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Proceedings of the 2 nd International Symposium and Workshop on Global Supply Chain, Intermodal Transportation and Logistics

May 29-30, 2008, Busan, KOREA

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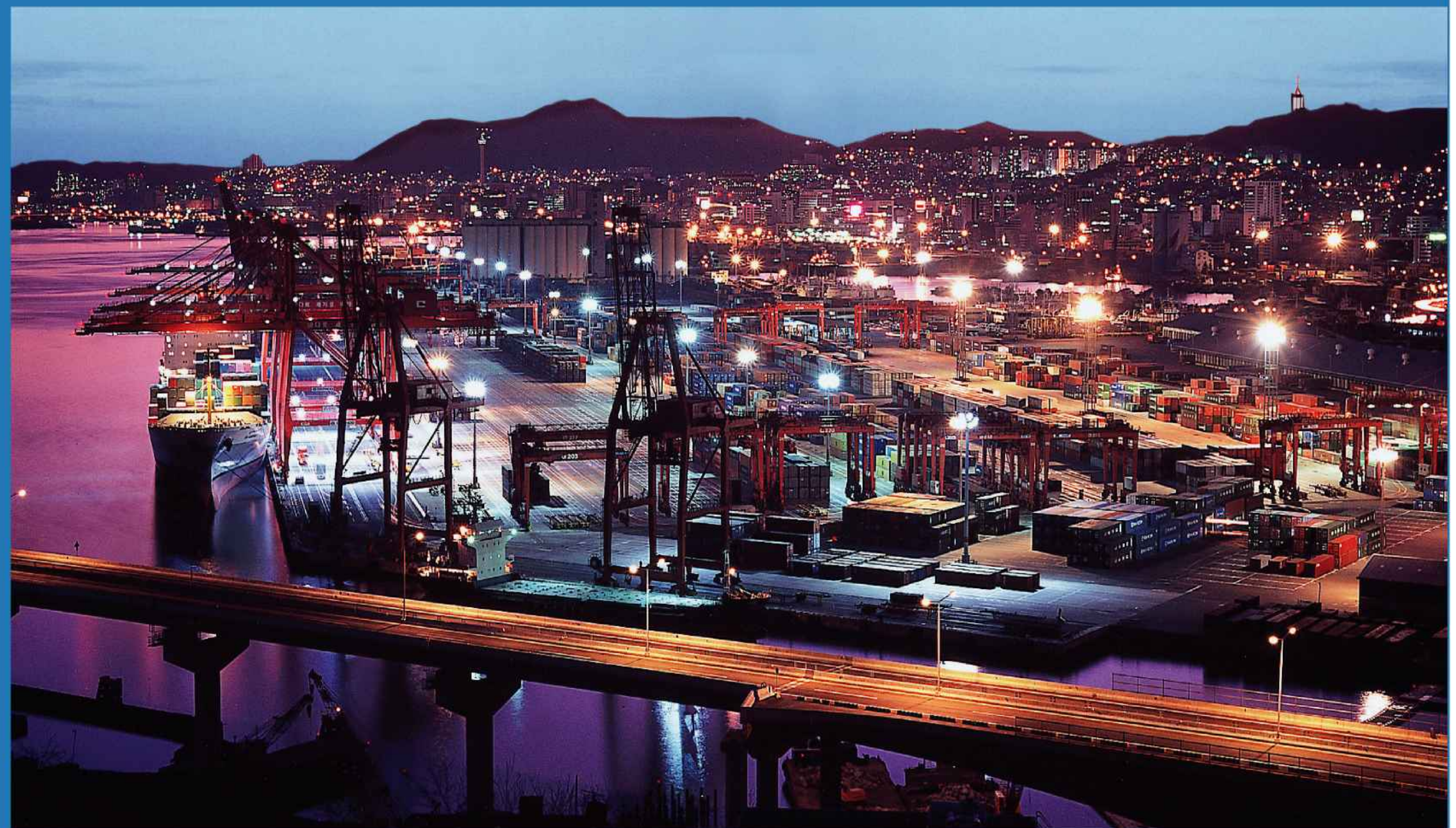

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Welcome Address

Ladies and Gentlemen,

With great pleasure, I would like to welcome you to the Workshops and Forums for the Global Supply Chain Management Conference.

First of all, I would like to express sincere gratitude to each and every one of you for joining today's and tomorrow's events. In this gorgeous city of Busan which symbolizes the phenomenal growth of the global logistics industry, we gather to exchange our innovative ideas and thoughts to stimulate the emerging paradigm of global supply chain management.

Today, we live in a globalized knowledge society characterized by never-ending innovations, real-time communications, and boundless strategic alliances with global business partners. These characteristics are the fuel that keeps the global economy running and humming. To sustain the more productive knowledge society than ever before, we need to create an opportunity like this conference. In addition, this conference will help us to not only grow as a supply chain professional, but also advance our knowledge bases by learning from each other.

I would remiss, if I forget to express sincere gratitude to host institutions, especially Pusan National University and Kyungsung University which generously sponsored next two days of conference activities. I am also grateful to both the Korean Society for Supply Chain Management (KSCM) and the University of Toledo which bring together their synergistic efforts to make this event successful. Last, but not least, I would like to thank our industrial partners including Total Soft Bank which would bring their practical expertise to the theme of this conference. I do strongly believe that when industry and academia open their communication and then share their knowledge and experience with each other, we can develop more innovative products and competitive services which will find their way onto the global marketplace.

I sincerely hope that this conference can be a catalyst to develop unimagined synergies which will benefit both the business and the academic community for years to come. In particular, given that the emerging concept of globalization and supply chain management has transformed the underpinnings of business strategies, I hope that this conference can be an important forum that brings about managerial changes essential for globalization and integration of business activities.

Welcome Address

Throughout this conference, I would like to remind you that traditional business models are no longer working and companies are competing against each other "business model versus business model". Quoting Bob Austrian, Banc of America Securities, fundamental business models and maxims that have been in place for decades are under siege. Although no one including myself knows exactly which business model works best for any particular organizational setting, everyone realizes that one cannot succeed in today's business environments without improving the level of competency in logistics skills and knowledge (or more broadly supply chain). That is to say, in today's $50 trillion Internet-driven "new world economy", logistics (especially, order fulfillment) is proven to be a major differentiator for many business successes and failures not to mention those of dot-com companies. Today's business transactions often involve not merely the movement of real-time information, but also the physical movement/coordination of goods.

According to the recent Banc of America Securities research, logistics penetration into new world economy would quadruple over the next five years, fueling industry growth of well over 50%. Logistics is still a huge market estimated at over $2 trillion internationally. To tap into this market or better position ourselves in this market, we have to be at the forefront of the evolution of global logistics or supply chain management. Thus, we have to develop strong knowledge bases in global supply chain management through the conference like this in Busan. Once again, I would like to thank you for your contribution to this conference and wish that you could enjoy this conference and the beautiful city of Busan.

Thank you so much.

Prof. Hokey Min

Program Co-Chair
James R. Good Chair in Global Supply Chain Strategy
Bowling Green State University, USA

Welcome Address

We would like to offer a very warm welcome to all the participants at the 2nd International Symposium and Workshop on Global Supply Chain, Intermodal Transportation and Logistics and I trust you will have a rewarding time at this conference and most enjoyable stay in Busan. We hope this conference will provide all the global family of supply chain management professional with a meeting to share and exchange research interests and applications that are of interests to both researchers and practitioners. An important outcome of this conference is the sharing expert¡¯s knowledge and state of the art research results on the various issues on the global supply chain. Moreover, this conference will provide a good opportunity to globalize the networking of the researchers and practitioners in the supply chain management.

Today, as the industrial systems become to be more complex, traditional approach of the supply chain management no longer suffices. Instead of classical way, development of new theory and its application in practices becomes a critical tool for the global supply chain management. Thus, the conference is established to disseminate significant research results, technical and methodological applications, case studies, and surveys concerned with the global supply chain management to both researchers and practitioners.

Finally, we would like to thank our colleagues and friends from academia and industries who contributed and reviewed and last but not least, we would like to thank all the members of the organizing committee for their role in making this conference a success and in doing their best to accomplish the ambitious goals for the conference. Special thanks are given to Dr. Hokey Min, Dr. Paul Hong, Dr. Won-Young Yun, Dr. Chang-Seong Ko, and Dr. Il-Kyeong Moon, Dr. Byung-Hun Ha who devoted enormous efforts to make this conference successful. We also wish to thank all the authors and their contribution to this conference. We wish your pleasant stay in this beautiful city.

Prof. **Young-Hae Lee**

Program Co-Chair
President of KSCM, KOREA

Prof. **Kap-Hwan Kim**

Program Co-Chair
Pusan National University, KOREA

MASTER SCHEDULE

May 29, 2008 (Thursday)

Venue: Induk Hall, Pusan National University

Time	Room A	Room B
08:45-09:15	Registration	
09:15-09:45	Program Co-Chairs' Welcome Remarks and Opening Address (Room A) Dr. Hokey Min, Bowling Green State University; Dr. Younghae Lee, Korean Society for SCM; Dr. Kaphwan Kim, Pusan National University	
09:45-10:00	Coffee Break	
10:00-11:30	**Session 1** The Use of Genetic Algorithm in Supply Chain Management	**Session 2** Reverse Supply Chain Management
11:30-13:00	Networking Luncheon (Light Buffet at the Sang-Nam International House)	
13:00-14:30	**Session 3** Supply Chain Network Design	**Session 4** Case Studies in Value Chain Management
14:30-14:45	Coffee Break	
14:45-16:15	**Session 5** Demand Planning	**Session 6** New Product Development
16:15-16:30	Coffee Break	
16:30-17:45	Practitioner's Session with Total Soft Bank Ltd. (Room A) (Moderators: Dr. Hokey Min, BGSU; Dr. Kaphwan Kim, PNU) Panel Discussions on the Future of Supply Chain Research (Moderator: Dr. Seung-Chul Kim, Hanyang University) (Panelists: Prof. Youngwon Park, University of Tokyo; Prof. Shuo-Yan Chou, National Taiwan University of Science & Technology)	
18:00-20:00	Networking Banquet (Appreciation Ceremony): Nongshim Hotel	

MASTER SCHEDULE

May 30, 2008 (Friday)
Venue: Induk Hall, Pusan National University

Time	Room A	Room B
09:00-10:00	Keynote Speech (Room A) "Creating an International Research and Education Panel for Supply Chain Management" Dr. Mark Vonderemse, University of Toledo; Dr. Paul Hong, University of Toledo	
10:00-10:15	Coffee Break	
10:15-11:45	**Session 7** The Use of Information Technology in Supply Chain Management	**Session 8** Global Sourcing
11:45-12:45	Closing Remarks and Luncheon (Light Buffet at the Sang-Nam International House)	
12:45-18:00	Industry Tour (Hyundai Motor Company and Hyundai Heavy Industries)	
18:30-20:30	Farewell Dinner (Chabatgol Traditional Korean Restaurant) (Participants from foreign countries and organizing committee members only)	

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Session 1

The Use of Genetic Algorithm in Supply Chain Management

Chair: Dr. Byung-In Park

1. **The evolution of genetic algorithm in supply chain modeling**
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   Won Young Yun, Pusan National University, Korea
   Il-Kyeong Moon, Pusan National University, Korea

The Evolution of Genetic Algorithm in Supply Chain Modeling

Hokey Min[a] and Gengui Zhou[b]

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[b]Associate Dean, College of Business Administration,
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Abstract

As one of the most efficient meta-heuristics, genetic algorithms (GAs) have been applied to a variety of challenging combinatorial problems in bioinformatics, phylogenetics, computer sciences, economics, and supply chain management (SCM). Such a popularity of the GA often misled some researchers to believe that the GA can be a panacea for solving all aspects of supply chain problems. In contrary to this belief, GAs did not necessarily outperform other alternative heuristics such as Tabu search and simulated annealing for certain types of supply chain problems. This paper synthesizes the past applications of GAs to supply chain modeling and then evaluates the extent of their successes and failures in solving supply chain problems. It also keeps track of their algorithmic evolutions as a way to tackle NP-complete or NP-hard supply chain problems. Based on the trends of GA evolutions, this paper identifies particular areas of supply chain problems for which GAs are most suitable and points a direction of future research agenda that have not been explored in the past.

A Study on Strategic Alliance Model in Express Courier Service Network Based on Consolidation Terminal

Jae-Jeung Rho [a], Ki-Ho Chung[b], and Chang Seong Ko[c *]

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[c]*Department of Industrial and Management Engineering,*
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Abstract
Recently, the demand for the direct shipment of purchased goods by express couriers has increased as the result of an explosive growth in e-tailing, telemarketing, and TV home-shopping industries. However, since too many express courier companies have been emerging over the last several years, competitiveness for market share is very severe among them. The consolidation terminal typically acts as a hub where ordered items from a number of service centers are combined, mixed, sorted, and transshipped to nearby service centers for local deliveries. This study suggests a network design model for strategic alliance based on consolidation terminal in order to overcome the circumstances in hot express courier service market. We propose an integer programming model and a solution procedure based on fuzzy set theory. To demonstrate practicality and efficiency of the proposed model and solution procedure, a numerical example is derived and tested.

[*] Corresponding author

Profit-based Reconfiguration of Express Courier Service Network with Multiple Consolidation Terminals

Hyun Jeung Ko [a], Young Hwan Sohn [b], Byung In Park [c], and Chang Seong Ko[d] *

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[d]*Department of Industrial Engineering, Kyungsung University, KOREA*
Email: csko@ks.ac.kr

Abstract
The productivity and service level-up of the express courier service is highly related to how to operate the consolidation terminals and their corresponded service centers. A consolidation terminal typically acts as a hub in express service network where the ordered products from a number of service centers are combined, mixed, sorted, and transshipped to nearby service centers for local deliveries. Network design is usually constructed based on the initial investment and operating costs for terminals and service centers in express couriers. However, continuous modification for network design is required according as the sales environment is rapidly changing.
This study suggests an approach to reconfigure an express courier service network with respect to assignments of service centers to consolidation terminals, adjustments of their cutoff times and extensions of terminal capacities. We propose an integer programming model and a genetic algorithm based solution procedure for allowing express couriers to maximize their incremental profit. To demonstrate the practicality and efficiency of the proposed model and its solution procedure, we performed an example problem with reduced data sets from an express courier in Korea.

* Corresponding Author

Optimal Routes Modeling for Customer-Oriented Container Truck Transportation

Ruiyou Zhang[a,b], Won Young Yun[a], and Il-Kyeong Moon[a]

[a]*Department of Industrial Engineering, Pusan National University, Busan 609-735, KOREA*
[b]*Institute of Systems Engineering, College of Information Science and Engineering, Northeastern University, Shenyang, Liaoning, CHINA*

Abstract
This paper documents a study carried out on a vehicle scheduling and routing problem in customer-oriented container truck transportation. Three types of container movements operate in container truck transportation: the importing of full containers, the exporting of full containers, and the importing (or exporting) of empty containers. There are also two types of resources, i.e., trucks and containers. However, new empty containers will also be needed or released during packing or unpacking operations. We consider a number of operation times, such as loading and packing times, as well as the time windows at the origins and destinations. By introducing a multiple directed graph, a mathematical model is created. A heuristic method is also developed in order to obtain the optimal solution, since the mathematical model is NP-hard in the strong sense. A number of numerical examples are studied and the results of the proposed heuristic method are compared with the lower bounds obtained from CPLEX.

Keywords: container truck transportation; graph; heuristics; multiple traveling salesman problem with time windows (m-TSPTW)

Session 2

Reverse Supply Chain Management

Chair: Dr. Seung-Chul Kim

1. **Pricing policies under competition and cooperation in a remanufacturing system**
   Ki Seung Jung, KAIST, Korea
   Hark Hwang, KAIST, Korea

2. **RFID system for centralized reverse supply chain in the apparel industry**
   Yoon Min Hwang, Information and Communication University, Korea
   Jae Jeung Rho, Information and Communication University, Korea

3. **Green management orientation, partner trust, information sharing and performance in supply chain management**
   Jinhwan Kim, Hongik University, Korea
   Sunhee Youn, Hongik University; Korea
   Paul Hong, University of Toledo, USA

4. **A closed-loop recycling system with minimum allowed quality level on returned products**
   Sang Hun Yune, KAIST, Korea
   Young Dae Ko, KAIST, Korea
   Hark Hwang, KAIST, Korea

Pricing Policies under Competition and Cooperation in a Remanufacturing System

Ki Seung Jung and Hark Hwang*

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Abstract

This paper deals with remanufacturing in a reverse logistics chain with one original equipment manufacturer (OEM) and one remanufacturer. The optimal pricing policies of the two parties are studied under two cases, competition and cooperation, through mathematical models with the objective of profit maximization. The first case is solved with a repeated game model and the second one with a search procedure. Also, sensitivity analysis is conducted to study the interactions between the two parties.

Keywords: Remanufacturing, Pricing, Repeated game

1. Introduction

Recent legislative changes and consumer awareness require companies to take back their products in order to recycle or remanufacture the end-of-use products. To remanufacture the used item, the manufacturer must retrieve them from the market where they are dispersed among consumers. This is accomplished by means of a reverse logistics chain. The agents in the reverse logistics chain are responsible for gathering, classifying, and finally transporting the used item to the manufacturer. Often they may also take up some of the activities of remanufacturing like disassembling and cleaning. Since the market is usually big in size, it is obvious that the manufacturer cannot maintain complete control over the entire chain; this may give rise to opportunistic behavior by some agents in the chain, particularly if the entire remanufacturing process can be duplicated. Toner cartridge industry is a typical example. Since the cost to remanufacture a cartridge is very low, remanufacturing of toner cartridges is a very profitable business and the business sells nearly $1 billion annually (Narisetti, 1998). Considering the size of the profits, it is not surprising that many remanufacturing companies now advertise that they will pay $10 or more for used toner cartridges.
This motivates the study of relationships between the OEM and the remanufacturer. The remanufactures can be a potential competitor for the OEMs by cannibalizing the sales of the OEM's new product. On the other hand, the OEMs have the advantage of being free of take-back quota when remanufactures are active in collecting end-of-use products. And communities and legislatures may want to reduce waste disposal and increase net remanufacturing activity by encouraging the local remanufacturers (Majumder et al., 2001).

* Corresponding Author

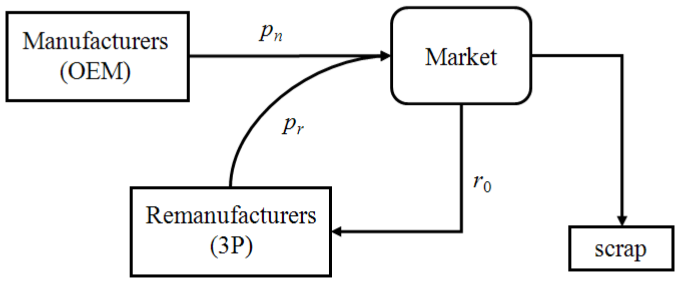

Figure 1. The framework of the system

Figure 1 shows the framework of the system we deal with. An OEM sells products at the price p_n under the "take-back requirement". If the take-back quota for the end-of-use products is breached, the OEM takes the responsibility by paying corresponding penalties. And once the lifetime of products ends, they are collected by a remanufacturer at the cost of r_0. After remanufacturing process they are released to the market with the price p_r. In this paper we study the system in figure 1 under two cases, competition and cooperation between the OEM and remanufacturer.

2. Notations and Assumptions

Notations:

Known parameters:

D_n demand rate of the new product [unit]/[time]

D_r demand rate of the remanufactured product [unit]/[time]

c unit manufacturing cost of a new product [$]/[unit]

δ obligatory take-back quota ($0<\delta<1$)

q unit penalty cost in case that the obligatory take-back quota is breached. [$]/[unit]

$\alpha(r_0)$ return rate of used products with regard to the acquisition cost ($\alpha(r_0)=r_0/c$)

Decision variables:

p_n unit price of the new product [$]

p_r unit price of the remanufactured product [$] ($p_r<p_n$)

r_0 unit acquisition cost for taking back the used products from customers [$] ($0<r_0<c$)

Assumptions:

1. Demand rate is dependent on the price of product.
2. The cost parameters are all known constants.
3. Shortages are not allowed.
4. Production rate of OEM and remanufacturer is large enough to meet the demand.
5. The unit acquisition cost(r_0) includes remanufacturing cost, thus there are no additional costs after take-back.

6. Used products are collected from customers at a fixed ratio of demand which is dependent on the unit acquisition cost r_0.
7. Obligatory take-back quota is assigned to OEM by environmental regulations. If the quota is breached, corresponding penalties (q) are charged.

3. Mathematical Model

When there is a price difference between product segments, customer can migrate from high priced segments to low priced segments. In order to capture the intuition that more customers are willing to migrate to low priced segments as the price difference increases, Zhang and Bell(2007) modeled the demand leakage as a linear function of the difference between the prices. For our study, the lower price of the remanufactured product triggers demand leakage from the new products to remanufactured products. Thus the price dependent demand functions are modeled as follows.

$$D_n(p_n, p_r) = a_n - b_n p_n - \gamma(p_n - p_r) \quad (1)$$

$$D_r(p_n, p_r) = a_r - b_r p_r + \gamma(p_n - p_r) \quad (2)$$

where a_n, b_n, a_r, b_r, and γ are positive constants.

3.1. Case of competition

The pricing policy of the OEM and the remanufacturer is studied through the repeated game model with the objective of maximizing the profit of each party.

3.1.1. OEM's profit

The OEM's profit function consists of three terms, i.e., sales revenue, manufacturing cost, and penalty cost. Assuming that the values of p_r and r_0 are known,

$$\pi_n\left(p_n \middle| p_r, r_0\right) = \left(p_n - c\right) \cdot D_n - q \cdot D_n \cdot \max\left(0,\ \delta - \alpha(r_0)\right) \quad (3)$$

Setting the first derivative of (3) equal to 0, we find that

$$p_n^* = \frac{(a_n + \gamma p_r)}{2(b_n + \gamma)} + \frac{c + q \cdot \max\left(0,\ \delta - \alpha(r_0)\right)}{2} \quad (4)$$

And the second-order derivative of π_n is

$$\left.\frac{\partial^2 \pi_n}{\partial p_n^{\,2}}\right|_{p_r,\, r_0} < 0 \quad (5)$$

Equation (5) shows that π_n is a concave function with the maximum value at p_n*.

3.1.2. Remanufacturer's profit

Since the return rate is dependent on the acquisition cost paid to the customers, it often fails to meet the demand of the remanufactured items. Thus the remanufacturer's profit function can be modeled with the known value of p_n as follows:

$$\pi_r\left(p_r, r_0 \middle| p_n\right) = \left(p_r - r_0\right) \cdot \min\left(D_r,\ D_n \cdot \alpha(r_0)\right) \quad (6)$$

Since D_r (p_n, p_r) has to be positive, π_r is defined only in the region satisfying the following conditions.

$$r_0 < p_r < \min(p_n,\ \frac{a_r + \gamma p_n}{b_r + \gamma}) \tag{7}$$

The following two cases are considered to find the optimum value of π_r.

Case i) $D_r > D_n \times \alpha(r_0)$

In this case, the profit function of remanufacturer in equation (6) becomes

$$\pi_r\left(p_r, r_0 \middle| p_n\right) = \left(p_r - r_0\right) \cdot D_n \cdot \alpha(r_0) \tag{8}$$

Also, r_0 has the following feasible region.

$$0 < r_0 < c \cdot \frac{a_r - b_r p_r + \gamma(p_n - p_r)}{a_n - b_n p_n - \gamma(p_n - p_r)} \tag{9}$$

The first and second derivative of equation (8) with respect to p_r are found to be positive and

$$\left.\frac{\partial \pi_r}{\partial p_r}\right|_{p_n, r_0} > 0 \tag{10}$$

$$\left.\frac{\partial^2 \pi_r}{\partial {p_r}^2}\right|_{p_n, r_0} = \frac{2 r_0 \gamma}{c} > 0 \tag{11}$$

From equation (11), π_r is a convex function of p_r, but the inequality (10) shows π_r is an increasing function in the region in equation (7). Thus it can be concluded that π_r has the maximum value at p_r* where

$$p_r^* = \min(p_n,\ \frac{a_r + \gamma p_n}{b_r + \gamma}) \tag{12}$$

From the second derivative of (8) with respect to r_0, we find that π_r is a concave function of r_0. Setting the first derivative equal to 0, π_r has the maximum value at r_0* where

$$r_0^* = \frac{p_r}{2} \tag{13}$$

Case ii) $D_r \leq D_n \times \alpha(r_0)$

The profit function of remanufacturer becomes

$$\pi_r\left(p_r, r_0 \middle| p_n\right) = \left(p_r - r_0\right) \cdot D_r \tag{14}$$

Also, a lower bound of r_0 is found and

$$r_0 \geq c \cdot \frac{a_r - b_r p_r + \gamma(p_n - p_r)}{a_n - b_n p_n - \gamma(p_n - p_r)} \tag{15}$$

Since the second derivative of (14) with respect to p_r is found to be negative, π_r is a concave function of p_r. Thus π_r has the maximum value at p_r* where the first derivative becomes 0.

$$p_r^* = \frac{(a_r + \gamma p_n)}{2(b_r + \gamma)} + \frac{r_0}{2} \tag{16}$$

With a similar procedure, it can be shown that π_r is a linearly decreasing function of r_0. Also, π_r becomes larger as the value of r_0 is smaller. Thus π_r is maximized at the lower bound of r_0 in equation (15) and

$$r_0^* = c \cdot \frac{a_r - b_r p_r + \gamma(p_n - p_r)}{a_n - b_n p_n - \gamma(p_n - p_r)} \tag{17}$$

Following the repeated game theory, the optimum solutions are obtained as follow: In the first step, OEM sets the price of newly produced items and then the remanufacture determines the price and the acquisition cost based on the price set by OEM. Note that if both parties have information regarding each other's decisions, the value of the decision variables is known to converge to an equilibrium after a series of decision-making steps. The game model has been adopted by many previous studies such as Monahan (1984), Lee et al. (1986), Fudenberg et al. (1986), Drezner et al. (1989), Parlar et al. (1994), Viswanathan et al. (2003), Souza (2004), and etc.

3.2. Case of cooperation

Assuming that the OEM and the remanufacture cooperate, this section studies the pricing policy that maximizes the sum of the total profit of each party. Adding up equation (3) and (4), the objective function can be expressed as

$$\pi_{sum}\left(p_n, p_r, r_0\right) = \left(p_n - c\right) \cdot D_n - q \cdot D_n \cdot \max\left(0,\ \delta - \alpha(r_0)\right) + \left(p_r - r_0\right) \cdot \min\left(D_r,\ D_n \cdot \alpha(r_0)\right)$$

(18)

In this case, the optimum values of p_n, r_0 and p_r are determined simultaneously in a way to maximize the profit. However, we find that it is impossible to derive a closed-form solution. Thus a grid search is adopted for the following feasible regions of the decision variables.

$$c < p_n \tag{19}$$

$$0 < r_0 < c \tag{20}$$

$$\max(r_0,\ \frac{p_n(b_n + \gamma) - a_n}{\gamma}) < p_r < \min(p_n,\ \frac{a_r + \gamma p_n}{b_r + \gamma}) \tag{21}$$

4. Numerical Experiments

For sensitivity study, we considered a remanufacturing system with the following parameter values: a_n=2000unit, b_n=50unit/\$, a_r=7000unit, b_r=20unit/\$, γ=40unit/\$, q=20\$/unit, δ=0.6, and c=50\$. Table 1, 2 and 3 list the results obtained for the various values of γ (the amount of demand leakage per price difference), the penalty q, and take-back quota δ. We observe that under competition, the increase in γ (the amount of demand leakage per price difference) causes the remanufacturer to lower the price of his product to increase his profit, which causes the OEM also to lower the price of his product not to lose his revenue. Consequently, the total demand becomes larger while each profit of the two parties decreases. The increase in γ under cooperation, however, reduces the price difference between the two parties and makes larger profit. As the penalty q increases as shown above in table 2, the OEM tends to increase the sales price and the remanufacturer also increases the price under competition. This is the OEM's price policy to supplement the loss caused by the penalty increase. But the increase of price is insignificant because the demand of each product is price sensitive. Under cooperation, penalty q higher than \$24 satisfies obligatory take-back quota. And it is verified that once the obligatory take-back quota is satisfied, raising penalty does not affect the remanufacturing system. As take-back quota δ increases, the OEM tends to increase the sales price in order to make up the losses caused by penalties under both cases. In this case the remanufacturer also tends to increase the price as well. The extent of price increases of both parties is not substantial due to the price sensitive demand. And from the sensitivity analyses, it is found that total profits under cooperation are always larger than the sums of profits under competition. That means the companies will make more money when they cooperate. In the aspect of return rate, however, it was verified that the competition of the two parties gives better results. Thus the government should encourage and support the independent remanufacturers to reduce the waste that can be remanufactured.

