class as briefly as possible. They have obstacles that prevent them from attending a traditional class due to the fact that their job schedule may not be flexible; if the situation is compounded by the fact that this particular student is a single parent who lacks transportation or childcare, distance learning helps remove those barriers. Thus, distance learning is indeed a bridge that can help!

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TRUCKLOAD UTILIZATION AND ITS INITIATIVES IN MITIGATING CARBON EMISSIONS AND OPERATION COST IN THIRD-PARTY LOGISTICS

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ABSTRACT

Carbon emission reduction in logistics and transportation industry has been highlighted in recent world economic forums. Logistics firms have been seeking ways to effectively improve operation efficiencies and mitigate carbon emissions. An operations review on a third-party logistics firm is conducted. The truckload utilization and its relationship with truck capacity, loading volume, fuel consumption, truck size, travelling distances and number of destinations are analyzed. Determinant factors are selected via factor analysis for developing truckload utilization model in solving bin packing problems. A best-fit model to improve the truckload utilization and reduce the usage of trucks is established as a basis for the future development of a truckload utilization system. Operation costs and carbon emissions could be reduced through the improvement of truckload utilization in the third-party logistics firm.

KEYWORDS

Third-party logistics, truckload utilization, carbon emission, bin packing problem

1. INTRODUCTION

With the severe competition in the logistics industry, third-party logistics (3PL) firms encounter the need of reducing operations cost and global pressure on mitigating carbon emission in their warehouse and truck operations. The carbon emission reduction initiatives in the logistics and transportation operations have been brought out in the World Economic Forum in July 2013 (Le Quere, 2014; Doherty et al., 2013; Doherty and Hoyle 2009). Facing the global trend and green initiatives carried out by leading logistics firms, other 3PL firms face fierce challenge in the competition on pricing strategy, operations costs, corporate image and marketing, and social responsibility, affected by the fluctuations in fuel consumption, fuel price, labour cost, and truckload utilization (Konur, 2014; Min and Jong 2006). To meet the needs of improving the operation efficiency and reducing the carbon emission during the consolidation of thousands of boxes into trucks each week, 3PL firms require a systematic and intelligent system to plan for loading various boxes on different pallets and packed into the trucks for cargo delivery, with the consideration of box size, arrival time, truck size, pallet size, and destinations (Levesque, 2011). This paper reviews the truckload utilization in the operations of 3PLs and the models developed for solving bin packing problems. An operations review has been carried out in a global 3PL firm in Hong Kong. With statistical analysis on the operations data, a best-fit model is proposed to improve the truckload utilization of the 3PL in solving the bin packing problem. A literature review on 3PL truckload utilization and bin packing problems is presented in Section 2 of the paper. The operations review and analysis framework are described in Section 3. The findings and results

of statistical analysis are discussed in Section 4, followed by the proposed model to be further developed for the 3PL firm. Finally, conclusions and future development are summarised in Section 5.

2. TRUCKLOAD UTILIZATION IN BIN PACKING PROBLEMS OF THIRD-PARTY LOGISTICS

The operations activities of 3PL started in the 1970s with companies outsourced logistics services to third parties. Ackerman and Wise (1985) presented the early state of 3PL concept in Council of Logistics Annual Conference. Lieb (1992) further described 3PL as the use of external companies to perform logistics functions that have traditionally been performed within an organization. The functions performed by the third party can encompass the entire logistics process or selected activities within that process. In early 2000s, 3PL included the contract logistics and defined as multiple logistics services provided by a single vendor on a contractual basis (Lewis and Talalayevsky, 2000; Razzaque and Sheng, 1998). Aicha (2014) reviewed the outsourcing of logistics activities and the selection of 3PLs in the past two decades with the consideration of logistics services in transportation, distribution, warehousing, inventory management, packaging and reverse logistics. Recent years, the globalization, offshoring, and complex supply chain network have incited the expansion of firms to specialize in transport and logistics services (Williams, 2014; Selviaridis and Spring, 2007; Kholer, 2001). Companies tend to outsource logistics activities in order to focus on their core competencies, such as manufacturing, wholesaling and retailing. The role of 3PL becomes more prominent in the 21st century as a professional logistician in providing services, including warehousing, cargo consolidation, distribution, customs, documentation, multi-modal transportation, and supply chain management (Ajakaiye, 2012; Chin et al., 2010). The extensive use of logistics services has further brought the concern from customers and government on greenhouse gases emitted from transportation and logistics services (EPA, 2013; EIA, 2012). This pushes 3PLs to map out the carbon footprint and reduce the carbon emission in their daily operations (Sathaye et al., 2010; Léonardi and Baumgartner, 2004).

Truckload utilization is a key performance indicator affecting the operation costs and truck emissions in 3PL. Improving truckload utilization cuts operations cost, increases revenues, and reduces congestion and pollution for the society (Van de Klundert and Otten, 2011; Min and Jong, 2006). Various analysis and modelling on truckload utilization have been carried out. Samuelsson and Tilanus (1999) developed a model to provide estimates on various measures for capacity utilization in regional less-than-truckload (LTL) distribution, considering the dimensions of time, distance, speed, and capacity. Hubbard (2001) described capacity utilization is high when trucks are hauled with a series of full loads with the support of computation tools and wireless networking applications. The utilization of each truckload is highly depended on the agglomeration of complementary demands into individual trucks. Tyan et al. (2003) evaluated the freight consolidation policies of global 3PL and developed a mathematical programming model to assist the evaluation of consolidation policies. Baykasoglu and Kaplanoglu (2011) proposed a multi-agent based load consolidation decision making approach for LTL orders to solve the complex interrelated factors including loading sequence, capacity limit, route selections, and cargo consolidation. Recent truckload utilization problems link not only with operation efficiency but also the volume of carbon emission. Christie et al. (2006) presented the applications of vehicle logistics optimisation to minimise operation costs, save energy sources, and meet international protocol on greenhouse

gas emission reduction targets. Sathaye et al. (2010) evaluated the cargo load consolidation and load factors together with freight truck trips, gross vehicle weight and pavement maintenance to mitigate road congestion and carbon emissions. Knour (2014) analysed an integrated inventory control and transportation model under the constraint of carbon cap using the truck costs and capacities as measurement. A heuristic search model was further proposed to solve the costs and emissions optimisation problem in inbound transportation.

Bin packing problem describes the situation in packing objects of various volumes into a finite and minimum number of bins or containers (Johnson et al., 1974). Studies on various types of bin packing problems and respective solutions have been carried out (Sim and Hart, 2013; Wäscher et al., 2007; Weisstein, 2000; Martello and Toth, 1990; Karmarkar and Karp, 1982; Johnson, 1974). With hundreds of boxes with various sizes and types to be loaded into different trucks, most of the 3PL firms rely only on experienced personnel to manually plan the loading sequence, vehicle routing, and pallets arrangement with reference to delivery schedule and cargo destination. Often the planning is carried out in an ad-hoc and non-systematic manner without evaluating the truckload bin utilization. Thus, bin packing models and optimisation tools are important decision support and planning tools for logistics practitioners to minimize the number of bins used. Bin packing problem is regarded as a combinatorial NP-hard problem (Paquay et al., 2011; Liu et al., 2006). In the basic variant of the bin packing problem, n items of sizes in $(0, 1)$ is measured and assigned to unit size bins. We identify that each bin may contain items of total size at most 1, and the goal is to minimize the number of bins used (Epstein and Levin, 2012).

One-dimensional problems define that the weight capacity of the bins is fixed, so the goal is to optimize the collection of items to bins which related to the number of bins used or the weight of items assigned to bins. Several researches of the one-dimensional bin packing problem in the context of operations research and theoretical analysis are available (Brusco et al., 2013; Csirik et al., 2006; Fleszar and Hindi, 2002; Hall et al., 1988; Johnson et al., 1974). While we are given that the rectangular bin $B = (W, H)$ is the width W and height H , and there are a set of n rectangles items with the dimensions W_i and H_i , ($i = 1, \dots, n$) waiting to be packed into the bins. The goal is to minimize the number of used bins in two-dimensional bin packing, and new approaches and algorithms of two-dimensional bin packing research are accessible (Cui et al., 2015; Wei et al., 2013; Puchinger and Raidl, 2007; Clautiaux et al., 2007; Boschetti and Mingozzi, 2003; Lodi et al., 2002b; Berkey and Wang, 1987). About three-dimensional bin packing is that we are given that the unlimited number of three-dimensional rectangular bins $B = (W, H, D)$ is the width W , height H and depth D , and also there are a set of n three-dimensional rectangles items having the dimensions W_i, H_i, D_i , ($i = 1, \dots, n$) waiting to be packed into the bins. The goal is to minimize the number of used bins. Several authors have made use of a variety of techniques such as genetic algorithm, and liner programming etc. in three-dimensional bin packing research area (Wu et al., 2010; Bischoff, 2006; Bortfeldt et al., 2003; Lodi et al., 2002a; Eley, 2002; Martello et al., 2000; Gehring and Bortfeldt, 1997; Chen et al., 1995; Scheithauer, 1991).

This paper evaluates the relationship between the critical factors impacting the carbon emission in the truck operations of logistics and transportation. Factors including truckload utilisation, fuel consumption, truck carbon emission, travelling distances, loading volume, and cargo destinations are analyzed with reference to their distribution and correlation are

examined. The significance of the factors is reviewed and the dimensionality is adjusted through the factor analysis into a principal component factor. The performance of the carbon emission in the logistics operations are established with reference to its relationship with truckload utilisation and travelling distance and fuel consumption, with the use of regression analysis. The results are adopted in the development of truckload utilisation bin packing model.

3. OPERATION REVIEW AND TRUCKLOAD UTILIZATION ANALYSIS FRAMEWORK

An operations review has been conducted, including a process mapping from customers contacting customer services, customer service officers preparing the daily order control forms, warehouse workers picking up the cargo and performing value-added operations, to traffic officers scheduling delivery orders, consolidating the cargoes into boxes and pallets, and arranging the pallets into trucks. Among 3PL operations, critical factors affecting the operations efficiencies and carbon emissions are identified. These include truckload utilization (percentage), carbon emission of truck (tonCO₂e), vehicle capacity (cubic meter (CBM)), number of destinations, fuel consumption (litre), loading volume (CBM), tonnes, and wastage per day (percentage). Improving truckload utilization in bin packing problem results in reducing operation costs and carbon emission. With over hundreds of boxes to be allocated in available trucks within an hour, cargo consolidation, vehicle capacity, destination locations, loading volume, are box dimensions are affecting the truckload utilisation. The planned truck routing with reference to the cargo destinations directly affect the travelling distances, fuel consumption, and carbon emissions. To evaluate the relationship between the truckload utilization, carbon emission, vehicle capacity, travelling distances, fuel consumption, and loading volume, we perform statistical analyses and proposed the model for further applications. The operations data are collected and reviewed. Summary statistics are provided in Table 1, based on 79 trucks performance. All data are statistically significance.

Table 1. Summary statistics on the operations data of impacting factors

Impacting factors	Mean	Std dev
Truck Utilization (TU)	0.5667	0.3348
Truck Carbon Emission (Em)	0.1811	0.1229
Loading Volume (Volume)	8.8367	6.7328
Fuel Consumption (Fuel)	16.9597	9.5062
Number of Destinations (Dest)	9.7722	6.5240
Vehicle Capacity (Capacity)	14.2911	4.2942
Wastage per day (Wastage)	0.9721	0.0195
Tonnes	8.9133	4.4742

4. TRUCKLOAD UTILISATION AND CARBON EMISSIONS STATISTICAL MODELING

The main methodology of this paper is to investigate the relationship between various operations items and the truck utilization and carbon emission. Hence, we propose a model based on the study on the relationship between various factors for further analysis.

4.1. Regression Analysis

The relationship among the carbon emission, truckload utilization, truck tonnes, truck size, travelling distances and fuel consumption is evaluated and regression analyses are conducted to investigate the relationship among the variables. Table 2 gives the estimates on the coefficient of correlation among the variables. All pairwise correlation coefficients are statistically significant. From Table 2, the truckload utilization is highly positive related with loading volume, fuel consumption, number of destinations, vehicle capacity and tonnes, while it is negatively related with wastage per day. These indicate that the higher the loading volume would have higher truckload utilization. However, the truck carbon emission is negatively related with loading volume, fuel consumption, number of destinations, vehicle capacity and tonnes but it is positively related with wastage per day. These indicate that the higher the loading volume would result in less carbon emission but the higher the wastage per day would result in more carbon emission. From these analyses, regression analyses are studied on the truckload utilization and truck carbon emission with these factors.

Table 2: Estimates of Pearson Correlation Coefficients

	TU	Em	Volume	Fuel	Dest	Capacity	Wastage	Tonnes
TU	1	-0.6632 (<.0001)	0.9023 (<.0001)	0.6361 (<.0001)	0.7072 (<.0001)	0.5204 (<.0001)	-0.8601 (<.0001)	0.5675 (<.0001)
Em		1	-0.6551 (<.0001)	-0.4486 (<.0001)	-0.6556 (<.0001)	-0.5066 (<.0001)	0.7391 (<.0001)	-0.5389 (<.0001)
Volume			1	0.815 (<.0001)	0.8421 (<.0001)	0.8129 (<.0001)	-0.8734 (<.0001)	0.8210 (<.0001)
Fuel				1	0.8328 (<.0001)	0.8142 (<.0001)	-0.7886 (<.0001)	0.8774 (<.0001)
Dest					1	0.7758 (<.0001)	-0.8295 (<.0001)	0.8451 (<.0001)
Capacity						1	-0.6887 (<.0001)	0.9289 (<.0001)
Wastage							1	0.7830 (<.0001)
Tonnes								1

All six factors are related with truckload utilization and truck carbon emission. Table 3 gives the estimates of the regression analyses of truckload utilization and truck carbon emission on six selected factors. In Panel A, all factors are significance in estimating truckload utilization and truck carbon emission individually. To develop the model in estimating truckload utilization and truck carbon emission, single factor may not be sufficient. In Panel B, all factors are examined simultaneously. In the truckload utilization model, it is useful and has large R^2 (96.88%). However, two of the factors, namely fuel consumption (Fuel) and number of destinations (Dest), are insignificance. Similarly, in the truck carbon emission model, it is useful and has large R^2 (65.49%). Among the six factors, three of them, namely loading volume (Volume), vehicle capacity (Capacity) and tonnes, are insignificance. From these analyses, it reveals that the six factors are important and suitable for estimating the truckload utilization and truck carbon emission. Due to the highly correlated among these six factors, factor analysis is performed to reduce the number of correlated factors needed to explain the variability in the data.

*Table 3: Estimates of the Regression Analysis***Panel A: Regression analyses with one independent variable**

Response	Predictors	Coefficients	Standard error	R ²	Adjusted R ²	F Value	p-value
TU	Intercept	0.1702*	0.027	81.41%	81.17%	337.28	<0.0001
	Volume	0.0449*	0.002				
TU	Intercept	0.1868*	0.060	40.46%	39.69%	52.33	<0.0001
	Fuel	0.0224*	0.003				
TU	Intercept	0.2120*	0.048	50.02%	49.37%	77.06	<0.0001
	Dest	0.0363*	0.004				
TU	Intercept	-0.0131	0.113	27.08%	26.13%	28.59	<0.0001
	Capacity	0.0406*	0.008				
TU	Intercept	1.0154*	0.036	73.97%	73.63%	218.8	<0.0001
	Wastage	-1.0216*	0.069				
TU	Intercept	0.1882*	0.070	32.21%	31.33%	36.58	<0.0001
	Tonnes	0.0425*	0.007				
Em	Intercept	0.2868*	0.017	42.92%	42.18%	57.9	<0.0001
	Volume	-0.0120*	0.002				
Em	Intercept	0.2794*	0.026	20.13%	19.09%	19.4	<0.0001
	Fuel	-0.0058*	0.001				
Em	Intercept	0.3018*	0.019	42.99%	42.24%	58.05	<0.0001
	Dest	-0.0124*	0.002				
Em	Intercept	0.3883*	0.042	25.67%	24.70%	26.59	<0.0001
	Capacity	-0.0145*	0.003				
Em	Intercept	0.0395*	0.017	54.63%	54.04%	92.73	<0.0001
	Wastage	0.3223*	0.033				
Em	Intercept	0.3130*	0.026	29.04%	28.12%	31.51	<0.0001
	Tonnes	-0.0148*	0.003				

*Table 3: Estimates of the Regression Analysis (Continue)***Panel B: Regression analysis with six independent variables**

Response	Predictors	Coefficients	Standard error	R ²	Adjusted R ²	F Value	p-value
TU	Intercept	0.8681*	0.050	96.88%	96.62%	373.17	<0.0001
	Volume	0.0590*	0.003				
	Fuel	-0.0016	0.002				
	Dest	-0.0015	0.002				
	Capacity	-0.0342*	0.005				
	Wastage	-0.3874*	0.058				
	Tonnes	-0.0137*	0.005				
Em	Intercept	0.0320	0.061	65.49%	62.62%	22.78	<0.0001
	Volume	-0.0010	0.003				
	Fuel	0.0089*	0.002				
	Dest	-0.0074*	0.003				
	Capacity	-0.0047	0.006				
	Wastage	0.3414*	0.070				
	Tonnes	-0.0004	0.007				

Note: * Significance at 5%.

4.2. Factor Analysis

Truck utilization and truck carbon emission are the responses and thus these are not inclusive in the factor analysis. Bartlett's Test of Sphericity based on these observations is performed and provide in Table 4. It reaches the significance level with probability less than 0.0001 which is less than 0.05. The result indicates that communality would exist within these six variables concerned. To identify and check communalities within those items and delete the item which is not appropriate to put into principal components analysis are presented in Table 5. The result states all items are well defined and suitable to run further in order to obtain the rotated component matrix and estimate the factor scores. Figure 1 show the scree plot and variance explained by factors. The first two factors can explain about 99% of variation among all six variables. Hence, two factors model is selected. And the rotated components and factor scores are shown in Table 6. Figure 2 gives the factor pattern before and after the rotation. From the rotated factor pattern, it is clear that fuel consumption (Fuel), number of destinations (Dest), loading volume (Volume), vehicle capacity (Capacity) and tonnes are grouped together as one group while wastage per day (Wastage) as another group. It is clear that the two groups are dominated by the operations facts.

Table 4: Bartlett's Test of Sphericity

Test	DF	Chi-Square	Pr > ChiSq
H ₀ : No common factors	15	606.5583	<.0001
H _A : At least one common factor			

Table 5: Communalities

Item	Initial	Extraction
Volume	1.000	0.858
Fuel	1.000	0.822
Dest	1.000	0.823
Capacity	1.000	0.900
Wastage	1.000	0.931
Tonnes	1.000	0.962

Note: Extraction by principal component analysis method

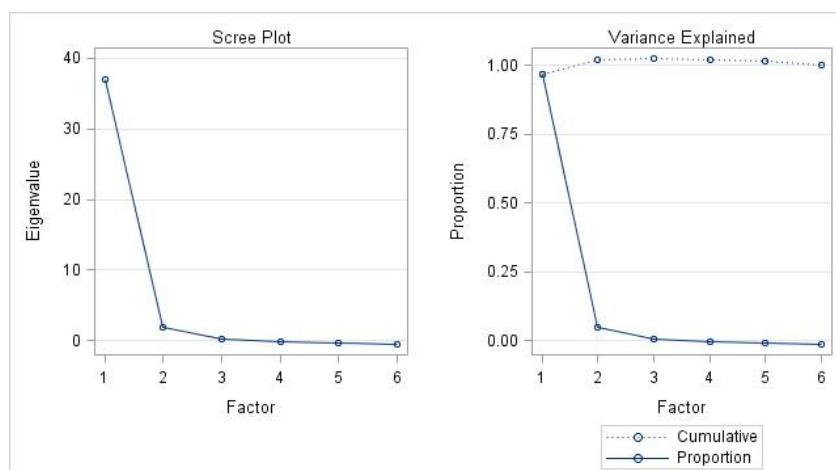


Figure 1: Scree Plot and Variance Explained by Factors

Table 6: Rotated Component and Factor Scores by Factor Analysis

Item	Rotated Component		Factor Scores	
	Factor 1	Factor 2	Factor 1	Factor 2
Volume	0.5559	0.7412	-0.0876	0.2644
Fuel	0.6845	0.5948	0.0624	0.0578
Dest	0.5993	0.6809	-0.0201	0.1525
Capacity	0.8561	0.4092	0.4176	-0.2496
Wastage	-0.3888	-0.8831	0.5638	-0.9747
Tonnes	0.8522	0.4861	0.9288	-0.4228

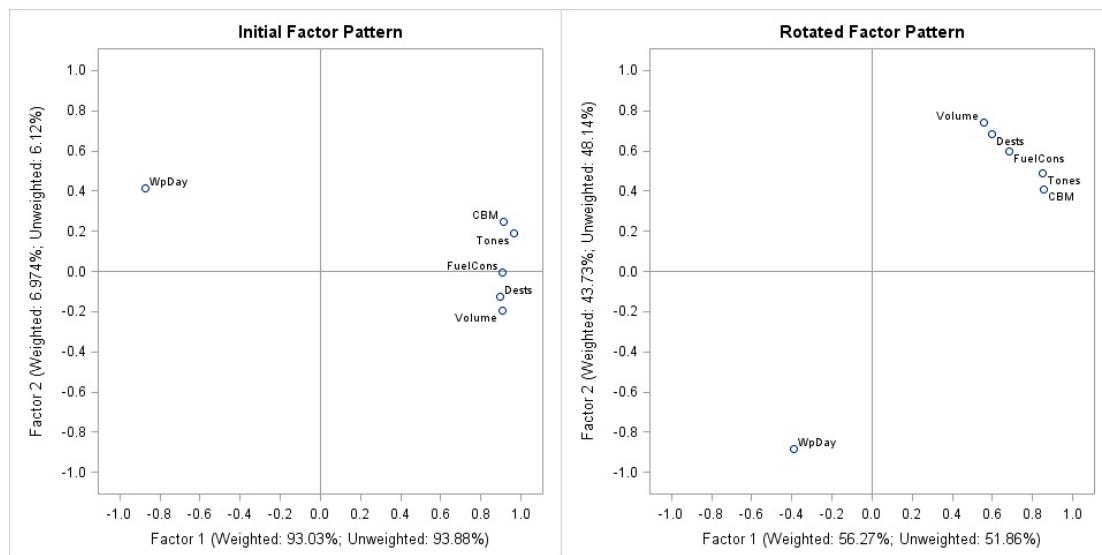


Figure 2: Factor Pattern before and after rotation

After performing the factor analysis, the two standardized factor scores stated in Table 6 are used to conduct the regression analysis. The multivariate regression model is defined as

$$Y = X\beta + \varepsilon$$

where $Y = (Y_1 \ Y_2)$, Y_1 is the truck utilization and Y_2 truck carbon emission, and $X = (F_1 \ F_2)$, F_1 and F_2 are Factor 1 and 2 from the factor analysis, respectively. Estimates by the regression analyses with two factors are shown in Table 7. The models are good as indicated by their large F -value and significance in each slope coefficients. Although the coefficients of determination, R^2 , in the model with two factors from factor analysis give slightly smaller value than that of using the original six variables, these models did not violate the assumptions of normality and independence of residuals through residual analyses.

Table 7: Regression analyses with two factors

Response	Predictors	Coefficients	Standard error	R ²	Adjusted R ²	F Value	p-value
TU	Intercept	0.5667*	0.015	83.51%	83.07%	192.42	<0.0001
	Factor1	0.0468*	0.016				
	Factor2	0.3169*	0.016				
Em	Intercept	0.1811*	0.010	53.90%	52.69%	44.43	<0.0001
	Factor1	-0.0259*	0.010				
	Factor2	-0.0897*	0.010				

Note: * Significance at 5%.

Provided with the multivariate model, one can estimate the truckload utilization and truck carbon emission given its operations information. In a scenario with high volumes of boxes to be distributed, this implies high utilization of the day. Suppose the utilization of the day is 95%, the wastage per day would be 5%. The loading volume of the parcels is 20 CBM with 18 destinations; the truck capacity is 22 CBM and fuel consumption is 30L, the estimated values of factor 1 and factor 2 for a 16 tonnes vehicle are 1.092 and 1.162. Thus, the estimated truck utilization is 98.6% and the truck carbon emission is 0.049 units. In a slack period, the utilization of the day is low at around 40%, the wastage per day would be 60%. The loading volume of the parcels is 2.5 CBM with 4 destinations, truck capacity is 12 CBM and fuel consumption is 5L, the estimated factor 1 and factor 2 for a 5.5 tonnes vehicle are – 0.893 and 0.893. Hence, the predicted truck utilization is 80.8% and truck carbon emission is 0.124 units. With this methodology, models could be built to estimate the truck utilization and truck carbon emission and hence the business could be improved by optimize its truck utilization and carbon emission in vehicle routing and bin packing.

5. CONCLUSIONS

Severe competition and global policies push the 3PL to seek effective ways to improve operations and reduce carbon emissions in their daily operations. This paper reveals the latest research on truckload utilisation and bin packing problems in 3PL operations. The paper further analyses operations of a 3PL firm. A statistical analysis has been carried out to evaluate the relationship of truckload utilisation and carbon emissions as well as their impacting factors in the daily logistics operations. A regression analysis is carried out to investigate the relationship among the variables and a factor analysis is conducted to obtain the two standardized factor scores for developing a multivariate regression model of truckload utilisation and carbon emission. The results of the analysis show that truck utilization and carbon emission depends on six critical operation factors, including loading volume, fuel consumption, tonnes, vehicle capacity, number of destinations and wastage per day. With the results obtained, a truckload utilisation bin packing model will be further developed incorporating the related factors. Considering the number of destinations is critically affecting the truckload utilisation and carbon emissions, it is recommended for the 3PL firm to integrate the vehicle routing optimisation during the cargo consolidation plan. Thus, future development on the bin packing model designs will consider maximizing the truck utilization and minimizing truck carbon emission in the daily cargo consolidation plan.

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IMMERSIVE VIRTUAL REALITY IN LOGISTICS, DATA ANALYTICS AND INDUSTRIAL APPLICATIONS

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ABSTRACT

Logistics and supply chain operations are becoming more complex with increasing demand for globalization, outsourcing, cargo hub consolidation, level of customization, division of labour, and fast response to disaster management. The support of technological advancement allows higher data visibility and visualization. The needs and expectations for big data analytics in the supply chain has multiplied. Rapid technological development often involves a massive amount of data without providing an intelligent interacting analysis platform. An interactive multi-dimensional virtual reality platform for big data analytics is needed for handling logistics emergency and recovery planning in which root causes must be identified immediately, followed by planning of subsequent recovery actions. This paper presents an updated review on current literature examining the impacts and applications of immersive virtual reality on logistics and supply chain as well as other important applications, including healthcare and manufacturing. A systematic literature review approach is followed over the period 2000-2015. A comprehensive taxonomy is also presented. An analysis of the latest development of virtual reality devices and future development on the virtual reality in logistics emergency and recovery planning are discussed.

KEYWORDS

Supply chain, virtual reality, big data analytics, logistics emergency and recovery, incident management

1. INTRODUCTION

With an increasing complexity in data and operation processes in global organisations, there is a growing demand for big data and process analysis in many industries, especially in supply chain and logistics. McKinsey Institute revealed that over half of 560 enterprises interviewed expect big data will help them to improve their operation efficiency (Manyika et al., 2011). Recent reports indicates that 97% of supply chain executives aware the need of big data analytics or understand how it benefit their supply chain, but only 17% of them have already implemented analytics in one or more supply chain functions (Pearson, 2014). With the support from the development of hardware systems facilitating more efficient data capturing, users in the companies could be provided with a higher data visibility. Thus, there arising the need of intelligent data exploration, analysis, and visualization. Companies lack of intelligent tools for data mining and further visualizing to users in limited period of time. Chen and Zhang (2014) evaluated the common big data problems in several aspects and discussed the big data techniques, including big data visualization. Their study also reviewed the batch-process-based big data tools, including Apache Hadoop, Dryad and Apache mahout. They

stressed the importance of the representation of knowledge in a more intuitive and effective way.

Supply chain, transportation, and logistics involve massive data manipulations as the operations cover complex and multiple facilities, loading and discharging ports, port of receipt, port of loading, transshipment hubs, and terminals for each shipment with several containers. Each shipment involves multiple parties, including shipper, consignee, and multiple notifying parties. There are various documents with huge data involved in one shipment. The milestones of container movements are captured and displayed in the system for tracking during the shipment delivery. Smooth operations and real-time updates are expected in the supply chain. Organisations emphasized the need of business and operation continuity in order to provide reliable services during daily operations and the management of crisis incidents. Often natural disasters cause crisis events. Recent literature discussed ways of managing disruptions in supply chain to ensure business continuity (Miller and Engemann, 2012; Oke and Gopalakrishnan, 2009). This paper presents a literature review on examining the impacts and applications of immersive virtual reality (VR) on logistics and supply chain as well as other important applications, including healthcare and manufacturing. A systematic literature review approach is followed over the period 2000-2015 on 102 papers. A comprehensive taxonomy is also presented. The analysis of latest development of portable VR devices is revealed. This paper reviewed the development from virtual supply chain to the VR in supply chain, analyzed the use of big data analytics in supply chain operations, and proposed the need of the use of VR and big data analytics in logistics emergency and recovery planning. Further development on the VR on logistics emergency and recovery planning is presented.

2. VIRTUAL REALITY: A LITERATURE REVIEW OVER THE PERIOD 2000-2015

An analysis is carried out regarding the global number of papers published by year and the number of papers are classified into six major categories, namely data analytics, education, healthcare, logistics and transportation, manufacturing and product design, and textile. The number of papers considering each key element of VR is reflected in Table 1. Researches on the use of VR in logistics and transportation have an increasing trend from 2000 to 2015. The use of VR in education draws research attentions during the last fifteen years. Large volumes of literatures investigate the medical and healthcare problems with the use of VR. Table 2 presents a detailed characterization of published research papers with reference to the six categorized framework. In the research of VR in logistics and transportation, land transportation, including the use of VR in traffic, tunnel, highway, and vehicle driving, shows a higher amount of publications when compared to marine and aviation, as shown in Table 3.

Table 1. Number of papers by key categories of VR in classification framework

Category	Time period			Total
	2000-2004	2005-2009	2010-2015	
▪ Data Analysis	2	4	4	10
▪ Education	4	6	12	22
▪ Healthcare	1	7	17	25
▪ Logistics and Transportation	5	11	16	32
▪ Manufacturing and Product design	2	3	6	11
▪ Textile	-	1	1	2
Total	14	32	56	102

Table 2 Type of information shared in VR

Authors	Education	Logistics and Transportation	Healthcare	Data Analysis	Manufacturing and Product design	Textile
Choi et al. (2015)					X	
Fernández and Alonso (2015)					X	
Ronchi et al. (2015)			X			
Bastiaens et al. (2014)	X					
Bauer et al. (2014)		X				
Duguleană et al. (2014)			X			
Feng et al. (2014)		X				
Kinateder et al. (2014)		X				
Lam et al. (2014)			X			
Lesk et al. (2014)			X			
Merchant et al. (2014)	X					
Pereira et al. (2014)			X			
Rus-Calafell et al. (2014)			X			
Van and Gerald (2014)	X					
Yin et al. (2014)		X				
Cui et al. (2013)		X				
Farra et al. (2013)	X					
Grajewski et al. (2013)					X	
Menck et al. (2013)					X	
Shneiderman et al. (2013)			X			
Sorva et al. (2013)	X					
Verdouw et al. (2013)		X				
Aurich et al. (2012)			X			X
Chan and Lau (2012)		X				
El-Khamesy and El-Wishy (2012)			X			
Kurzweil Accelerating Intelligence (2012)			X			
Laver et al. (2012)			X			
Nečas and Klapetek (2012)				X		
Rinaldi et al. (2012)						X
Abulrub et al. (2011)	X					
Chou et al. (2011)		X				
Duston et al. (2011)			X			
Gollnick et al. (2011)		X				
Hall et al. (2011)			X			
Li (2011)		X				
Mikropoulos and Natsis (2011)	X					
Prendinger et al. (2011)		X				
Plumert et al. (2011)		X				
Riva et al. (2011)			X			
Rizzo et al. (2011)			X			
Saposnik and Levin (2011)			X			
Bruno and Muzzupappa (2010)						X
Kilmon et al. (2010)	X					
Krooshof et al. (2010)					X	
Lee et al. (2010)	X					
Ohno and Kageyama (2010)					X	
Pack (2010)		X				
Peng et al. (2010)					X	
Saposnik et al. (2010)			X			
Snider et al. (2010)				X		
Wong (2010)		X				
Wiecha et al. (2010)	X					
Ye et al. (2010)		X				
Yin (2010)	X					
Yuen et al. (2010)		X				
Qin et al. (2009)		X				
Bordinck et al. (2008)			X			

				X
Choi and Cheung (2008)				
Chun et al. (2008)		X		
Gurusamy et al. (2008)			X	
Limniou et al. (2008)	X			
Monahan et al. (2008)	X			
Reif and Walch, (2008)		X		
Wilson et al. (2008)			X	
Aggarwal et al. (2007)			X	
Gregg and Tarrer (2007)			X	
Infotech (2007)				X
Lau et al. (2007)		X		
Lomov et al. (2007)				X
Marion et al. (2007)		X		
Mühlberger et al. (2007)		X		
Ohno and Kageyama (2007)				X
Schultheis et al. (2007)	X			
Shu et al. (2007)		X		
Valdés and Barton (2007)				X
Chan and Lau (2006)	X			
Choi and Cheung (2006)				X
Demiris (2006)			X	
Goldmann and Steinfeldt (2006)	X			
Griffith et al. (2006)				X
Han et al. (2006)		X		
Keim et al. (2006)				X
Nicholson et al. (2006)	X			
Rönkkö et al.(2006)	X			
Lau and Chan (2005)		X		
Lu et al. (2005)	X			
Riva (2005)			X	
Bruzzone et al. (2004)		X		
Hammond et al. (2004)			X	
Hoen et al. (2004)		X		
Zhao et al. (2004)		X		
Wenzel et al. (2003)		X		
Henn et al. (2002)	X			
Keim, D. A. (2002)				X
Naps et al. (2002)	X			
Rowe and Cohen (2002)		X		
Yoshioka (2002)				X
Haluck and Krummel (2000)	X			
Kaufmann et al. (2000)	X			
Korves and Loftus (2000)				X
Rohrer (2000)				X

Table 3 Type of logistics and transportation shared in VR

Authors	Logistics and Transportation		
	Aviation	Marine	Land Transportation
Ronchi et al. (2015)			X
Kinateder et al. (2014)			X
Yin et al. (2014)	X		
Cui and Fan (2013)		X	
Zhang et al. (2013)			X
Chou et al. (2011)			X
Gollnick et al. (2011)	X		
Plumert et al. (2011)			X
Fuellerer et al. (2010)			X
Yuen et al. (2010)			X
Qin and Zhang (2009)		X	
Cai and Huo (2008)		X	

Chun et al. (2008)		X	
Lau et al. (2007)			X
Marion et al. (2007)	X		
Mühlberger et al. (2007)			X
Schultheis et al. (2007)			X
Sciomachen and Tanfani (2007)		X	
Shu et al. (2007)		X	
Han et al. (2006)			X
Goldmann and Steinfeldt (2006)	X		
Lau and Chan (2005)		X	
Bruzzone et al. (2004)			X
Kim et al. (2003)		X	
Rowe and Cohen (2002)	X		

3. VIRTUAL REALITY IN SUPPLY CHAIN AND BIG DATA ANALYTICS

Literature in the previous decades explored the opportunity of virtual supply chain business through electronic communications and information transfer (Gunasekaran and Ngai, 2004; Serve et al., 2002; Rohrer, 2000; Chandrashekhar and Schary, 1999). Danuta (2010) discussed the importance of virtual supply chain to cope with the constant changes in time and space barriers. Virtual supply chain operating in changing business environment focuses on supporting operations and solving supply chain problems. Virtualization of logistics and supply chain operations result in modified patterns of logistics professional carriers. Verdouw et al. (2013) analyzed the virtual supply chain management to be achieved by the Internet of Things in the floricultural sector. Operations with the use of electronic means and internet have been developed from a two-dimensional to a three-dimensional view, through the use of VR. Traditionally, the use of VR is adopted in a number of industries, such as textile manufacturing (Lomov et al., 2007; Gray, 1997), gesture and vocal interface validation (Infotech, 2007), applied in manufacturing industries (Choi et al., 2015) and medical procedures (El-Khameesy and El-Wishy, 2012). VR technology has been extended to applications in the design and operations of logistics and supply chain. Lau, Chan and Wong (2007) proposed a virtual container terminal simulator for the design of terminal operations. The virtual terminal provides an intuitive, interactive and flexible environment for operators to train and evaluate themselves on their skills in crane operations, including loading and unloading of containers. The developed simulator facilitates the optimal design of terminal operations and enables a real-time distributed virtual environment that simulates container terminal operations.