Table 1. Sensitivity analysis when gamma varies

Gamma	Case	pn	r0	pr	Dn	Dr	Total Profit	Return Rate	Scrap Quantity
40	Competition	164.71	28.83	127.65	10282.1	5929.3	1760611	57.67%	4352.8
	Cooperation	220.50	22.90	201.10	8198.7	3754.0	2043607	45.80%	4443.7
50	Competition	155.11	30.09	120.44	10511.0	6324.7	1676268	60.17%	4186.3
	Cooperation	220.00	23.60	202.41	8120.2	3831.4	2044772	47.20%	4287.4
60	Competition	147.14	31.19	114.53	10685.8	6666.6	1593588	62.39%	4019.2
	Cooperation	219.30	24.10	203.33	8076.2	3892.0	2045835	48.20%	4183.5
70	Competition	140.27	32.14	109.51	10832.8	6963.3	1516668	64.28%	3869.5
	Cooperation	219.10	24.60	204.40	8015.3	3941.6	2046787	49.20%	4071.8

Table 2. Sensitivity analysis when penalty q varies

q	Case	pn	r0	pr	Dn	Dr	Total Profit	Return Rate	Scrap Quantity
20	Competition	164.71	28.83	127.65	10282.1	5929.3	1760611	57.67%	4352.8
	Cooperation	220.50	22.90	201.10	8198.7	3754.0	2043607	45.80%	4443.7
22	Competition	164.77	28.85	127.68	10280.3	5929.5	1760271	57.70%	4348.8
	Cooperation	220.90	23.40	200.50	8138.7	3806.0	2041362	46.80%	4329.8
24	Competition	164.76	28.85	127.68	10278.6	5929.8	1759934	57.69%	4348.7
	Cooperation	219.70	30.00	203.10	8350.7	3602.0	2040671	60.00%	3340.3
26	Competition	164.78	28.85	127.69	10276.9	5930.1	1759601	57.76%	4338.0
	Cooperation	219.70	30.00	203.10	8350.7	3602.0	2040671	60.00%	3340.3

Table 3. Sensitivity analysis when delta varies

Delta	Case	pn	r0	pr	Dn	Dr	Total Profit	Return Rate	Scrap Quantity
0.6	Competition	164.71	28.83	127.65	10282.1	5929.3	1760611	57.67%	4352.8
	Cooperation	220.50	22.90	201.10	8198.7	3754.0	2043607	45.80%	4443.7
0.7	Competition	165.77	29.11	128.14	10206.8	5942.1	1746011	58.22%	4264.7
	Cooperation	221.40	23.20	201.40	8129.7	3772.0	2027279	46.40%	4357.5
0.8	Competition	166.82	29.39	128.63	10131.6	5954.8	1731542	58.77%	4176.9
	Cooperation	221.80	23.50	201.20	8085.7	3800.0	2011068	47.00%	4285.4
0.9	Competition	167.87	29.67	129.13	10056.5	5967.4	1717203	59.34%	4089.2
	Cooperation	223.20	23.80	202.10	7995.7	3802.0	1994998	47.60%	4189.7

5. Conclusions

This study deals with the interaction between an OEM and a remanufacturer where remanufactured products cannibalize the OEM's market under the assumption of competition and cooperation of the two parties. We first developed the mathematical models with the objective of maximizing the profit of each party. The optimal prices of new and remanufactured products and acquisition cost were found based on the repeated game model.

And the model was extended to the case in which the OEM and the remanufacturer cooperate to increase the sum of their net profits. Through numerical experiments, we studied how the system responds to changes of the parameter values. It was found that the competition of the two parties raises return rate, though the net profits under cooperation are always larger than the net profits under competition.

Acknowledgments
This work was supported by the Korea Research Foundation Grant funded by the Korean Government (MOEHRD) (KRF-2007-313-D00909).

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RFID System for Centralized Reverse Supply Chain in the Apparel Industry

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Abstract.
Due to customer's high expectation for products, alleviating return policy for customer service and government's reinforcement of customer protection law, return rate is getting more increased day by day. Therefore reverse supply chain management (RSCM) has become more important factor for inventory management. In the apparel industry, efficient RSCM is more critical because of its characteristics of relative high return rates and high MVT (Marginal Value of Time). However it is difficult to allocate resources to return activities during sale season. And return activity of season apparel is concentrated at the end of season. To solve this problem, this paper proposes RFID system for centralized reverse supply chain management. Through the RFID based smart shelve / fitting room and inbound/outbound facilities, RFID system can collects data and generates various useful information such as attractiveness of product and return type. These available information and functions by RFID support efficient return decision making and return handling. Consequently, RFID system will be applicable solution for RSCM. In strategic point of view, RFID system should be consider as forward and reverse SCM tool.

Keywords: RFID System, EPC Network, Return, Reverse Supply Chain Management (RSCM), Centralized Reverse Supply Chain, Apparel Industry

1. Introduction

Recently, because of customer's high expectation for products, alleviating return policy for customer service, and government's reinforcement of customer protection law, the return rate is getting more and more increased. In general, 6% of the whole sold merchandize is returned (J.R. Stock, 2002). Especially, the return rate of the apparel industry is almost 19.4% (Norek, 2002). Product return rates as a percentage of catalog sales are reported to range from 10 to 20 % for casual apparel and as high as 35~40 % for high fashion (Dowling, 1999; Catalog Age, 2002). The value of seasonal apparel products tend to be decreased during the season and to be highly degraded after season ends. If returned products can not be resold quickly and efficiently, the value of the products will be decreased dramatically. So, apparel industry is required effective reverse supply chain management (RSCM).
Approximately, 4.5% of the total distribution costs are expended for return management costs and the return management cost in the USA was estimated up to $43 billion. At the retail level alone, returns add up to $16 billion a year. (Meyer 1999; Norek 2003) And remanufacturing in the U.S. is a $50 billion per year industry (Corbett CJ. and Kleindorfer PR., 2001). To eliminate return it is the best solution for return problems.

But it's not easy and it often brings customers' dissatisfaction. Therefore, businesses should focus on to minimize the cost and maximize the efficiency of return management. However, return management is not easy to manage because present bar code-based return management is not capable of handling return products in real time. Indeed, much of the work is still done by hand and under the bar code-based system, each item level return management is not possible. So, current reverse supply chain has uncertainty, low visibility, and low traceability. Also, it is necessary for various members in the supply chain to collaborate, but current support technologies and systems like the bar code-based POS (Point-of-sales) system are insufficient for the complete collaboration. Therefore, a need for a different model is arisen to overcome these limitations.

Radio frequency identification (RFID) is an identification technology that uses low-powered radio transmitters to read data stored in a transponder (tag) at some distances (Finkenzeller, 2003). Currently, many researchers emphasize adopting RFID in item-level to overcome challenges in strategic, tactical, and operational SCM level such as handling of differentiated material flows, efficient customization, and multi-company networks, and many companies are considering RFID technology as a way to improve their supply chain performance (Kärkkäinen 2003). However, almost research related RFID is not focused reverse supply chain management, but forward supply chain management.

In this context, this research will suggest RFID system for effective reverse supply chain management in the apparel industry. The structure of the paper is as follows: Section 2 discusses the background and current problems of reverse supply chain management in the apparel supply chain. Section 3 briefly describes RFID technology and EPC Network which enables the seamless sharing of RFID-related data over the Internet. Then, we suggest RFID system for centralized reverse supply chain and its impacts such as return decision making and return process improvement in the section 4. Section 5 closes with concluding remarks.

2. Reverse Supply Chain Management in the Apparel Industry

2.1. Characteristics of Apparel Return

In most industries, many kinds of return happen and they might be large burden to the organizations in terms of return and inventory handling cost. Especially, in the apparel industry, return is a more serious problem. The return rate of apparel industry is higher than that of other industries.

First, the return rate of apparel industry is about 19.4%. It's about three times of return rates of other industries (Norek, 2002). This high return rate is caused due to characteristics of apparel products. The apparel product is a high customer-sensitive product. Therefore, after purchasing, it should be met necessary conditions for customer satisfaction like size, color, state after washing, and view of others (Catalog Age, 2002).

Second, the apparel is a high MVT (Marginal Value of Time) product. The MVT indicates the degree of value of products after launching. The flow of returned products represents a sizeable asset stream for many companies, but much of that asset value is lost in the reverse supply chain through time progress (Blackburn et al. 2004). The marginal value of time is represented by the slopes of the lines in Figure 1. Time sensitive products (high MVT) like apparel products can lose its value at rates in excess of 1% per week as shown in figure 1; and the rate increases as the product gets near the

end of its life cycle.
The value of seasonal apparel products generally tend to be decreased during the season and to be highly degraded after season ends. In general, after end of selling period, return can just be disposed or can be sold at a lower price in secondary market. Therefore, in the apparel industry, if returned products can not be resold quickly and efficiently; the value of the products will be decreased dramatically due to the high MVT. Hence, quick return handling of retailers is very important to the apparel industry.

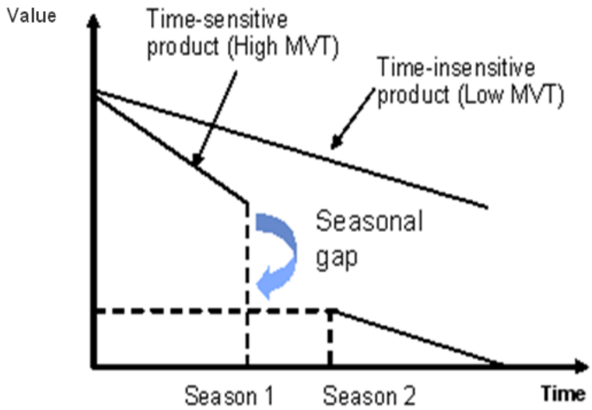

Figure 1. High MVT of the seasonal apparel

Last, return management of apparel products is more difficult due to various kinds of items. Unlikely other general manufacturer, apparel companies usually develop numerous Stock Keeping Units (SKUs) in a season, with an average of 15,000 SKUs in their collection at a particular time (Abernathy et al, 2000). And consumers expect those items developed in one season to be coordinated together. The combination of different sizes, colors, styles, fabrics, price lines, and consumer groups means that a retailer must carry an enormous range of different products. So, return handling activities such as picking, sorting, and inspection are more difficult and take more time. Also, due to characteristics of labor intensive industry, apparel return handling cost is relatively high. In the following section, we will discuss the return management in the apparel industry.

2.2. Types of Apparel Return

Generally, in logistics area, return is referred as the product which is returned from forward supply chain. The returned products in a reverse logistics flow can be separated into following categories in apparel industry: Non defective return, defective return, over stock return (excess return), bad stock return. First of all the type of return is classified as quality of product. If the product has quality problem, then the product is returned to reverse supply chain. So, defective return has been discovered by the retailer or by the customer to be truly defective. In many cases, a firm will inform the manufacturer of the defect and the manufacturer will compensate the retailer with a new product or repayment, in the form of a check or a credit. On the contrary defective return, non defective return occurs without quality problem from customer. In apparel industry, generally the selling product is guaranteeing the return right for customer within some warranty day (7 or 15 days) for service.

Next, the return can classify the character of stock in inventory. First, the over stock (excess) return is first-quality items that the company has in excess, but will continue to sell. The firm may have overestimated demand and ordered too many. This return also results from an overzealous manufacturer. This may be due to inaccurate forecasts, or because production constraints require a minimum production quantity, which is greater than the demand. Marketing may also be a large source of excess product for the distributor. The distributor or the vendor may offer a special promotion, which provides the retailer an incentive to purchase a larger than usual order. If the retailer in unable to sell the product, the distributor may experience a significant increase in returns.
Finally, bad stock is other type of stock in retail inventory. It means returning the bad-stock which remains somewhere in the backroom for a long time, even though merchandize has no probability of sales. As managers find it is hard to recognize where it is, it should be handled through a regular actual inspection. Because of inadequate labor for current inspection process, bad stock stays in inventory for a long time.

Table 1. Types of return in apparel industry

Return Types	**Explain**
Non defective return	The returned product without defects from customers within a given period
Defective return	The returned product with defects of quality
Over-stock return (Excess return)	The return of the over-stock which is the excess inventory without sale possibility anymore
Bad-stock return	The return of the bad-stock which remains somewhere in the back-room for a long time without recognition

3. Networked RFID System

RFID is an automatic identification technology where information is carried by radio waves (RFID handbook, 2003). This technology allows remote integration of objects using radio waves to read data from RFID tags which are at some distance from an RFID reader. Where bar codes require manual, close-range scanning, RFID permits remote, non-line-of-sight, automatic reading (S. Sarma et al. 2001). This technology is used of to collect information automatically by radio frequency data communication between and object and an RFID reader. The fundamental operation of an RFID system is as follows. Firstly, when an RFID tag goes into the sensing range of antenna's electromagnetic field, it sends information to RFID reader. The RFID reader perceives the signal and receives the tag information. The RFID reader then converts this information to a digital signal, and verifies it. Finally, if this information is normal, it is then sent to a computing system or another type of controller (Emerson R., 2004) Based on relatively improved ability of RFID, such as faster identification speed and larger data storage, it is possible to identify more effectively each item as item itself (RFID handbook, 2003).
Networked RFID system developed by Auto-ID Center is called as the EPC (Electronic Product Code) Network The system can enable a device can and identify a product and

then, access crucial information about it, such as when and where it was made; where it was shipped from; and how it was handled, used and maintained (Kulkarni et al., 2005) EPC Network is leading the development of industry-driven standards for the Electronic Product Code™ (EPC) to support the use of RFID in today's fast-moving, information rich, trading networks. The EPC Network is a secure mechanism to connect servers containing information related to the item identified by EPC numbers. The servers, called EPC Information Services or EPCIS, are linked via a set of network services.
In the aspect of SCM, the EPC Network is a method for using RFID technology in the global supply chain by using inexpensive RFID tags and readers to pass Electronic Product Code numbers. In other words, the EPC Network is a set of technologies that enable immediate, automatic identification and sharing of information related to each item in the supply chain. In that way, the EPC Network will make organizations more effective by improving their true visibility of information about each item in the supply chain. Some components that compose EPC Network are listed below.

- EPC (Electronic Product Code): this code provides unique identifier for each object.
- RFID tag: A Tag communicates with readers by using radio wave and it is responsible for exchanging data stored in a chip.
- RFID reader: A reader communicates with tags to obtain the stored data.
- ALE (Application Level Events): to ensure that only significant "events" and data packets are propagated to application and information systems (Filtering, collection and reporting of RFID data). This is upgrade version of Savant.
- ONS (Object Name Server): ONS tells the computer systems where the information about the object carrying an EPC is located on the network. ONS has similar functions with DNS (Domain Name Server) of these days.
- The EPC Information Service (EPCIS): an interface to a networked database which allows trading partners to access and exchange well-defined subsets of their live real-time data, through a standard interface
- PML (Physical Markup Language): this language is developed in the eXtensible Markup Language (XML) format for communicating data directly captured by the EPC network in a structured way

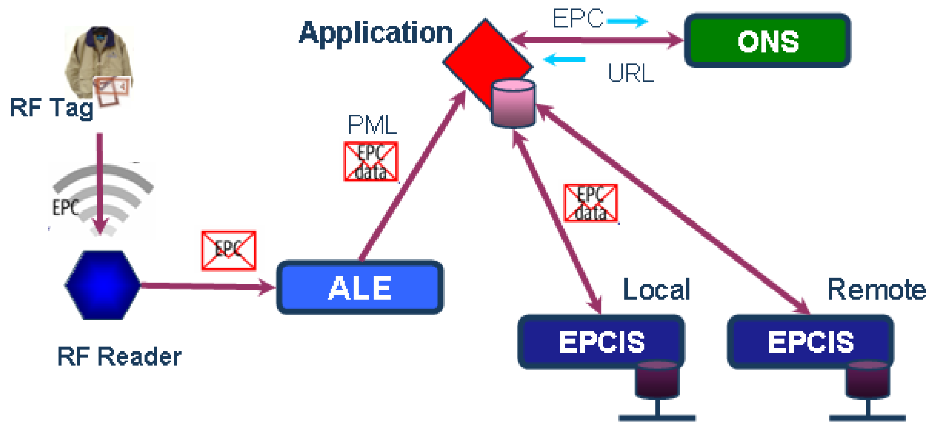

Figure 2. EPC Network (Auto-ID Lab, 2004)

The EPC attached to the product, will enable full traceability of the product while it moves through the supply chain. In conjunction with Auto-ID's Object Naming Service (ONS) and Physical Markup Language (PML), the EPC enables a seamless flow of product information throughout the product's life cycle which creates the industry's supply chain. RFID brings us closer than ever to realize an integrated, seamless supply chain that not only reduces cost, but also virtually eliminates inefficiency and drives benefits for all stakeholders, manufacturers, retailers, and consumers. (C. Wong et al. 2002)

The characteristics of using RFID in terms of information are summarized. First, by using RFID with EPC Network, quality of tag information that user can obtain from the tag is better than legacy ID system such as bar code. Also, it ensures availability of relevant useful product information. Second, the usefulness of information is closely tied to its timely availability of user groups. Timeliness ensures maximum uptake and utility of the information and enables users to effectively integrate it into their decision-making. RFID with EPC Network ensures ready availability of product information which means timely convenience. We can obtain information such as tracking, real-time location, and state of product at the right time. Third, by using EPC Network, unique product "footprint" is made available. Item can have its own address to access, which means managers can handle and trace each product by item level. Hence, its accuracy of information becomes higher than ever before.

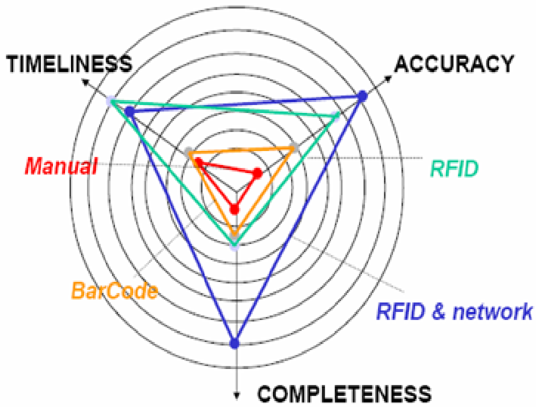

Figure 3. Characteristics of networked RFID System (Auto-ID Lab, 2004)

In recent years, numerous studies have attempted to find and explore RFID application with these characteristics on the forward supply chain management (D. McFarlane 2003; R. Angeles 2005 et al.). However, relatively few studies have been devoted to an analytic, detailed examination of the RFID application on the reverse supply chain, especially return management. Thus, we will attempt the RFID based return management in the next section.

4. RFID System for Centralized Reverse Supply Chain in Apparel Industry

4.1 Centralized Reverse Supply Chain Model

Generally, reverse supply chain has two types as the return evaluation and handling position – centralized and decentralized reverse supply chain model. In this research, centralized reverse supply chain model is selected for RFID applying. Every returned product is sent to central location (centralized return centers) for testing and evaluation to determine its condition and issue credit. Centralized return centers are processing facilities devoted to handling returns quickly and efficiently. Therefore this centralized handling process is more adaptable to apply RFID system.

In a centralized reverse supply chain model, all products for the reverse logistics pipeline are brought to a central facility, where they are sorted, processed, and then shipped to their next destination. This model has the benefit of creating the largest possible volumes for each of the reverse logistics flow retailer, which often leads to higher revenues for the returned items. It also allows the firm to maximize its return on the items, in part, to sortation specialist who develop expertise in certain areas and can consistently find the best destination for each product. This reverse supply chain model has advantage more consistent return handling, high space utilization, labor savings, downsize transportation costs, and compacting disposition time. In apparel industry, the retail stores send product back to one or more centralized return centers.

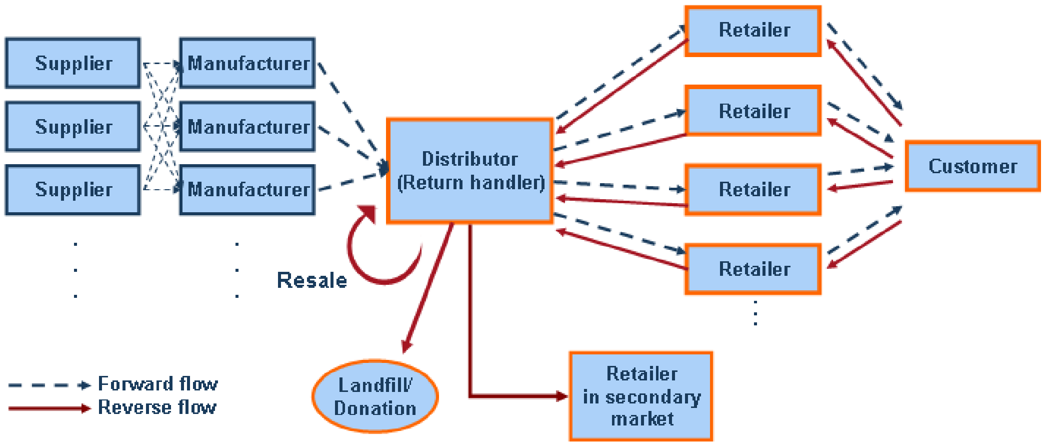

Figure 4. Centralized reverse supply chain model in apparel industry

4.2 Return Process of Centralized Supply Chain in Apparel Industry

Generally, return process is composed with return inbound activity of customer or retailer, and return outbound activity by retailer or return handler. This paper extends the return process to inbound activity of new product by retailer and purchasing process of customer in retail shop. The information made from the process will apply for over stock and bad stock handling for return.

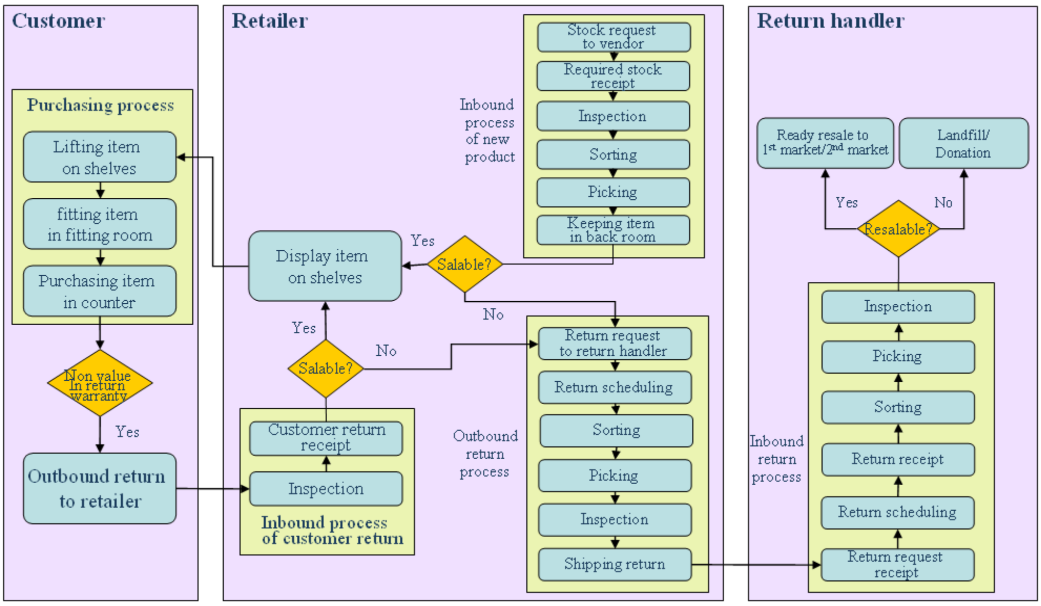

Figure 5. Extended return process of centralized reverse supply chain

To analyze return process, Firstly, the new products are transported to retail from distributor with inspection of the product type, quantity and quality. Then the products are sorted, picked, and kept in backroom. Next, retailer displays the keeping product on shelve for customer. Customers look around the retail display and they lift item from display shelve. If they have concern, they will enter the fitting room to wear the apparel. Finally, they decide purchasing. After purchasing, it is possible to return by customer in case of defective product or non defective product which is dissatisfied for customer as the size, color. When retailer receives and inspects the return, if the products are resalable as current item, retailers try to resale on the display directly. Otherwise, the retailer should send back the product to return handler.
For return activity for return handler, retailer discuss return schedule with return handler. After fix the return type, date, and quantity, retailer begins to sort and pick the products which are decided as return. Then return handler receipt the product and sort the product for inspection. They inspect the number and status of the returned products compared with invoice. Because returning of the products means asset movement from retailer to return handler, they check the amount carefully. Recently, all these activities are done manually. And this inspection process is labor intensive work and takes long period. After inspection, return handler evaluates the value of returned products. If return has sufficient value in market, they could directly resale to other retailers or second market such as outlet, warehouse store. In case of non-resalable, they destroy or donate. After end of season, they keep the product, available for next season, in their warehouse.

4.3 Design RFID System for Centralized Reverse Supply Chain Model

Designing the RFID system begins from RFID tag attaching on apparel product at each items. And the RFID systems are composed with smart shelf / fitting room and inbound/outbound facilities. Through these facilities, the return related data are acquired and created information transmitted through the RFID system to the integrated information repository.

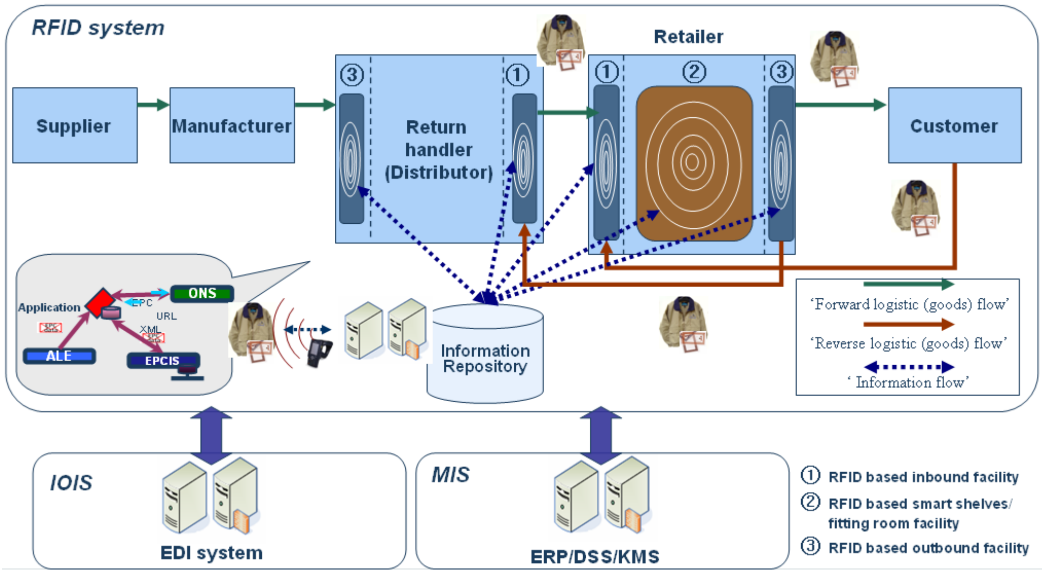

Figure 6. RFID System for centralized reverse supply in apparel industry

The RFID based smart shelf set up the fixed RFID reader on each sectors of shelf. When items were displayed or removed from the smart shelf by retailer, the attached tag is detected by RFID reader and sends the information to information repository. These smart shelves are installed in display room and backroom in retail shop. This system automatically recognizes the product identification and position on shelf. And if customer lifts the item form smart shelf, the event is recognized by RFID reader automatically. Like smart shelves, smart fitting room designed by RFID reader to detect entered product in the room.

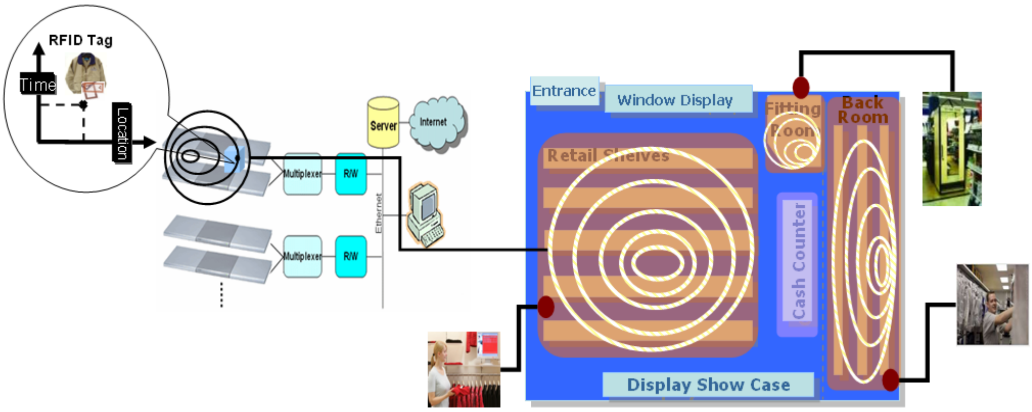

Figure 7. RFID based smart shelf / fitting room system

In addition, RFID based inbound and outbound system support return management. RFID system provides “scan-free” inbound- and outbound-logistics data collection automatically. By accurately delivering data down to the items, the RFID accelerates information flow across inventory network, enabling proactive management of backroom in retails and warehouse in centralized return center. It consists of a single RFID enabled portal at the sending and receiving dock where return send and arrives from its origin, together with the IT system necessary for automatic acknowledgement of arrival and invoice reconciliation. This system allows workers to check return inventory more efficiently.