With the growing importance of the applications of VR on supply chain operations, Lau, Chan and Wong (2008) proposed an information visualization framework that considered key human factors for effective complex data perception and cognition with the use of VR technology. The developed visualization system is applied on an express cargo handling centre where users are able to effectively perceive operation details and carry out timely decision making. With the aid of VR technology, it can reduce human error due to misinterpretation of information. Yuen, Choi and Yang (2010) proposed a full-immersive CAVE-based VR simulation system of forklift truck operations in warehouses to improve warehousing management. This virtual environment provides drivers with a fully immersive practice of forklift truck operations in which virtual accidents can be created and visualised to enhance safety awareness without any real dangers. VR has been adopted in ship vessel operations, ship buildings and container terminals (Cui et al., 2013; Cai and Huo, 2008; Kim

et al., 2003). The technology has been used to determine stowage plans for containers to be loaded on vessels considering various objectives, including optimal space allocation, optimal synchronisation among dispatching operations and minimisation of the berthing time. Sciomachen and Tanfani (2007) proposed a three-dimensional bin packing problem (3D-BPP) approach for optimising stowage plans and terminal productivity. Another problem in logistics is the three-dimensional loading and vehicle routing. Fuellerer et al. (2010) proposed an algorithm to solve the complex problem combining three-dimensional loading and vehicle routing. These researches show that the need of data visualization tools such as VR (VR) to transform complex system data into powerful information which both management and analysts would find it easy to understand.

With the technology advancement, companies operate with massive volume of data each day in their daily supply chain operations, forecasting plan, and project analysis. Besides operational data, companies collect and analyze market data for latest pricing and product information for business planning and development. New technologies are developed to facilitate the collection of enormous big data for market research, operation analysis, and decision support. Organizations are continued to look for efficient ways to retrieve the big data and present them in an user-friendly interface. With the lack of intelligent systems capable of efficiently retrieving valuable and useful data from massive database, companies are not able to easily search in the large database during their decision making process to solve their daily operation problems. Only with the increase of data transparency in the systems and the support of intelligent interactive user-interface can assist frontline personnel and managers to carry out prompt decisions in the competitive business environment (LaValle et al., 2011). Big data is unique due to the volume, variety, and velocity of data. Data access and storage is less costly than before (McAfee et al., 2012). Big data are being used to transform medical practice, modernize public policy, and inform business decision making (Mayer-Schonberger and Cukier, 2013). There is a need to collect and analyze data in short period of time with the support of advanced technologies in an easily accessible information searching engine. This results a significant interest in the development of business intelligence and big data analytics. The techniques, technologies, systems, practices, and methodologies are developed to analyze critical business data and assist personnel to support their decision making processes in their daily operations in a timely and efficient manner. The analyzed data assists better planning, organizing, and controlling throughout the entire supply chain process. With the popularity of the big data tools and philosophies developed, these techniques will change long-standing ideas about the value of experience, the nature of expertise, and the practice of management (Chen et al., 2012; McAfee et al., 2012).

The increasing importance of data to supply chain managers should lead to an amplified awareness and sensitivity to their need for high quality data products (Hazen et al., 2014). Data inaccuracy and operations errors are costly in supply chain operations. Through big data analytics, detail information for business operations will be more accurate. Data science, predictive analytics, and big data are each thought to be part of an emerging competitive area that will transform the way in which supply chains are managed and designed (Waller and Fawcett, 2013). Provost and Fawcett (2013) note that data science is not simple data-mining algorithms and skillful data scientists must be able to view business problems from a data perspective. Supply chain will extract value out of big data. Information is coming from instrumented, interconnected supply chains transmitting real-time data about fluctuations in

everything from market demand to the weather (LaValle et al., 2011). This growing combination of resources, tools, and applications has deep implications in the field of supply chain management, presenting a doozy of an opportunity and a challenge to our field (Waller and Fawcett, 2013).

4. LOGISTICS EMERGENCY AND RECOVERY PLANNING WITH BIG DATA ANALYTICS IN VIRTUAL REALITY

Delivering seamless and reliable services are crucial for logistics and transportation companies, especially under severe condition and unpredictable incidents. Prompt and organized logistics emergency and recovery plan are expected from customers to the logistics service providers when disasters occur. The possible disasters include enterprise resource systems break-down, terminal and dock strike, earthquake, tsunami, and typhoon, such as Chichi earthquake in Taiwan in 1999, tsunami in the Indian Ocean in 2004, hurricane Katrina in the US in 2005, and the Myanmar cyclone in 2008. There are literatures investigating humanitarian logistics on the distribution of emergency goods to the incident locations (Alexander, 2005; Altay and Green, 2006; Perry, 2007; Liberatore, 2014) and crisis incident management of logistics and transportation companies in handling the impacted shipments (Harrald et al., 1989; Molino, 2006). Further literatures are summarized below, followed by two recommended scenarios on the use of VR to assist the logistics emergency and recovery planning.

Emergency recovery management increases attention in literature, such as the need for improved incident response were proposed in Ozbay and Kachroo (1999) and proposed a non-convex programming model for allocating emergency response resources to minimize the risk under the natural disaster were considered in Sheralli et al. (2004). Besides, logistics vulnerability increases under the circumstances of emergency. Emergency logistics management has increasingly drawn researchers' attention too which aims to relief supply chain and distribution contingent in order to making recovery plans, for instance, an ant colony optimization based heuristics is mentioned by Yi and Kumar (2007) that decompose the original emergency logistics problem into two decision-making phases; an emergency logistics co-distribution approach for dynamically responding to the urgent relief demands is proposed by Sheu (2007); or a bio-inspired algorithm is discussed by Zhang et al. (2013) for route selection for emergency logistics management. It relies heavily on big data collection, extraction, and analysis technologies (Sheu, 2007; Peng et al., 2011; Li, 2012). Moreover, the number of using VR applications in the field of logistics is soaring for operation process improvement (Reif and Walch, 2008; Li, 2011; Chan and Lau, 2012; Feng et al., 2014; Bauer et al., 2014). Logistics corporations often suffer from resources limitation when handling sudden emergency recovery actions. Operations personnel are required to perform complex daily operation issues as well as sudden emergency recovery actions. Decision making, communication, and response to all impacted parties are necessarily be carried out instantly when incidents occurred, e.g. vessel collision, cargo damage, port closure, etc. Inadequate planning, lack of immediately available resources, and poor data accessibility result in incorrect judgements and decisions.

Recovery action on vessel and shipment planning impacted by natural disasters are critical in the operations of ship liners. The support of interactive VR to facilitate the instant and accurate recommendation on the vessel re-routing and shipment recovery plan is vital to

ensure smooth operations and allow more time for the personnel in carrying out communication issues with customers as well as conducting higher priority issues. On 11 March 2011, an earthquake was occurred in Pacific coast of Tohoku. The earthquake triggered tsunami waves impacting the Sendai. Important ports, including Tokyo and Sendai, are seriously impacted. Vessels are advised not to berth the terminals due to nuclear radiation releases that impact the health of crew members as well as unsafe berthing conditions in the terminal. The immediate recovery plan of thousands of impacted laden and empty containers required to be carried out, involving huge data analysis, including the affected shippers and consignees, cargo destinations, cargo nature, shipment routings, estimated delay of shipments, and available spaces of recovery vessels. The use of interactive VR as user-interfaces facilitating the data exploration in huge volume of data will assist ship planners, traffic coordinators, and operations personnel to handle complex shipment recovery actions during the disaster incident. Interfaces between users, VR devices, and data exploration tools are illustrated in Figure 1.

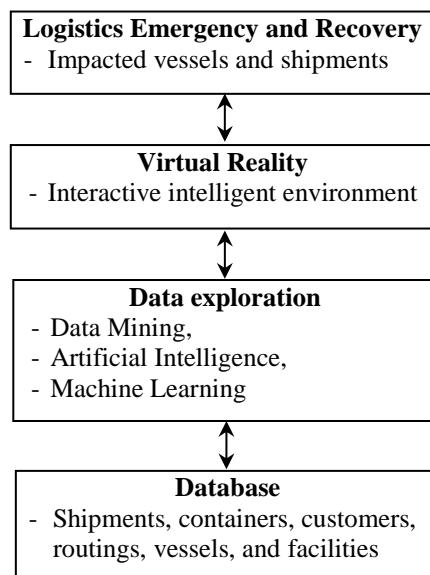


Figure 1. Interfaces among logistics emergency and recovery, VR and data exploration.

In the event of a vessel collision, container damage, or vessel damage, the ability to analyse the root cause immediately as well as retrieve the impacted containers for recovery action is crucial. On 17 June, 2013, a vessel MOL Comfort, which is a 2008-built post-Panamax container ship chartered by Mitsui O.S.K. Lines (MOL), suffered a crack amidships in severe weather when it is sailed from Singapore to Jeddah, Saudi Arabia. There were 4,382 containers of 7,041 TEU loaded on the vessel. A message was send from MOL to the alliance shipping companies about the incident. Instant root cause analysis and recovery action planning is required by all the impacted shipping companies. Thousands of containers with their corresponding shippers, consignees, cargo control parties, final destinations, cargo natures, cargo volume, and cargo delivery routes are required to be reviewed. Whether the ship broken into two parts is due to poor stowage planning, vessel configuration, ballast issues, or other possible reasons are needed to be immediately investigated. These involve the analysis of large amount of data in an instant fashion. VR would be a vital tool for the marine operation personnel to analysis the situation in a three-dimension and interactive way.

VR visualization could be carried out by developing an interactive platform allowing audiences to view through stereoscopic glasses with the support of motion capture system, computer workstations, projector display, and other related accessories. Cave Automatic Virtual Environment (CAVE) has been developed by pioneers as a fully immersive and interactive visualization system that provides extremely vivid stereoscopic views of sceneries in 3D design (Cruz-Neira et al., 1992; Cruz-Neira, 1993; Repperger, 2003; Lau et al., 2008). It is a low cost, high performance generic system that provides a versatile and powerful VR platform for cost effective design, analysis and evaluation of complex engineering systems and operations. Mobile VR platform could be achieved with the support of smartphone device and display device. Some outstanding products include Oculus VR, Google Cardboard, ZEISS VR One, Samsung, and Project Morpheus. Some products are with display size between 4.7 and 5.2 inches while some with tracking sensors and high degree of field of views.

5. CONCLUSIONS

The complexity of supply chain operations is increasing along with the trend of globalisation, outsourcing, better transportation connectivity, technology advancement, higher expectation of communication flow, higher concern on data security, and the need of faster response to disaster management. There is a vital need for industrial practitioners, especially logistics and transportation personnel, in searching for intelligent tools to support the analysis of huge amount of data in limited time. This paper examines the impacts and applications of immersive VR on logistics and supply chain as well as other important applications, including healthcare and manufacturing. A systematic literature review approach with a comprehensive taxonomy is followed over the period 2000-2015 with 102 papers. The uses of VR in logistics and transportation as well as in supporting logistics emergency recovery action are discussed. Two scenarios with the opportunities of the use of VR in maritime operations, namely earthquake incidents and vessel collision, are reviewed. The analysis of latest development of portable VR devices is evaluated. Further development on the VR on logistics emergency and recovery planning is presented.

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ON CORPORATE DECISION (TOWARDS FIASCO PREVENTION)

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ABSTRACT

We take the view that corporate decisions are generated, individually or collectively, mostly with feeling, intention, belief, ethics, and/or other mental abilities. A decision can be extremely good or bad or anything in between with respect to some perspective. In a decision there are: (i) the deliberation of decision alternatives qualitatively or quantitatively, and (ii) the outcome of the selected alternative. There is the possibility that a good decision or “no decision” might yield bad outcome. We propose a systemic, biological spectrum-based approach to the understanding, explaining, evaluating and predicting of decisions for appropriate outcomes towards corporate fiasco prevention.

Information management, managerial decision, corporate governance

DECISION THEME AND DECISION THEORY LANDSCAPE

Corporate decisions are exercised by humans who run the institution (organization, corporation, firm, enterprise, etc.) in business, industry or government, nationally or globally. We take the view that corporate decisions are generated, individually or collectively, mostly with feeling, intention, belief, ethics and/or other emotion-driven or emotion-related abilities. In the face of some situation, a decision can be extremely good or extremely bad or anything between the *two extremes*, George Kelly's dipole concept [1], with respect to some perspective.

A Brief Literature Review on Decision Theory

Over many decades there have been different approaches to decisions and decision making to arrive at theories, frameworks, processes and/or techniques for different applications in different disciplines. We start with a quick overview of decision theories which belong to one or more of the three domains: lower level domain called decision neuroscience, middle level decision science as we used to know, which has been developed for applications in institution, market and economy, and higher level decision neuroeconomics domain.

1. Decision science approach

Traditional and modern decision theory is summarized in Berger [2], North [3] and Weirich [4], and many others. Within our context, we review several decision development concepts. One can trace back to the decision-relevant development from consumer choice and behavior in market by Paul Samuelson. Samuelson proposed the WARP (Weak Axiom of Revealed Preference) on choice of preference. The WARP was extended to GARP (Generalized Axiom of Revealed Preference) [4].

A Utility function then associated values to choices (or decision alternatives) and outcomes. Von Neumann & Morgenstern included the element of uncertainty in their Expected Utility (EU) theory [6]. The EU over time called Discount Utility was added as discussed in Matta, Goncalves

& Bizarro [7]. Kahneman & Tversky [8] with their prospect theory was next as an alternative to EU theory. Prospect theory looks at values assigned to gains or losses and decision weights rather than probabilities. Prospect theory thus extended the limitations of expected utility approach.

2. Decision neuroscience approach

At the neurophysiological level, according to Daeyao Lee, decision making involves multiple brain areas through coordination [9]. To understand the lower level brain disorders and their effects, Lee took a top-down view to explore how prospect theory and reinforcement learning theory related to low-level brain decisions. Lee reviewed various functions used in decision making under risk in economic context, such as utility function for maximizing expected values, value function, discount function and forgetting function for improved inter-temporal choices involving delays of rewards. He examined the shapes of the functions to determine the strength of risk, averse or seeking, in the context of prospect theory. Consequently, Lee provided an extensive review of decision making and the linkage between neurological level and psychological level, together called *cognitive neuroscience*. Any deviation from normal behavior would lead to different types of neurological and psychiatric disorders. This line of thoughts has involved others such as Kable & Glimcher [10] and Kavli Foundation [11].

3. Decision neuroeconomics approach

In 2011, a new line of thought by Kahneman [12] called Think Fast or Think Slow. It consists of System I which is limbic-driven (think fast) and System II which is neocortex-driven (think slow). It further shows the psychological influence, linking economics to psychology, together called behavioral economics [13]. The new trend is to look at neuroscience, psychology, and economics as an integrated neuroeconomics [14, 15].