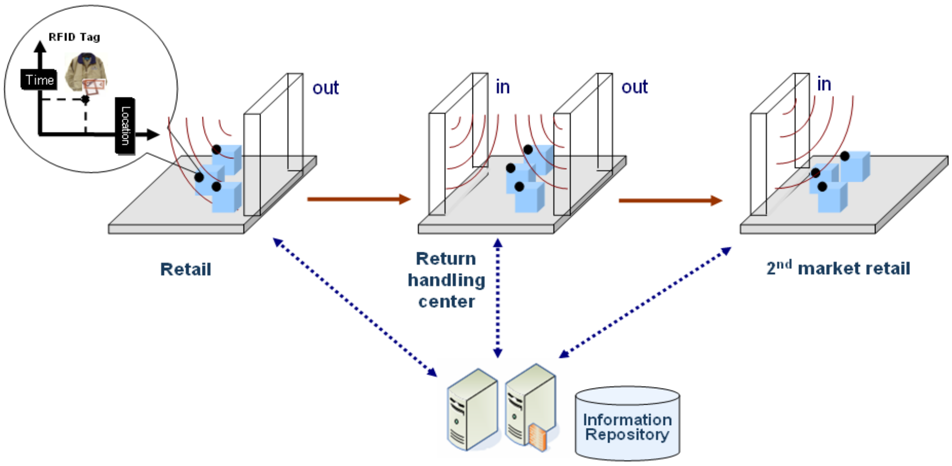

Figure 8. RFID based inbound / outbound system

4.4. Information on RFID System for Apparel Return Management

The data can be collected throughout the whole return process on reverse supply chain with designed RFID system. Each player stores necessary information into item in accordance with data set of RFID system. Especially, the inbound and outbound data of a product can be automatically stored in information repository of RFID system, when a tagged product passes by the fixed RFID reader. And these data can be shared with whole players in supply chain through EPC Network. The data acquired by RFID system is classed six type following the extended return process; Basic product information (product ID), product inbound information in retail, Product status information in retail, Product sale information, Returned product information from customer, Returned product information from retailer. Also, Retailer can manage the sales and return information by item level through the RFID technology. For example, when return occurs, the staff can check the returned item efficiently by RFID reader and stores information related to the return into RFID Network.

Table 2. Information on RFID System in return process

Return player	**Return process**		**Information by RFID system (Source data)**	**Information type**
Retailer	Inbound new product process	Inbound goods in retail for sale	Item inbound information (Product ID, date, inspector)	Static
		Keeping item in back room for sale	Item keeping information (Product ID, date, location)	Static
	Sale process	Salable?	Product attraction information (Product ID, # of purchasing/fitting/lifting)	Dynamic
		Display item on shelves	Display information (Product ID, date, location)	Dynamic
	Inbound customer return process	Return from customer	Return inbound information (Return product ID, return type, return reason, date, inspector etc.)	Static
	Outbound return process	Return to return handler	Return outbound information (Return product ID, return type, return reason, date, inspector etc.)	Static
Customer	Purchasing process	lifting item on shelves	Lifting amount data on attraction information	Dynamic
		fitting item in fitting room	Fitting amount data on attraction information	Dynamic
		Purchasing item in counter	Purchasing amount data on attraction information	Dynamic
Return handler	Inbound return process	Inbound return from retailer	Item inbound information (Return product ID, date, inspector)	Static
		Resalable?	Return type information (Over stock/bad stock, defective/non-defective)	Static

With analyzing the data and forming information repository, the RFID system data can be used to various application areas. It provides full reliability for information usage on each return processes. In each process, the RFID system provides proper information to each return player. Especially, RFID system creates reliable attraction information for return decision making. This product attraction information analyzed and formed from product status data such as frequency of lifting from shelve, and frequency of entering the fitting room. The kinds of available information and function of RFID system expect to impact return decision making like excess stock return, return transshipment, automatic return handling, and return tracking/tracing.

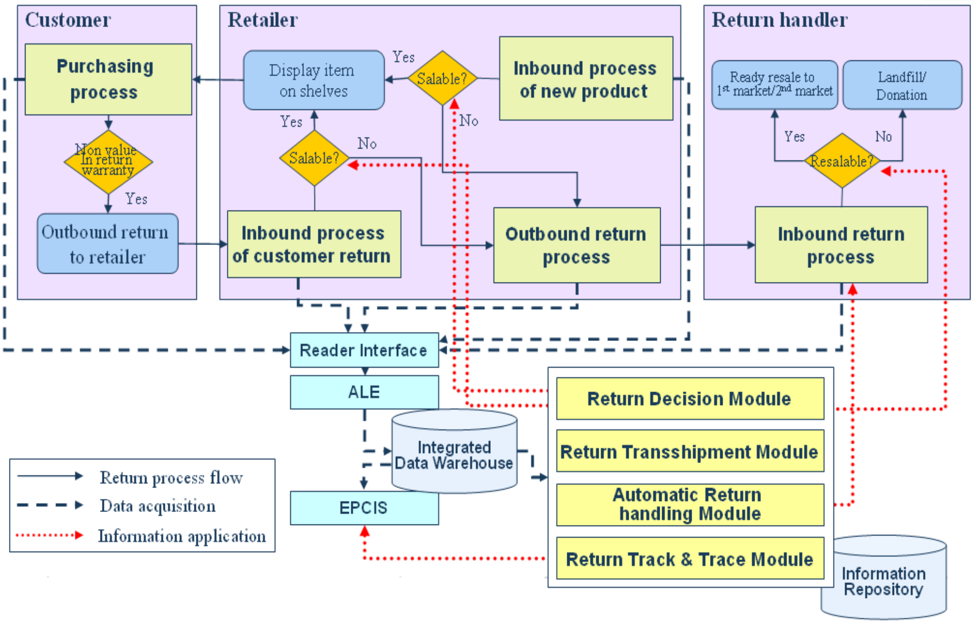

Figure 9. Impact area of the RFID System on return process in apparel industry

5. Conclusion

Nowadays the reverse logistics are very troublesome, because it needs too much labor to sort and deal with the returned goods. And current information technology like barcode is insufficient to support the RSCM. For logistics managers, this research provides RFID system as applicable solution for their RSCM. The recent emergence of RFID systems is the means of connecting an individual product tagged with a RFID chip to a network system and thereby, it can carry complete information associated with the product throughout its lifecycle. And the system provides various information such as attraction, return type information for each item. This available information expect to apply effective return decision making, return transshipment, automatic return handling, and return track and trace. The most important aspect of using this kind of information is the improvement of operational efficiency in retail backroom and the improvement of decision making of return. The new information from smart shelf and smart fitting room can leverage retailers' effective return management. In addition, efficient acquisition of product information using RFID readers can reduce inspection lead time in return process. All the benefits can be implemented through RFID along with EPC Network, the one of the most standardized systems of RFID. Finally, further studies remains in quantitative analysis of RFID impact for RSCM. Also, accessing the economic effect such as Return on Investment (ROI), cost-benefits analysis of RFID system for forward and reverse SCM is required. These kinds of research will illuminate and verify the complete value of the RFID system in the aspect of supply chain management.

Acknowledgement

This work was supported in part by "Development of Sensor tag and Sensor node technology for RFID/USN" project of ETRI through IT Leading R&D Support Programs of MIC, Korea

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Green Management Orientation, Partner Trust, Information Sharing and Performance in Supply Chain Management

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Abstract
The purpose of this paper is to examine (1) the drivers of performance outcomes of green supply chain management; (2) the interrelationships between green management practices and partner trust which in turn impact the extent of information sharing (i.e., sharing general and risk information with partners).
We present a research model, key variables, and several hypotheses which are tested by PLD (partial least squares). We collected the data from supply chain managers of 180 companies in Korean steel industry. Companies are selected from KOSPI (Korean Composite Stock Price Index) or KOSDAQ (Korea Securities Dealers Automated Quotation). If the size of the company is too small, those companies are excluded because the context of very small companies is different from those of big companies, and it gives us difficulty to achieve the generalization.
The research results show statistically meaningful relationships between: (1) green management and partner trust, green management and information sharing (i.e., general and risk management); (2) partnership trust and information sharing (i.e., general and risk management); (3) three performance measures (i.e., customer outcome, operational process outcome and financial outcome) are affected by the extent of risk information sharing, but partially supported by that of general information sharing; (4) partner trust has moderating effect on the three performance outcomes (i.e., customer outcome, process outcome and financial outcome).

Keywords: Green Management Orientation, Partner Trust, Information Sharing, Supply Chain Performance Measures, Korean firms.

1. Introduction

With the continuous destruction in environment firms increasingly pay attention to green management. A new paradigm "Sustainable Development" intends to seek balance between environmental safeguards and economic development. For specific implementation Agenda 21 has been adopted by UNCED: UN Conference on Environment and Development) that was held in Rio de Janeiro, Brazil. In response to these new developments outstanding firms in EU, USA and Japan have been striving for environment friendly business. They have been adopting Eco-SCM as a specific organizational implementation initiative. This focused on reduction of total costs

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throughout product life cycles (including the new product development, commercialization and recycling processes) by participating suppliers and waste disposal firms (Ansari and Bell, 1997).

An extended supply chain involves integration of diverse functions (production, purchasing, logistics and distribution) among business entities (suppliers, manufacturers and customers). This requires integration of internal organizational resources and inter-organizational network participants. Effective supply chain management assumes strategic collaboration and sharing information resources among participating organizations. As the scope of collaboration expands and the extent of information sharing increases, corresponding business risks multiply as well. Important success factors of effective supply chain management are trust, partnerships, strategic collaboration. Trust is certainly an important element even in a very small business network (Monczka, et al., 1998; Sako, 1998). Information sharing and strategic partnership are listed essential aspects of green supply chain management (Ofori, 2000; Zhu et al., 2007, 2008). Outstanding performance in supply chain is the results of integration of supply chain management practices (Zhu and Sarkis, 2004; Kainuma and Tawara, 2006; Zhu et al., 2007). However, little is known on how Korean businesses implement green management while incorporating critical information flows and strategic partnerships across organizations.

The purpose of this paper is to examine (1) the drivers of performance outcomes of green supply chain management; (2) the interrelationships between green management practices and partner trust which in turn impact the extent of information sharing (i.e., sharing general and risk information with partners). In the following section a research model is presented along with hypotheses that explore interrelationships between variables. Research methods, research results and implications of this research will be discussed in the subsequent sections as well.

2. Literature Review

2.1 Green Management Orientation

Green supply chain management (GSCM) is defined as a set of business philosophy and practices intended to control and support improvement of environmental results through supply chain, extended participations beyond purchasing and procurement for the purpose pollution reduction, recycling, reuse and supplementing hazardous materials Narasimhan(1998) and consideration of environmental factors in supply chain and purchasing (Qinghua, 2004). Green management considers eco-efficiency for economic considerations and clear production for environmental concerns (Kim, 2005).

2.2 Partner's Trust

Trust refers to the condition in which one party is able to anticipate what the other party will do, or expect that the other party will act in an acceptable way (Sako, 1991). Partner's trust refers to the extent to which participants in supply chain are willing to count on each other for mutual interests and problem resolutions. Number of studies have paid attention to the role of trust in knowledge acquisition and argued that social capital has impact on intellectual capital exchange and combination(Nahapiet and Ghoshal, 1998, Gulat (1995) and Tsai and Ghoshal (1998). Kale et al. (2000)

conceptualize mutual relationship, mutual trust, mutual respect, and personal friendship as relationship capital, and give the research result that this relationship capital has effects on organizational education and core asset protection (Kim, 2006).

2.3 Information Sharing

Information sharing in supply chain is defined as the scope, frequency and intensity to which critical and proprietary information is communicated to participating entities (Monczka et al., 1998; Mentzer et al., 2000). Many researchers have emphasized the importance of information sharing in the course of executing supply chain management (Balsmeier and Voisin, 1996; Lambert and Cooper, 2000; Mentzer et al., 2000; Noble, 1997; Towill, 1996). Firms attempt to secure visibility throughout the value chain by means of information sharing. However, if firms cannot be sure of the accuracy or the value of the received information, execution of supply chain management would be quite difficult. Therefore, this study attempted to conceptualize and measure information sharing as co-ownership of information.

Table 1. Constructs, Definition and Literature Base

Constructs	Definitions	Literature Base
Green Management Orientation	A set of business philosophy and practices intended to control and support improvement of environmental results through supply chain	Godfrey, 1998; Narasimhan, 1998; Kainuma and Tawara, 2006;. Zhu et al., 2008
Partner's Trust	The extent to which participants in supply chain are willing to count on each other for mutual interests and problem resolutions	Monczka et al., 1998; Holmberg, 2000; McAdam and McCormack, 2001; Metters, 1997; Lee et al., 1997; Mason-Jones and Towill, 1999; Berry et al., 1999; Alvarez, 1994.
Information sharing	The scope, frequency and intensity to which critical and proprietary information is communicated to participating entities.	Monczka et al., 1998; Mentzer, 2000; Towill, 1996; Balsmeier and Voisin, 1996; Lalonde, 1998; Stein and Sweat, 1998; Yu et al., 2001; Vokurka and Lummus, 2000; Lancioni et al., 2000; Ballou et al. 2000.
Supply chain Performance	The extent of outcome measures in terms of customers, processes and financial outcomes	Tompkins and Ang, 1999; Beaman, 1996; Narasimhan and Jayaram, 1998; Spekman et al. , 1998a; Hewitt, 1999; Beaman 1998;Gunasekaran et al., 2001.

2.3 Supply Chain Performance

Holmberg (2000) suggest that new supply chain performance measures are required. Bechtel and Jayaram (1997) contend that measurement system in supply chain should be integrated, which can gauge the outcome of the entire processes. Kiefer and Novack (1999) emphasize the importance of customer-oriented perspective in measuring supply chain performance. Since end customer is the final target of the supply chain output, true supply chain value excellence can be achieved (Tompkins and Ang, 1999). Beaman (1996) presents four characteristics as performance measurement systems including inclusiveness, universality, measurability, and consistency which are effective in measuring general performance. Supply chain performance measurement in this study adopts customer related outcomes in terms of use customer responsiveness and customer satisfaction (Narasimhan and Jayaram, 1998; Spekman et al. , 1998a; Hewitt, 1999; Beaman 1998) and operational process outcomes in terms of supplier transaction performance, delivery performance, customer service, and logistics cost. (Gunasekaran et al., 2001).

3. Research Model and Hypothesis Development

Green management orientation is strategic intent in organizational level(Godfrey, 1998; Narasimhan, 1998). The extent of green management orientation depends on external environmental pressures (e.g., government regulations, industry standards, competitive benchmarking). Green management orientation is also an expression of firm's strategic intent in that top management commits to green initiatives in terms of explicit communication in terms of its importance and organizational commitment toward the goals related to eco-efficiency and clean production (Kainuma and Tawara, 2006;. Zhu et al., 2008.

Zaheer et al. (1998) found that inter-organizational trust reduce the negotiation cost and conflicts, and have positive effects on performance. It is economic assets which lower the transaction cost (Dyer, 1997; Uzzi and Lancaster, 2003), and is considered as critical variable in generating information sharing and inter-organizational collaboration (Aoki, 1988; Nishiguchi, 1994). Dyer and Chu (2003) found that supplier's perceived trustworthiness has positive impact on auto manufacturers.

If there is lack of trust, opportunism hinders information sharing regarding cost or new idea (Laron, 1992; Uzzi, 1997). Trust reduces negotiation and monitoring cost resulting in improved supply chain performance. Studies show that inter-organizational trust is related with positive economic performance such as increased competitive advantage, improved performance, reduced transaction cost, and augmented satisfaction (Barney and Hansen, 1995; Zaheer et al., 1998; Geyakens et al., 1998). Inter-organizational communication has been recognized as important role in building effective supply chain (Alvarez, 1994; Speckman et al., 1998; Chizzo, 1998; Humphreys et al., 2001; Tattum, 199).

Information sharing is the scope, frequency and intensity to which critical and proprietary information is communicated to participating entities. As effective information flows in supply chain, it has effects on enterprise decision making regarding supply chain effectiveness and efficiency. The extent of information determines the quality of information shared and delivery of reliable and timely information among supply chain participants. The presence of information technology infra and inter-organizational information systems determine the level of information sharing. Partner's trust and information sharing information improve the effectiveness of inter-organizational communication.

Value creation and delivery in supply chain is based on the extent of information availability and timely use information. Therefore, supply chain performance in terms of customer requirements, operational process outcomes and financial performance is heavily dependent upon the information sharing practices.

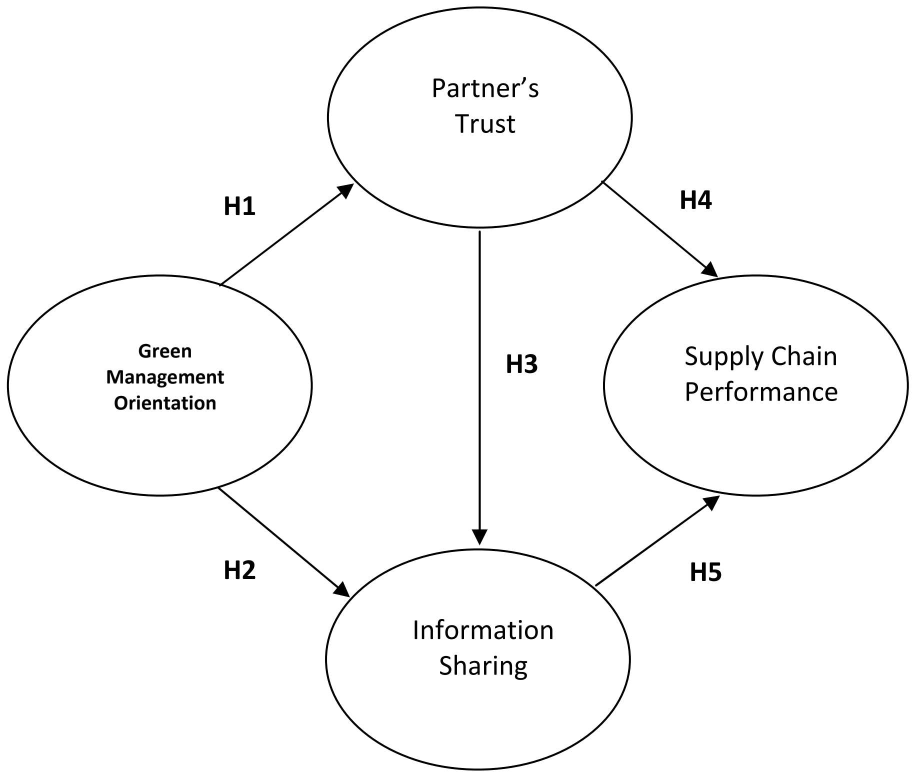

Figure 1. Research Model

Based on the above theoretical rational and practical implications we posit the hypotheses in the below.

H1: Green Management Orientation and Partner's Trust is positively related.
H2: Green Management Orientation and information Sharing is positively related.
H3: Partner's trust and Information Sharing are positively related.
H4: Partner's trust and supply chain performance is positively related.
H5: Information Sharing is positively related to Supply Chain Performance.

4. Research Methods

4.1. Sample

We collected the data from supply chain managers of 142 companies. Companies are selected from KOSPI (Korean Composite Stock Price Index) or KOSDAQ (Korea Securities Dealers Automated Quotation). If the size of the company is too small, those companies are excluded because the context of very small companies is different from those of big companies, and it gives us difficulty to achieve the generalization.

For three months, from June till September 2007 we contacted supply chain managers and explained the purpose of the research, and sent questionnaires to those who showed interest through fax, email, and regular mail. Most of them are managers in purchasing and manufacturing department. Out of 400 managers 142 managers responded and sent usable questionnaire. Table 2 is the summary of quality characteristics of the respondents.

Table 2. Respondent Characteristics

Classification		Number of Responses	%
Types of Business	Manufacturing	91	64.0
	Electronics and Communication	13	9.2
	Logistic and Services	38	26.8
Number of Employees	Less Than 50	65	45.8
	50-100	27	19.0
	100-500	21	14.8
	500-1000	7	4.9
	More than 1000	22	15.5
Position in Supply Chain	Raw Materials Suppliers	16	11.3
	Component Parts Suppliers	22	15.5
	Component Parts Assemblers	11	7.7
	Finished Products Assemblers	44	31.0
	Logistic Services Providers	25	17.6
	Other Service Providers	24	16.9
Position and Title of Respondents	Supply Chain Specialist	17	12
	Assistant Manger	29	20.4
	Manager	29	20.4
	Director	39	27.5
	Senior Executives	18	12.5
	CEO	10	7
Total		142	100

4.2 Measurement

We measure the latent variables (constructs) using the multi items (Appendix A). Most of the questions in the survey were adopted from the past studies with necessary modification. Each item uses 5 point Likert scale. Table 3 and Table 4 show the descriptive statistics and Pearson correlations among constructs.

Table 3. Mean and Standard Deviation of Variables

Variable	Mean	SD	Theoretical Range	Actual Range
1. GrMgt	4.160	1.398	1.00-7.00	1.00-7.00
2. RiskInfo	4.329	1.443	1.00-7.00	1.00-7.00
3. PaIno	4.621	1.398	1.00-7.00	1.00-7.00
4. Trust	5.036	1.167	1.00-7.00	1.00-7.00
5. CusPer	5.011	1.264	1.00-7.00	1.00-7.00
6. InPer	4.605	1.282	1.00-7.00	1.00-7.00
7. FinPer	4.216	1.170	1.00-7.00	1.00-6.50

Table 4:Pearson Correlation Coefficients(n=142)

	1	2	3	4	5	6	7
1. GrMgt	0.808						
2. RiskInfo	0.639*	0.839					
3. PaIno	0.549*	0.446*	0.856				
4. Trust	0.493*	0.465*	0.446*	0.870			
5. CusPer	0.500*	0.586*	0.616*	0.702*	0.922		
6. InPer	0.619*	0.633*	0.588*	0.578*	0.763*	0.918	
7. FinPer	0.655*	0.514*	0.458*	0.492*	0.614*	0.763*	0.917

*, Significant at 0.01 level respectively (two-tailed)
Diagonal elements: square root of AVE; off-diagonal elements
See Appendix A for definition of variables.

5. Research Results

5.1 Structured Equation Modeling: Partial Least Squares (PLS)

We test the hypotheses in Figure 1 and Figure 2 using PLS (PLS 2.0 M3 Version). It is proper to use PLS in analyzing small sample size and exploratory study (Wold, 1985), and PLS solves several theoretical and estimation problems (Hulland, 1999). Since PLS does not assume the distribution, it is not appropriate to use goodness-of-fit-measures (Chin, 1998). Rather, it is recommended to evaluate overall significance level of explained variances between constructs and endogenous variables.
Research model is assessed through the reliability and validity of values between

measures and constructs. We evaluated the reliability using the each item's loading in each construct (Table 5). All the measured values are over 0.7 on each latent variable at the significance level of 0.001 (one-tailed test). The composite reliability of each construct is all above 0.90 which is adequate measure according to Nunnally (1978)'s recommendation.

Average variance extracted (AVE) assess the convergent validity of the research model. If AVE is more than 0.5, it is considered to have adequate convergent validity (Hari et al., 1995).

Discriminant validity of the research model is tested by the correlation between square root of AVE and each construct. As Table 4 presents diagonal elements are the square root of AVE and off-diagonal elements are the correlations between constructs. Since all the values of diagonal elements are bigger than the values of non-diagonal elements, it is believed to have proper discriminant validity. All these results show that the model has the acceptable level of reliability and validity.

Table 5 shows factor loadings of each construct including composite reliability. The results suggest adequate level of construct, convergent and discriminant validity

Table 5: Results of Factor Analysis for every Construct (Varimax Rotated)

<table>
<tr><th>Green Management</th><th>Factor 1
Green</th><th colspan="2">Composite Reliability</th></tr>
<tr><td>item 1</td><td>0.896</td><td colspan="2" rowspan="8">0.94</td></tr>
<tr><td>item 2</td><td>0.852</td></tr>
<tr><td>item 3</td><td>0.832</td></tr>
<tr><td>item 4</td><td>0.827</td></tr>
<tr><td>item 5</td><td>0.822</td></tr>
<tr><td>item 6</td><td>0.802</td></tr>
<tr><td>item 7</td><td>0.799</td></tr>
<tr><td>item 8</td><td>0.796</td></tr>
<tr><td>Eigenvalue</td><td>5.882</td><td colspan="2"></td></tr>
<tr><td>Cumulative variance (%)</td><td>65.351</td><td colspan="2"></td></tr>
<tr><td>Cronbach alpha</td><td>0.932</td><td colspan="2"></td></tr>
<tr><th>Type of Information Share</th><th>Factor 1
Risk</th><th>Factor 2
Partner</th><th>Composite Reliability</th></tr>
<tr><td>item 1</td><td>0.840</td><td></td><td rowspan="5">0.93</td></tr>
<tr><td>item 2</td><td>0.826</td><td></td></tr>
<tr><td>item 3</td><td>0.818</td><td></td></tr>
<tr><td>item 4</td><td>0.753</td><td></td></tr>
<tr><td>item 5</td><td>0.715</td><td></td></tr>
<tr><td>item 6</td><td></td><td>0.824</td><td rowspan="4">0.93</td></tr>
<tr><td>item 7</td><td></td><td>0.786</td></tr>
<tr><td>item 8</td><td></td><td>0.762</td></tr>
<tr><td>item 9</td><td></td><td>0.740</td></tr>
<tr><td>Eigenvalue</td><td>6.778</td><td>1.157</td><td></td></tr>
<tr><td>Cumulative variance (%)</td><td>61.571</td><td>10.520</td><td></td></tr>
<tr><td>Cronbach alpha</td><td>0.912</td><td>0.908</td><td></td></tr>
</table>

Table 5: Results of Factor Analysis for every Construct (Varimax Rotated)—Continued--

Trust	Factor 1 Trust	Composite Reliability
item 1	0.903	0.94
item 2	0.897	
item 3	0.895	
item 4	0.854	
item 5	0.847	
item 6	0.822	
Eigenvalue	4.544	
Cumulative variance (%)	75.735	
Cronbach alpha	0.936	

Table 5: Results of Factor Analysis for every Construct (Varimax Rotated) –Continued--

Type of Performance	Composite Reliability	Factor 1 Customer	Factor 2 Operational Process	Factor 3 Financial
item 2	0.91	0.885		
item 3		0.867		
item 4		0.849		
item 1		0.808		
item 8	0.95		0.819	
item 9			0.782	
item 10			0.773	
item 13	0.95			0.902
item 14				0.885
item 12				0.769
item 11				0.686
Eigenvalue		9.550	1.516	0.892
Cumulative variance (%)		68.213	10.829	6.370
Cronbach alpha		0.956	0.923	0.937

5.2 Hypothesis Test

We tested the posited hypotheses. These hypotheses were empirically tested using three sub-constructs of organization information capacity. PLS creates standardized βs which shows path coefficient and interprets OLS regression. We conducted bootstrapping to examine estimated parameters and confidence interval. Figure 2 shows the summary of path coefficient of each construct and R2.

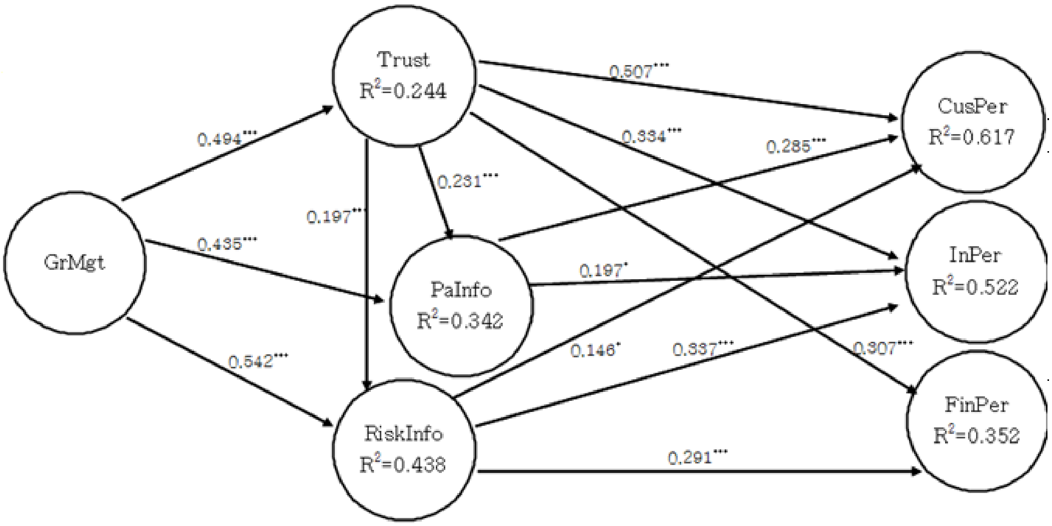

Figure 2. Green Management, Partner Trust, Information sharing and Performance Path Model
(Only significant paths and their PLS path coefficients are shown)

We hypothesized green management is positively related to partners' trust. The path coefficient (1) between green management and risk information sharing partner Information sharing; (2) Risk information sharing and three sets of performance measures (i.e., customer, information and financial) is related at all statistically significant level ($p<0.001$)(H1~H5 supported).

6. Conclusion

This study empirically tested the supply chain practices of firms in three Korean industries (i.e., manufacturing, electronics and IT and logistics and services). The contribution of this study is: (1) conceptual framework of supply chain practices of three Korean industries industry in terms of drivers of green management orientation, partners trust and information sharing; (2) the validation of relationships between information sharing with supply chain outcomes.
This study suggests that Korean firms across industry are aware of green management issues and they also implement necessary inter-organizational relationship management along with appropriate information sharing practices. This study indicate that their high level of strategic and organizational capabilities along with knowledge management (i.e, information sharing) are critical in building high level of supply chain performance outcomes.

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Appendix: Survey Questionnaire Items

Constructs	#	Item
Green Management Orientation (GrMgt)	1	The extent of consideration of environmental reputation in selecting suppliers for purchasing decisions
	2	The extent of recycling, reuse and use of environmental friendly supplements
	3	The extent of collaboration planning among diverse functions for environmental improvement goals
	4	The extent of top management concerns about green management
	5	The extent of environmental regulatory pressures from customers
	6	The extent of environmental consideration in product design, packaging and distribution
	7	The extent of environmental cost measures and cost allocations.
	8	The extent of losing customers due to environmental performance.
Partners' Trust (Trust)	1	The extent of involving decision making that affects one another.
	2	The extent of willingness to work toward the common goals.
	3	The extent of capabilities to help one another.
	4	The extent of confidence on one another in fulfilling mutual commitments,
Information Sharing (1) Partner Information Sharing (PaInfo)	1	Sharing planning information on related products and services.
	2	Sharing change details on related products and services.
	3	Sharing the performance records on related products and services.
	4	Sharing on information of developing new products and services.
	5	Sharing inventory related information on related products and services.
Information Sharing (2) Sharing Risk Information (RiskInfo)	6	Sharing risk information in terms of Inventory, raw materials and management capabilities.
	7	Sharing information on poor quality products, materials and services
	8	Sharing information on market changes (price, technologies and design)
	9	
Performance (1) Customer	1	The extent of flexible responses toward customer requirements
	2	The extent of product and service delivery reliability.
	3	The extent of quality improvement of product and services.

Performance (CustPerf)	4	The extent of customer satisfaction.
Performance (2) Operational Performance (CustPerf)	1	The extent of task processing and lead time reductions.
	2	The extent of reduction in production cycle and new product development time.
	3	The extent of improvement in efficiency utilization of assets and facilities.
Performance (3) Financial Performance (FinPerf)	1	The extent of improvement in cash flows.
	2	The extent of sales increase.
	3	The extent of improvement in return on investment (ROI).
	4	The extent of improvement of asset turnovers.

A Closed-Loop Recycling System with Minimum Allowed Quality Level on Returned Products

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Abstract
This paper deals with a closed-loop recycling system in which a stationary demand is satisfied by remanufactured products as well as newly manufactured products. In this system only those products that satisfy a minimum allowed quality level are bought back from customers for recycling purpose. Thus the collection rate of used products is expressed as a function of the quality level and unit bought-back price. Also, it is assumed that products are either manufactured or remanufactured in an EPQ setting. Treating the quality of recycled products as a random variable, we develop a mathematical model for a single remanufacturing and a single manufacturing run in a cycle with the objective of minimizing the production and inventory costs. Decision variables are the length of cycle, the minimum allowed quality level and the unit bought-back price of used products. To illustrate the validity of the model, example problems are solved.

Keywords: closed-loop recycling system, minimum allowed quality level, bought-back price

1. Introduction

The faster change in the customers' consuming behavior and decrease in product life cycles causes rapid product flows and faster generation of waste and exhaustion of natural resources (e.g., Beamon, 1999). Thus more attention is given to collection of used/returned products for remanufacturing purpose. The recycling system enables to reduce waste and conserve natural recourses. Additionally, economic value and social value can be added to the corporation by implementing recycling system. Imre Dobos and Knut Ritcher (2004) mentioned that reverse logistics manages backward process, i.e., the used and reusable parts and products return from the customers to the producers. Environmental consciousness forces companies to initiate such product recovery systems. In this way natural resources can be saved for the future generations, so the firms can contribute to the sustainable development efforts. This study analyzes a situation where the returned items are recycled so that the firm saves the mining of other natural resources with recycling.

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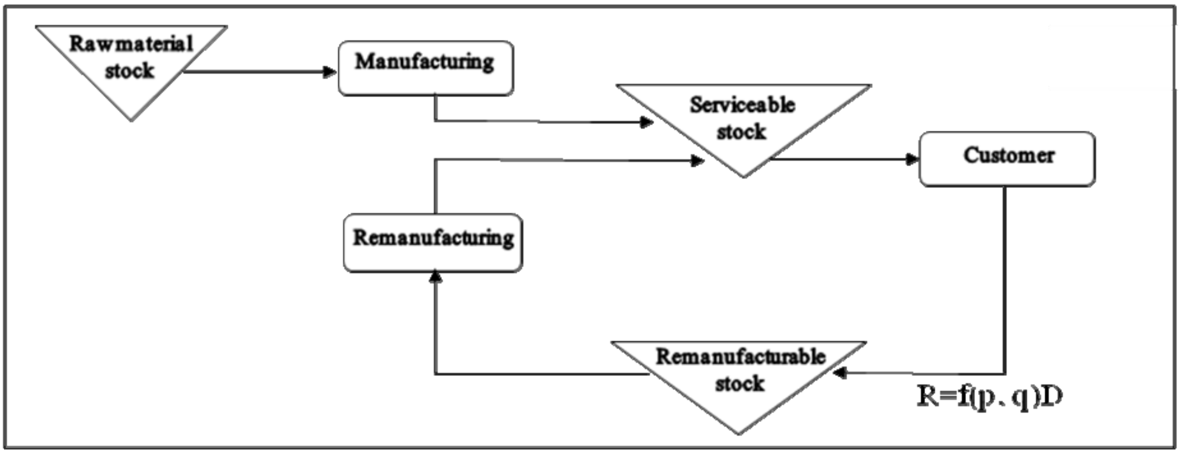


Figure 1. Flow in manufacturing and remanufacturing system

Figure 1 is the diagram of the problem we deal with. We propose a closed-loop recycling system which has manufacturing and remanufacturing process. Stationary demand is satisfied by manufacturing and remanufacturing process. The return rate of used products is assumed as a function of the quality level and unit bought-back price announced by company. Only those products that satisfy a minimum allowed quality level are bought back from customers for recycling purpose. But the quality of returned products varies and is treated as a random variable. Returned products are transferred to the remanufacturing process without disposal. The unit remanufacturing cost is assumed to be dependent on the quality of product returned. After the remanufacturing process, remanufactured products are stored in the serviceable stock. Since no shortage is allowed, new products have to be newly manufactured and stored in the serviceable stock to satisfy the market demand. For the manufacturing process, raw materials are purchased from outside in an EOQ setting. We assume a single manufacturing batch and a single remanufacturing batch per cycle. In this paper, the minimum allowed quality level, the unit bought-back price and the cycle length are determined through the development of mathematical models such that the average total cost per unit time is minimized.

2. Notations and Assumptions

The following notations and assumptions are introduced to develop the model.

Notations:

Decision variables:

T	Length of a manufacturing and remanufacturing cycle [time]
p	Price ratio of a single returned product relative to a new product ($0 \le p \le 1$)
q	The minimum allowed quality level ($0 \le q \le 1$)

Input parameters:

$a,\ \theta$	Parameters for the price function with $0 \le a \le 1$
$b,\ \Phi$	Parameters for the quality function with $0 \le b \le 1$
$c,\ \delta$	Parameters for the remanufacturing cost function
h_S	Holding cost per unit per unit time for serviceable stock [\$]/[unit][time]

h_R Holding cost per unit per unit time for recycled stock [$]/[unit][time]
h_{raw} Holding cost per unit per unit time for raw material stock [$]/[unit][time]
C_M Manufacturing cost per unit [$]/[unit]
$(1/\gamma)D$ Remanufacturing rate [unit]/[time]
$(1/\beta)D$ Manufacturing rate [unit]/[time]
S_R Remanufacturing setup cost [$]
S_M Manufacturing setup cost [$]
D Demand rate [unit]/[time]
p_n Selling price of single product to customer [$]/[unit]
C_{raw} Purchasing cost for raw material per unit [$]/[unit]
C_o Ordering cost for raw material [$]
parameters:
R The accepted quantity of returned products for remanufacturing [unit]/[time]
C_R Remanufacturing cost per unit [$]/[unit]
$H_{S,1}$ The average inventory cost for serviceable stock by manufactured products [$]/[time]
$H_{S,2}$ The average inventory cost for serviceable stock by remanufactured products [$]/[time]
H_R The average inventory cost for remanufacturable stock [$]/[time]
H_{raw} The average inventory cost for raw material [$]/[time]

Assumptions:

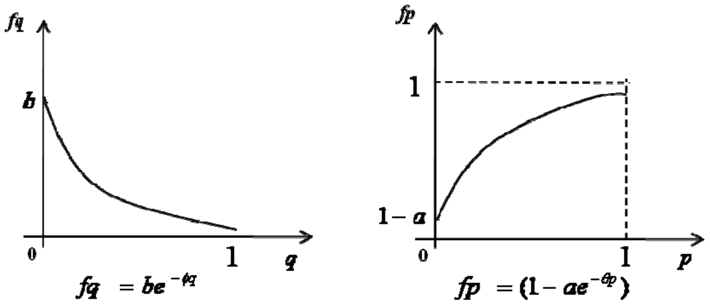
1) Demand is known and constant.
2) Return rate of the used products depends on the minimum allowed quality level and ratio of the bought-back price of a returned product to that of a new product.
3) The quality of returned products is uniformly distributed.
4) There is a no disposal with returned products, all of the returned products head to remanufacturing.
5) Unlimited storage capacity is available.
6) Unit remanufacturing cost is affected by the quality level of returned product.
7) Remanufacturing products are 'as-good-as-new'.
8) Raw material required for the remanufacturing of new products is purchased from outside in an EOQ setting.
9) A single remanufacturing and a single manufacturing run in a cycle.
10) No shortage is allowed.
11) Infinite planning horizon is considered.

3. Development of Mathematical Model

3.1. Return rate

The quantity R of returned products accepted for remanufacturing is assumed to be a function of price factor and quality factor. The return rate is a modified version of the demand function of Vörös (2002). It is further assumed that the two factors are independent each other. The quality factor explains the customer's behavior of returning used products against the minimum allowed quality level prescribed by the manufacturing company. The mathematical form of quality function is assumed to be f_q

= $be^{-\varphi q}$ as shown in figure 2. Likewise, the price factor indicates the customer's behavior of returning used products against the ratio of the bought-back price of a returned product to that of a new product. The mathematical form of quality function is assumed to be $f_p = (1-ae^{-\theta p})$ as shown in figure 2. Input parameter values, a, b, Φ and θ, can change the shape of the function. In this study, the return rate of used products is formulated as a function of the two factors and $R = R(p,q) = D(1-ae^{-\theta p})be^{-\varphi q}$.



(a) quality factor (b) Price factor

Figure 2. Factors affecting the return rate

3.2. Holding cost expression

Let T denote the cycle time of the system under study which is defined as the time interval between two adjacent points where the inventory level of returned products is zero. It is assumed that cycle consists of a single remanufacturing run of length T_R and single manufacturing run of length T_M . Thus $T = T_R + T_M$. We have three different inventory stocks in the system, remanufacturable stock, serviceable stock and raw material stock (Figure 3).

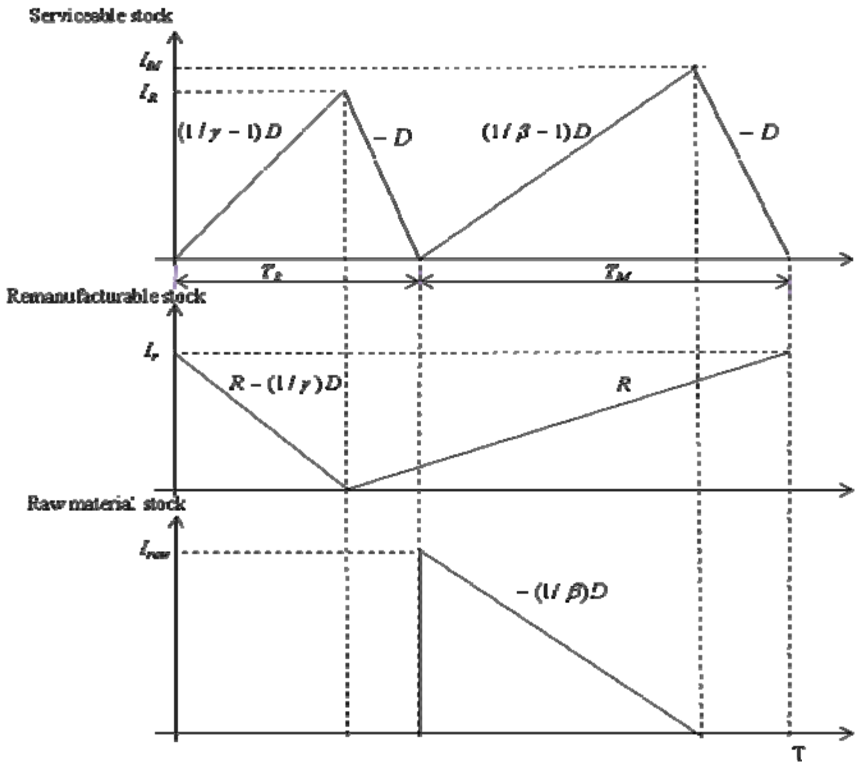


Figure 3. Inventory levels of three different stocks in the system

3.2.1. The average inventory cost of serviceable stock by manufactured products

The average inventory cost for serviceable stock by manufactured products is found as

$$H_{S,1} = h_s \times \frac{1}{2} \times T_M \times (1-\beta) D T_M \times \frac{1}{T} = \frac{1}{2} h_S \left(1 - \frac{R}{D}\right)^2 T(1-\beta) D$$
$$\text{where, } T_M = \frac{\{D-R\}}{D} T \tag{1}$$

3.2.2. The average inventory cost of serviceable stock by remanufactured products

The average inventory cost for serviceable stock by remanufactured products is determined as

$$H_{S,2} = h_s \times \frac{1}{2} \times T_R \times (1-\gamma) D T_R \times \frac{1}{T} = \frac{1}{2} h_s \left(\frac{R}{D}\right)^2 T(1-\gamma) D$$
$$\text{where, } T_R = \frac{R}{D} T \tag{2}$$

3.2.3. The average inventory cost of remanufacturable stock

The average inventory cost of remanufacturable stock is found as

$$H_R = h_R \times \frac{1}{2} \times T \times (T - \gamma T_R) \times Q_a \times \frac{1}{T} = \frac{1}{2} h_R T R \{1 - \gamma(\frac{R}{D})\}$$
$$\text{where, } T_R = \frac{R}{D} T \tag{3}$$

3.2.4. The average inventory cost for raw material stock

The average inventory cost for raw material stock is determined as

$$H_{raw} = h_{raw} \times \frac{1}{2} \times \beta T_M \times (\frac{1}{\beta}) D \beta T_M \times \frac{1}{T} = \frac{1}{2} h_{raw} T (1 - \frac{R}{D})^2 D\beta$$
$$\text{where, } T_M = \frac{\{D-R\}}{D} T \tag{4}$$

3.3. The average total cost

The average total cost has various cost terms and consists of the average inventory holding cost, average setup cost, average ordering cost, average remanufacturing cost, average manufacturing cost, average purchase cost and average buy-back cost.

Average inventory holding cost:
The average holding cost is the sum of the four inventory costs in equations (1) through (4).

$$\frac{1}{2}h_R TR\{1-\gamma(\frac{R}{D})\}+\frac{1}{2}h_s(\frac{R}{D})^2 T(1-\gamma)D$$
$$+\frac{1}{2}h_S\left(1-\frac{R}{D}\right)^2 T(1-\beta)D+\frac{1}{2}h_{raw}T(1-\frac{R}{D})^2 D\beta \tag{5}$$

Average setup cost

The average setup cost for remanufacturing and manufacturing batch is

$$\frac{S_R + S_M}{T} \tag{6}$$

Average ordering cost

The average ordering cost for raw material can be expressed as

$$\frac{C_O}{T} \tag{7}$$

Average remanufacturing cost

The average remanufacturing cost is the product of the expected remanufacturing cost and the number of returned products.

$$R\times E(C_R) \tag{8}$$

where, $C_R = ce^{-\delta x}$

$$E(C_R)=\int_q^1 \frac{ce^{-\delta x}}{1-q}dx=-\frac{c}{\delta}\cdot\frac{1}{1-q}\cdot\left(e^{-\delta}-e^{-\delta q}\right)$$

Average manufacturing cost

The average manufacturing cost equals the amount of demand that cannot be satisfied by remanufactured products multiply by the unit manufacturing cost as

$$(D-R)\times C_M \tag{9}$$

Average raw material cost

From equation (9), the average amount of raw material needed can be expressed as

$$(D-R)\times C_{raw} \tag{10}$$

Average buy-back cost

The buy-back cost occurs when the used products are purchased from customers equals

$$R\times p\times p_n \tag{11}$$

Now, the average total cost can be expressed as

$$TC(T,p,q)=\frac{S_R+S_M}{T}+\frac{C_O}{T}$$
$$+R\times E(C_R)+(D-R)\times C_M+R\times p\times p_n+(D-R)\times C_{raw}$$
$$+\frac{1}{2}h_R TR\{1-\gamma(\frac{R}{D})\}+\frac{1}{2}h_s(\frac{R}{D})^2 T(1-\gamma)D+\frac{1}{2}h_S\left(1-\frac{R}{D}\right)^2 T(1-\beta)D$$
$$+\frac{1}{2}h_{raw}T(1-\frac{R}{D})^2 D\beta \tag{12}$$

Suppose p and q are known. Then the first and second partial derivatives with respect to T become

$$\frac{\partial TC(T,q,p)}{\partial T} = -\frac{S_R + S_M}{T^2} - \frac{C_O}{T^2} + \frac{1}{2}h_S\{(\frac{R}{D})^2(1-\gamma)D + (1-\frac{R}{D})^2(1-\beta)D\} + \frac{1}{2}h_R R\{1-\gamma(\frac{R}{D})\} + \frac{1}{2}h_{raw}(1-\frac{R}{D})^2\beta D \tag{13}$$

$$\frac{\partial^2 TC(T,q,p)}{\partial T^2} = \frac{(S_R + S_M)}{T^3} + \frac{2C_O}{T^3} > 0 \tag{14}$$

Since S_R, S_M, C_O, and T are all positive, the value of the second derivative is greater than zero. Thus, TC is convex in T with known values of p and q. Consequently, setting the first partial derivative to zero and solving for T, we obtain the following optimum value of T.

$$T^* = \sqrt{\frac{2(S_R + S_M + C_O)}{h_S\{(\frac{R}{D})^2(1-\gamma)D + (1-\frac{R}{D})^2(1-\beta)D\} + h_R R\{1-\gamma(\frac{R}{D})\} + h_{raw}(1-\frac{R}{D})^2\beta D}} \tag{15}$$

In the model, we have three decision variables, real number T, real number p and q each of which is within the range of 0 to 1. We find that it is impossible to express the optimal values in closed form due to the mathematical complexity in the objective function. Thus a heuristic algorithm is developed based on the particle swarm optimization.

4. Solution procedure

4.1. Particle swarm optimization

Particle swarm optimization is a method for optimization of continuous nonlinear functions. Particle swarm optimization was introduced by James Kennedy and Russell Eberhart (1995). The method was discovered through simulation of a simplified social model. James Kennedy and Russell Eberhart (1995) were introduced this methodology using metaphor of bird flock and fish school. As we mentioned it is inspired by social behavior among individuals, these individuals (we call them particles) are moving throughout an n-dimensional search space, each particle stands for a potential solution of the problem, and the particles remember the best position (so1ution) it has reached before. All the particles can share their information about the search space, so they can obtain the global best solution. In each of iteration, every particle updates and calculates its velocity according to the given algorithm.

4.2. The proposed algorithm

We present the particle swarm optimization meta heuristic as follow:

Step1) *Initialize an array of particles with random positions and velocities on p-q dimensions.*
Step2) *Calculate the T*.*
Step3) *Calculate the TC for each particle on the search space.*
Step4) *Check stop criterion. If satisfy the criterion then stop. Else go to step5.*
Step5) *Update the pbest value of each particle and gbest value.*
Step6) *Update the position of each particle using pbest, gbest and previous velocity.*
Step7) *Go to step2.*

5. Numerical Experiments

The proposed algorithm is programmed in C++ language. The performance of the proposed heuristic is tested and compared with near-optimal solutions obtained by a grid search method. The numerical values of the parameters for the test problem are: h_S= 4, h_R=3, h_{raw}=1, C_M=30, S_R=5000, S_M=5000, D=1000, p_n=100, C_{raw}=20, C_O=1000, a=0.9, b=0.9, c=50, γ=0.6, β=0.5and δ=1. With three different values of θ and three different values of Φ, a total of nine cases were solved.

Table 1. Performance of proposed heuristic

		Solution by Particle Swarm Optimization (Number of particles=100)						
θ	Φ	p	q	T	Remanufacturing lot size	Manufacturing lot size	Total Cost	Computation time (second)
6	0.7	0.09	0.61	12.82	3787.14	9039.77	45508.99	<0.01
	1	0.08	0.37	12.88	3761.43	9128.02	46164.46	<0.01
	2	0.07	0.07	12.11	4111.35	7999.60	46701.09	<0.01
2	0.7	0.09	0.59	17.23	2558.42	14674.60	47862.42	<0.01
	1	0.07	0.31	17.21	2562.71	14647.92	48182.61	<0.01
	2	0.06	0.11	17.02	2599.64	14421.37	48483.73	<0.01
1	0.7	0.06	0.51	20.76	2009.24	18755.03	48534.51	<0.01
	1	0.04	0.20	20.42	2052.54	18376.30	48709.83	<0.01
	2	0.05	0.16	20.80	2003.82	18803.24	48976.82	<0.01

Table 2. Performance of grid-search algorithm

		Solution by Grid-search						
θ	Φ	p	q	T	Remanufacturing lot size	Manufacturing lot size	Total Cost	Computation time (second)
6	0.7	0.09	0.62	12.85	3777.37	9073.19	45508.91	69.89
	1	0.08	0.33	12.74	3819.65	8929.51	46160.18	68.64
	2	0.06	0	11.83	4255.94	7574.37	46560.67	69.04
2	0.7	0.09	0.62	17.29	2546.89	14746.49	47861.87	68.01
	1	0.07	0.31	17.23	2557.98	14677.33	48182.59	68.29
	2	0.05	0	16.15	2781.63	13372.43	48348.57	69.10
1	0.7	0.06	0.51	20.7	2009.26	18754.80	48534.51	67.60
	1	0.04	0.20	20.43	2052.18	18379.42	48709.83	67.76
	2	0.02	0	19.56	2170.97	17396.79	48756.49	68.56

As shown in the table 1 and 2, the computation time of particle swarm optimization is less than 0.01 second in all cases. However, the computation time of grid-search algorithm takes more than 1 minute.

Table 3. Gaps between PSO and grid-search

		Solution by PSO	Solution by Grid-search	Gap %
θ	Φ	Total Cost	Total Cost	100*(PSO-Grid)/Grid
6	0.7	45508.99	45508.91	0.0002%
	1	46164.46	46160.18	0.0930%
	2	46701.09	46560.67	0.3016%
2	0.7	47862.42	47861.87	0.0011%
	1	48182.61	48182.59	<0.0001%
	2	48483.73	48348.57	0.2796%
1	0.7	48534.51	48534.51	0%
	1	48709.83	48709.83	0%
	2	48976.82	48756.49	0.4519%

As shown in the table 3, the performance of particle swarm optimization based heuristic is as good as grid-search algorithm, i.e. the maximum difference to near optimal solution is 0.4519%. Consequently, the proposed algorithm gives near-optimal solution within a very short time.

6. Conclusions

This paper studies a closed-loop recycling system through the mathematical model where the stationary demand can be satisfied by remanufactured products and newly manufactured products. We introduce the concept of the minimum allowed quality level of returned items which has been of importance in real world situations but ignored in the literature. The return rate is formulated as a function of the quality level and unit bought-back price. Due to the complexity of the model, we develop a heuristic algorithm based on the particle swarm optimization to solve the model. The proposed algorithm is programmed in C++ language. To examine the performance of the proposed heuristic, the solutions are compared with near-optimal solutions obtained by grid search method. We find that the proposed algorithm generates the almost same results as grid search method taking almost no computing time.

Acknowledgments

This work was supported by the Korea Research Foundation Grant funded by the Korean Government (MOEHRD) (KRF-2007-313-D00909).

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Session 3

Supply Chain Network Design

Chair: Dr. Geon Cho

1. **A framework for managing supply chain flexibility using a neural network**
   Young Hae Lee, Hanyang University, Korea
   Jung Woo Jung, Hanyang University, Korea
   Dong Won Cho, Hanyang University, Korea

2. **Analytic network process for analyzing supply chain relationship**
   Taioun Kim, Kyungsung University, Korea
   Hokguan Jo, Kyungsung University, Korea

3. **Supply chain network for sustainable competitive advantages: case studies of global firms operating in greater Shanghai areas**
   Mingu Kang, Zhejiang University, China
   Xiaobo Wu, Zhejiang University, China
   Paul Hong, University of Toledo, USA

4. **An improved spatial scheduling algorithm for block assembly shop in shipbuilding company**
   Shiegheun Koh, Pukyong National University, Korea

A Framework for Managing Supply Chain Flexibility Using a Neural Network

Young Hae Lee*, Jung Woo Jung, and Dong Won Cho

Dept. of Industrial Engineering, Hanyang University, KOREA

Abstract

With the increasingly rapid globalization of markets and the everlasting needs of a diverse customer base, recent business environment is more fiercely competitive than ever before. In this situation, most business communities are recognizing that having competitiveness with the endeavour of only single company is no longer adequate; instead, it is emphasizing that all parties in the supply chain should continuously struggle together with enhanced cooperation. Despite of the importance of supply chain flexibility, there is scant attention paid to its research with the limited availability of its literature article. In particular, there is a lack of quantitative models for system level of performance measuring total flexibility for all parties in supply chain. Moreover, many researches ignored the relation between improved flexibility and its cost.

The object of this study is the development of a method for managing supply chain flexibility. Prior to treating supply chain flexibility, three unilateral measures were suggested for each company: time flexibility, quantity flexibility, and cash-flow flexibility. Then, supply chain flexibility was expressed as a weighted sum of the three unilateral measures. Neural network theory was used to find the relationship among the three unilateral measures and the profit-to-revenue ratios for all companies in the supply chain, and the resulting weights were used to develop a single measure of supply chain flexibility. This method can analyze the complex relationships among the different flexibilities for each company in the supply chain, and can overcome many of the drawbacks of previous measures, including the use of only after-the-fact measures to forecast a future profit-to-revenue ratio. Because cost factors are also considered in the supply chain flexibility measurement, excessive expenses in increasing flexibility can be avoided. Thus, this managing method can be expected to provide efficient management of flexibility of the supply chain.

Keywords: Supply chain, flexibility, neural network theory

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Analytic Network Process for Analyzing Supply Chain Relationship

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Abstract
In today's competitive and interrelated manufacturing environment, companies should deal with complex problems related to the supply chain (SC), because it focuses on material, money, information flows from vendor to customer and its reverse flow at the same time. The criteria related to the supply chain performance are interrelated with each other. In analyzing the performance of SC relationship and inter-dependence, Analytic Network Process (ANP) can be well suited. ANP which is an extension of AHP (Analytic Hierarchy Process), is a systematic approach that can deal with both hierarchical criteria and their dependencies.
In this paper, a framework of supply chain performance is proposed based on both AHP and ANP format. Multi-criteria decision structures are constructed with hierarchy and dependency. A super-matrix is defined and solved following the proposed steps. ANP-based model is applied for decision making in prioritizing the alternatives for the improvement of SC performance.

Keywords: ANP (Analytic Network Process), AHP, SCM, SC performance

1. Introduction

Supply chain management (SCM) is an approach to satisfy the demands of customers for the products and services via integrated management in the whole business processes, in terms of material flow, fund flow and information flow, from raw material procurement to the product or service delivery to customers. Recently, much attention has been focused on the reverse logistics because of environmental problems.
The immediate target of SCM is to increase productivity and reduce the entire inventory and the total cycle time. But, the ultimate goal of SCM is to increase profit, customer satisfaction and market share along with all the chains of SCM.
In the SCM, the supplier selection is an important issue. There are many methods in supplier selection. They are case based reasoning systems, statistical models, decision supports systems, data envelopment analysis, AHP (Analytic Hierarchy Process), artificial intelligence, or mathematical programming. For supplier selection, 23 criteria are identified from a survey of 273 purchasing manager. Quality, delivery and performance history were perceived as the most important criteria (Talluri and Narasimhan, 2003).
AHP has been widely used in the domain of SCM. Lee et al. (2001) suggested quality, cost, delivery and service as decision criteria in applying AHP for the supplier selection.