Other authors contributed in this newest approach, neuroeconomics [16, 17, 18]. To expose high-level decisions involving low-level neuron activities, they developed experiments to use fMRI and PET technology to decipher neural activities of millions of neurons in brain area and/or of a single neuron (applicable in experiments on animals) when human made a high level decision.

None of the above pioneers however have given thoughts, as far as we know, on the decision domains from a systemic perspective of von Bertalanffy-Boulding's general systems theory or GST [19, 20], although there has been many application of GST in multiple disciplines . They haven't considered George Kelly's Personal Construct Systems or PCT [1] to understand the decision making from the decision makers' model of their world, while PCT and its repertory grid (RG) technique have been explored for use in numerous disciplines, including business.

We propose a different approach to decision as presented in the next section. We base our approach on the biological spectrum system ranging from protoplasm to biosphere for structuring the decision domain, which is parallel to but different from GST. Decision making is investigated from a system thinking approach using PCT for problem solving towards fiasco prevention.

A PROPOSED SYSTEMIC APPROACH TO DECISION

We observe that human is the key component at the middle of all components of the biological spectrum (Figure 1 – top blue box) ranging from protoplasm, cell, organism (including *human*), population (e.g. *professional*), community e.g. *market* or *business ecosystem* (Moore 1996) [21],

and biosphere (e.g. *economy*). While the lower components (protoplasm and cell) support the human component, the latter is everywhere in all higher components (population, community, ecosystem, biosphere) and supports them. This view is different from von Bertalanffy-Boulding 9-level skeleton of science [18, 19]: frameworks, clockworks, thermostat, open systems, plants, animals, humans, social systems, and transcendent systems.

In our approach, the frameworks (multiple frameworks - static) becomes one single framework (our proposed biological spectrum), where the clockworks and thermostat are expressed as cybernetics exercised on each of the biological spectrum components as described in Nguyen [22] and shown in the top blue box of Figure 1. Each will have its own, component-specific systems thinking guiding the decision making (cell decision making, human decision making, expert decision making, corporate decision making, economic decision making within George Kelly's principles [1] as sketched in the dotted **black** polygon of Figure 1.

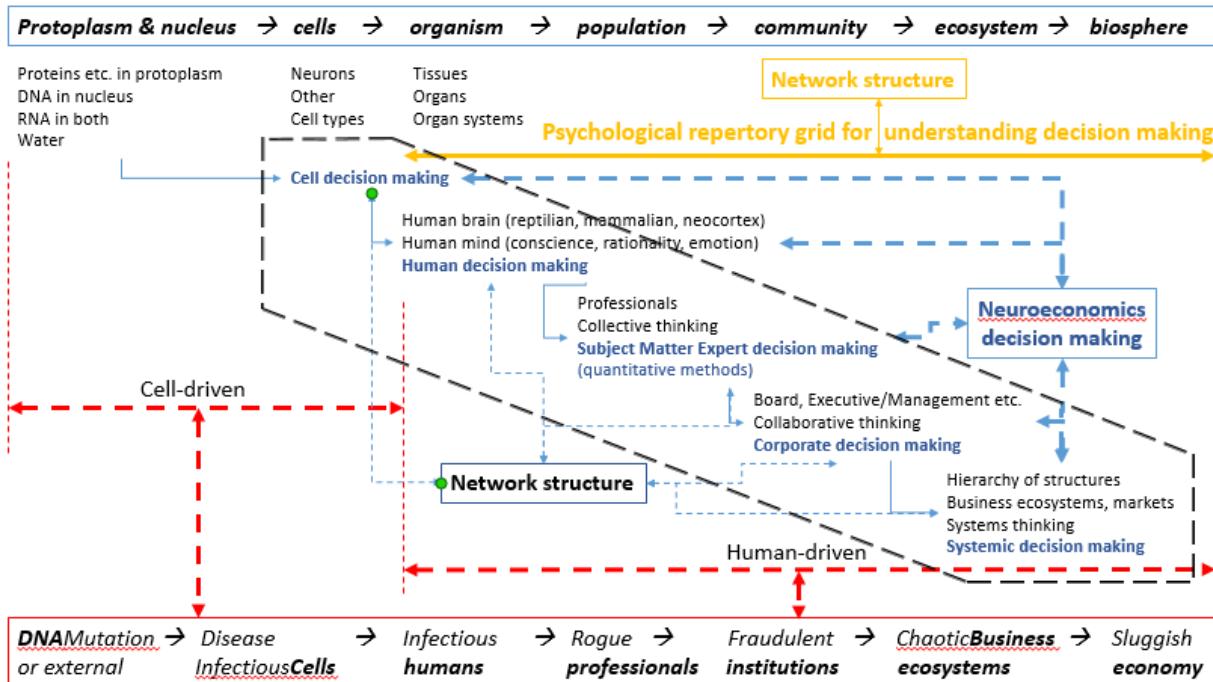


Figure 1. Decision making in the biological spectrum landscape

We would like to elaborate a little bit the rather busy Figure 1 on *Decision making in the biological spectrum landscape*. The top **blue** box sketches the biological spectrum from protoplasm to biosphere. The bottom **red** box is the same spectrum viewed from the perspective of anomalies. In the middle are five levels of hierarchical decision making in **blue**: cell, human, subject matter expert (SME, collective thinking), corporate (collaborative thinking) and systemic (economic) decision making (systems thinking) within the dotted **black** polygon. Each component is a complex network of supporting entities (not shown), following some network structure [23]. For example, the cell component will include the proteins as major components of macromolecules, cellular systems, cellular exchanges, energy and DNA/genes governing all cell functionalities and behavior. At the human component, the corresponding (or analogous) entities (not shown) supporting it are: tasks, projects, transactions, accounts and policies governing the functionalities and behavior of human-employees.

From the human level up, there is the psychological influence (dark yellow), which will be explored with consideration on the cell-driven decision and human-driven decision (shown in dotted red line). The psychological aspect of decision will be explored for better understanding human decisions, using George Kelly's Personal Construct Theory [1] and his repertory grid technique under the umbrella of neuroeconomics decision making (little blue box in the middle left and its associated dotted blue line). Each decision making level is further explained below.

A cell consists of protoplasm (also called cytoplasm) and the nucleus [24]. Protoplasm houses proteins and other components while the nucleus contains DNA. RNA is located in both and responsible for protein synthesis and messages between protoplasm and nucleus. The rest is water (75%). There is the communication between proteins within a cell and between cells. It results in what scientists called *cell decision making* [25].

At the next level (organism), the human brain consists of three brains in one or triune (the Maclean's model) [26]: (i) the reptilian brain, the oldest brain and part of the subconscious mind, (2) the mammalian brain or limbic which connects information to memory driven by emotion, and (iii) the neocortex, the newest brain where most of the thinking is done. The reptilian brain consisting of the brainstem and the cerebellum is capable of heart rate, breathing, body temperature, balance, etc. It is compulsive and rigid, and is capable of decision such as flight or fight, and mating. As such, it is expected that, the lower-level contribution is more procedural, straight stimulus and response (unconditional or conditional).

The mammalian brain might control more of the human behavior. It tends to drive humans to make decision based on what they feel. The neocortex, primarily the prefrontal cortex and the precuneus [27] are believed to be overpowered by the older brains due to signals sent out by the amygdala. If decision makers are angry, they most likely triggered by the reptilian brain. If they cry while thinking of a past event, they would be influenced by the mammalian brain. If they consciously respond with logical thinking, they exercise the functionalities of the neocortex and precuneus.

The decision to drop the atomic bombs in Hiroshima and Nagasaki [28] was argued as not completely driven by numerous sophisticated computational studies of all sides, Japanese and US, even Russia. These included political studies, where and when to drop the two bombs, Little Boy or Fat man, estimated casualties, etc. It ended up, arguably, with President Truman statement "When you have to deal with a beast, you have to treat him as a beast", a statement revealing a decision more affected by the limbic system.

The decision of Richard Fuld Jr. of Lehman Brothers at the last hour [29] was to wait for the Fed to bailout as in the previous case of Bear Stearns in March 2008 [30]. The decision was a guess despite all prior negotiations and studies to get Bank of America and Barclays bank to involve. It did not happen. These two examples are to show the element of emotion in the decision, not completely quantitative. The complex nature of the human brain, its biology and psychology has something to do with the final decision. The above are sort of confirmed by Descartes' error by Antonio Damasio [31], i.e. decisions are mostly emotional [32]. With the above in mind, we now present and discuss the proposed model in the next section.

Based on the biological spectrum framework detailed above, we approach the systemic decision domain from a different angle, aiming at fiasco prevention. We look at (i) *homeostasis* in the *human body* (the organism component), (ii) *stability* in an *institution* (business, industry, government or otherwise, in the community component), (iii) *equilibrium* in market, hierarchies

of structures or *business ecosystems* (the ecology component) and (iv) *balance in economy* (biosphere component) as *norms*. The norms defined in a human body are e.g. 98.7 F degrees, normal ranges of blood counts or ranges of triglycerides, etc. The norms in an institution or organization include anything it defines and qualifies in terms of stable operational attributes and ranges. A norm in the market and in the economy would be any congressional Acts, SEC regulation and rules and other mechanisms to keep the market in equilibrium, e.g. no surplus of supply or no shortage of demand, or the import rate being balanced out the export rate. Note that these norms are complex at each level and consist of a rules or formulas to be observed and satisfied by operational activities.

Any deviations from the norms at any component level are potential symptoms of problematic happenings and consequences, not only in its own level but all levels above it [33], a property called *complementarity*. Deviations at cell component level e.g. gene mutation in DNA, or virus hosted in a cell, etc. might give symptoms leading to some infectious disease in the human body. Deviations at institution level e.g. huge financial gains or losses, large incentives, etc. can also be indications of suspicious activities by a rogue employee (the case of Nicholas Leeson of Barings Bank), a fiasco in an institution (the case of Andrew Fastow of Enron). If these deviations are significant enough to bring the business operations out of control according to some criteria, they should be investigated because of potential critical consequences (Red box at the bottom of Figure 1).

Crucial to all abnormal outcomes, externally (such as the collapse of Bear Stearns which affected Lehman Brothers) or internally (such as Repo 105 or Repo 108 in Lehman Brothers) is the *decision* made by human decision makers whether they are leaders, executives, managers or subject matter experts (SMEs). Their decision might aggravate further deviations from the norms abnormally even more. We collectively call these outcomes *exceptions*.

The decisions collectively, one after another, would bring the institutions from point A to point B (for example, from where it is (A) to reach stability (A to X) or fiasco (A to Y). If these are not addressed in time, they could eventually bring the institution to fiasco leading the institution to bankruptcy, business ecosystems to collapse and the economy to its knee with long-term ripple effects.

A MODEL FOR UNDERSTANDING DECISIONS

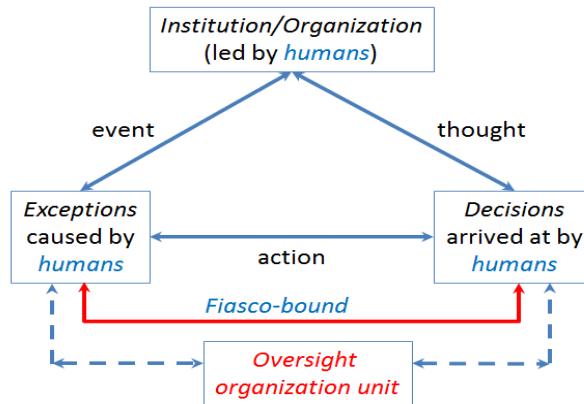


Figure 2. Conceptual modeling

From the perspective of corporate fiasco, we propose the following model of basic components in an institution or organization (business or government): (i) the *institution* or *organization* led by humans, (ii) the *exceptions* (errors, mistakes, wrongdoings, cover-ups, frauds, etc.) and (iii) the *decision* by humans which cause the exceptions or fix them (one way or another, in a good way or bad way). Multiple systems thinking on exceptions and decisions as presented in the framework of Figure 1 are exercised. These three intertwine back and forth and cyclically as shown in Figure 2.

In some organizations, when crisis happens, a crisis management team is formed to handle it together with the main stream management. In our proposed model, we elevate the crisis management team to a permanent structure for enhanced management control and enhanced corporate governance. We call it Oversight organization unit (labeled in red).

We will look at the model from the initial perspective: clockwork at the human component level, within the larger context of institution, market and economy levels as required. Information on every pair of exception-decision is elicited. The human decision makers behind this pair of exception-decision are interviewed for details. We use the RG technique as described below.

Understanding, Explaining, Evaluating and Predicting Decisions

The key for understanding decisions is to elicit, analyze and evaluate all factors involving in a decision from the decision makers' perspective, i.e. to go inside their mind. We refer to George Kelly's famous work on Personal Construct Theory - PCT [1] used in clinical environment with his patients.

PCT is very intriguing to us. His *first fundamental postulate* states “A person’s processes are *psychologically channeled* by the ways in which he *anticipates events*” [1]. To us, the *person* is our *decision maker*. The person’s *process* would be the decision maker’s *mental process in deliberating the decision alternatives*. The decision alternatives can be those *anticipated events* which follow, if implemented. In Kelly, the anticipated events are channeled by what Kelly explained as “*means to an end*”. This is why some decision makers commit potential frauds as in *the means justify the end*. Kelly did not restrict *psychologically* to just psychologically but it could be physiologically, sociologically or otherwise. The fundamental postulate is suitable perfectly to our biological spectrum framework fostering our systems thinking as sketched in Figure 1. Kelly’s *construction corollary*: “A person *anticipates events by construing their replications*” is also suitable to our investigation. It is based on prior experience and lines of thoughts of the person, i.e. the decision makers’ view of their world (or environment).

Kelly proposed the repertory grid (RG) as a mean to understand his patients in clinical environment. The RG has been used and further adapted to many different disciplines by Bourne & Jenkins [34], Easterby-Smith [35], Fransella & Bannister [36], Fromm [37], Korenini [38], including business applications by Stewart & Stewart [38]. Our proposed adaptation of RG is to extend the technique within the biological spectrum framework which includes *decision neuroscience, decision science, decision economics and psychology*.

There are two major tasks: (1) building a repertory grid, and (2) analyzing it for the understanding, explaining (interpreting), evaluating it and predicting the decision and outcomes.

Building Repertory Grid

First we, the interviewers, and/or the decision makers (DM) look at the problem at hand (the intertwined *exceptions* exposed and *decisions* on them) to identify the *elements* involved. The

elements can be people, things or objects, activities or events, or other more specific business elements such as projects, tasks, accounts, policy, transactions, etc. Since the elements should be of the same *category* as suggested by Stewart & Stewart [39, 40], we consider multiple *categories* of elements. Each will have its own RG.

For Barings case, the people can be: Leeson himself, his different boss, his employees, his customers, his counter partners in Tokyo Japan, SIMEX, the top executives in the UK, etc. The things or objects can be the futures in SIMEX or Nikkei 225, error account 88888, incentives, etc. The activities or events can be Kim Wong's initial loss of £20K, George Seow's loss of £100K, Kobe earthquake, the doubling scheme during January-February of 1995. They can also be the decisions to conceal the losses in error account, Barings audits, meetings with customers, etc. [41, 42].

1. Asking (eliciting) the what

We, the interviewers, need to be un-biased, objective, non-suggestive so that we can get the most out of the decision makers' mind. The RG suggests a selection of *elements* of the same category as triads and elicit their *constructs* (factors, properties, attributes of elements) via interviews. This "same category" criterion can be relaxed if elements of different categories make sense. As a start, we ask the DMs to select 3 elements at random from one category, e.g. *people* category. For the Barings example, the three elements are shown on the first row of Table 1, and marked with an “*”.

Table 1. Repertory grid example

Similarity	Element1 Leeson	Element2 Customer	Element3 Employee someone	ElementN Boss	Difference
<i>Aggressive</i>	(*) ✓		(*) ✓		(*) X	<i>Relaxed</i>
<i>People-oriented</i>	(*) X	(*) ✓			(*) ✓	<i>Self-centered</i>
<i>Detailed</i>	(*) ✓		(*) X	(*) ✓		<i>Superficial</i>
<i>Why: incentive</i>						<i>Why: passive</i>
...

We then ask the DMs

- Which two of the three selected elements have in common (or similarity properties) in terms of how they feel about them in the context of the problem (exception or decision) at hand? We identify the similarity as a construct. For example, an answer is that Leeson and a particular employee are both *aggressive*. We place it in the column Similarity, and mark the two elements identified with a tick mark (“✓”).
- We then ask in what way the two similar elements differ from the third. The decision makers come up with: *relaxed*, *passive*, *confined*, etc. as opposite construct. We want the answer be specific. It cannot be “not aggressive” or “unaggressive” (not specific enough). In this example the opposite is that the Boss is described as *relaxed*. The opposite is entered in the last column, and is marked in the grid as a cross mark (“X”). The initial results are as shown.

2. Asking (eliciting) why (Hinkle's laddering up)

For the dipole *similar-different* (or *similar-opposite*), we would ask the DMs to specify the one pole of (*aggressive*, *relaxed*) they prefer to work with. For example the preferred pole is

aggressive. They have to find the reason why. There is a wide range of reasons why people are aggressive. Just like the selection of elements or first level constructs, we want to really nail down to the most relevant why's. The reason why to *aggressive* can be the *financial incentives* or *plain fear of fraud being found* as in Barings' Leeson case.