* Corresponding Author

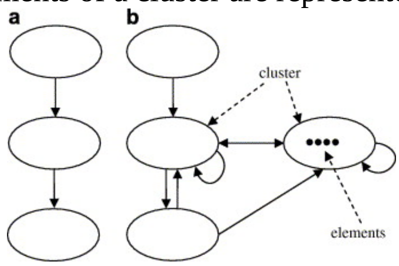
Christopher and Towill (2000) proposed quality, cost, lead-time and service level as a SCM performance measure. They classified quality, cost and lead-time as a market qualifier, and service level as a market winner. AHP is a clear and simple method for multi-attribute decision making. However, independence is assumed among the decision attributes in the hierarchy. Saaty proposed an ANP (Analytic Network Process) as a more general form of AHP (Saaty, 2001; 2005). An ANP incorporates feedback and interdependent relationships among decision attributes and alternatives.

The purpose of this paper is to propose an ANP framework for analyzing SCM relationships. Section two addresses the nature of ANP and its characteristics. Section three suggests steps for analyzing SCM relation using ANP. Also, implementation is performed according to the steps. Last section addresses conclusions and discussion.

2. Analytic Network Process

The basic assumption of AHP is the condition of functional independence of the upper part, or cluster, of the hierarchy, from all its lower parts, and from the criteria or items in each level. Saaty suggested the use of AHP to solve the problem of independence among alternatives or criteria, and the use of ANP to solve the problem of dependence among alternatives or criteria. Strategic decisions in SC intelligence using ANP was dealt in Raisinghani, and Meade (2005). A comparison of AHP and ANP in the SCM is proposed in Nakagawa and Sekitani (2004). Yuksel and Dagdeviren (2007) adopted ANP in SWOT analysis for a textile firm case. Applying an ANP for the supplier selection in an electronic firm is given in Gencer and Gurpinar (2007).

The structural difference between AHP and ANP is illustrated in Figure 1. A hierarchy has a goal or a source node or cluster. It also has a sink node or cluster representing the alternatives of the decision. Unlike a hierarchy, a network spread out in all directions and its clusters of elements are not arranged in a particular order. Nodes of the network represent components of the system; arcs denote interaction between them, where the directions of arcs signify directional dependence. For example, X ->Y means that the elements of a component Y depends on component X. Interdependency between two clusters, termed outer dependence, is represented by a two-way arrow. Inner dependencies among the elements of a cluster are represented by looped arcs.



(a) a hierarchy (b) a network

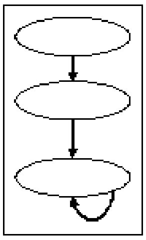
Figure 1. Structural difference between a hierarchy and a network

Assume that there is a system of N clusters or components, where the elements in each component interact or have an impact on the other elements. The component h, denoted by C_h, h = 1,….,N, has n_h elements, that are represented by e_{h1}, e_{h2}, …, e_{hnk}. A priority vector derived from paired comparisons in a usual way represents the impacts of a given set of elements in a component on another element in the system. When an element has no influence on another element, its influence priority is assigned as zero. A supermatrix is composed of the priority vectors derived from pairwise comparison matrices. An example of supermatrix is shown in Figure 2. The Components C_i alongside the supermatrix include all the priority vectors derived for nodes that are parent nodes in the C_i cluster.

$$
\begin{array}{ccc}
 & & \begin{array}{ccc} C_1 & C_2 & C_N \\ e11\ e12\ ..\ e1N1 & e21\ e22\ ..\ e2N2 & eN1\ eN2\ ..\ eNnN \end{array} \\
W = & \begin{array}{cc} C_1 & \begin{array}{c} e11 \\ e12 \\ . \\ e1n1 \end{array} \\ . & \\ C_2 & \begin{array}{c} e21 \\ e22 \\ e2n2 \end{array} \\ . & \\ C_N & \begin{array}{c} eN1 \\ eN2 \\ . \\ eNnN \end{array} \end{array} & \begin{bmatrix} W_{11} & W_{12} & W_{1N} \\ W_{21} & W_{22} & W_{2N} \\ \vdots & \vdots & \vdots \\ W_{N1} & W_{N2} & W_{NN} \end{bmatrix}
\end{array}
$$

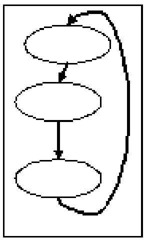
Figure 2. Supermatrix of ANP (Source: Saaty, 2005)

Hierarchy assumes feedback or interaction. It follows one-way direction. The entry in the last row and column in the supermatirx is the Identity matrix I as shown in Figure 3(a). Holarchy is a hierarchy with feedback loop. The priority at top level element is determined in terms of the elements at the bottom level. Figure 3 shows supermatrix structure of hierarchy and holarchy.



$$
W = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ W_{21} & 0 & 0 & 0 & 0 & 0 \\ 0 & W_{32} & 0 & 0 & 0 & 0 \\ \cdots\cdots & & & & & \\ 0 & 0 & 0 & 0 & W_{n,n-1} & I \end{bmatrix}
$$

(a) Hierarchy structure of supermatrix



$$
W = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & W_{1n} \\ W_{21} & 0 & 0 & 0 & 0 & 0 \\ 0 & W_{32} & 0 & 0 & 0 & 0 \\ \cdots\cdots & & & & & \\ 0 & 0 & 0 & 0 & W_{n,n-1} & 0 \end{bmatrix}
$$

(b) Holarchy structure of supermatrix

Figure 3. Supermatrix comparison (Hierarchy and Holarchy)

3. ANP Steps for SC relationship analysis

Steps for implementing ANP model are proposed as six or seven steps according to the authors. The following Table 1 summarizes various steps suggested in the literatures.

Table 1. Steps for implementing ANP

Step	Gencer and Gurpinar (2007)	(1) Agarwal and Shankar (2002) (2) Agarwal, Shankar and Tiwari (2006)	Yuksel and Dagdeviren (2007)	This paper (Kim and Ho (2008))
Goal	Supplier selection in electronic firm	(1) SC performance index (2) Modeling performance of lean, agile and leagile SC	Strategy for SWOT analysis	SC relationship analysis
1	Analyze supplier selection problem	Model construction and problem structuring	Convert into hierarchical structure	Problem definition and hierarchy analysis
2	Find three main criteria and sub-criteria.	Pairwise comparison matrices between component/attribute levels	Pairwise comparison of the SWOT factors	ANP model construction
3	Determine alternatives.	Pairwise comparison matrices of inter-dependencies	Determine inner dependence among the SWOT factors	Supermatrix formation
4	Determine the interactions between and within clusters and elements.	Supermatrix formation and analysis	Calculate the inner-dependent priorities of the SWOT factors	Find eigen vectors from pairwise comparison
5	Construct the supermatrix.	Selection of best alternative	Calculate the local priorities of the SWOT sub-factors	Fill in supermatrix with unweighted
6	Change the unweighted supermatrix into weighted one.	Calculation of SC performance weighted index	Calculate the overall priorities of the SWOT sub-factors	Find the steady state of the supermatrix

7	Make the supermatrix as a steady state by multiplying by itself.		Calculate the importance degrees of the alternative strategies	Result analysis
8	-	-	Calculate the overall priorities of the alternative strategies	-

Step 1. Problem definition and hierarchy analysis

The first step is to define the problem and analyze the hierarchy of the problem. In this step, decision criteria are identified and their relationships are analyzed. For the SCM performance, material/money, information/flow and reverse logistics are adopted as main decision criteria. As sub-criteria for material/money, cost, quality and new product development are suggested. As sub-criteria for information/flow, web-based system, customer responsiveness and collaboration are adopted. As sub-criteria for reverse logistics, green design, return channel and law/regulations are assumed. For the performance index, production/investment, knowledge and environment are assumed. The concepts of economy of scale/scope, economy of expert and economy of sustainability correspond to the three indices respectively. Figure 4 shows the hierarchy of decision variables for SCM performance.

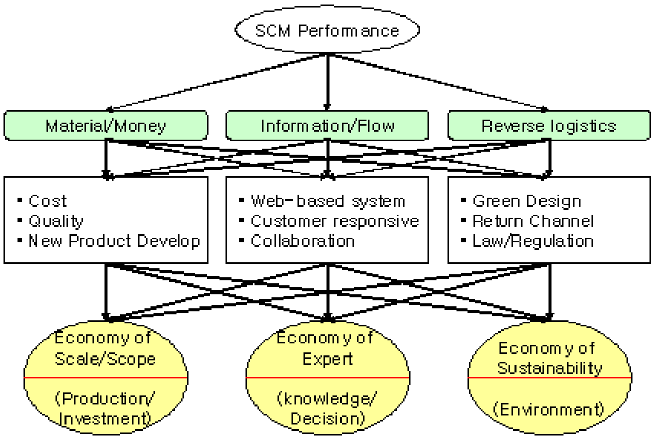


Figure 4. Decision Variables for SCM performance

Step 2. ANP model construction

In step 2, ANP model is constructed considering the dependency and inter-relationship. In this step, the interactions between and within clusters and elements are determined. The ANP model with its control hierarchy is provided in Figure 5.

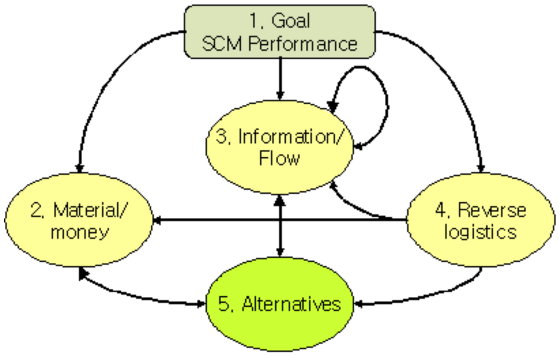


Figure 5. ANP control hierarchy for SCM performance

Step 3. Supermatrix formation

Supermatrix is constructed according to the ANP model built in step 2. The supermatrix structure which follows the same structure given in Figure 2 is shown as Figure 6. The detailed version of the supermatrix is given in Table 1. In the supermatrix, Wij means the sub-matrices in which cluster i depends on cluster j.

$$W = \begin{array}{cc} & \begin{matrix} M & I & R & A \end{matrix} \\ \begin{matrix} M \\ I \\ R \\ A \end{matrix} & \begin{bmatrix} 0 & 0 & W13 & W14 \\ 0 & W22 & W23 & W24 \\ 0 & 0 & 0 & W34 \\ W41 & W42 & W43 & 0 \end{bmatrix} \end{array}$$

Figure 6. Supermatrix for SCM performance
(M: Material/Money, I: Information, R: Reverse logistics, A: Alternative)

Step 4. Find eigen vectors from pairwise comparison

For each cluster, eigen vector (e-vector) is calculated from a pairwise comparison. Table 2 illustrates criteria weights of three alternatives with respect to the cost in material/money criterion. For all columns except the zero elements, e-vector is calculated.

Table 2. Criteria (material) weights with respect to the goal

MM (cost)	Production	Knowledge	Environment	e-vector
Production	1	3	3	0.60
Knowledge	.33	1	1	0.20
Environment	.33	1	1	0.20

Step 5. Fill in supermatrix with unweighted one

Using the eigen vectors from the pairwise comparison for each criteria, the cell of supermatrix is constructed as Table 3. The cells with zero correspond to those clusters which do not have interactions with each other.

Each column consists of several clusters. In each cluster, the sum of e-vector sums to 1. Thus, the sum of all values in each column may exceed 1. For each column, normalize the value in the same column that column-sum is 1 (named "column-stochastic"). Table 4 shows the normalized supermatrix

Table 3. Unweighted supermatrix for SCM performance using ANP

		Material			Information			Reverse			Alternative		
		CO	QU	NP	WB	CR	CL	GD	RC	LR	PR	KN	EN
Material	CO							0.11	0.12	0.57	0.33	0.64	0.58
	QU		0			0		0.31	0.32	0.10	0.53	0.26	0.31
	NP							0.58	0.56	0.33	0.14	0.10	0.11
Information	WB				0.11	0.26	0.30	0.64	0.56	0.53	0.54	0.58	0.48
	CR		0		0.31	0.10	0.54	0.26	0.32	0.33	0.30	0.31	0.17
	CL				0.58	0.64	0.16	0.10	0.12	0.14	0.16	0.11	0.35
Reverse	GD										0.10	0.07	0.12
	RC		0			0			0		0.26	0.28	0.32
	LR										0.64	0.65	0.56
Alternatice	PR	0.60	0.12	0.11	0.64	0.57	0.63	0.57	0.63	0.69			
	KN	0.20	0.32	0.31	0.10	0.10	0.14	0.32	0.28	0.24		0	
	EN	0.20	0.56	0.58	0.26	0.33	0.24	0.11	0.09	0.07			

Table 4. Normalized supermatrix for SCM performance using ANP

		Material			Information			Reverse			Alternative		
		CO	QU	NP	WB	CR	CL	GD	RC	LR	PR	KN	EN
Material	CO							0.04	0.04	0.19	0.11	0.21	0.19
	QU		0			0		0.10	0.11	0.03	0.18	0.09	0.10
	NP							0.19	0.19	0.11	0.05	0.03	0.04
Information	WB				0.05	0.13	0.15	0.21	0.19	0.18	0.18	0.19	0.16
	CR		0		0.15	0.05	0.27	0.09	0.11	0.11	0.10	0.10	0.06
	CL				0.29	0.32	0.08	0.03	0.04	0.05	0.05	0.04	0.12
Reverse	GD										0.03	0.02	0.04
	RC		0			0			0		0.09	0.09	0.11
	LR										0.21	0.22	0.19
Alternatice	PR	0.60	0.12	0.11	0.32	0.28	0.31	0.19	0.21	0.23			
	KN	0.20	0.32	0.31	0.05	0.05	0.07	0.11	0.09	0.08		0	
	EN	0.20	0.56	0.58	0.13	0.17	0.12	0.04	0.03	0.02			

Step 6. Find the steady state of the supermatrix

The supermatrix which is constructed in step 5 is an unweighted one. Each column consists of eigenvectors. The element in the supermatrix is a column stochastic which means the sum of a column sums to one. The unweighted supermatrix is multiplied by the priority weights from the clusters, which yields the weighted supermatrix. By multiplying the weighted supermatrix by itself until the supermatrix's row values converge to the same value for each column of the matrix, the steady state is obtained. Table 5 represents supermatrix in a steady state. All the column values converge to a same value.

Table 5. Supermatrix for SCM performance with a steady state in 16th iteration

		Material			Information			Reverse			Alternative		
		CO	QU	NP	WB	CR	CL	GD	RC	LR	PR	KN	EN
Material	CO	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
	QU	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
	NP	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Information	WB	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
	CR	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
	CL	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Reverse	GD	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	RC	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
	LR	0.08	0.08	0.08	0.08	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Alternative	PR	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
	KN	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
	EN	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11

Step 7. Result analysis

The result is analyzed and suggestions can be found. From the steady state data of the supermatrix, the alternative with the highest priority can be chosen as the most important alternative for the SCM performance measure. Table 5 represents the steady state of supermatrix in 16th iteration. Among the alternative, PR gives the highest priority, and then EN and KN order. This corresponds to the priority sequence of economy of scale/scope, economy of sustainability and economy of expertise.

4. Conclusion

In the SCM, several attributes are combined and interrelated with each other for the optimal decision making problem. In the past, AHP model has been adopted for the hierarchical and multiple criteria decision problem. But in the AHP, independence among criteria is assumed. AHP model allows the dependency and interrelationship among decision variables.

In this paper, an ANP model is adopted and applied for the SCM performance analysis. Three attributes which are material/money, information/flow and reverse logistics are assumed for the analysis. As performance indices, production/investment, knowledge and environment are adopted. Three performance indices correspond to economy of scale/scope, economy of expert and economy of sustainability respectively. An ANP-based framework is proposed to solve the SCM performance. A supermatrix is constructed using the priority vectors. The priority vectors are the principal eigenvectors of the pairwise comparison matrices.

Future research is needed by changing the structure of SCM hierarchy. Also, by changing ANP control hierarchy, the result can be compared with the original one. The sensitivity can be tested according to the modified structure.

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Supply Chain Network for Sustainable Competitive Advantages: Case Studies of Global Firms Operating in Greater Shanghai Areas

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Abstract
Increasingly, global supply chain network is becoming an essential feature of competitive firms. This global network is based on core competencies of the focal firm and complementary strengths of network participants. Sustaining such global network requires integration of strategic alliances and outsourcing practices that carefully considers the competitive contexts.
This paper examines the supply chain network formation and implementation of global firms that are currently operating in Greater Shanghai Areas. A model presents key variables that indicate their strategic priorities, process practices and outcome measures. It also suggests unique aspects of their Chinese operations in supporting their global network of businesses.
Case studies include global firms from Switzerland, Korea and USA. Their annual sales are up to 100 million ($). Particular attentions are paid in their outsourcing, manufacturing and logistical networks. We also examine how these firms anticipate their strategic opportunities and challenges and prepare in the contexts of changing market dynamics in view of 2008 Beijing Olympics and Shanghai World Trade Shows.

Keywords: Global supply chain network; sustainable competitive advantages; Outsourcing practices; Case Studies of Global firms in China.

1. Introduction

Increasingly, global supply chain network is becoming an essential feature of competitive firms. This global network is based on core competencies of the focal firm and complementary strengths of network participants (Stack, et al., 2005; Youngdahl, et al., 2008). Sustaining such global network requires integration of strategic alliances and outsourcing practices that carefully considers the competitive contexts (Weidenbaum, 2005).
This paper examines the supply chain network formation and implementation of firms that are currently operating in Greater Shanghai Areas. A model presents key variables

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that indicate their strategic priorities, process practices and outcome measures. It also suggests unique aspects of their Chinese operations in supporting their global network of businesses.

2. Conceptual Background

2.1. Growing Chinese Market

China has grown both in supply and demand aspects. China has offered low cost manufacturing and rich supply network base for global firms. With increasing Chinese middle and upper class, Chinese market also provided a huge potential for premium brands.

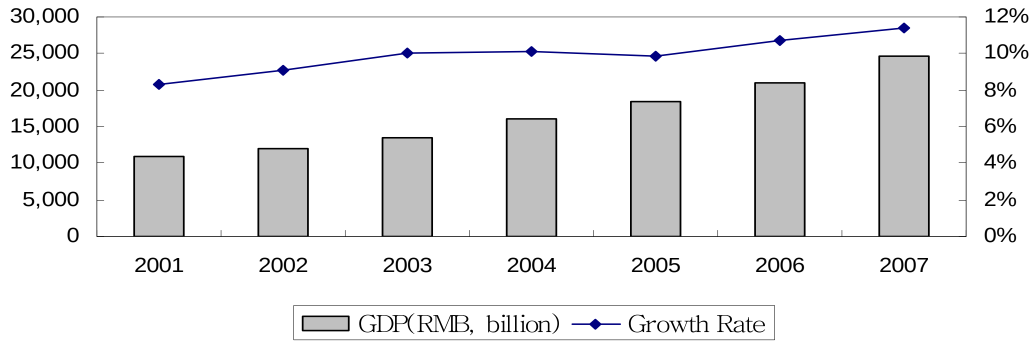

Figure 1. GDP Growth of China (2001–2007)
(Source: National Bureau of Statistics of China)

Figure 1 shows that the average annual GDP growth rate of China for the past seven years is 9.9%. Continuous expansion of privately-held firms and massive inflows of foreign direct investment Chinese economic growth sustained such high rate of economic growth. Recently, service sector is also becoming the engine of growth of the economy. For example, according to the statistical report of the City of Shanghai service sectors contribute to the 51.9% of the regional economic growth and 13% of annual growth is reported in 2007. High impact growth occurs in financial and banking, IT and logistical services.

2.2. Growth of Middle and Upper Middle Class (Size and location)

With sustained economic growth the size of middle class in China has also rapidly increased. Such impressive expansion contributed to the social stability and the formation of huge consumer market. These growing Chinese middle class people are the engine of growth (ZhangJing, 2007). According to Chinese Brand Strategy Association potential size of consumers that purchase high brand products is 100.006 millions that is about 13% of the total population. This suggests that China has the third largest consumer market in the world next to Japan and USA. Ernst & Young Survey Report predicts that by 2010, brand product consumers will increase up to 200.005

millions and by 2015 the rate of increase will be 29% more and therefore China will have second largest consumer market in the world.
Chinese major market and production clusters are Changjiang Delta and Zhujiang Delta and Bohai Area that covers Beijing and Tenjn. By 2007 these three cluster areas will produce 35% of Chinese GDP.

3. Supply Chain Network Competitive Advantages in China

Chinese market presents unique features for both Chinese firms and other global firms that operate in China. Both global firms (i.e., foreign firms that operate in China with multiple networks of operations across national borders) and Chinese firms need to be at minimum cost-effective, market competitive and strategically positioning in the rapidly growing and highly competitive Chinese market. It is essential for all these firms to either integrate their supply chain network on their own (i.e., vertical integration) or utilize supply chains through effective outsourcing.
Figure 2 indicates that supply chain network capabilities of firm impacts the business performance. However, two important drivers of the content and the nature of supply chain network capabilities are market reality and strategic priorities. Chinese market suggest unique context for global firms that operate in China. For the purpose of this paper global firms refer to firms that engage in their businesses more than its original nations but spread out to the world with their global products that are demanded in the diverse segments of customers.

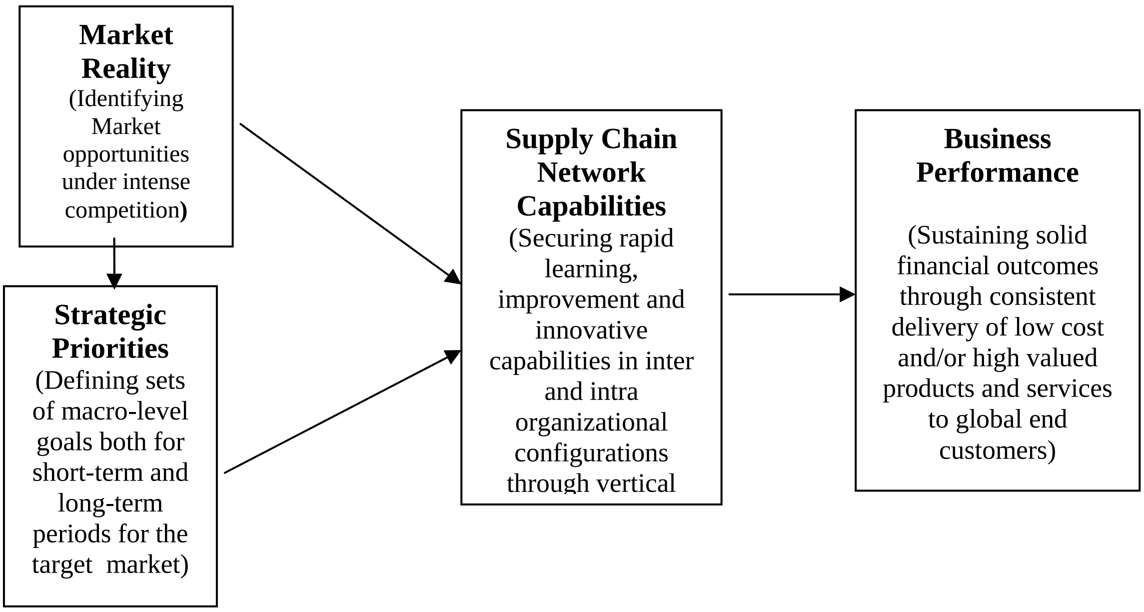

Figure 2: Research Framework

4. Case Illustrations

Based on the structured interview questions we contacted the executives of four firms and conducted both personal and telephone interviews.

Changjiang Delta Area in the greater Shanghai is regarded as the center of Chinese economic activities. Total economic output from Changjiang Delta areas (that include 16 cities within 300 km radius away from Shanghai) is 18.9% of the entire Gross Domestic Product (GDP) of China. With the rapid formation of sizable middle class China has transformed into a huge market with great potential for growth. It is noted that in this context many global firms strive to penetrate into this growing Chinese market.

E-Land is a Korean fashion clothing firm. It has successfully marketed middle to upper level casual brand in Korea. From its beginning its key functional strategy was clear--production through outsourcing and marketing through franchise style promotion. Its corporate function has consistently maintained the core competencies in terms of strategic planning, merchandising, and design. Its business strategy focus was sustainable competitive advantage through differentiation. In 1994 E-Land started its marketing effort in China. Different from Korea, its strategy in China was to premium brand strategy. Currently, E-Land has introduced 15 different brands of products. Its operation network extends to 150 cities and 500 department stores in China. It has 1,700 direct sales outlets. The entire production is done through outsourcing. It secures raw materials through direct sourcing (i.e., massive purchasing of quality materials at low cost) and provide to its suppliers. It also directly involves in quality management processes of its suppliers and assures high premium brand images.

Since its inception in 1998 Dongkwang International has rapidly grown as a fashion clothing merchandiser with the annual sales of $100 millions in 2007. Including China it has branches in four different regions of China. Its outsourcing is primarily in production. It does not maintain its own manufacturing facilities. Instead, the corporate offices in Korea closely collaborate with Chinese suppliers in all aspects of business processes including front-end product development and final commercialization processes. Dongkwang implements its selection criteria of suppliers in China very carefully. All suppliers are small and medium sized firms with 200-300 employees. All suppliers have essential functional capabilities in design, production, and marketing and yet not large and competitive enough to market its own products independently. In this way, based on highly collaborative relationships Dongkwang utilizes the benefits of outsourcing and still high level of quality management control on its small and medium suppliers. In this way, Dongkwang has maintained its competitive advantages in terms of cost, flexibility, delivery and customer value. By effectively utilizing its Chinese supplier base Dongkwang has successfully secure its market position both in Korea and China.

Swatch is the largest watch maker in the world. Based on its 157 processing facilities in Switzerland it has successfully marketed 20 different brands in the global market over the years. In May 2000, it started its operation in Shanghai, China. In a very short period sales volumes in China were the second largest among its global group sales. Its 15 different brands target all market segments. Its low cost brands are sold at $30-50 while high premium jewelry brands are marketed in the range of $15,000 to $80,000. With the rapid growth of sizable upper middle class, such brands are successfully marketed in China. Swatch successfully combines its diverse global capabilities. Its core competencies in new product development and brand power are derived from its Switzerland corporate operations while trade functions in China (particularly export functions and tariff regulations) are handled through outsourcing. Its distribution channel is through strategic partnership with local wholesale merchandisers which handles about 90% of the total sales in China and only 10% of sales are through its fully owned sales outlets. In this way, Swatch minimizes the risks related to market changes through wholesale merchandising and at the same time enhances the benefits of direct marketing and service efforts through its own outlets.

Ault has grown as a vertically integrated firm that does product development, production, and marketing of AC-DC Converter in USA. With its rapidly losing its competitiveness with high cost of manufacturing in USA, in 1987 Ault built its first factory in Korea. With its own manufacturing and started offshore insourcing Ault's USA corporate functions focused on strategic management and product development. It also streamlined its organizational structures to be flexible and efficient. Through Ault Korea it strengthened its cost competitiveness through better management of purchasing and production functions. In 1990s it started manufacturing operations in a city nearby Beijing China. In Shanghai it formed a corporation for marketing management and product development.

In its early stage of Chinese operations, Ault China focused on assembly functions with the semi-finished work-in-process from Korean operations. Gradually, through its Shanghai Corporation Ault China received raw materials from China and secured its cost competitiveness and established speed delivery system. Besides, Ault China entirely outsourced its non-core operations (e.g., trans, linear adapter) and focused instead on manufacturing of high premium value products. In this way Ault China achieved core competitive strengths through high level of collaboration among its suppliers and strived to maintain complementary strategic alliances. Ault China has developed solid local supplier base for the acquisition of component parts for the Chinese domestic market, cost reduction through outsourcing, responsive supply chain structures for flexible delivery, product development and commercialization of high premium brand products. Its complete set offerings of AC DC converter are applicable for diverse electronic products. However, because of ease entry this market is extremely crowded. Ault could survive in this extremely competitive environment only because it has constantly adapted to changing market reality through enhancing its core competitiveness through sustained strategic development and persistent innovation. Table 1 is a brief summary of the above four firms as described above.

Table 1: Summary of Four Firms

Name	Products	Corporate Offices	Year of Entry to China	Main Supply Chain Activities in China	Outsourcing in China
E Land	Fashion Clothing	Korea	1994	Production Outsourcing and marketing	Production
Dongkwang	Fashion Clothing	Korea	2000	Production outsourcing	Production
Swatch-China	Watches	Switzerland	2000	Import, marketing and distribution	Import, marketing and human resource
Ault-China	AC-DC Converter	USA	1997	Purchasing, production, new product development and exporting	Production

5. Outsourcing Management Matrix

The decisions to either vertically integrate or horizontally connect through outsourcings depend on their risk management and market positioning strategies. Table 2 summarizes the four patterns of how firms may manage their risks in response to the two profit impact possibilities: low and high.

Table 2: Outsourcing Management and Market Positioning Matrix (Adapted from Gelderman and Semeijin, 2006)

Profit Impact	Outsourcing Risk	
	Low	High
High	Leverage products and services exploit market penetration and expansion in China.	Strategic products and services form partnership for long-term market position in China
Low	Non-critical products and services ensure efficient cost strategy in China	Bottleneck products and services assure supply advantages through outsourcing in China

6. Patterns of Outsourcing Strategies

Figure 3 shows the typology of outsourcing strategies. Outsourcing strategies are based on two parameters: (1) strategic focus (i.e., low cost by operational efficiencies or differentiation by premium value); (2) level of outsourcing (high or low). Four types of outsourcing strategies are: (1) service and logistics offerings for low cost strategy products and services with high level of outsourcing of their major components; (2) leverage core competencies through low cost products with vertical integration (with low level of outsourcing); (3) virtual network firms with high level of premium value products through outsourcing network arrangements; (40 strategic competitive positioning through premium value products with high level of vertical integration and low level of outsourcing.

Level of Outsourcing	Low Cost	Premium Value
Low	Leverage Core Competencies (e.g., Swatch Cost Brands)	Strategic Competitive Positioning (e.g., Swatch-Premium)
High	Economies of Scale Product Offerings (E-Land Korea for Cost Brands; Ault-China)	Virtual Network Product Offerings (E-Land China; Dongkwang)

Figure 3: A typology of Outsourcing Strategies

The above outsourcing patterns are effective responses to the growing problems that global firms face in China. Not all global firms become successful in Chinese market. It is quite challenging for global firms to establish successful outsourcing network with Chinese suppliers (particularly small and medium enterprises that may not have quality management practices and his service capabilities. It is more challenging to develop long-term relationships with high performing Chinese suppliers without seeing them moving on to develop their own brands of products or increasingly demanding more management control and high cost/revenue sharing.

E-Land (EL)' production of the products for Chinese market is 100% outsourcing in China. Production for Korean market is 50% of outsourcing in China. The typical problems for global firms that do outsourcing in China are trust issues in terms of quality and delivery. To resolve these problems E Land manage contracts with their outsourcing suppliers in strictly tested contract terms, conduct post purchase follow-up and adopt systematic evaluations. By utilizing production and quality control teams at the factory floor level E Land ensures high quality management. E Land does not sourcing through many diverse small raw materials suppliers. Rather, E-land chooses direct sourcing to its OEM factories from the very front line raw material producers. In this way E Land sustain high cost competitiveness and excellent quality reputation with their customers.

Thus, as shown in Figure 2 E Land adopt low cost strategy through high level of outsourcing in China. In this way, E Land sustains its competitive advantages with low cost and high volume flexibility. E Land also maintains diverse product lines by seasons, brands and product order volumes. This is by adopting premium value strategies with high level of outsourcing. This is an example of virtual network product offerings.

Dongkwang (DK) selects small and medium enterprises as their outsourcing partners. With its relative advantage in negotiation power DK does not mainly dominate but manage and support its suppliers to maintain high level of design, sales and distribution capabilities. In this way, DK market premium brands of products to diverse market segments at massive volumes. These small and medium outsourcing suppliers are highly capable, reliable partners and they behave like their own factories. DK effectively manages deep business relationships with its outsourcing suppliers that fulfill multiple customer requirements in terms of time, cost and delivery and product innovativeness. Through its high quality relationships with its suppliers DK could capture major Korean market.

Swatch (SH) entrusts import, tax, consulting and human resource management to highly specialize Chinese local firms. By utilizing their expert knowledge and relational competencies SH enhances productivity (cost reduction) and excellent risk management for changing market conditions. SH has contracted with the largest Chinese wholesale distributors and utilizes the existing well-established national distribution network. In view of high professional nature of expert relationships its inter-organizational structure is horizontal and equal level of relationships. In this way, SH has achieved rapid business growth while building brand images among Chinese growing middle and upper class consumers. SH offers both low priced watches and high premium watches in two opposite market elements. SH also maintain low level of outsourcing because of the utilization of its own factories.

The initial labor cost of Ault China (AC) was 1/10th of its labor cost in Ault Korea (AK). However, by bringing 100% of raw materials from Korea it was not possible for AC to be competitive in terms of price advantages or speed for customers. Because of its complex nature of products AC had to maintain inventories for more than 5,000 raw materials component parts and supply chain issues between AC and AK were quite frequent and serious.

To resolve these issues AC started localization of its component parts by organizing purchase teams and engineer teams. Direct sourcing was from electronic component suppliers in Hwadong areas. Within one year AC could purchase almost all of their component parts from Chinese suppliers. In this way AC secured all the component parts through 100% outsourcing suppliers. In this way AC maintained high level of outsourcing and low cost AC-DC Converter production. In case of linear adapter its cost structure was not competitive enough to keep its complete assembly product lines. By discontinuing its own production in Hyangha AC chose 10% outsourcing strategy. In this way AC could secure mass production of its low cost and high quality products.

6. Discussion and conclusion

Business environment in China is becoming more challenging and difficult. In China, appreciation pressures for RMB (Chinese monetary unit), government demands of improving human resource conditions, price hikes of raw materials, intense competition, and value added taxes, and tax law changes it is no longer possible to compete based on cost reduction in manufacturing or outsourcing. Emerging trends are strategic outsourcing with portfolio management (Belcourt,2006l McIvor, 2008).

This paper provides Chinese business contexts with the particular focus on strategic outsourcing. This research model is useful to analyze the patterns of outsourcing in China. The case illustrations present how global firms successfully determines the level of outsourcing in view of their product and market segment characteristics. Outsourcing strategies discussed in this paper suggest that increasingly global firms that locate in China become sophisticated in terms of complex configurations of their competencies through diverse sets of outsourcing with small and medium size suppliers (Arbores and Ordanini, 2006). In view of rapidly emerging Chinese middle and upper consumers and vast majority of low cost conscious Chinese customers strategic outsourcing continues requires low cost and premium strategies but with much more careful choices of other business competencies.

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An Improved Spatial Scheduling Algorithm for Block Assembly Shop in Shipbuilding Company

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Abstract
Motivated by a software development project in a shipbuilding company, we propose a production scheduling algorithm for the block assembly shop in a shipbuilding company. The problem is very complicated and time consuming because it should consider both scheduling and spatial arrangement of each block simultaneously. To reflect the scheduling dynamics, we propose an improved schedule policy, named the LCA (Largest Contact Area) policy. Using real shipyard data, we showed that the block assembly scheduling system based on the policy made a good performance.

1. Introduction

The blocks, which are the basic units in shipbuilding processes, are assembled through a number of processes (e.g., cutting off, bending, small assembling, medium assembling, and large assembling) and finally erected to a ship in a dry dock. According to the bottom shapes of them, the blocks can be classified into two categories, flat blocks and curve blocks. Since their bottoms are flat, the flat blocks can be laid and move on a wide roller conveyor. Using this roller conveyor, the flow shop control method can be used to assemble the flat blocks, and so the shipbuilding company can gain a high productivity in the flat block assembly shop. In case of curve block assembly shop, however, there equipped numerous poles on ground, which are called *pipe jigs* whose heights can be adjusted. This workspace is one of the bottleneck resources of shipbuilding industry and the area utilization of it is very important to improve the productivity of shipbuilding.
To schedule the curve block assembly shop, the spatial scheduling algorithm is needed. In the past, some experienced schedulers made the block assembly schedules manually. Since the schedule needs consideration of the geometric configuration of the blocks, it requires very long time to get a good result. During the last decade, the efforts to automate the scheduling process have been made worldwide, especially in Korea, the most powerful country in shipbuilding industry.
To the best of our knowledge, the first attempt to automate the spatial scheduling of a shipbuilding yard made by Lee et al.[2]. Based on the results of Lozano-Perez[3] and the computational geometry theory[6], they developed the spatial scheduling algorithm for the block assembly shop. In the study, they employed two-dimensional arrangement algorithm of Lozano-Perez[3] for the spatial layout of convex polygons in rectangular workspaces and extended it to the three-dimensional dynamic spatial scheduling by including a time axis.
Koh et al.[1] also developed the spatial scheduling algorithm for the similar block assembly schedule problem. They divided the problem into two phase problems such as scheduling phase followed by spatial layout phase. The scheduling phase devoted to

find block operations schedules with consideration of workload balance by Genetic Algorithm, while the layout phase arranged blocks with consideration of the determined schedules.

For the special case in which blocks are allocated along the narrow work lanes, Park et al.[5] solved the block assembly scheduling problem by applying the spatial scheduling algorithm. In this special case, the spatial scheduling is rather easy because the spatial layout considers only block lengths, in other words, a single-dimensional arrangement.

Lastly, Park et al.[4] considered a spatial scheduling problem for the block paint shop in a shipbuilding company. They proposed two sequential spatial scheduling algorithms because the block painting process consists of two consecutive operations of blasting and painting. And a batch layout was considered in their study because blocks in a blasting or painting cell are proceeded simultaneously and moved in a batch.

The results of the earlier studies, however, are not used in real situation now. In this study, we develop an automatic spatial scheduling algorithm that improves the space utilization, and so, can be usable in real situation. To do this, we present a new block arranging strategy and analyze the effect of the strategy.

This paper is organized as follows. In the following section we introduce the existing spatial scheduling algorithm based on the configuration space theory. In section 3, we propose a new block arranging strategy called LCA (Largest Contact Area) policy. Section 4 shows the performance of the policy. Finally, we conclude the paper with a summary and some directions for future research in section 5.

2. Existing spatial scheduling algorithm

The arrangement algorithms based on the configuration space theory can perform the spatial scheduling for a given day relatively easily and effectively[1, 2, 4]. And therefore, this study uses this technique to search for the candidate points of block arrangement on a given day. This section briefly explains the process.

(1) Convex polygon representation of a block

We assume that the block is a convex polygon as shown in Fig.1. To represent the convex polygon block, the system stores the vertex points in counter-clockwise order from the left-most bottom vertex (called reference point).

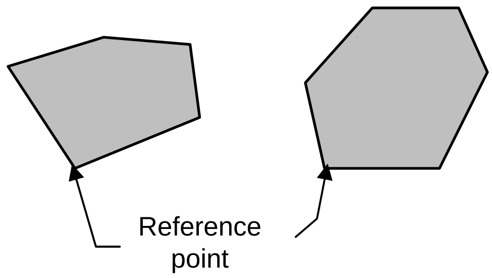

Figure 1. Block representation

(2) Search for possible area

As shown is figure 2, one can easily find the area in which the reference point of the new block (candidate for arrangement) can be located. Here, the work area is assumed to be a rectangle.

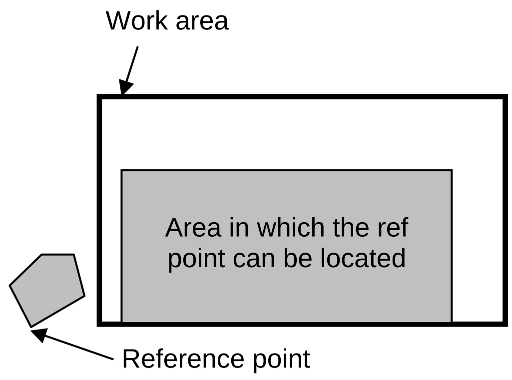

Figure 2. possible area to locate

(3) Search for impossible area

On a given day, there may be a number of blocks that were arranged on earlier days and are now at work. For each existing block, using the results of Lozano-Perez[3], one can find a convex polygon in which the reference point of the candidate block cannot be located because of the collision with the existing block.

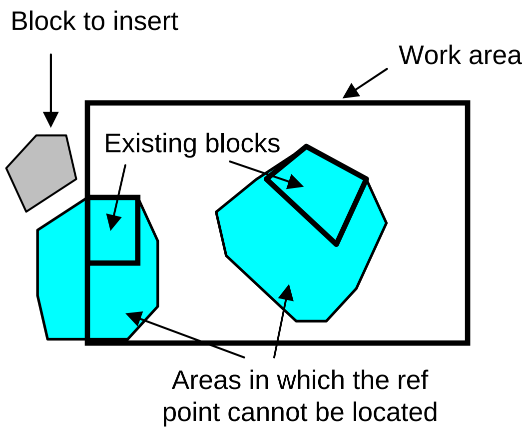

Figure 3. Impossible area to locate

(4) Search for feasible area

Using the results of the last two steps, one can find the feasible area for the candidate block in which the reference point can really be located.

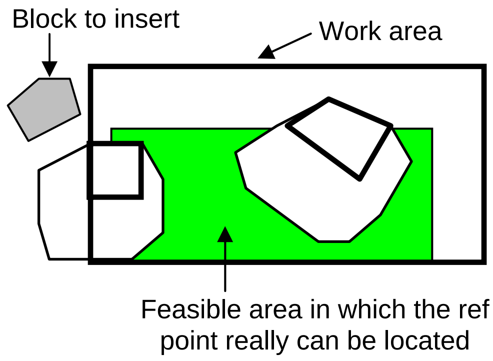

Figure 4. Feasible area to locate

(5) Select a point from the feasible area

The last step is selecting a point from the feasible area and locating the candidate block on the point. But the feasible area consists of numerous points in it. Therefore, the point selecting policy is the vital part of the spatial scheduling problem. Lee et al.[2] adopted four positioning strategies (i.e., maximal remnant space utilization strategy, maximal free rectangular space strategy, initial positioning strategy, and edging strategy) to select the best position among the vertices of the feasible area shown in figure 4.
While Lee et al.[2] searched the vertex points of the feasible area in figure 4 to select the best point, Koh et al.[1] searched the boundary line of the feasible area at a given scale interval, e.g., one meter. And they proposed two-phase algorithm to improve the performance. Park et al.[4] looked for the best position through the grid search, which first divides the feasible area by the grid with a specific scale.

3. Largest Contact Area (LCA) policy

In this section, we propose a new policy to select a better position. This policy uses a scoring system that evaluates the positions on which the entering block can be lacated. Using this scoring system, the abovementioned four positioning strategies of Lee et al.[2] can be combined into one system.
First of all, we define the *contact length* (CL) of the entering block for a position as the length of contact between the entering block and the existing block or the wall of the workspace when the reference point of the entering block is located at the point. For each edge of the entering block, we can easily find the CL value.

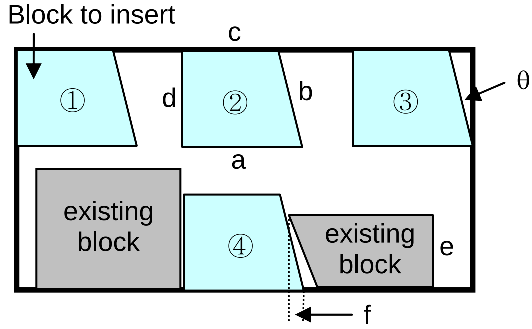

Figure 5. Calculating CL value

For example, the CL values for four candidate positions in figure 5 are d + c + (a - c) cos(90-θ), c + (a - c) cos(90-θ), c + max{(a - c) cos(90-θ), d cosθ}, and d + a + e cosθ + f for the positions ①, ②, ③, and ④, respectively. Note that we use d cosθ for edge b of position ③, not b cosθ. Among these 4 candidate positions, position ④ has the largest CL value, and therefore the entering block should be located on the position ④.

If the problem were just to maximize area utilization of the workspace on a day (like the *nesting* problem), it would be sufficient to consider the CL value. But this is a scheduling problem for a period of time, which makes an assembly schedule of the blocks that have their own processing times. To reflect this time dynamic nature, Park et al.[4] proposed, so called, the backtracking algorithm.

To consider this feature, we define the *contact area* (CA) of the entering block for a position as the multiplication of the CL value by the common processing time with contacting block. Here, the common processing time with the wall of workspace is the processing time of the entering block.

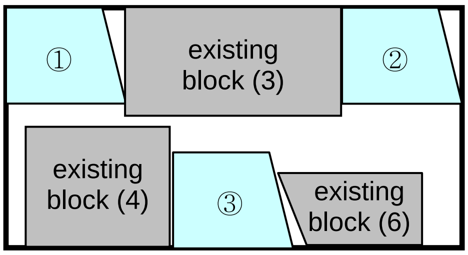

Figure 6. Calculating CA value

For example, we want to insert the block of figure 5 into the workspace that has three existing blocks as figure 6. Let the processing time of the entering block be 5 days and the remaining times of the existing blocks be 3, 4, and 6 days. (Look at the values in the parentheses.) Then, the CA values for three candidate positions are 5d + 5c + 3 max{(a - c) cos(90-θ), d cosθ}, 3d + 5c + 5 max{(a - c) cos(90-θ), d cosθ}, and 4d + 5a + 5(e cosθ + f) for the position ①, ②, and ③.

Now we present an algorithm to arrange blocks using CA value as follows:

Step 0. Set Day = the first day

Step 1. For each block that can be located in the workspace on the day,

Step 1.1 Find the feasible area of figure 4.

Step 1.2 Calculate CA values for all grid points in the area.

Step 1.3 Select the best position for the block

Step 2. Insert the block that has the biggest CA value.

Step 3. If there remains a block that can be inserted on the day, go to Step 1.

Step 4. If the day is the last day of the planning period, stop the algorithm.

Step 5. Set Day = the next day, and go to Step 1.

4. Performance test

This section shows the result of the LCA-based algorithm. The system was developed in Microsoft Visual C++ 6.0 and used real data of S shipbuilding company. The CPU time required to schedule over 1,000 blocks for 3 months is shorter than 3 minutes with a laptop computer of 1.10 GHz Pentium M processor and 512MB RAM.

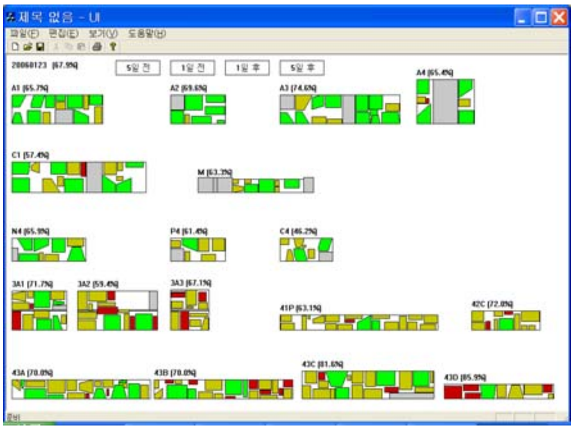

Figure 7. Arrangement result

As one can see in figure 7, the area utilization is improved a little as compared with Koh et al.[1]. The average area utilization for the scheduling horizon is about 69%, while the value was about 67% in Koh et al.[1].

5. Conclusions

An improved spatial scheduling algorithm is introduced for a block assembly scheduling in shipbuilding company. We proposed an algorithm with the LCA policy and developed computer aided scheduling system. The system shows some improvement in area utilization as well as CPU time, but we think it is not satisfactory level. Therefore, the authors are now studying to improve the performance of the system.

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Session 4

Case Studies in Value Chain Management

Chair: Dr. Koichi Ogawa

1. **Value creation, innovation, and human resource management: a case study of APPLE Valley Cluster (AVC)**
   Gyewan Moon, Kyungpook National University, Korea
   Paul Hong, University of Toledo, USA
   Youngwon Park, University of Tokyo, Japan
   Jaikwon Choi, Kyungpook National University, Korea

2. **Value chain management of mobile phone and role of semiconductor: case illustrations from mobile phone companies**
   Youngwon Park, University of Tokyo, Japan
   Ogawa Koichi, University of Tokyo, Japan
   Tatsumoto Hirohumi, University of Tokyo, Japan
   Paul Hong, University of Toledo, USA

3. **The effect of technological platform on global supply chain: case study of Intel's platform business in PC industry**
   Tatsumoto Hirohumi, University of Tokyo, Japan

4. **An improved order picking system by using the concept of bucket brigades**
   Pyung-Hoi Koo, Pukyong National University, Korea

Value Creation, Innovation and Human Resource Management: A Case Study of Apple Valley Cluster (AVC)

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Abstract

The primary driver of all types of innovation is people. Managing creative resources of people is the heart of human resource management. Although exploring value creation and human resource management is an important topic, very little research attention has been paid on the role of human resource management in continuous, organizational and systematic innovation initiatives.

This paper presents a model that links value creation, product/process innovation, and human resource management. Apple Valley Cluster (AVC) refers to IT industry innovation cluster in Kumi Technological Park of Taegu-Kyungpook Area, South Korea. Samsung and LG Electronics function as its core along with their suppliers, government organization and regional universities for the advancement and growth of IT industry. A primary element for the formation of innovation cluster in AVC is human resource capabilities. A research model is presented for an effective assessment and development of innovative human resources. Data analysis of 210 college students and 310 firms in AVC suggest specific steps for the formation of innovative clusters that utilize dynamic and capable human resources.

Keywords: Value Creation, Innovation, Human Resource Management, APPLE Valley Cluster

1. Introduction

Three critical elements of value creation are: (1) Creation of new technology and new products through innovative breakthroughs or functional enhancement; (2) process innovation on the existing innovative products through fulfilling the multiple requirements (e.g., quality, cost and speed); (3) revenue-generating business system in the global market through differentiation and utilization of new product and process innovation (Nobeoka, 2006). In other words, three types of innovation are product innovation, operational process innovation and business innovation. In this sense, value creation and innovation are closely connected.

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The primary driver of all three types of innovation is people. Managing creative resources of people is the heart of human resource management (Brewster, 2004).. Although exploring value creation and human resource management is an important topic, very little research attention has been paid on the role of human resource management in continuous, organizational and systematic innovation initiatives. In this paper we assess the status of regional innovation clusters in terms of human resources management and explore strategic options to develop and supply critical needs of human resources.

Apple Valley Cluster (AVC) refers to IT industry innovation cluster in Kumi Technological Park of Taegu-Kyungpook Area, South Korea. Samsung and LG Electronics function as its core along with their suppliers, government organization and regional universities for the advancement and growth of IT industry. A primary element for the formation of innovation cluster in AVC is human resource capabilities.

This paper examines the status of demand and supply of human resources which is a critical success factor of innovation cluster. Human resources occur with the inconsistencies in demand and supply—particularly with the practical gap between the supply (e.g., college graduates) and the demand (e.g., firms' employment needs) of human resources. A research model is presented for an effective assessment and development of innovative human resources. Data analysis of 210 college students and 310 firms in AVC suggest specific steps for the formation of innovative clusters that utilize dynamic and capable human resources.

2. Literature Review

2.1 Study on cluster

Cluster refers to Industrial park in which firms in the related industry work together for realizing synergy effect. Four common characteristics are: (1) cluster is the combined set of related firms, expert knowledge workers, service providers, universities, research centers, and functional organizations in particular industries. They are geographically stay and work together with both competitive and collaborative relationships (2) cluster takes the form of integration. Clusters connect suppliers and customers vertically. Horizontally cluster integrates horizontally customers, technologies and channel relationships. (3) Cluster highly regards the value of knowledge creation and knowledge sharing network. Cluster usually includes universities and research organizations. (4) Cluster also functions as organic network that engages in diverse forms of innovation in terms of new business incubators, innovation centers, venture capital firms, financial institutions, and receives support of central and regional governments.

According to Porter (2000), four factors determine competitiveness of a cluster. (1) human resources that meet the requirements of particular industry, capital, and effective downstream organizations in terms of physical, scientific and technology; (2) requirements to develop high premium value products for sophisticated customers (3) protect knowledge assets and encourage investment and rules that govern business activities, incentives and competition and collaboration relationships (4) reduction in transaction expenses, facilitate the exchange of ideas and sufficient numbers of suppliers through flexible outsourcing, sufficiently available numbers of professionals and industry academic collaborative relationships (Gilley, et al., 2004).

Nonaka(1995) suggest patterns of leaders that guide innovation clusters are (1) vision provider (VP) provides vision to the cluster members for the future direction of industry and development plans fro basic technologies prior to commercialization of products Individuals (e.g., Steven Spielsburg), universities (e.g., Stanford University) and Government (e.g., Finland). (20 System organizers (SO) are middle managers that specify vision and commercialize the products. Good examples HP, Toyota, NOKIA, Ericson, and med-sized innovative firms. (3) Specialized Supplier (SS) develops expert knowledge elements for successful commercialization of a product. SS offers diverse technologies, component parts and after services. Venture, small and medium enterprises, venture capital, accountants and lawyers take this role.

Nonaka (1995) also classified four types of cluster development. (1) university-initiated like Silicon Valley (2) Reseach Institution-initiated like Daeduk Valley in Daejun, Korea (3) large global firm-initiated like Cambridge Technopolis, Swedish Sista Scientific Park, (4) government-initiated like Sophia Antipolis.

2.2 Research Framework

2.2.1 History and core competence of Apple Valley Project

Apple Valley Cluster (AVC) refers to IT industry innovation cluster in Kumi Technological Park of Taegu-Kyungpook Area, South Korea. Samsung and LG Electronics function as its core along with their suppliers, government organization and regional universities for the advancement and growth of IT industry. Its history suggests that it was government-initiated at its inception. However, increasingly it is by global business (e.g., Samsung and LG)-initiated and government support its efforts and universities strategically align as well.

For rapid development of Apple Valley Cluster four important factors are noted. (1) in view of supply chain and logistics costs, products that are small in size, light in weight and complex in style are handled (e.g., mobile display). Participating firms utilize network that include geographically-close organizations (2) with simplified production transform into innovation cluster as technological park (3) emphasize mutual trust and competition and build an open and cooperative network. The primary driver of Apply Valley Cluster is human resource capabilities. The following sections explore the status of Apply Valley Cluster and the policy options for its continuous existence.

2.2.2 Research Framework

This study examines the status of human resources that are critical component of innovation cluster capabilities. Our special focus is on supply and demand gap of human resources. This occurs when substantial numbers of people who enter job markets do not meet necessary skills and knowledge requirements of potential employers. To explore the causes of such discrepancies we conducted surveys. Table 1 is a summary of research framework.

Table 1: Framework for the Assessment Human Resources Shortage

Analysis Factors	Students (Supply Side)	Firms (Demand Side)
Current Status	Most desired professions and industry upon graduation	Status of human resources demand by industry. Status of human resources shortage by industry.
General knowledge and skill set requirements	Perceived skill and knowledge requirements of the desired professions and industry.	Desirable skills and knowledge requirements from firm perspective
Knowledge and Skill Sets Shortages	Perceived deficiencies in their own skill and knowledge capabilities for desired areas of employment.	Negative experiences with the new hires in terms of job performance and desirable skill sets.
Critical knowledge and skills set requirements for actual employment	Most desired competency requirements for the employment in the desired professions and industry. Self-assessment of their own employable competencies. Effort priorities in terms of securing critical knowledge and skill set for employment.	Critical knowledge and skill set requirements of the new hires for actual job offers.

3. Analysis Results

3.1. Causes of Supply and Demand in Human Resource Gap

Based on this research model we have collected data from 210 students from six universities in Taegu-Kyungpook Area and 310 firms in Kumi Technological Park from July till September 2007. The analysis is based on the comparative details of the student and firm respondents.

3.1.1. Status of demand and supply of human resources

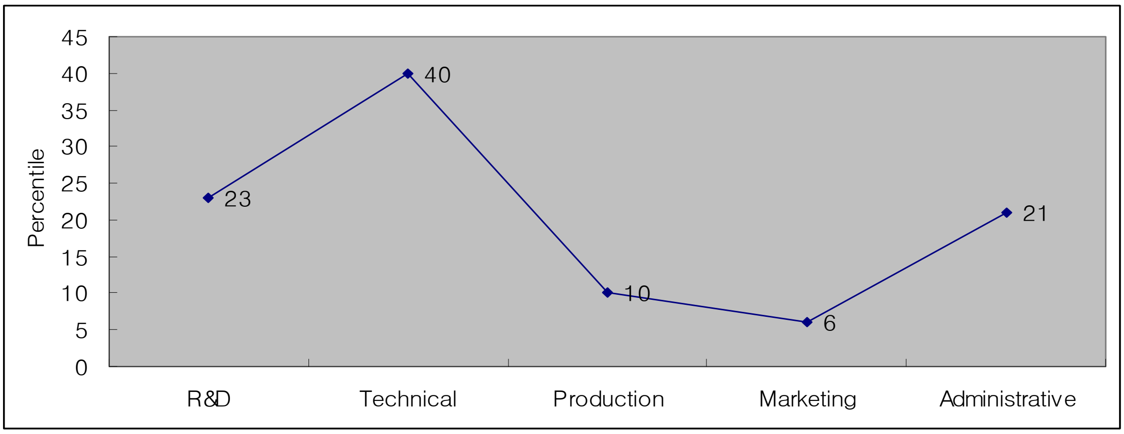

Figure 1. Most desired profession by students

Note: Students prefer in the order of Technical l(40%), R&D(23%), administrative(21%), production(10%) and marketing(6%).

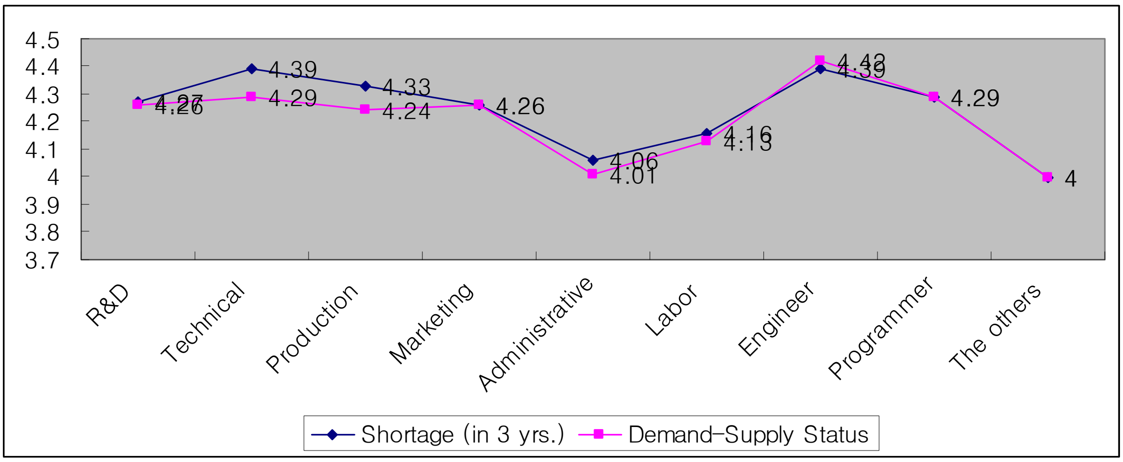

Figure 2: Workforce Demand and Supply Status

Note: 6 (Severe shortage); 5 (Relative shortage); 4 (Average) 3 (Relative oversupply) 2 (extreme oversupply); 1 (N/A)

Shortages for the new hires by profession are in the order of Engineer (4.42), technical (4.39), programmer (4.29), R&D (4.27), marketing (4.26), production(4.33), laborer(4.16), and administrative(4.06).