Take for example that hypothetically, the reason for being *aggressive* is *incentive*. Then, the next question to ask is what would be the opposite of *incentive*. We want to make sure the opposite of *incentives* is the why of *relaxed*, and this opposite makes sense. Else, we would have to further investigate the proper reasons. A possible opposite is *passive*.

At this point, we have two options: (i) continue to elicit the why's of *aggressive* or (ii) abstract further by asking additional reasons *why being incentive* or why its opposite *passive*. Thus, we can have several first-level why's and more why's of the original why's, until we and the DMs both feel that the associated construct *aggressive* is detailed enough.

The process continues until all important constructs are addressed. Practically, Valerie Stewart [40] suggests the number of first level constructs is around 9. The number of why's of each why would be around 5. Of course, after we embark on the analysis, there is the possibility that the table (grid) shows some discrepancies. We would go back to the initial grid for correction.

3. Asking (eliciting) how (Landfield's laddering down)

The purpose of the laddering down is to find the *how's* concerning a similarity or difference. Take for example the construct *aggressive*. Aggressiveness can be active or passive. The how of being *aggressive* can be recognized by the way the DMs yelled at others on the phone when taking orders, the pressure to the traders, and other attitudes with intention to cause harm. It could be also explored from the other pole *relaxed*.

4. Filling in all cells of the grid

There are empty cells in the grid after all the first level constructs, and the why-construct, and how-construct are enumerated and placed at the two opposing ends as observed in Table 1. They have to be filled in with tick marks and cross marks by the DMs. The DMs go to each cell and mark the empty cell appropriately. If inconsistency is found at this time or later, the DMs fix the entries in the cells. An example filled-in table is shown in Table 2.

Table 2. Filling-ins example

Similarity	Element1 Leeson	Element2 Customer	Element3 Employee someone	ElementN Boss	Difference
<i>Aggressive</i>	(*) ✓	✓	(*) ✓	X	(*) X	<i>Relaxed</i>
<i>People-oriented</i>	(*) X	(*) ✓	X	X	(*) ✓	<i>Self-centered</i>
<i>Detailed</i>	(*) ✓	✓	(*) X	(*) ✓	X	<i>Superficial</i>
<i>Why: incentive</i>	✓	✓	X	X	✓	<i>Why: passive</i>
<i>How: yelling</i>	X	✓	X	X	✓	<i>How: silent</i>
...

We explore all answers to fill in each and every grid during the elicitation phase above within the context of the biological spectrum. It means that the answer can be at any component level: cell, human, institution, market or economy. We, the interviewers, need to have a working knowledge on the three decision domains. For example, at the cell component level, we should be able to

classify their answers as originated from Maclean's model, following neural patterns of decisions such as those described in Campbell et al. [43], or otherwise.

Analyzing the repertory grid with considerations on integrated neuroeconomics

The methods for analyzing the grid are well documented in various sources [35, 36, 39]. We only present a simple one here for illustration.

To start we compute the matrix *Elements by Elements*. In the two columns Element1 and Element2, if the row has the same tick mark or cross mark, we count it as 1, otherwise it is 0. In this example, the first row and third row both have (✓ and ✓) therefore a value of 1, the second row (X and ✓) therefore zero. For all three rows, the total is 2. We continue with two other elements to build a matrix Elements versus Elements as shown in Table 3.

Table 3. Elements versus Elements example

Elements	Element1 Leeson	Element2 Customer	Element3 Employee someone	ElementN Boss
<i>Element1</i>		2	7	4	8
<i>Element2</i>			5	6	4
<i>Element3</i>				1	7
...					...

The value 8 in the first row indicates that the two element1 and element have the most similarities. And so is the third row on element3 and elementN. This is an indication that the three elements (1, 3 and N) shown belong to some sort of a cluster of similarities. As such, when we complete the table we can identify the clusters. The process is the same for the others matrices: *Constructs versus Constructs*, and *Constructs versus Elements*. Also, instead of using the dichotomy scheme (✓ and X), we can use a ranking scheme or a rating scheme (e.g. from 1 for complete similarity to 5 for complete difference).

On the surface, the repertory grid is simple to build and to compute. There are computer programs (e.g. Focus or Ingrid) available to prepare analyses by cluster analysis or principal component analysis [35, 39].

The elicitation and interpretation however are extremely difficult since we attempt to go inside the mind of the decision makers to find hidden facts on how the decision makers see his problems, environment, and world, and their logic. It requires some knowledge of the discipline in question, interview tactics, some working knowledge of decision neuroscience, decision science, decision neuroeconomics, as we have alluded to earlier. It also requires some characteristics of a psychologist such as patience, un-biasness, communications skills, emotional stability, ethics, inter-personal skills, open-mindedness, compassion, etc.

Therefore, it has to start small when the first significant exceptions occur. These interviewers, hereafter labeled as subject matter experts (SMEs) would be trained sufficiently, much like the operations research analysts in the old days of MSOR. They will work alongside with management, auditors, regulators, consultants and other professionals in the institution on a regular basis. They should have full access of management by exceptions systems for the detection of exceptions. The exceptions should be transparent to all responsible parties.

DISCUSSION

In this discussion, we don't actually have any interview with decision makers on a critical situation to work on. So we proceed somewhat differently without losing the generality of the proposed technique.

There are a couple of past examples under consideration: Nicholas Leeson of Barings Bank, Andrew Fastow and Jeff Skilling and their executive team of Enron [44], and Richard Fuld Jr. of Lehman Brothers [45]. All three cases involved bankruptcy, costly impact, and long-term ripple effects. We can investigate courts records, congressional hearings, hundreds of media articles, and research articles on each case for information on how to capture the decision makers' view of the problem they faced, from their perspective. Of course it is not the same as an actual interview.

We chose the simplest case of the three: Leeson of Barings bank. It turned out that this case revealed some interesting results, undetectable from Leeson's professional and/or social behavior.

For this particular case, we did not have court records or congressional hearing. We basically based our constructed scenario primarily on Adams Curtis' 52 minute-documentary [46], the Rogue Trader manuscript [41], the Rawnsley' Going for Broke manuscript [42], and numerous media records as well as Leeson's involvement in numerous interviews afterwards with an attempt to understand Leeson decision model. The Curtis documentary involved interviews with Nicholas Leeson himself, his former wife Lisa, Peter Norris, CEO of Barings Investment Bank, Steve Clarke, Hong Kong Merchant Banker, Ron Baker, and Pamela Chiu. Of course, the interview format, and questions did not follow the grid technique, but they helped find out partially why Leeson and Norris did what they did. The Rogue Trader authored by Leeson himself reflected how Leeson brought down the bank. Rawnsley retold the latest events which brought a bank to collapse. We thought it should be sufficiently adequate for the illustration of our proposed technique because our focus is on the technique itself.

From Leeson's manuscript, Leeson spent two-third of his book on what happened, and explained how they happened. Why he did what he did were explained sporadically in the remaining of the manuscript. Among the people he described, there were his employees, his superiors or people in supporting organizational units, his clients, SIMEX authority and others which involved the *people* category. The error accounts, futures, options, margin payments, etc. would constitute the category of *objects* he handled. Fraud, hidden schemes, meetings, audits, etc. would be part of the category of his *activities*.

The first thing we spot in the attempt to understand Leeson's model of his financial world was that Leeson was not in for money [41, 42]. He said he could have walked off with all bearer bonds (equivalent to blank checks) from Jakarta's office with a bundle of money and never had to work again [41, p. 26-27]. He was ambitious. He was a go-getter. He left Morgan Stanley because he did not get the trader's job. He was very successful in Jakarta at his first job overseas to sort out all transactions in Settlements.

Leeson showed he cared about his employees but in reality he was careless about them. He settled Kim Wong's errors [41, p. 39] because he hired her. She sold rather than bought 20 contracts which yielded a loss of about £20K. He later bailed out George Seow who bought rather than sold 100 contracts worth around £8M with a loss around £150K [41, p. 56]. Both

were recorded in the 88888 error account. The reason was that he could not afford to report the loss. It would mean the death to his career.

He was manipulative in terms of people, he used them. He had a strong tendency for fraud. He would find every which way to conceal the mistakes of others and mostly his. He was a hard worker person. He liked pressure. He was quick in recognizing holes in the system.

Leeson was a very private man. He did not share his thoughts fully with anyone, including his wife, Lisa. He was extremely high-risk taker. He used Martingale's doubling scheme during February of 1995 with the hope that Nikkei index went up again in short time, after Kobe. The world to him was a game. At the end, he did not blame anyone. He wrote a note "I am sorry" and walked away.

Leeson was lucky in his job. He fixed Jakarta's problem and got recognized. He traveled with Tony Dickel [41] to gain tremendous experience. He learned from everyone and anyone. He looked for loopholes and worked around the systems. He took advantage of other people's ignorance.

We could see that his decision was based on the situation in front of him. He would have stopped the fraud scheme a couple of times. Actually he has thought of it. Circumstance drove him to success and to disaster. He committed fraud because opportunity for committing frauds was there. That was the way his brain was wired and his mind worked.

The thoughts and facts found in these documents, again, can only be used for construing partial repertory grids. It is far from what we were looking for a collection of grids on different categories: people, process, things, regulations, etc. embedding the problem at hand. The way the interviewers exercise the interviewers for elicitation and analysis would constitute what we label as system thinking on fiasco prevention. Also it turned out that the approach identifies the needs for an Oversight organization if a scheme for prevention is conceptualized. We will try to formalize the system thinking and address the Oversight unit in another paper.

CONCLUDING REMARKS

This paper addresses *decisions and the decision making on exceptions* from the perspective of the *decision maker's model of the problem space in the environment* they are responsible for. It is based on the theory of personal constructs and repertory grid technique fathered by George Kelly for the elicitation, analysis and evaluation of decision constructs. It proposes a modified technique, which can be value-added to other computational approaches, such as decision analysis, expected utility theory, prospect theory, etc. As such it could address the challenge of corporate and economic fiasco prevention. The development of our technique takes into account the functionality and behavior of the brain as proposed by Paul Maclean's three brains in one [26], discussed in Daniel Kahneman's thinking systems (system I and system II) [12] and the neuroeconomic view of biology, psychology and economics [5].

In summary:

- We proposed an approach to *analyzing and interpreting decision and decision making process* based on George Kelly's Personal Construct Theory and the repertory grid [1]. The grid is a 2-dimension matrix of elements and constructs of decisions with

considerations on biology, psychology and economics interpretations, in addition to computational mechanisms and methods widely exercised in decision science.

- We developed within a *systemic* framework based on biological spectrum in nature. In this spectrum, we look for anomalies via analogies (similarities) and homeomorphism. This is different than Ludwig von Bertalanffy's General System Theory or GST [19] for unity of science by isomorphism. It is also different from Kenneth Boulding's GST version describing the skeleton of science [20]. To address the considerations on biology, psychology and economics, the technique incorporates recent thoughts of neuroeconomics in recognizing the nature and factors involved in the decision.
- We identified, in the process, the need of an Oversight organization unit. It will cost the institution in terms of creating the unit and run it with its own management team and SMEs as the opposite, independent and parallel part of the whole organization. But the cost would be minimum as compared to the cost of fiascos or bankruptcy, once the latter happens.
- The PCT of George Kelly is very enticing and his RP technique is easy to understand and apply. The reality in fiascos prevention is that it requires someone who is decision science-trained and neuroeconomics-knowledgeable. It becomes a new category of subject matter experts in its own right.

With the big picture sketched in Figure 1, we explore the analogies of exceptions between levels. We narrow down to a practical model for addressing the issue of understanding decisions towards corporate fiasco prevention. We draw some insights and lessons learned from the literature to guide our proposed model.

- The first is that we can use Paul Maclean's classification to initially identify the nature and type of a decision, e.g. when a decision maker angrily overrides a comment of his peer or subordinate, his logical thinking is overpowered by the limbic brain.
- The second is about the emotion played in decisions according to Antonio Demasio, and the psychological aspect.
- The third is that we will not forget and/or down play the importance of the quantitative methods well established and well used from Bayesian analysis to dynamic programming, and many other theories such as prospect theory and beyond.
- The fourth is we need to exercise the system thinking across all decision domains from neuroscience thinking to neuroeconomics thinking besides quantitative thinking.

A new perspective appears from the above discussion in the previous sections. Exceptions have to be monitored and double checked. Decisions could be questioned. But the responsible parties such as in Baring case [41, 42] or in Enron case could be blinded for any reasons and take no actions as reported in Dharan & William [47]. We need an Oversight organization unit, different than common crisis management organization [48, 49]. To properly carry out the monitoring and investigation tasks, the Oversight organization should be tasked by the Board of Directors with sufficient authority as shown in Figure 2. This organization unit does not do strategies or consulting, just operationally execute properly the defined tasks. It reports directly to the board of directors. Like a judge in the judiciary system, the Oversight organization personnel will be highly paid but receive no commissions. It is independent and staffed with its own subject matter experts such as the interviewers we mentioned earlier.

Our approach gives a value-added to the management of exceptions and understanding managerial or executive decisions. It would be an incremental step towards prevention of business failures.

The fiasco prevention is a very complex and difficult task. Our paper is just a scratch on the surface of this kind of problems. We hope it will start a series of discussions leading to a prevention theory.

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STUDY OF PRICE MATCHING PERFORMANCE BETWEEN TWO RETAILERS WHEN CONFRONTING AN ONLINE SHOP OFFERING THE LOWEST PRICE

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ABSTRACT

Price matching (PM) is a common pricing strategy for consumer product retailers. Electronic appliance shops and supermarkets, which are considered main PM users, often guarantee that they will reduce the price of a certain product to match the lower price of a competitor. It is common for PM adopted by retailers to target only a limited number of rival brick-and-mortar stores located within the local market, although the lowest price is usually offered by online shops.

Therefore, this paper assumes a situation in which two brick-and-mortar retailers compete against each other, one of which adopts PM that considers only the lower price of its local competitor while ignoring the lowest price offered by an online shop offers. Analytical model is proposed to examine how such a PM policy, which targets only a store located within the local market, is influenced when a net shop not covered by the PM policy offers the lowest price—a more accurate reflection of reality. We then develop a triangle market model as an extension of Hotelling's linear-market model, in which two stores and one online shop are located at the apexes of the triangle, customers are evenly located on the three equal sides, and customer utility is assumed to be determined by retail price and distance to a store.

We analytically explore the demand size and revenue of the store adopting PM under the effect of Internet sales and then determine conditions in which PM could increase the revenue of a retail store when the lowest price is found in an online shop. Finally, we then propose several managerial implications derived from the analytical findings.

KEYWORDS

Price matching, Price competition, Triangular market model

INTRODUCTION

Price matching (PM) is a pricing strategy whereby a retailer reduces the price of a product if a customer claims that its competitor offers a lower price. PM is a common pricing strategy that is often adopted by supermarkets and electronics and appliance shops. At the same time, PM is a common research theme in academia, especially in the areas of marketing, economics, and operations management.

Real PM policies set several conditions that are required to be effective. For example, the availability of a lower priced item at a rival shop (i.e., PM on availability) and the exclusion of a mistakenly advertised lower price are common conditions. Target, one of the largest retail chains in the US, offers a real-world example of PM application and its PM policy is detailed on the company's website (Target, 2015). This paper focuses on a common PM condition: stores limit competitors that are subject to PM guarantees to only several brick-and-mortar stores within the local market. In other words, real PM policies usually ignore the fact that the lowest price is commonly offered by an online shop.

Customer channel selection, such as between a neighborhood brick-and-mortar shop or an online shop, is influenced by channel attributes including price, service, and ease of use (Blattberg, Kim, and Neslin 2008, Chap.25). Thus, the fact that PM policies commonly ignore the effect of e-business surely influences customers' channel selection. When the lowest price is offered by an Internet retailer, the effectiveness of PM that targets only rival brick-and-mortar stores could be undermined. The unanswered question is whether and how the lowest price offered by e-business (hereafter an *online shop*) affects the performance of PM that a brick-and-mortar store (hereafter a *store retailer*) provides to its customers when it considers the lower price of a brick-and-mortar rival store (hereafter a *competitor*).

This paper considers the PM policies of two competing store retailers located within a certain local market when the lowest price is offered by an online shop that is not eligible for PM. Developing a triangular market model to capture the competition among the two store retailers and one online shop as an extension of the well-known Hotelling model, we determine whether and if yes when PM that targets only a local competitor and ignores the lowest price of an online shop is beneficial. In addition, assuming a situation in which the PM policy offered by a store retailer does not influence the total demand of the online shop (hereafter the *independent online shop case*), and in which transportation cost does not affect the customer's choice of an online shop (hereafter the *no distance effect case*), we analyze how e-business influences the performance of PM and what kind of strategy a store retailer should utilize to make PM effective.

The remainder of this paper is organized as follows. Section 2 briefly summarizes literature on PM. Section 3 explains assumptions and models. In Section 4, we analyze the model to determine the conditions when PM, even when it does not consider the lower prices of online

shops, is still beneficial for a store retailer. Section 5 discusses the analytical findings, and Section 6 concludes the paper.