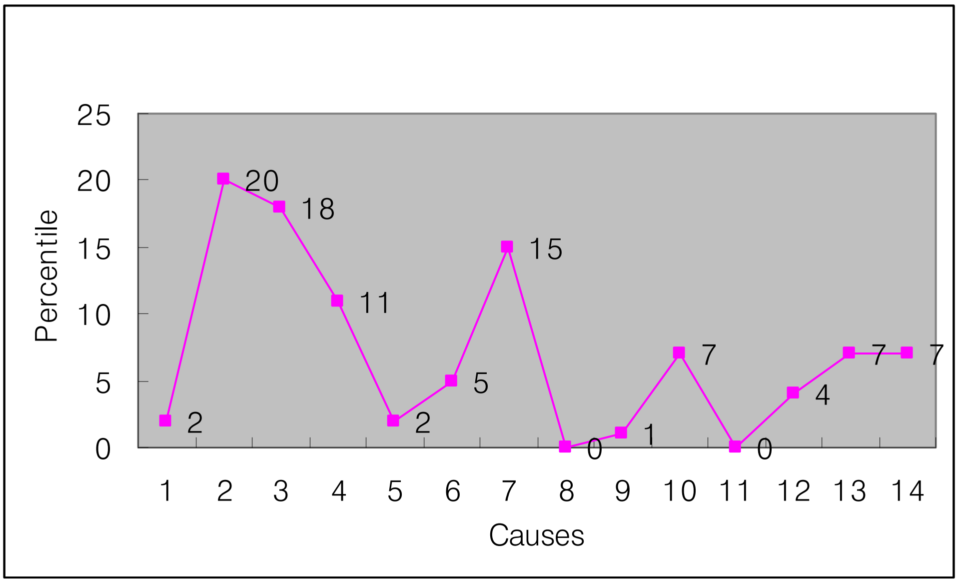

Figure 3: Causes of Human Resource Shortages

Note: 1 (lack of information on human resource needs);
2 (low preference to the small and medium enterprises);
3 (inclination to avoid small and medium enterprises);
4 (low salary and benefit packages);

5 (preference to work in Seoul metropolitan areas);
6 (undesirable work conditions);
7(shortage of competent workforce);
8 (poor prospects of mobile and display industry);
9 (high level of work quality and performance requirements);
10(avoidance of production floor work);
11(inconsistency between student competencies and job requirements);
12(lack of due diligence and positive attitude);
13(lack of technical and functional skill set requirements);
14 (mismatch between job seekers and firm requirements)

The large shortages are in engineering and technical areas. The main reasons are shortage in qualified personnel, lack of adequate training in technical and functional expertises, tendency to avoid small and medium enterprises (SMEs), and low preference of SMEs. The prospects in the next three years in terms of human resource shortage and graduates preference, technical and production areas would be most affected because the gap between students' preference and firm employment needs is most obvious. The primary reasons for difficulty in securing needed human resources are: low preference for SMEs, the tendency to avoid SMEs and lack of qualified personnel.

3.2. Causes of poor human resource quality and employment requirements

3.2.1. Students' perceived skill requirements and firms' skill expectations

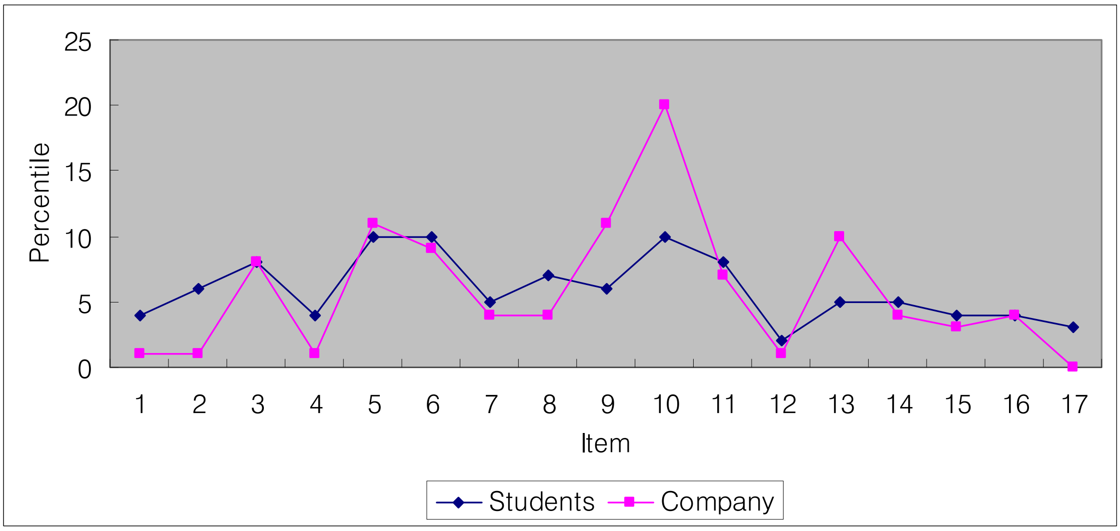

Figure 4: Comparison of Student Perception and Firm Requirements

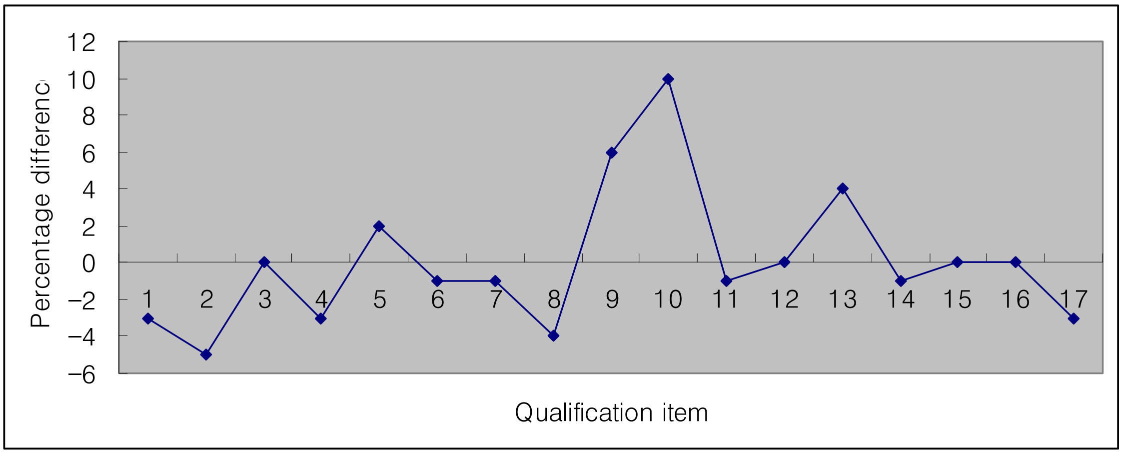

Figure 5: Comparison of Student Perception and Firm Requirements

Note 1: Difference between firm requirements and student perceived requirements. The larger + numbers, firm requirements are larger than students' perceived requirements. The larger – numbers, students' perceived requirements are larger than firm requirements.
Note 2: 1 (Command in Foreign language)
2 (Communication skills)
3 (Computer skills)
4 (Organizational adaptability).
5 (Technical skills)
6 (Functional specialized knowledge)
7 (Problem solving skills)
8 (Creativity)
9 (Real work competencies)
10(Due diligence and sincerity)
11 (Work attitude)
12 (Loyalty to the firm)
13 (Professionalism)
14 (Multiple task performance skills)
15 (Human relation skills)
16 (Technical expertise)
17(Equipment handling knowledge)

In general, students regard due diligence and sincerity, functional specialized knowledge, and technical skills. Firms regard due diligence and sincerity, technical skills and real work competencies. Both students and firms regard due diligence and sincerity as important but firms regard its importance in much greater degree. Sizable gap exists between firms' actual and students' perceived requirements in terms of real work competencies and communication skills.

3.2.2. Comparison of Student Perception and Firm Experiences

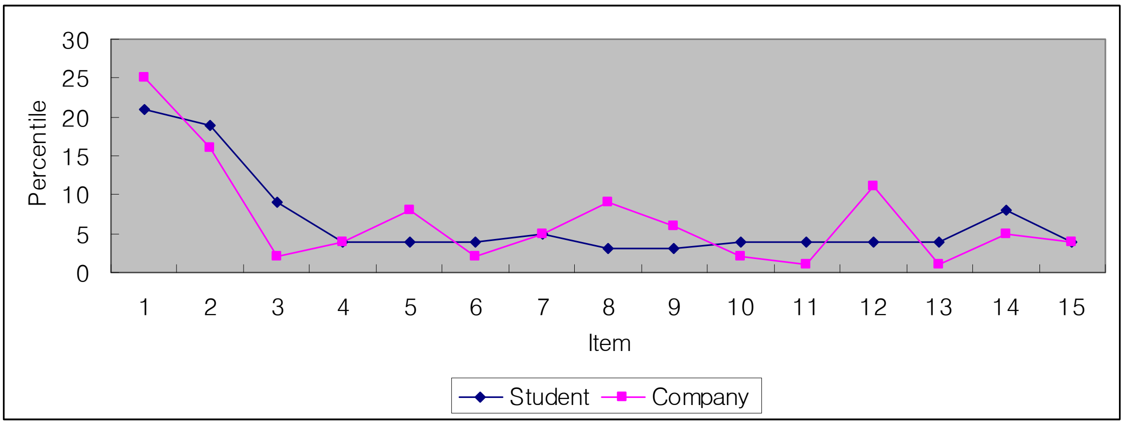

Figure 6 : Student Need Perception and Negative Firm Experiences

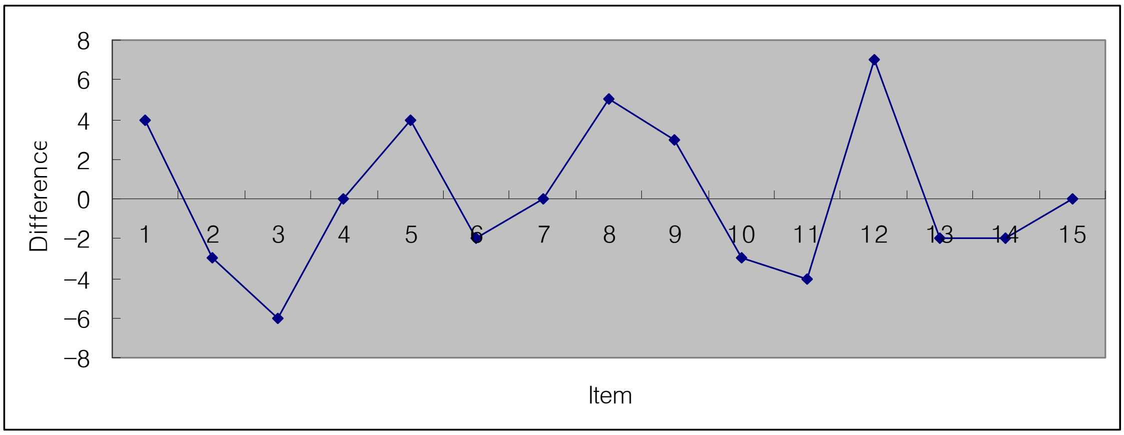

Figure 7: Difference between Student Need Perception and Firm Negative Experiences

Note 1: Difference between firms' negative experiences and student perceived improvement needs. The larger + numbers, firm's negative experiences are larger than students' improvement needs. The larger – numbers, students' perceived improvement needs are larger than firms' negative experiences.

Note 2: 1 (Command in Foreign language)
2 (Communication skills)
3 (Computer skills)
4 (Organizational adaptability).
5 (Technical skills)
6 (Functional specialized knowledge)
7 (Problem solving skills)
8 (Creativity)
9 (Real work competencies)
10(Due diligence and sincerity)

11 (Work attitude)
12 (Loyalty to the firm)
13 (Professionalism)
14 (Multiple task performance skills)
15 (Human relation skills)
16 (Technical expertise)
17(Equipment handling knowledge)

Students' perceived improvement needs are great in command in foreign language, communication skills and computer skills. Firms' negative experiences are in the areas of command in foreign language, communication skills, and loyalty to the firm. The largest difference between students' perceived improvement needs and firm's negative experiences are in the areas of loyalty to the firm, computer skills and creativity.

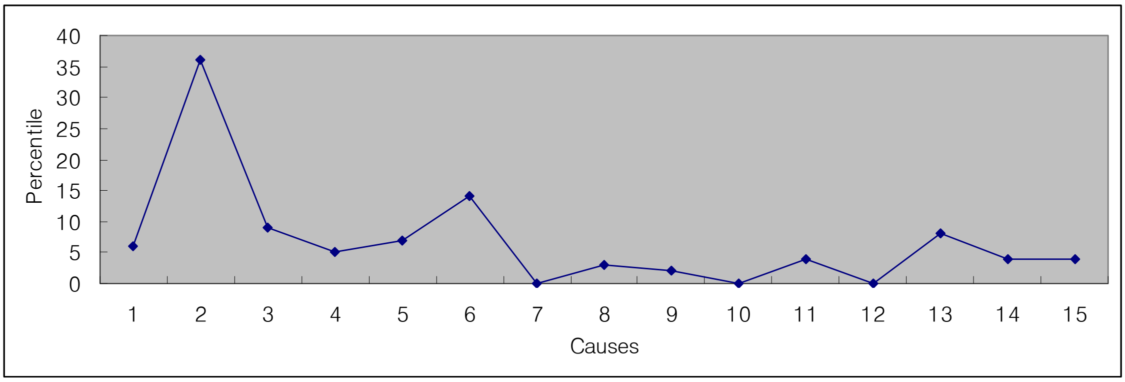

Figure 8: Causes of Poor Job Performance

Note: 1 (lack of practical experiment and job-related training)
2 (lack of real work based education)
3 (lack of new technical area education/training)
4 (mismatch between educational outcomes and firms' requirements)
5 (lack of specialized knowledge experts that firms need)
6 (lack of training in humanities)
7 (lack of educational facilities and infrastructure)
8 (lack of training in creativity)
9 (lack of problem solving and project management)
10 (inconsistency between educational processes and firm's demand)
11 (lack of good faculty resources)
12 (lack of student motivation)
13 (loss of qualified personnel to other areas)
14 (gap between students' expected salary and firm's actual offer salary)
15 (mismatch between students' abilities and salary expectation)

Main reasons for poor job performance are lack of practical experiment and job-related training (36%), lack of training in humanities (14%), lack of new technical area education/training (9%), loss of qualified personnel to other areas(8%), lack of specialized knowledge experts that firms need (7%), inconsistency between educational processes and firm's demand(5%). It is noted that lack of practical experiment and job-related training (36%) and lack of training in humanities (14%) are quite substantial reasons for poor job performance. This may require development of practical corrective action programs.

3.2.3. Evaluation Criteria between students and firms for employment decision

Figure 9 shows evaluation criteria between students and firms at the time of employment decision. All the values are average of the student and firm respondents from the data collected.

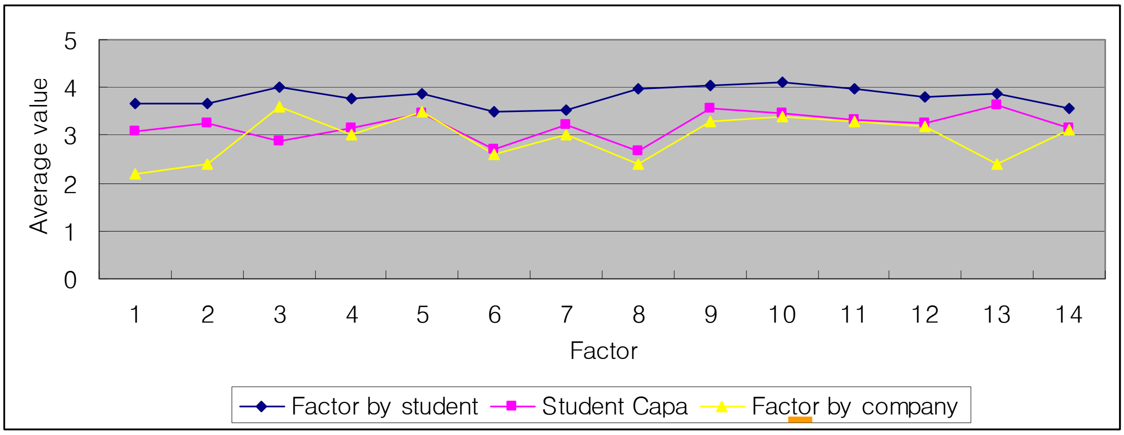

Figure 9: Employment Requirements by Student and Firm Evaluation

Note: 1(extremely unimportant \)
2 (not so important)
3 (average)
4 (important)
5 (extremely important)

Note: 1 (school reputation
2 (GPA and grade)
3 (real work experiences)
4 (specialized knowledge related to the worked)
5 (personality/fitness/motivation)
6 (professional certificate)
7 (computer skills)
8 (command in foreign language)
9 (organizational adaptability)
10 (interview performance and communication skills)
11(problem analysis and solving ability)
12 (project management skills)
13 (capabilities and growth potential)
14 (quality documents—e.g., resume)

Firms regard real work experiences, personality/fitness/motivation, interview performance and communication skills, organizational adaptability and human relations skills. On the other hand, students rated high on interview performance and communication skills, organizational adaptability and command in foreign language. Many regard that they possess capabilities and growth potential, organizational adaptability, human relations and communication abilities and humanities/fitness/motivation. Inconsistencies between firms and students are most obvious in the areas of real work experiences, humanities/fitness/motivation. Firms tend to regard these very highly but students put them in the lower priority list.

4. Growth policies and problems for regional electronic industry

4.1. Status and Problem Areas in Electronic Industry and Cluster Growth Policies

We first present some of the exemplary cases from other countries in their innovation clusters (Bartram, 2005; Bennington, et al., 2003).). We then compare electronic industry growth policies and their problem areas of Apple Valley Cluster (AVC) in Kumi and Taegu Area. We also recommend practical policy options for successful innovation cluster.

4.1.1. Success factors of innovation cluster (based on oversea's examples)

Based on the prior research some of the success factors of innovation clusters are listed as below:

- Accurate analysis of the objective reality of related organizations and their environmental contexts and in search of realistic policy options
- Formation and utilization of collaborative network of research intensive universities, firms and government toward active innovation cluster activities
- Open cultural infrastructure for regional innovation and passionate entrepreneual leadership and dynamic partnership among key participants for the purpose of regional growth and development
- Existence of core firms that operate in the global market with substantial innovative capabilities
- Active financial support of central or regional government for the success of clusters in the form of direct fund support or tax benefits
- Favorable climate and geographical conditions that encourages the presence of knowledge habitat and enable new knowledge creation and dissemination through organizational learning processes

4.1.2. The Status of Regional Innovation Cluster

Apple Valley Cluster includes 59 household electronic firms, 159 electronic IT equipment firms, 9 semi-conductors in Kumi area. It also includes eastern and southern part of Taegu Technological Park and Kyungpook Technological Park as well. The vision is to transform up Kumi Industrial Park as the global electronic cluster. Taegu Area is becoming mobile innovation cluster based on Chilgok mobile valley and the Third Industrial Park. Besides, the initiatives to nurture and develop mini-clusters, regional innovation café, R & D infrastructure development. However, the foundational work is not as fast as intended and the participation of large firms is somewhat limited as of now.

4.2. Status and Key Policy Issues of Kumi Innovation Cluster

Various policy initiatives are under progress with the purpose of strengthening the industrial capabilities, network expansion, and organizational structure for continuous area firms' support in the four areas of industry (i.e., Display, Mobile and Digital Household Electrical and Electronics). Some of these initiatives are:

- Formation of regional collaboration network, constructing mini-cluster of specialized business categories, management regional innovation café
- Dynamic network utilization through the strategic alliance of regional governments (city-provincial and state, 3), university reassert centers (9), support institutions (7).
- Based on 9 mini-clusters based on diplay, mobile, electronic IT component parts, development of R & D, general management and marketing innovation initiatives and application of problem solving approaches.
- Formation of regional innovation care with specialists in each area (200) in March 2004.

In Kumi Four Areas, both digital electronic technological Park and R & D Foundation are solidly in progress particularly with Samsung's Mobile R & D Technological Research Centers are under construction. Key areas of concern are accumulation of technological know-how because of lack of specialized human resources knowledge pools and lack of infrastructure for creation and transfer of in-depth knowledge. In case of Kumi Innovation Cluster knowledge intensive economy, labor market, relational proximity and governance structure are sound. However, network and organizational learning are not particularly strong.

4.3. Status of Taegu Innovation Cluster and Problem Areas

The City of Daegu has strategic plan to connect Daegu Gyungpook Innovation Science and Technology (DGIST) and Kyungpook National University with Kumi Industrial Park for the enhancement of R & D functions and infrastructural capabilities. The long term plans also include short- and mid-term plans of building up mobile technological park factories and reforming mobile innovation cluster with the broad partnership of Kyungpook National University, Mobile Valley, and Kumi Industrial Park. However, the implementation of these strategic plans is being delayed except the very first step of the formation of cell group for mobile knowledge research and building support organizational systems for small and medium enterprises such as Mobile Technology Building (Kyungpook National University), Mobile Commercialization Center and Embedded SS Technological Support Center.

Table 2 is prepared with the consultation of cluster participants and Lee and Lee (2006).

Note: Source: Lee, SK and Lee, K.L. (2006). An Analysis of Kumi Technological Park and Strategic Development Options for Its Innovation Capabilities, National Planning, 41(2).

Table 2: Current Status and Formation Requirements of Innovation Cluster

Classification	Current Quality Status	Cluster Formation Requirements
Production	1. Next generation technology development and new product development. 2. Mass production system for focused products 3. Lack of interrelationships with the related industry 4. Simplified production methods and lack of technical human resources 5. One firm responsible from production to commercialization.	1. Establish Joint development System 2. Focus on complex chip development with systematic alignment. 3. Simplified production methods and secure the steady inflows technical human resources 4. Set direction for global industry development 5. Building Joint technological collaboration and marketing system
R & D	1. Lack of detail industry statistics and data base 2. Lack of medium and long term technologies and lack of market analysis capabilities 3. Lack of roadmap for technology development as the advanced leading nation 4. Weak R & D base	1. Establish detail industry statistics and data base 2. Government's role as the focal organization for data base 3. Adoption and implementation of imported technologies. 4. Formation of knolweedge base Clusters (Strengthening R & D base)
Integration of R & D and Production Research	1. Simple information sharing with International firms 2. Lack of development of suppliers for equipment and raw materials 3. Difficulty of knowledge sharing among the same industry firms (little collaborative knowledge sharing for technological mutual support)	1. R & D, production and cross-functional collaboration (mutual support) 2. Maximization of front and back end integration efforts. 3. Initiation efforts for standardization (300 md wafer, next generation DRAM) 4. R & D structures based on Technological Park

Business Support	1. Lack of system division among domestic firms 2. Lack of technology development support structures 3. Lack of collaboration between industry and academics. 4. Dependence on individual handling of machines.	1. Outsourcing of production 2. Strengthen technology development support structure 3. Strengthen collaboration between industry and academics. 4. Learning effect on human interactions.

4.4. Policy recommendations for HR development and Innovation Cluster

Figure 10 shows the inter-relationships between Innovation Cluster and Industry Human Resources. Some of the key points are:

- Strengthening R & D infrastructure and improvement of educational system and change in residence requirements for development of specialized human resources pools.
- Develop world class universities in the focused areas of specialization through the alliance with regional strategic industry and entrepreneurial venture firms
- Encourage venture start-ups by professors and graduate students, support venture projects by college students, engage in joint research and establish entrepreneurial centers.
- Effective management of regional research centers like Daegu Kyungpook Innovation, Science and Technology (DGIST)
- Collaborative research with other institutions and research exchanges.
- Apple Valley Cluster includes 59 household electronic firms, 159 electronic IT equipment firms, 9 semi-conductors in Kumi area. It also includes eastern and southern part of Taegu Technological Park and Kyungpook Technological Park as well. The vision is to transform up Kumi Industrial Park as the global electronic cluster.
- Based on DGIST establish Daegu Technopolis.
- IT Industry Cluster and related infrastructure including regional network, apartment complex for foreigners and high tech villages, digital information technologies park, component part supplier technological park.
- Expanded regional network for building large base of knowledge workers and technogical experts.
- Mobile industry clusters, next generation semi-conductor technological reseach center, 4G cellular phones and communication systems and make the Daegu areas as the growth engine for the next generation industry.

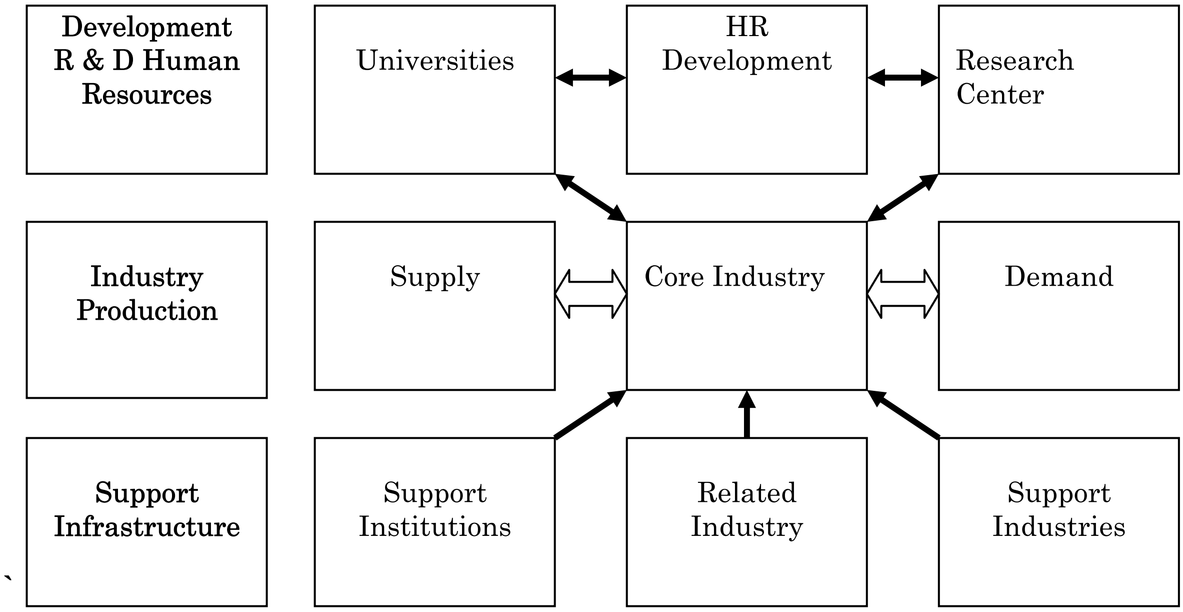

Figure 10: Innovation Cluster and Industry Human Resources
(Source: Innovation Cluster and Industry Human Resources. Daegu Kyungpook Research Center (2005))

5. Conclusion

This paper presents a model that links value creation, product/process innovation, and human resource management. A primary element for the formation of innovation cluster in AVC is human resource capabilities. For effective success of AVC involves multiple requirements. Korean global firms (e.g., Samsung and LG) should engage in continuous value creation and delivery to the global customers. In reality this paper shows inconsistencies between demand and supply of human resources in the areas of Daegu-Kyungppok area of South Korea. A careful analysis addresses issues of value creation and delivery in the larger context. Increasingly, global firms engage with fellow cluster members including universities and governments. Synergic effects through strategic alliances, geographical proximity and collaborative/competitive relationships secure firms to reap the benefits not only in their domestic markets and but also in the global market.

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Value Chain Management of Mobile Phone and Role of Semiconductor: Case Illustrations from Mobile Phone Companies

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Abstract
Since the semi-conductor elements are about twenty percent of total components cost of mobile phones, the market prospect of semi-conductor is closely related to the growth of mobile phones. Since the core components of mobile phones is affected by semi-conductor elements, the relationships between value chain management of semi-conductor chips and mobile phone manufacturers is worthy of careful examination. As of now very few papers have ever focused on this dynamic reality and paid needed research attention. This paper is an effort to fill this research gap in this important area. In exploring the nature of relationships between mobile phone and semi-conductor, it is important to recognize that a few manufacturers dominate in this global market.
This paper first introduces a brief industry background of semi-conductor and mobile phone. We presents a research model of value chain management of global mobile phone manufacturer with the special focus on the role of mobile baseband chip on the value chain management of mobile phones. This case explores the relationships between NOKIA and TI that has successfully set the global de facto standard in the semi-conductor industry.
Positioned both in the front and backend of value chain, NOKIA and TI maintain complementary nature of strategic alliances for their mutual competitive advantages. In 1994, NOKIA intentionally divided the value chain structure into specialized fashion. However, in 2000s it moves toward more vertical integration in its value chain and adopts single chip strategy in response to the increasing influences of semi-conductor suppliers like TI.