LITERATURE REVIEW

One stream of research has studied PM from a management view. Chen, Narashimhan, and Zhang (2001) studied the condition in which PM either facilitates or intensifies price competition, taking into account customer heterogeneity, especially customers' different behavior with respect to store loyalty and search cost. Using experimental studies, Kukar-Kinney (2006) examined how consumer store loyalty is influenced by the two key characteristics of PM: refund depth (the amount that is refunded to a customer) and the scope of the policy (the number of competitors eligible for PM). She found that the scope of PM is a more significant factor than the refund depth for repeated, long-term purchasing. One variation of PM is a posterior PM policy, in which a retailer matches the lower price if a price markdown occurs after a customer purchases a product. Lai, Debo, and Sycara (2010) analyzed the performance of posterior PM when strategic consumers make a buy-or-wait choice in anticipation of a lower future price. Koh, Moon, and Schellhase (2012) explored PM policies when consumers are heterogeneous with respect to loyalty, either price sensitive or store loyal. They found that the number of loyal customers determines the benefit of using PM. One common requirement of PM is product availability: a retailer offers the lower price only if the product is available at the competitor's location. Nalca, Boyaci, and Ray (2013) studied the effect of product availability verification as a PM condition on retail prices, order sizes, retailer profits, and consumer surplus. They concluded that while PM on availability results in lower profits for retailers, it is widely used in real retail business situations.

Another stream of PM research has been conducted by economics scholars. The prevalent view in economics literature has been rather negative with a number of scholars arguing that PM policies have anti-competitive effects. Starting from the seminal work of Salop (1981), PM was considered to result in collusion between competitors, leading to higher equilibrium prices. Edlin (1997) suggested PM could facilitate cartel prices and potentially violate antitrust laws. On the other hand, Cort (1997) believed PM serves as means of price discrimination that may not only raise but also lower equilibrium prices, benefiting consumers. Finally, signaling theory presented empirical evidence in support of the alternative view that consumers perceive PM as a signal of low prices (e.g., Biswas et al., 2002; Srivastava and Lurie, 2004; Moorthy and Winter, 2006).

The rapid expansion of online shopping in the past decade has not been adequately reflected in research publications related to PM. This paper employs a modeling approach to contribute to the existing literature by introducing an online shop with the lowest price to a conventional

setting of PM policies between brick-and-mortar stores. The model we propose can more accurately reflect the real retail competition represented by e-business, which has developed as a main distribution channel and threatens the sales of conventional stores. As a result, our analysis offers insights into retail pricing strategies, in particular PM policies that are now widely adopted in the consumer product market.

MODEL

Triangle market model

Based on the triangular market model (Tsai & Lai, 2005) as an extension of the linear market model of Hotelling (1929), we developed a model in which a store retailer that adopts PM (hereafter *Retailer 1*), another store retailer that offers a lower retail price than Retailer 1 (hereafter *Retailer 2*), and an online shop with the lowest retail price (hereafter *Retailer 0* or *online shop*) are located on its vertexes $(0,0)$, $(1,0)$, and $(0.5, \sqrt{3}/2)$, respectively, and customers are evenly distributed on its three sides (see Figure 1). Therefore, the total amount of customers in the triangular market is three.

We then assume that each customer located on a side of the triangular market will choose the retailer offering his or her highest utility. This utility is defined in Equation (1) as a function of retail price and distance between the customer and the retailer:

$$U_i = a_i - p_i - k_i d_i \quad (1)$$

We assume two brick-and-mortar stores are symmetric, $a_1 = a_2$. In Equation (1), k_i denotes the impact of the transportation cost a customer perceives when visiting Retailer i . Without loss of generality, we assume $k_0 \geq 0$ and $k_1 = k_2 = 1$. Note that higher k_0 means that customers tend to be more hesitant to use an online shop. In other words, k_0 captures the difference in customer channel preference between conventional stores and Internet shops. All symbols and notations are listed in Table 1.

Note that we use a Euclidean distance so that the distance between a customer located at point (x, y) on a side and a store located at vertex (x', y') is determined as $\sqrt{(x - x')^2 + (y - y')^2}$; for example, the distance between a customer located at point $(0.5, 0)$ and the online shop is $\sqrt{3}/2$. In a sense, we assume that although customers are located on the sides of the triangle market, they can move inside of the triangle when shopping. This setting is consistent with Tsai & Lai (2005).

Indifference point among the three stores

The indifference point, $\bar{P} = \bar{P}(\bar{x}, \bar{y})$, is defined as the point at which all three utilities become equivalent when PM is not adopted. When the three points at which a perpendicular line from the indifference point intersects a side of the triangle are set as I_{01} , I_{12} , and I_{02} , as shown in

Figure 1, the demand sizes of the online shop, Retailer 1 (which adopts PM), and its rival store, Retailer 2, are determined, respectively, as follows:

$$\bar{D}_0 = 3/2 - \sqrt{3}\bar{y}. \quad (2)$$

$$\bar{D}_1 = (3/2)\bar{x} + (\sqrt{3}/2)\bar{y}.$$

$$\bar{D}_2 = 3/2 - (3/2)\bar{x} + (\sqrt{3}/2)\bar{y}.$$

Note that the bar above a symbol (—) represents the initial situation, that is, the situation before Retailer 1 adopts PM.

In addition, once the indifference point is determined, the retail prices of the three retailers before PM are adopted are decided as follows:

$$\bar{p}_0 = a_0 - \bar{U} - k\sqrt{(1/2 - \bar{x})^2 + (\sqrt{3}/2 - \bar{y})^2}$$

$$\bar{p}_1 = a_1 - \bar{U} - \sqrt{\bar{x}^2 + \bar{y}^2}$$

$$\bar{p}_2 = a_2 - \bar{U} - \sqrt{(1 - \bar{x})^2 + \bar{y}^2}$$

\bar{U} is the utility level at the indifference point \bar{P} , and we assume \bar{U} is high enough for retail prices to be non-negative.

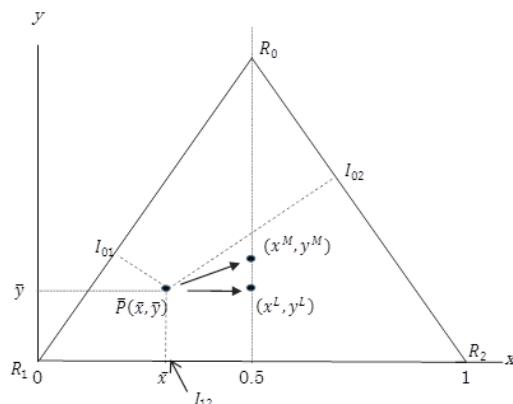


Figure 1 Triangle market

Table 1 Notations and symbols

<i>Symbols</i>	
$U_i = U_i(x, y)$	The utility that a customer can gain from retailer i : $U_i = a_i - p_i - k_i d_i$
a_i	The potential market size for Retailer i assuming $a_i > 0$ and $a_1 = a_2$.
p_i	The retail price of Retailer i : $p_1 \geq p_2 > p_0$.
k_i	Coefficient denoting a transportation cost for Retailer i assuming $k_0 \geq 0$ and $k_1 = k_2 = 1$.
$d_i = d_i(x, y)$	Distance between Retailer i and the customer located at point (x, y) .
$\bar{P} = \bar{P}(\bar{x}, \bar{y})$	Indifference point at which all three utilities $U_i, i = 0, 1, 2$, are equivalent for the given retail prices.
D_i	Demand size of Retailer i .
G	$G \equiv (a_1 - p_2) - (a_0 - p_0)$.
π_i	Revenue of Retailer i .
<hr/>	
<i>Index</i>	
i	$i = 0, 1$, and 2 represent a store retailer adopting PM, a rival store retailer, and an online shop, respectively.
$-$	Diacritical mark denoting the initial situation
M	Superscript denoting the indifference point after adopting PM.
L	Superscript denoting the independent online shop case.
N	Superscript denoting the no distance effect case.

Assumption of price matching

In terms of the PM policies this paper considers, we established the following assumptions for tractability:

1. Customers know all the retail prices in the market.
2. All the customers who are eligible for price matching ask a retailer to do so.
3. The two store retailers are symmetric: $a_1 = a_2$ and $k_1 = k_2 = 1$.
4. Product availability at the competitor does not restrict customer's claiming PM.
5. PM does not target the lowest price offered by the online shop.

In reality, some assumptions above may be less supported. For instance, some customers may not know the competitor's price or understand that a retailer sets product availability as a requirement for customers to claim PM. Thus, our setting can be regarded as an ideal situation in which PM is most beneficial for customers.

MODEL ANALYSIS

Effect of price matching on demand and revenue

This subsection investigates the effect of PM on sales when two store retailers and one online shop compete against one another but the PM policy does not consider the lowest prices offered by the online shop. In the initial situation before PM, the initial indifference point $\bar{P}(\bar{x}, \bar{y})$ determines the retail prices. Once Retailer 1 offers PM, the indifference point after PM, $P^M(x^M, y^M)$, is determined as $x^M = 0.5$ since the two retail stores are assumed to be symmetric. Lemma 1 shows the necessary conditions for the indifference point after PM, P^M , to exist.

Lemma 1

The indifference point after PM, P^M , exists if

$$(a) \quad G - \frac{\sqrt{3}}{2}k \geq 0.5, \text{ and}$$

$$(b) \quad G \leq 1,$$

where $G \equiv (a_1 - p_2) - (a_0 - p_0)$.

Proof. Due to the assumption of the two symmetric store retailers, the location of the indifference point after PM, $P^M = P^M(x^M, y^M)$, should be located on the line at $x = 0.5$. In addition, the utilities at P^M , $U_0^M = U_0^M(0.5, y^M) = a_0 - p_0 - k(\sqrt{3}/2 - y^M)$, and $U_1^M = U_1^M(0.5, y^M) = a_1 - p_2 - \sqrt{1/4 + y^{M2}}$ should be equal. Thus, define $A(y^M) = \sqrt{1/4 + y^{M2}}$ and $B(y^M) = G + k(\sqrt{3}/2 - y^M)$, which are continuous at $0 \leq y^M \leq \sqrt{3}/2$. If $A(y^M = 0) \leq B(y^M = 0)$ and $A(y^M = \sqrt{3}/2) \geq B(y^M = \sqrt{3}/2)$, then there exists such y^M that satisfies $A(y^M) = B(y^M)$ due to the middle point theorem, which results in $U_0^M = U_1^M$. Since $A(y^M = 0) \leq B(y^M = 0)$ requires $G - \frac{\sqrt{3}}{2}k \geq 0.5$ and $A(y^M = \sqrt{3}/2) \geq B(y^M = \sqrt{3}/2)$ requires $G \leq 1$, one obtains the conditions (a) and (b). (Q.E.D.)

One knows from Lemma 1 that a constant G can be interpreted as the difference in the customer's surplus between choosing Retailer 1 and choosing the online shop. Therefore, Lemma 1 implies that the customer value of the online shop should be close to that of the retail shop and that the transportation cost of Internet shopping (i.e., k) should be relatively low compared with the cost of shopping at a traditional local store. In other words, when an online shop is valuable for customers and, consequently, when there exists a certain level of competition between brick-and-mortar shops and net shops, the equilibrium after PM exists.

Next, Lemma 2 determines the indifference point after PM.

Lemma 2

If the indifference point after price matching (x^M, y^M) exists in the triangle region of the market, the point is determined as

$$\text{if } k = 1, \ x^M = 0.5 \text{ and } y^M = \frac{G^2 + \sqrt{3}G + 0.5}{2G + \sqrt{3}}, \text{ and} \quad (3)$$

$$\text{if } k \neq 1 \text{ and } k \geq 0, \ x^M = 0.5 \text{ and } y^M = \frac{k(2G + \sqrt{3}k) \pm \sqrt{(2k + \sqrt{3}G)^2 + G^2 - 1}}{2(k^2 - 1)}, \quad (4)$$

where $G \equiv (a_1 - p_2) - (a_0 - p_0)$.

Proof. Due to a symmetric structure of the store retailers, x^M should be $x^M = 0.5$. Thus, one can determine the value of y^M by solving $U_0^M = a_0 - p_0 - k(\sqrt{3}/2 - y^M) = a_1 - p_2 - \sqrt{1/4 + y^{M2}} = U_1^M$, which can be rewritten as a quadratic function with respect to y^M . Solving it results in Equations (3) and (4). (Q.E.D.)

At this time, the difference in the demand before and after PM for each store is determined as follows:

$$\Delta D_0 = \sqrt{3}(\bar{y} - y^M).$$

$$\Delta D_1 = \frac{3}{2}(0.5 - \bar{x}) + \frac{\sqrt{3}}{2}(y^M - \bar{y}).$$

$$\Delta D_2 = -\frac{3}{2}(0.5 - \bar{x}) + \frac{\sqrt{3}}{2}(y^M - \bar{y}).$$

Store retailer's profit after adopting price matching

We set the price and demand of Retailer 1 before PM as p_1 and \bar{D}_1 , respectively, and the price and demand after PM are denoted as $p_1^M (= p_2)$ and D_1^M , respectively. The change in Retailer 1's revenue due to adapting PM is therefore determined as follows:

$$\begin{aligned} \Delta\pi_1 &= \pi_1^M - \bar{\pi}_1 = p_2 D_2^M - p_1 \bar{D}_1 \\ &= p_2 \left(\frac{3}{4} + \frac{\sqrt{3}}{2} y^M \right) - p_1 \left(\frac{3}{2} \bar{x} + \frac{\sqrt{3}}{2} \bar{y} \right) \end{aligned}$$

The condition in which PM raises the revenue of Retailer 1 is presented as Proposition 1:

Proposition 1

$$(a) \ \pi_1^M < \bar{\pi}_1 \text{ if } \bar{y} > -\sqrt{3}\bar{x} + \sqrt{3} \frac{p_2}{p_1}.$$

$$(b) \ \pi_1^M > \bar{\pi}_1 \text{ if } \bar{y} < -\sqrt{3}\bar{x} + \frac{\sqrt{3}}{2} \cdot \frac{p_2}{p_1}.$$

(c) Otherwise, whether or not $\pi_1^M > \bar{\pi}_1$ can be determined by numerically examining Equations (1), (2), and (3).

Proof. $\Delta\pi_1 = p_2 \left(\frac{3}{4} + \frac{\sqrt{3}}{2} y^M \right) - p_1 \left(\frac{3}{2} \bar{x} + \frac{\sqrt{3}}{2} \bar{y} \right) > 0$ is equivalent to

$$y^M > \frac{p_1}{p_2} \left(\sqrt{3} \bar{x} + \bar{y} \right) - \frac{\sqrt{3}}{2}. \quad (5)$$

Also, $0 \leq y^M \leq \sqrt{3}/2$ since y^M should be within the triangle market. Thus, $\pi_1^M \geq \bar{\pi}_1$ requires satisfying $\frac{p_1}{p_2} \left(\sqrt{3} \bar{x} + \bar{y} \right) - \frac{\sqrt{3}}{2} \leq \frac{\sqrt{3}}{2}$. In addition, if $0 > \frac{p_1}{p_2} \left(\sqrt{3} \bar{x} + \bar{y} \right) - \frac{\sqrt{3}}{2}$, then $\pi_1^M > \bar{\pi}_1$ is always guaranteed. (Q.E.D.)

Proposition 1 states what kind of initial situation of competition is required to make PM beneficial for the retailer. Figure 2 illustrates the three conditions of Proposition 1. When the initial market state, \bar{P} , is located within the area determined by points $S2$, R_1 and $S3$ (i.e., a dark gray triangle in Figure 2), the retailer always benefits from PM, whereas when \bar{P} is located within the area determined by points R_0 , $S1$, and $S5$ (i.e., the white area located in the upper side of the triangular market), PM will degrade the retailer's revenue. This can be interpreted to mean that PM tends to be effective when the market share of the online shop is relatively large but the market share of the retailer that adopts PM is originally relatively small. When the initial condition, \bar{P} , is located in the gray-colored area in Figure 1, which is determined by points $S1$, $S2$, $S3$, $S4$, and $S5$, careful scrutiny may be required to judge whether to offer PM. This is the case when the market shares of the three retailers are relatively similar and, thus, competition among the stores is intensive. In such a situation, the benefits of PM are not determined straightforwardly.

Although it appears intuitive that an online shop with the lowest price would negatively affect the PM policy of a store retailer with a higher price, our analysis otherwise. In fact, a certain level of the online shop sales resulting from the lower cost of e-business will support an increase in sales related to PM for the store retailer despite the original price of the retailer's product being higher and less attractive to customers.

We can interpret this finding as follows. Two factors influence a customer's store choice in our modeling framework: price and distance. If PM can reduce the effective price to the customers, the importance of customer distance to the store increases. At the same time, it is possible to understand distance as the generalization of non-price factors that influence consumer's store choice. So, if a store retailer can differentiate its service from e-business, for example, with in-store displays and face-to-face customer service by employees, there is a good chance that the store retailer can capture a certain number of customers from the online shop via PM. Proposition 1 presents a possibility of the sort of store switching that might occur when non-price competition becomes more important due to PM lessening the impact of price

competition between brick-and-mortar and Internet channels.

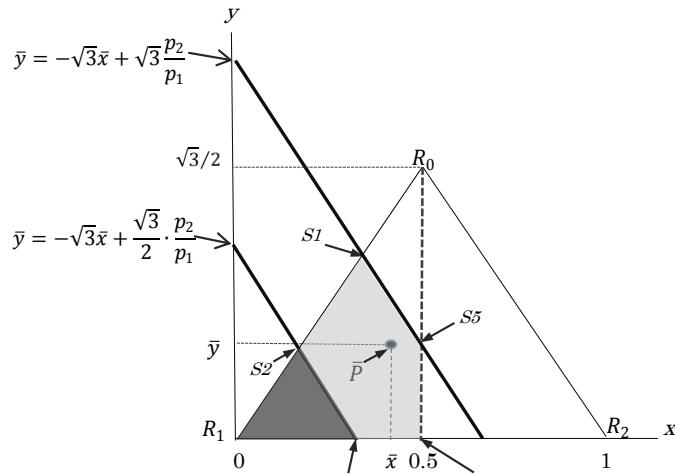


Figure 2. Conditions to be $\pi_1^M > \bar{\pi}_1$

Next, Lemma 3 shows the sensitivity analysis of the indifference point after PM.

Lemma 3

π_1^M increases in k , $a_1 (= a_2)$ and p_0 , while π_1^M decreases in a_0 and p_2 .

Proof. y^M is determined as the intersection of the two functions $A(y) = \sqrt{1/4 + y^2}$ and $B(y) = G + k(\sqrt{3}/2 - y)$. Obviously, $B(y)$ increases in $k, a_1 (= a_2)$ and p_0 and decreases in a_0 and p_2 while $A(y)$ is independent of these parameters. Thus, y^M increases in k , $a_1 (= a_2)$, and p_0 while y^M decreases in a_0 and p_2 . Since greater y^M leads to greater π_1^M , we obtain the results. (Q.E.D.)

We know from Lemma 3 that PM tends to be beneficial when the purchase-related cost that customers perceive in online shopping is high and the lowest price offered on the Internet is not as low as that of the store channel. One conclusion in this subsection is that there exists a case in which even PM that only matches the lower price of a local competitor, ignoring the lowest price of an online shop, is still profitable for a retailer—and a certain level of competition between store and online channels is necessary for PM to be beneficial.

Case in which PM does not affect online shop sales (Independent online shop case)

This subsection explores the situation in which PM that Retailer R_1 offers affects only the sales of competitor R_2 , and the demand for the online shop is independent from the PM (i.e., $\Delta D_0 = 0$). We call the setting of this subsection the *independent online shop case* and use the superscript “L” to represent the indifference point after PM in this case. Note that symbols

π_1^M and π_1^L represent the revenue of Retailer 1 when PM influences the demand for the online shop and when PM does not influence it, respectively.

Figure 3 illustrates the shift of the indifference point from the initial case to the independent online sales case. The sales amount of the online shop is determined by the value of y at the indifference point. Assuming that PM does not influence the demand for the online shop, the value of y keeps the value of \bar{y} even after PM is adopted (i.e., $y^L = \bar{y}$). Proposition 2 shows the comparison between these two cases.

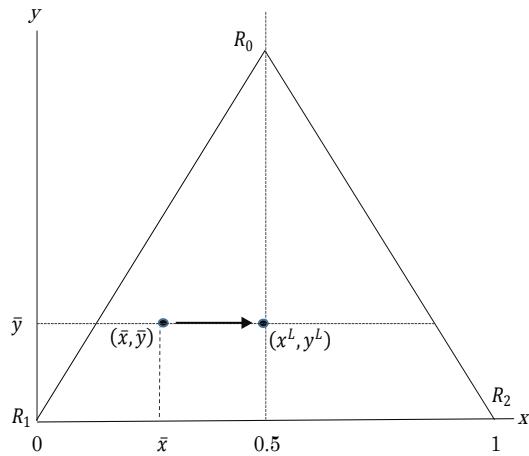


Figure 3. Independent online shop case.

Proposition 2

When Lemma 1 is held,

- (a) $\pi_1^M > (=, or <) \pi_1^L$ if $y^M > (=, or <) y^L = \bar{y}$, respectively.
- (b) y^M increases as k increases.

Proof. (a) From Equation (2), $\Delta D_0 = 0$ is equivalent to fixing y^L to the level of \bar{y} . Thus, after PM, the indifference point of the independent online shop case should be $P^L = P^L(0.5, \bar{y})$.

$\pi_1^M - \pi_1^L = p_2 \left(\frac{3}{4} + \frac{\sqrt{3}}{2} y^M \right) - p_2 \left(\frac{3}{4} + \frac{\sqrt{3}}{2} \bar{y} \right) = \frac{\sqrt{3}}{2} p_2 (y^M - \bar{y})$, so examining whether or not $y^M > \bar{y}$ determines whether $\pi_1^M > \pi_1^L$. Note that y^M is determined by $a_1 - p_2 - \sqrt{1/4 + y^{M2}} = a_0 - p_0 - k \left(\frac{\sqrt{3}}{2} - y^M \right)$. At the region of $0 \leq y \leq \sqrt{3}/2$, $A(y) = \sqrt{1/4 + y^2}$ is continuous and monotonously increasing in y while $B(y) = G + k(\sqrt{3}/2 - y)$ is continuous and monotonous decreasing in y . Since, from Lemma 1, $B(0) = a_1 - p_2 - a_0 + p_0 + \frac{\sqrt{3}}{2} k > 0.5 = A(0)$ and $B(\sqrt{3}/2) = a_1 - p_2 - a_0 + p_0 < 1 = A(\sqrt{3}/2)$ and

y^M is defined such that y satisfies $A(y^M) = B(y^M)$, we know that $\bar{y} = y^L < (=, or >)y^M$ results in $\pi_1^M > (=, or <)\pi_1^L$.

(b) The $B(y)$ is always on the point of $(\sqrt{3}/2, G)$, irrelevant of the value of k , and the slope of $B(y)$ becomes steeper as k increases. Thus, it is clear that the intersection between $g(y)$ and $h(y)$ becomes greater as k increases. (Q.E.D.)

We can interpret Proposition 2 to mean there is a risk that a retailer may either overestimate or underestimate the sales increase due to PM if the retailer establishes the PM policy without taking into account the effect of an online shop with the lowest price—the retailer misunderstands π^L as π^M . In addition, the intensive of this inaccurate estimation depends on the initial situation before PM (i.e., \bar{y}). For instance, if the value of \bar{y} is low enough (i.e., the market share of the online shop is large), the sales increase caused by PM tends to be underestimated.

Case in which an online shop has no distance effect (No distance effect case)

It is said that Internet shopping is free from any geographic restriction. Customers living in rural areas can receive the same service from online shopping as urban customers. Thus, in this subsection, we investigate an extreme case in which distance of the online shop does not negatively affect a customer's purchase decision (i.e., the case of $k = 0$). We call this setting a *no distance effect case* and use the symbol N to represent this case.

Proposition 3.

(a) $(x^N, y^N) = (0.5, \sqrt{G^2 - 0.5})$

(b) $y^M \geq y^N$ and $\pi_1^M \geq \pi_1^N$.

Proof. (a) At the indifference point of the no distance effect case, $U_1 = a_1 - p_2 - \sqrt{0.25 + y^{N2}} = a_0 - p_0 = U_0$. Thus, we easily obtain $(x^L, y^L) = (0.5, \sqrt{G^2 - 0.5})$.

(b) Since y^N is determined by $a_1 - p_2 - \sqrt{1/4 + y^{N2}} = a_0 - p_0$, by for the proof of Proposition 2, y^N is the value of y^M when $k = 0$. From Proposition 2, y^M increases in k

so that $y^N \leq y^M$. Since $\pi_1^M - \pi_1^N = p_2 \left(\frac{3}{4} + \frac{\sqrt{3}}{2} y^M \right) - p_2 \left(\frac{3}{4} + \frac{\sqrt{3}}{2} y^N \right) = \frac{\sqrt{3}}{2} p_2 (y^M - y^N) \geq 0$, and thereby $\pi_1^M \geq \pi_1^N$. (Q.E.D.)

Proposition 3 states that the revenue of Retailer 1 when online shoppers do not perceive distance cost is smaller than that when they strongly feel such a cost, although PM does not influence the sales of online shops. It is safe to say that, in a broad sense, e-business shoppers may view

distance cost as any psychological burden, such as privacy concerns, risk of fraud, delay of delivery, or damage of the ordered item during the transportation.

DISUCCSSION

We can develop the following interpretation from the analytical findings in Section 4, especially from Propositions 2 and 3.

Interpretation of the analytical results

Although PM offered by a brick-and-mortar store targets only a neighboring competitor with a lower price while ignoring the lowest price of an online shop, the benefits that the store retailer can gain by PM increase:

- (i) *when the competition between brick-and-mortar retailers and e-business intensifies,*
- (ii) *when the price of the neighboring competitor is lower, and*
- (iii) *when customers feel that shopping via the Internet is less comfortable and more troublesome.*

In addition, ignoring the effect of an e-business with the lowest price leads to improper estimation of the benefits due to PM.

From the interpretation above, we can develop the following managerial implication for a brick-and-mortar store that considers adopting PM to compete with its local rival.

Managerial implications

Although PM ignores the lowest price offered by an online shop, it could still be an effective pricing strategy if:

- (i) *the market share of e-business is similar to that of brick-and-mortar stores, and*
- (ii) *the price gap between the store that will offer PM and its rivals is relatively large.*

Moreover, the merits of the PM policy can be emphasized by advertising the superior characteristics of shopping at traditional stores compared to the Internet (e.g., customer's direct examination of product quality, and excellent service by the sales staff).

In addition, it is necessary for retail management to understand the interaction between store and direct channels to achieve adequate PM management.

The findings above are, in a sense, counterintuitive. This is because we find that PM is profitable even when it does not target the lowest price of an online shop, and even if the market share of Internet shopping is high. In addition, it is common for traditional retailers, such as supermarket chains and department store, to emphasize the superiority of a traditional store

over online shopping. We show another reason that communication on the part of retailers' with customers about the advantages of shopping at brick-and-mortar stores is useful, supporting the effectiveness of PM and resulting in higher profits.

CONCLUDING REMARK

PM is a common pricing strategy for retailers. Under PM, a store reduces its price to the lower price offered by a competitor for the same product. It is common for PM policies to be limited to local brick-and-mortar competitors that are located within the retailer's local market. In other words, PM policies usually ignore the fact that the lowest price is commonly offered by an online shop. Since customers choose either a neighbor brick-and-store shop or an online shop by evaluating several attributes, with retail price being the main factor, one unanswered question is whether and how the lowest price offered by e-business affects the performance of the PM policy that a brick-and-mortar store offers when the policy only considers neighboring brick-and-mortar rivals.

We develop a triangular market model, as an extension of Hotelling's linear market model, in which two brick-and-mortar stores and one online shop compete against one another, and where one of the two brick-and-mortar stores adopts a PM policy that does not target the lowest price of the online shop. Analytical examination of the model finds that PM is still beneficial if the web sales have a certain level of market share and the store that adopts PM is not strong in the market. In addition, we study the effect of PM on revenue, assuming, first, that the PM does not affect the sales volume of the online shop, and second, that customers do not perceive any distance costs related to net shopping. We find that if retailers groundlessly assume that net shopping does not influence local retail competition, they may over- or underestimate the benefits of PM. Our analysis determines the impact of misunderstanding the effect of online shopping on the performance of PM. We then develop several managerial interpretations and implications to help retail managers make PM more effective.

Several key issues regarding retail competition under PM require future research. First, for simplicity, we set up several assumptions regarding PM. Relaxing these assumption would make PM analysis more practical. For instance, PM often requires the availability of a product with a lower price (i.e., PM on availability). Thus, including inventory information, even uncertainty regarding such information, could enhance the applicability of the research. Also, in real shopping situations, not all customers claims price reductions even if PM is available. Consumer behavior, such as store loyalty or a perceived difficulty in claiming PM, could be a key factor that influences the performance of PM and should be studied to increase the quality of PM research.

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SUSTAINABILITY AND DATA ANALYTICS IN RESPONSE TO DYNAMIC SUPPLY CHAIN INFRASTRUCTURE

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ABSTRACT

The increase in climate change raises the awareness of societal stakeholders to act as key-drivers in motivating and pushing corporations to monitor their sustainability data transparency, analyse their operations performance, and improve their operations related to environment, social governance, and corporate social responsibility. This paper evaluates the current importance of the societal stakeholders that impact the compliance of companies towards these environmental, social and governance practices in their supply chain operations. Latest review on the sustainability reporting and its data analytics are carried out, followed by a review of the development of a sustainability reporting and data analytics model, namely, sustainability software and online platforms in facilitating and supporting supply chain practitioners in decision making process. The model has been further developed as a dashboard and applied to a maritime supply chain firm. A case analysis has been conducted to illustrate the importance of analytics data in supporting complex decision making process. Additional intelligent data analytics functionalities are recommended as future development for the sustainability reporting and data analytics dashboard in supply chain operations.

KEYWORDS

Sustainability reporting; Supply chain management; Global Reporting Initiative; Corporate Social Responsibility

1. INTRODUCTION

The increase in climate change awareness is compelling companies to transition away from the more traditional ‘business-as-usual’ operations to encompass sustainability along the supply chain as part of their corporate scheme. More importantly, societal stakeholders, defined here as sustainability verification bodies, government, non-governmental organizations (NGOs), stock exchanges, and shareholders, are demanding higher transparency and accountability on a company’s data analytics and reporting related to environmental, social governance (ESG), corporate social responsibility (CSR), and sustainability. At the forefront of this changing economic environment, business strategies have been refined, allowing leading businesses and multinationals to embrace practices that incorporate focus not only on the financial elements but also the environmental and social aspects. It is now critical for companies to succeed in managing their sustainability impact in correlation with financial growth. This measurement of a company’s sustainability performance through evaluating environmental, social, and economic aspects, is known as the “Triple Bottom Line”, which is increasingly important as companies engage in both ethical and sustainable strategies that will define their brand and role in managing leading sustainable practices in the future.

Managing the collection of data to monitor and benchmark performance as well as achieving corporate goals in sustainability is complex. Conducting detailed assessments in the supply

chain is even more sophisticated as companies struggle to successfully capture data from suppliers, shippers, manufacturers and external parties. In effect, there are a growing number of companies that seek decision support tools to present data analytics and address the precise issues of data consolidation and management across their network supply chains. This paper argues that as a result of societal pressures, businesses are required to become more holistic in their approach to operational management by considering their supply chain through a triple bottom line perspective, and should recognize the benefits of software and online platform solutions as a decision-support tool which aids the process of achieving measurable sustainability goals.

The objective of this paper is two-fold. First, the paper aims to determine the importance of societal stakeholders that impacts a company's compliance towards incorporating environmental, social and governance practices in their operations across the supply chain in forms of data analytics and sustainability reporting. Second, the paper highlights the role of sustainability related decision-support online tools to help companies manage, measure and report on their sustainability performance through quantifiable and measurable means, i.e. via data analytics. Overall, this paper focuses in contributing to the literature regarding long-term and sustainable business processes as well as the increasingly role of software as a decision-support tool in areas for sustainability.

2. THE ROLE OF STAKEHOLDERS IN SUSTAINABILITY REPORTING AND DATA ANALYTICS ALONG THE SUPPLY CHAIN

This section will first provide a general overview of the stakeholders that affect businesses corporate sustainability strategy and examine existing literature on the impacts and benefits of data analytics and sustainability reporting along the supply chain. Who are the stakeholders that put pressure on companies to invest in the triple bottom line perspective? The increasing levels of external governing bodies that require detailed evaluations of a company's supply chain exacerbate the need for companies to enhance the reporting structure. To manage a sustainable supply chain effectively, companies are required to focus on a multitude of external facets, all of which demand detailed and verifiable data to meet the criteria set. The key drivers, including sustainability verification bodies, stock exchanges, governmental pressures, stakeholders, and consumers and corporate customers, as shown in Figure 1.

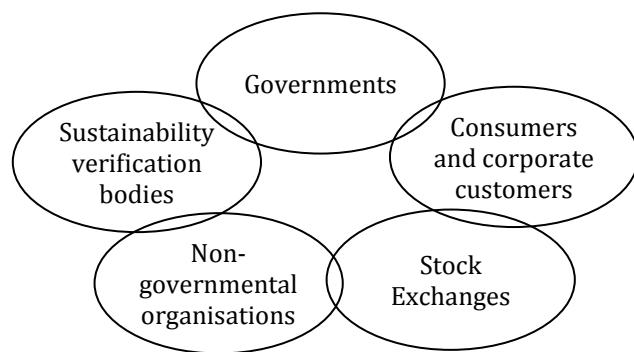


Figure 1. Key drivers on the demand of sustainability reporting

Sustainability verification bodies

Companies now face verified auditing from external bodies to ensure that they are meeting clearly defined standards for the management of sustainability. These bodies include the Global Reporting Initiative (GRI), Carbon Disclosure Project (CDP), Clean Cargo Working Group (CCWG) and BSR, The Higgs Index, ISO 14001 and 26000 series among many others. It is notable that the latest versions of GRI G4 and the upcoming ISO14001:2015 – which is still in revision – have placed emphasis on the consideration of operating practices along the supply chain.

Stock exchanges

Increasingly, the stock exchanges have become key drivers in mandating sustainability reporting, expanding this practice throughout the supply chain to cover scope three suppliers. Transparency on sustainability impact throughout the corporate supply chain is becoming paramount. These mandates have led to increases in the reporting of sustainability data globally, similar to annual corporate financial reporting. Last October 2014, the Singapore Stock Exchange announced a sustainability-reporting mandate across all listed companies. In another example, in 2012, the Hong Kong Stock Exchange (HKEx) announced that companies could voluntarily provide sustainability reports with best practice recommendations (HKEx, 2012). Using the GRI G4 as a framework, the HKEx aims to raise the standard in 2015 to a comply-or-explain semi-mandate requirement. The Hang Seng Index also launched a Corporate Sustainability Benchmark Index in 2010 to promote CSR in listed corporations.

Governmental pressures

Governments are increasingly incorporating objectives in the reduction of CO₂ emission targets as well as managing of the natural resources in their countries during their long term plan. The China's 13th five-year plan focuses strongly in the reduction of greenhouse gas (GHG) emissions. These targets are creating "change management" process within manufacturers and shippers alike to manage their business processes in a more ethical fashion, whilst reducing negative impact on the environment.

Shareholders

Increasingly corporate investment requires proof from firms that they are conducting business in an environmental and corporate responsible manner. This has given rise to significant investment in tangible metrics and analytics surrounding Environmental and CSR based practices.

Non-governmental organisations

Non-governmental organisations (NGOs) play a large role in raising awareness of a company's ethical and socially responsibly practices, which has been further elevated in recent years by the role of social media.

Cost-saving philosophy – Beyond stakeholder pressures are Ethical companies continue to focus heavily on supply chain optimization as a means of reducing cost and increasing global efficiencies. The use of Sustainability metrics is a key enabler to obtain transparency towards cost saving opportunities as well as optimal working practice strategies.

3. LITERATURE REVIEW IN SUSTAINABILITY REPORTING AND DATA ANALYTICS

Having examined the key-drivers in a company's sustainability practice along their supply chain, this paper now turns to provide a more thorough perspective on the role of data analytics and sustainability reporting. The measurement on sustainable development and the management of impact have been raised in the World Economic Forum in January 2015 (World Economic Forum, 2015). The opportunities and challenges on the impact assessment, goal setting, execution, sustainability reporting and data analytics are discussed. Data analytics are described as an opportunity to provide new insights and visibility on the challenges of sustainable development. This includes the reporting and analysis in logistics and supply chain industry. The carbon emissions through the electricity consumption, warehouse operations, truck emissions, and use of papers, carton boxes, and wooden pallets in logistics firms are expected to be measured, analysed and reported regularly.

There are increasing concerns on how the logistics and supply chain corporations can benefit not only the employees and society but also improve the operations efficiencies, generating higher sales, and facilitating better data analytics with the use of sustainability reporting (Burritt and Schaltegger, 2014; Colicchia et al., 2013). With the higher data transparency and visibility, the operation performance, including the sustainability statistics, can be better measured and evaluated. Bourlakis et al. (2014) examined the sustainability performance of the Greek dairy chain. The key performance factors related to efficiency, flexibility, responsiveness and product quality were assessed. Lee and Wu (2014) adopted a multi-methodology to integrate sustainability performance measurement into logistics and supply networks. The developed method supported the decision making process on green practices of freight transport logistics. Ahi and Searcy (2014) proposed a mathematical model to assess sustainability in the supply chain after evaluating the dependent factors that impact the sustainability performance. The environmental, economic, and social dimensions of performance were evaluated. Ahi and Searcy (2015) further carried out an extensive literature review on the identification and analysis of the metrics on green and sustainable supply chain management. The most frequently used metrics are quality, air emissions, greenhouse gas emissions, energy use, and energy consumption.

With the wide adoption of GRI, Chen et al. (2014) assessed the patterns and correlations between the levels of environmental management practices (EMPs) and financial performance of companies. It was found out that the number of EMPs has a strong correlation with the improvement on the innovation performance of various companies in Sweden, China, and India. Barkemeyer et al. (2015) conducted hypothesis testing through a content analysis of 933 GRI sustainability reports of companies from seven sectors in 30 various countries. It is found that the output effectiveness of GRI was successfully developed through the dissemination of sustainability reporting from the companies.

Big data analytics in sustainability performance reporting requires the support of systems for better decision making processes. Hallstedt et al. (2010) developed an approach to assess sustainability integration in a company's strategic decision system, based on established guidelines and a Bob Willard scale of sustainability integration. The performance of two companies are reviewed and found that there are potential ways to improve in the sustainability integration. Wognum et al. (2011) explored the information systems that

support the sustainability in food supply chains. The systems used assist personnel in the supply chain to communicate with their customers and make immediate decisions in daily operations. Pishvaee et al. (2012) addressed the problem of socially responsible supply chain network design under uncertain conditions by developing a bi-objective mathematical programming model with its objective functions on minimizing the total cost and maximizing the supply chain social responsibility. LINGO 9.0 optimization software is adopted to solve the proposed Robust probabilistic programming (RPP) model. Other systems and modelling analysis on sustainability performance include Yercan and Yildiz (2011) and Bakshi and Fiksel (2003).

4. METHODOLOGY ON SUSTAINABILITY PERFORMANCE INDICATORS AND DATA ANALYTICS

“Without measurement, you can’t manage” – sustainable supply chain management is only possible through the incorporation of tools that support accurate, transparent and verifiable analytics. The use of current standard tools serves only basic functions and simple operations, but the supply chains for most companies are too complicated to be supported without strong software system applications. These tools cover the whole supply chain spectrum down to supplier and sub-supplier level. The need for these products is essential to cover the key elements, such as, energy consumption, fuel and fuel management, water, wastage, and air emission.

Furthermore the supply chain incorporates the need to evaluate transport and logistics modes and elements that support the distribution of products. The need to review impact assessment is also important when evaluating logistics impacts, this includes road freight mileage, air freight impact, ocean freight impact, vehicle efficiency, rail and barge operation, and route optimization to minimize fuel and carbon impact. A sustainability reporting and data analytics model for tackling complex supply chain infrastructure and problems is developed considering the resistance and barriers in capturing and measuring key sustainability data, refer to Figure 2.

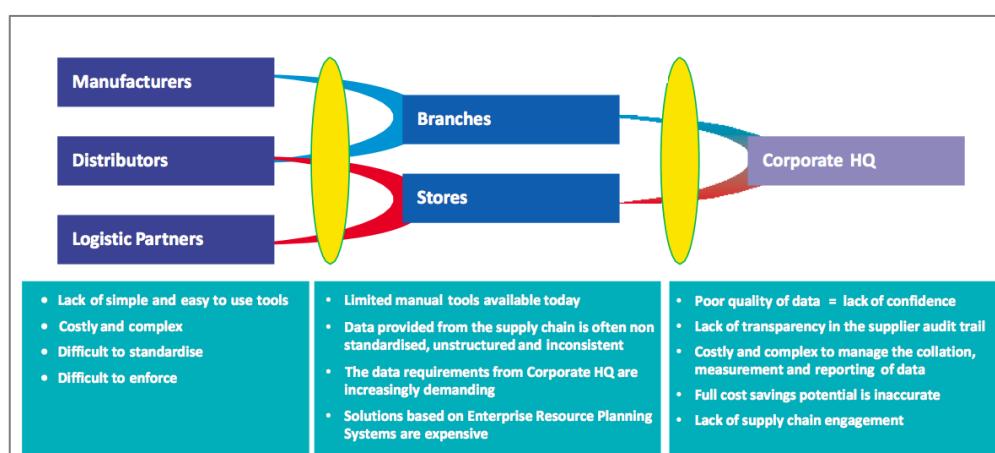


Figure 2. A sustainability reporting and data analytics model developed for tackling complex supply chain infrastructure and problems (Source: Turnkey Solutions, 2014b).

Capturing all the above mentioned analytics requires investment at every element of the supply chain, and the need for detailed analytical tools to support all elements of the supply

chain is necessary. To maximize the benefits and accuracy of sustainability reporting and analytics, the use of systems and software solutions that cover both governance reporting and supply chain infrastructure are essential. Equally important is the “buy in” from both global companies and their suppliers who service the supply chain, to incorporate best practices related to sustainability.

Multinational firms have continued to invest heavily in education and auditing of their supply chain partners. The issue has remained that additional workload and cost can be seen as demotivation to incorporate sustainability practices. To overcome this, the use of simple, simplified data collection and analytics tools are essential to increase utilization in the supply chain as well as improve accuracy of reporting, leading to better decision making and cost reduction within the supply chain network. A system for sustainability reporting and data analytics in the supply chain operations is developed. One of the screenshots showing the sustainability performance indicators in the monitoring module is shown in Figure 3. The figure is displayed with demo data only considering the commercial purpose and data confidentiality.

The screenshot shows a web-based application for managing ocean freight. At the top, there's a navigation bar with links for Dashboard, Monitoring, Reports, Records, Settings, and User Admin. On the right side of the header, it says "admin (Hong Kong Administrators) Logout" and "Change Language". Below the header is a search/filter bar with fields for Consumer Type, Location Type, Consumer, Country, Report date from, To, Carrier, Origin, Destination, Upload, and Refrigerated. There are also buttons for Delete All 63 Records, Previous, Next, and a page size dropdown set to 20. Underneath the search bar is a message: "Displaying Ocean Freight 1 - 83 of 83 in total". The main content area is a table with columns: Start Date, End Date, Consumer, Origin, Destination, Carrier, Refrigerated, Trunkline, Container Size, TEU capacity, Cost (USD), Cost (USD), Distance (km), Energy (kg), Reference number, Remarks, and two icons for document upload. The table contains 83 rows of shipping data, each with a unique reference number and a timestamp between March 2015 and April 2015. Some rows show documents uploaded, indicated by small document icons next to the upload columns.

Start Date	End Date	Consumer	Origin	Destination	Carrier	Refrigerated	Trunkline	Container Size	TEU capacity	Cost (USD)	Cost (USD)	Distance (km)	Energy (kg)	Reference number	Remarks		
2015-03-01	2015-03-23	APC Logistics	LONDON	NEWCASTLE (UK)	CMA-CGM	Yes	Intra-Europe	20.00 TEU	20.00	EUR 8,000.00	10,526.32	334.00	953.91	v0411			
2015-04-01	2015-04-30	Dockland Shipping	HONG KONG	LONDONDERRY	Hapag-Lloyd	Yes	Asia - North Europe	40.00 TEU	40.00	USD 30,000.00	10,000.00	9,837.00	30,140.57	v5006			
2015-04-01	2015-04-30	Worl Logistcs	GLASGOW (UK)	LONDON	UniFeeder A/S	Yes	Intra-Europe	10.00 FEU	20.00	GBP 10,000.00	16,129.03	789.00	2,218.32	v0108			
2015-03-23	2015-03-27	Worl Logistcs	GLASGOW (UK)	HONG KONG	OOCL USA Inc (OOCL)	Yes	Asia - North Europe	20.00 FEU	40.00	USD 36,000.00	1403	3,856.04	9,841.00	38,152.82	v5008		
2015-03-14	2015-03-17	Worl Logistcs	TOKYO	FELIXSTOWE	Independent Container Lines (Intra MV GUL)	Yes	Asia - North Europe	40.00 FEU	80.00	USD 4,500.00	4,500.00	11,253.00	68,970.84	v5009			
2015-03-10	2015-03-12	Bengal Tiger Lines	NEWCASTLE (UK)	LONDON	MCC Transport Singapore	No	Intra-Europe	20.00 TEU	20.00	GBP 5,000.00	10,000.00	334.00	625.25	v4440			
2015-03-10	2015-03-13	Worl Logistcs	NEWCASTLE (UK)	BRISTOL	Zim Integrated Shipping Services Ltd (Zim Line)	Yes	Intra-Europe	40.00 FEU	40.00	USD 6,800.00	13,112.90	784.00	4,467.82	v5006			
2015-03-07	2015-03-09	Bengal Tiger Lines	FELIXSTOWE	TOKYO	Hamburg Sud	No	Asia - North Europe	30.00 TEU	10.00	USD 40,000.00	11,253.00	4,929.89	5,510.00	v5005			
2015-03-06	2015-03-09	Worl Logistcs	HONG KONG	KOREA STRAIT	UniFeeder A/S	No	Intra-Asia	30.00 TEU	10.00	USD 30,000.00	30,000.00	1,144.00	3,001.00	v6096			

Figure 3. Sustainability data analytics in supply chain operations for ocean freight sector (demo data only).

The importance of verified data collection allows companies to make positive decisions on their business. This is incorporated through all members of the supply chain importing and uploading key sustainability data on energy, fuel, water and wastage and allowing dynamic tools calculate the impact of the supply chain. Thorough collection of data must also be consolidated into detailed dashboard reporting allowing companies to gain transparency of their entire supply chain through the collection of information from all their key suppliers. A dashboard for sustainability data analytics is developed and shown in Figure 4. These detailed data analytics are consolidated in the dashboard through the reporting of each of the company's key suppliers, leading to accurate strategic information which can be used to improve carbon and sustainability impact, as well as report directly to stakeholders and auditing parties.

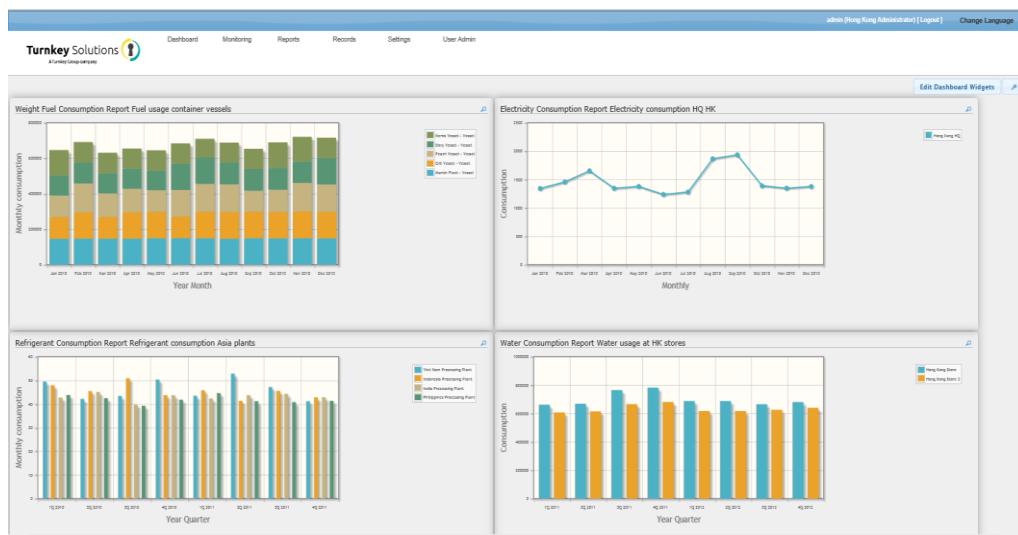


Figure 4. Sustainability dashboard for supply chain data analytics (Source: Turnkey Solutions, 2014a)

5. CASE ANALYSIS ON SUPPLY CHAIN SUSTAINABILITY IN SHIP LINER OPERATIONS

Sustainability reporting supports corporations to analyse huge amount of complex supply chain data and make decisions with reference to the analyzed figures. Kuehne and Nagel, one of the world's leading logistics providers and ship liners, aims to the "Go Clean – Go Green" initiatives to reduce carbon emissions through vessel speed reduction, port handling, sailing schedule alignment and equipment sharing (Van der Wal, 2011; Kuehne+Nagel, 2010). With the support of sustainability data, including vessel speed, carbon emissions, and fuel consumption, vessel operators can determine the optimal speed to minimize the cost and carbon emission. Kuehne+Nagel initiated slow steaming in their operations in selected vessels. Thirteen vessels in the same route have carried out economical speed consuming 10,000 MT fuel. Compared to the regular speed vessels consuming 12,000 MT fuel, the slow steaming vessels result a 16% savings in carbon emission, from 37,000 MT CO₂ of 20.5 knots to 31,000 MT CO₂ of 19 knots in vessel speed.

Besides enabling shippers to retrieve reliable data on their seafreight carbon footprint, Kuehne+Nagel launched carbon intelligence tool in 2009. The tool is a carbon management program designed to calculate carbon footprint of a customer in the supply chain, including warehousing and distribution. The tool aims to identify potential carbon reduction initiatives along supply chains. Two components are developed in the carbon intelligence tool, namely, global facility carbon calculator and global transport carbon calculator. The former one provides a tool to reduce resources consumption while the latter one measures carbon emissions and conducts carbon reporting. Siegle (2014) reported a study in the Department for Environment, Food and Rural Affairs (Defra UK) that two tonnes of freight cargo carrying 5,000 km by a small container vessel emit 150 kgCO₂e, compared to 6,605 kgCO₂e if the freight cargo is carried out by air for the same distance. Thus, the decision on the mode of transportation for a cargo affects not only operation costs but also the carbon emission in the trip of the cargo. Thus, the carbon intelligence model in Kuehne+Nagel serves as an intelligence dashboard for data analytics and decision support tool.

6. CONCLUSIONS

Data transparency, reporting, and analytics in sustainability are increasing important, especially in dynamic supply chain logistics operations. Various societal stakeholders, including governments, sustainability verification bodies, NGO, HKEx, and customers, drive ship liners, truck operators, airlines, and logistics firms to improve their operations that impact the environment, social governance, and corporate social responsibility. This paper reviews the current importance of the societal stakeholders in driving the logistics firms to report their sustainability activities and initiate programmes to reduce carbon emissions. A sustainability reporting and data analytics model is developed to facilitate and support supply chain practitioners in decision making process. The model has been further developed as a dashboard and applied in a maritime supply chain firm. A case analysis has been reviewed illustrating the importance of sustainability data analytics in assisting the decision making process on complex supply chain and logistics operations. Future development on the sustainability performance and data analytics tool is recommended, including additional intelligent features and functionalities to identify correlation of significant factors towards operation efficiencies in a corporation.

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