Keywords: Value Chain Management, Semiconductor, Baseband LSI, Nokia, TI

1. Introduction

As of 2006, one of seven people in the world purchases mobile phone (handset) in one way or another. Increasingly, semi-conductor industry provides dynamic and complex features in this growing global mobile phone market. Until now, Intel has dominated the huge semi-conductor market with its MPU (i.e., IC semi-conductor) as the almost monopolistic supplier to the personal computer (PC) products. However, as the global demands for PC products have slowed down, the emerging new market potential for semi-conductor is somewhere else on the horizon. Since the semi-conductor elements are about twenty percent of total components cost of mobile phones, the market prospect of semi-conductor is closely related to the growth of mobile phones.

Although the brand power of mobile phone is the primary indicator of their competitive power, two other factors (i.e., product development capabilities and value chain management) are essential in sustaining their global competitive position. This growing demand of semi-conductor in the mobile phones shows diverse sets of products that reflect the complex requirements in terms of each communication methods (e.g., GSM, CDMA), cultural specifications, user characteristics, functionality and performance parameters, size minimization trends and cost reduction essentials. Since the core of the above complexity is affected by semi-conductor elements, the relationships between value chain management of semi-conductor (particularly product development capabilities of the baseband chip suppliers) and mobile phone manufacturers is worthy of careful examination. As of now very few papers have ever focused on this dynamic reality and paid needed research attention. This paper is an effort to fill this research gap in this important area.

In exploring the nature of relationships between mobile phone and semi-conductor, it is important to recognize that a few manufacturers dominate in this global market. For example, NOKIA (# 1 marketer in the global mobile phone market) and TI (its primary semi-conductor supplier) illustrate this reality. Our interviews suggest that the role of TI is critical in value chain management (VCM) of NOKIA's mobile phone. TI has expanded its market scope by its Digital Signal Processor (DSP) in keeping with the increasing digitalization of mobile phone by NOKIA. With its successful integration with British Baseband ARM processor, TI has become the core supplier of LSI (Core chip that governs communication functionalities) to NOKIA and therefore secured its superior competitive position in European GSM mobile phone market.

This paper first introduces a brief industry background of semi-conductor and mobile phone. We presents a research model of value chain management of global mobile phone manufacturer with the special focus on the role of mobile baseband chip on the value chain management of mobile phones. This case explores the relationships between NOKIA (the top global mobile phone manufacturer) and TI (the dominant semi-conductor supplier) that has successfully set the global de facto standard in the semi-conductor industry. We further examine the role of the dynamic collaborative relationships between TI and NOKIA's on the successful implementation of VCM. In view of the key lessons derived from the case illustrations of NOKIA and TI, we then discuss further theoretical implication and conclude with managerial implications.

2. Value Chain Management and Product Architecture

2.1 Value Chain Management of Mobile industry

One major way to analyze a firm's competitive advantages is value chain management. Most of products and services involve horizontally connected business activities. Value chain refers to all the business activities including acquisition of raw materials, transforming intermediate products, manufacturing and assembling the final products, distribution, sales and services after sales (Barney, 2001; Al-Mudimigh et al., 2004). Firms doing in the similar value chain may have different management resources and organizational capabilities depending on how they configure their core competencies (Barney, 2002; Ray et al., 2004).

Resource-based view suggests that value chain analysis focuses on innovative organizational capabilities that are critical for continuous performance results for

sustainable competitive advantages (Penrose, 1958; Barney, 1986; Montgomery and Wernerfelt, 1988; Barney, 2002). Such organizational capabilities are internally generated and yet effective utilization of external resources also contributes to the building of a new level of organizational capabilities. No firms can effectively integrate all their activities in the value chain. Instead firms may effectively link their business activities to the external value chains for the purpose of strengthening their own business organizations and ultimately achieving competitive advantages (Park, 2005). Cohen and Levinthal (1990) regard absorptive capacity as organizational innovation processes that integrate the internal R & D capabilities and externally developed technologies. Increasingly, firms strive to enhance their own learning and organizational capabilities through strategic alliances with other firms that may have significant impact on their own value chain performance (Comes-Casseres, 1996; Hagedoorn, 1993; Teece, 1992; Hagedoorn and Duysters, 2002).
By analyzing interrelated business activities of value chain it is possible to identify firm's competitive advantages. This study examines how the key players in the mobile industry utilize their strategic alliances and collaboration arrangements for enhancement of their value chain management. Figure 1 shows the value chain of mobile communication industry that offers diverse sets of communication services and other related business services including platform, handset, solution, contents. The value chain of mobile industry includes content provider, content aggregator, mobile portal provider, network operator (mobile service provider), handset vendor, application developer, application platform vendor, infrastructure & equipment vendor, technology platform vendor. Particular firms may play the roles of multiple players.

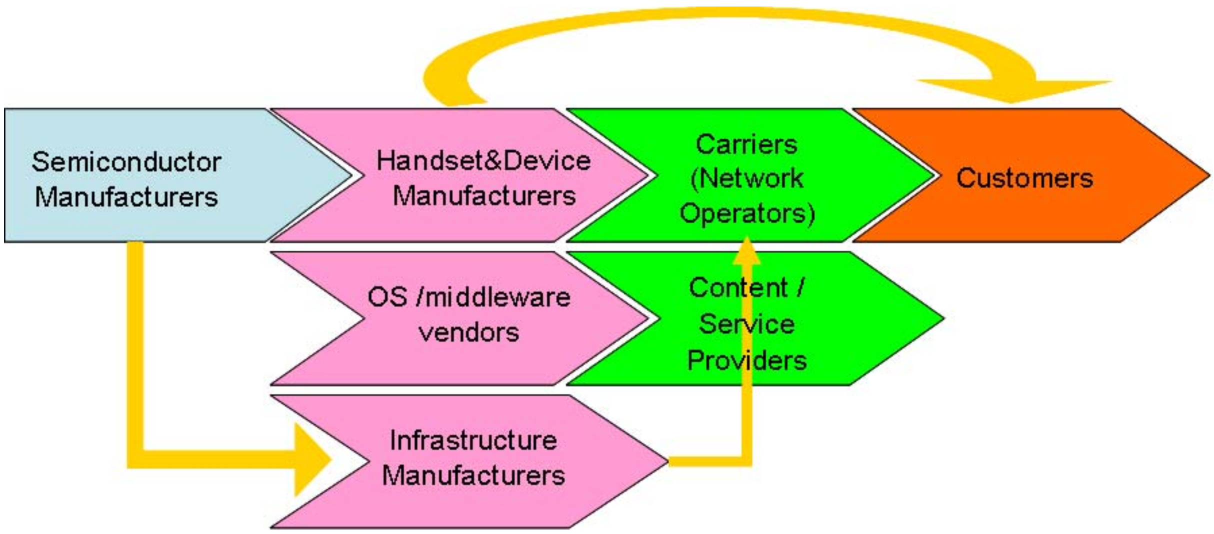

Figure 1. Value Chain of Mobile Industry

Within the value chain of mobile industry we examine the relationships between mobile phones and semi-conductor that is positioned in the backend as the infrastructure equipment provider. Figure 2 shows that frontend infrastructure (i.e., gateway, switch and base station) has impact on the performance of mobile phones. Semi-conductor affects both infrastructure network equipment and handsets.

The focus of our analysis is on the relationship between semi-conductor chip and mobile phone. From handset manufacturers' perspective, increasing importance for the value chain management of mobile industry depends on semi-conductor chip. Semi-conductor chip has been the core value component for mobile phone. In the next generations mobile phone (that will be drastically different from the current ones because of the higher level of service offerings) development of integrative semi-conductor chip is becoming increasingly strategic. Multi-chip development is the central aspect of the next generation mobile phone because the functions of voice, data and video functions are all combined and integrated in single processing mechanism (RNDBIX, 2007.2).

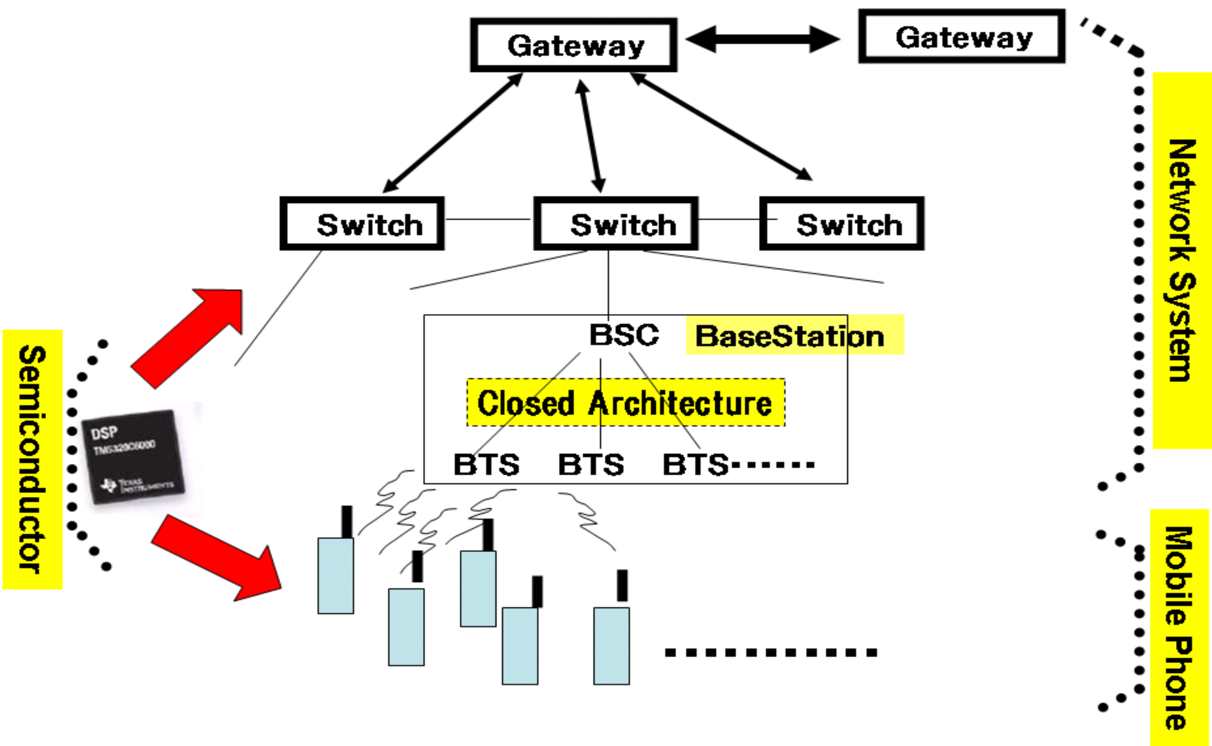

Figure 2. Relationship among semiconductor, Network system, and Handset

2.2 Value Chain Management and Product Architecture

One critical element for the meaningful analysis of value chain management of the above mentioned mobile phones is product architecture. Figure 3 shows the rich interrelationships among product, process and value chain (Fine, 1998, 2004). Strategic details are the interactive outcome of product, process and value chain. No firm may control all areas of value chain. Manufacturing system (including make-buy processes) connects value chain and work process. On the other hand, product architecture is how product and value chain meet. Product architecture determines the details of make-buy components.

In general product architecture is the basic design philosophy which governs how products are divided in terms of component parts, product functions, and component interfaces through design processes (Fujimoto, 2001). In other words, product architecture is the basic concept on how to link core components of a product together. The most important classification of product architecture is modular and integral (Ulrich, 1995; Fine, 1998; Baldwin and Clark, 2000; Fujimoto, 2001). Products with modular architecture have one to one relationships between function and module and each component is obviously divisible. On the other hand, products with integral architecture show that functions and component parts are integrated as indivisible unit. Automobile is a good example for this. The relationship between function and module is not one-to-one but many-to-many. Therefore, designers of each module are responsible for the detailed requirements and yet they all need to collaborate closely. It is not easy to comprehend the whole by merely looking separate parts. Even the same product may have different architecture depending on the product position and process layer (Fujimoto, 2003). All products are located in continuum between two extreme axis of modular and integral (Park et al., 2007).

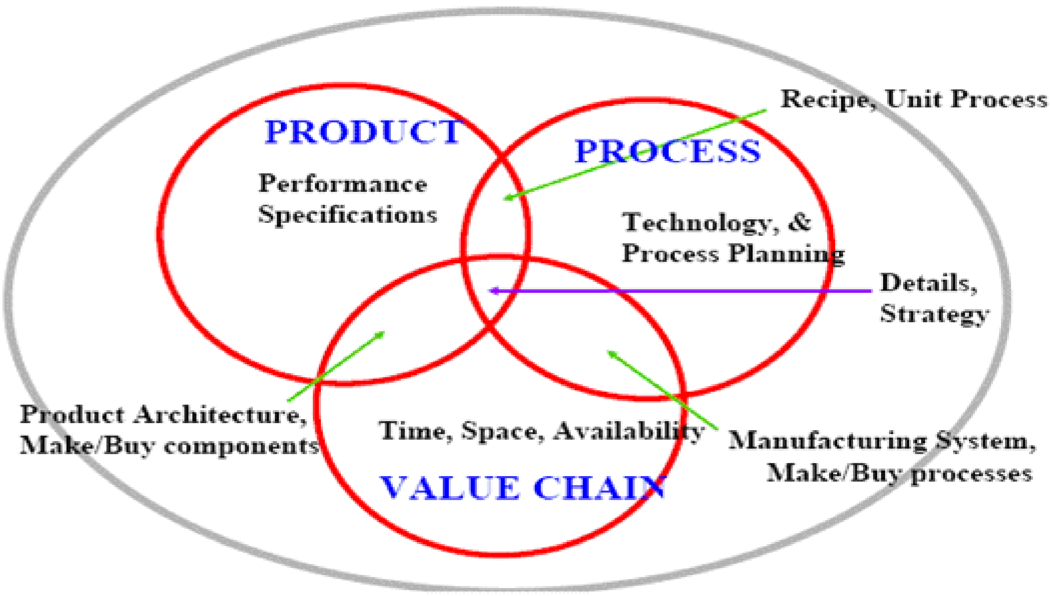

Figure 3. Relations among product, process, and value chain
(Source: Fine (1998, 2004))

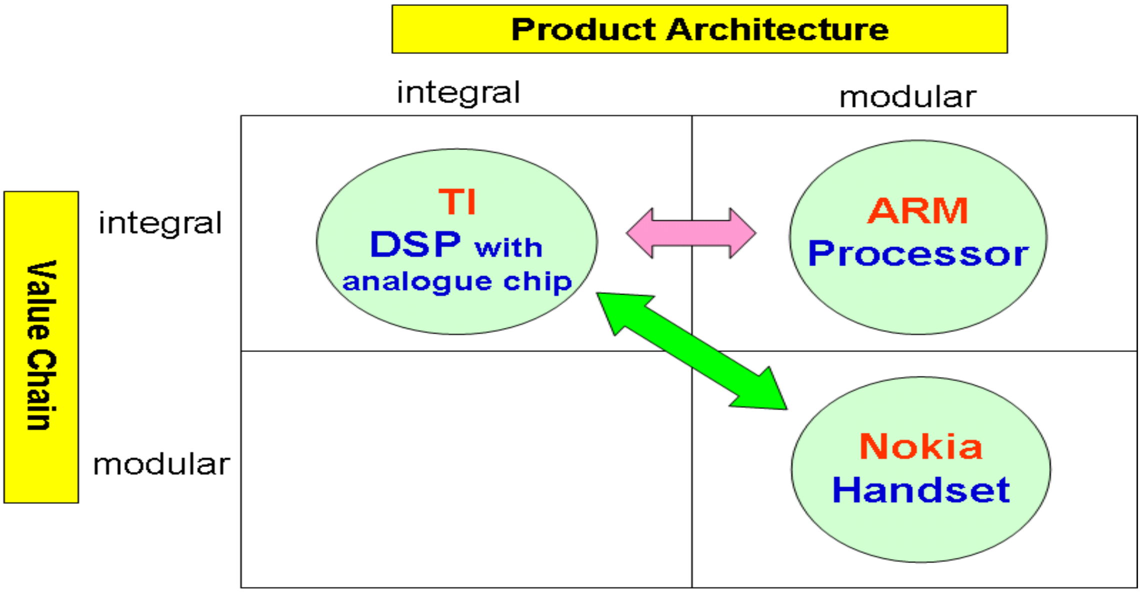

Figure 4. Research Model

This paper analyzes the case of Texas Instruments (TI--the semi-conductor manufacturer) that maintains an absolute competitive advantage in the market of Digital Signal Processor (DSP) through its strategic alliance with NOKIA (global handset manufacturer) since 1994. Figure 4 is our research model that shows the evolution of TI's strategy in terms of value chain and product architecture. TI has changed its collaboration patterns with NOKIA in different time periods.

3. Case Study

3.1. Interview methods

Our study is based on interviews in mobile industry. For the comparative analysis of mobile phone manufacturers and semi-conductor manufacturers we conducted interviews with executives that have involved in supply chain. Our case analysis utilized both the information gathered through executive interviews and internal data from Texas Instrument.

3.2. History of Texas Instruments (TI)

Texas Instruments (TI) is based in Dallas, Texas, USA, renowned for developing and commercializing semiconductor and computer technology and has production and distribution network in more than 25 countries of the world. The history of TI started in the middle of 1920s when four men purchased Geophysical Service Incorporated (GSI), a pioneering provider of seismic exploration services to the petroleum industry. During World War II, GSI built electronics for the U.S. Army Signal Corps and the U.S. Navy (Yukio, 1995). After the war, GSI continued to produce electronics, and in 1951 the company changed its name to Texas Instruments. In 1954, TI successfully developed the first transistor radio and started the electronic age. In 1959 TI's another landmark discovery was the integrated circuit (IC). Currently, TI is the No. 3 manufacturer of semiconductors worldwide after Intel and Samsung, and is the top supplier of chips for cellular handsets, as well as the No. 1 producer of digital signal processor (DSP) and analog semiconductors. Wireless communications has been a primary focus for TI, with around 50 percent of all cellular phones sold world-wide containing TI chips. The Wireless Terminal Business Unit (WTBU) of the Semiconductor division is the world's largest supplier of wireless chipsets. Ti also offered its global customers integrated chip sets and OMAP™ Application Processors including reference design. Other focus areas include chips for broadband modems, education, productivity solutions, PC peripherals, digital consumer devices, telecommunication infrastructure, and radio frequency identification (RFID). TI also offers turnkey solutions for analogue technologies.

Table 1. Comparison of Texas Instruments and NOKIA (in million$)

	TI	Nokia
Sales	14, 255	49, 420(29780)
Net Profit	3,367	6,155
Profit Rate	23.6%	15.5%
ASP	-	122 $

(Source: KETI (2007) and IR data of each firm)

3.3. NOKIA’s Value Innovation and Supply Chain Management

NOKIA was established in 1865 as a wood-pulp mill. In the late 1980s and early 1990s, the corporation ran into serious financial problems. Jorma Ollila, who became the CEO in 1992, made a strategic decision to concentrate solely on telecommunications. It is now the world's largest manufacturer of mobile telephones. Nokia produces market mobile phones of every major market segment including Europe, USA, Middle East, Asia, and China. Nokia's subsidiary Nokia Siemens Networks produces telecommunications network equipments, solutions and services. With its close participation in developing Global System for Mobile Communications (GSM) Nokia came to dominate the world of mobile telephony in the 1990s, in mid-2006 accounting for about two billion mobile telephone subscribers in the world, in more than 200 countries. It also produces protocol, including GSM, CDMA, and W-CDMA (UMTS). Supply chain management continues to be one of Nokia's major advantages over its rivals, along with greater economies of scale. As of 2006, ASP (Average Sales Price) of cellular phones is $122 and it has absolute superior cost advantages compared to the 2nd to 5th ranked global competitors (KETI, 2007).

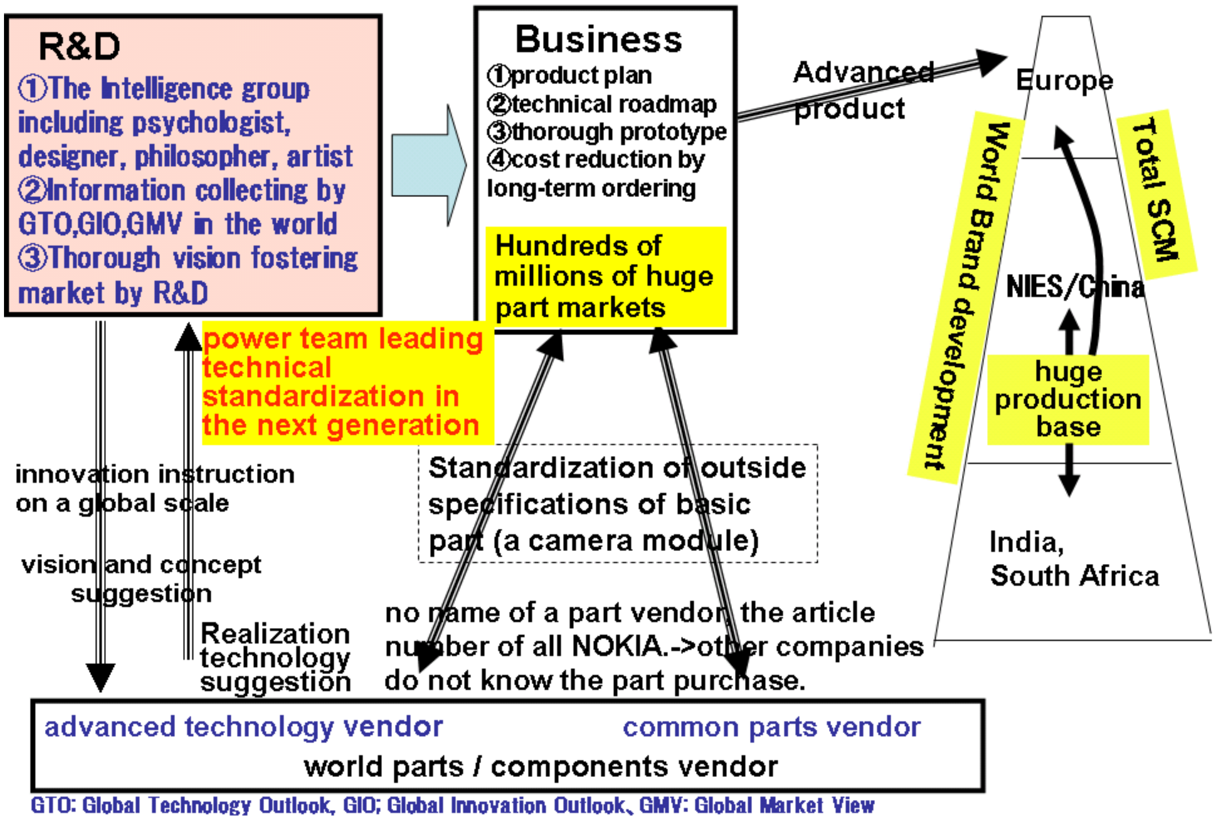

Figure 5. Nokia Value Innovation

NOKIA's production methods of its mobile telephones have a few distinct characteristics. First, most of the phones are assembled in their own ten factories which manufacture more than 400 millions and cover 40% of the global market. NOKIA does not outsource its manufacturing functions with its concern over time-consuming contract negotiations and slow responsiveness for market demands. However, basic low cost models that focus only voice communication are outsourced to OEM/EMS. Each business unit is free to choose factories by using their internal EMS production.

Second, acquisition of all component parts is through its huge network of suppliers. Highly skilled engineers who have sufficient technical know-how are assigned to handle complex procurement details of the component parts that exceed to 150 billions per year and 4 billions per day.

Third, NOKIA's two step assembly methods. NOKIA has been moving toward platform of handset's core component parts including chipsets. In response to customer orders it produces by different configurations of hardware and software which is slight modification of Dell methods. NOKIA adopts similar manufacturing processes for the development of new models of mobile phones. Just as auto-manufacturers produce different models of cars based on same platforms, so does NOKIA's models have different platform designations such as S30, 40, 60 and 80. It unifies baseline platforms of mobile phones and then uses standardized platforms for new products that include supplementary functions such as camera and MPs. By using platform designs NOKIA quickly develops new products that have the same baseline technologies and yet have diverse external features and unique functions. For example, with S60 platform NOKIA produced 700 millions of mobile phones with 44 different models. This type of production methods is unique to NOKIA. Platform design methods have generated other added benefits. The percentage of R&D expenditures dropped to 8%. The reduction of product development processes are 20% (more than the improvement rate in other manufacturing processes) and 30% reduction in product development cost is also reported (Chosun Daily, 2007.5.25).

Fourth, all the quality inspection is through outsourcing. Finally, the manufacturing unit cost is 20$ and is sold at $88. At present NOKIA is working on developing low cost handsets ($10). Its strategy is not "mass sales with low prices" but "mass sales with high profits". For example, as the top market leader, the average prices of its mobile phones are the lowest among the top global five manufacturers. Yet, its profit rate is more than 33% because of its double sales volume compared to that of its close 2nd competitor. In summary, NOKIA's business success is based on unique cost control methods through standardization platform, small royalty payment, price negotiation power of component parts (Chosun Daily, 2007.5.25).

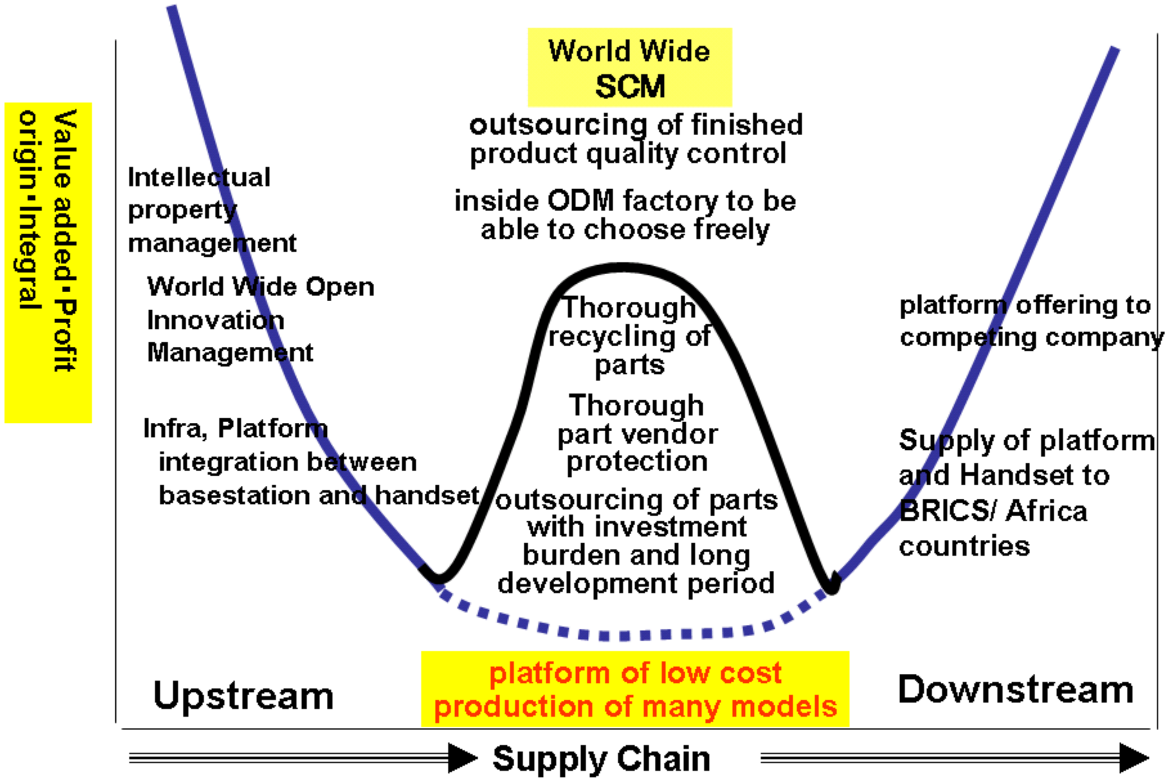

Figure 6. NOKIA's Supply Chain for Value Creation

4. Product Architecture of TI's DSP Applied in GSM handset of Nokia

4.1. The history of TI's technology development of Digital Signal Processor

Analogue signals such as voice, video image and movies are changed into digital signals through AD converters. These digital signals are processed in rapid speed by LSI DSP (Digital Signal Processor). DSP is large scale integrated (LSI) chip which digitalizes signals and then process them. DCP LSI is divided into DSP and FPGA (fit to small scale production) and large scale production system. Texas Instruments (TI) holds the largest share in DSP market. DSP has contributed to the performance enhancement and cost reduction of household electronics. DSP also facilitated collapsing the size of voice and video data, quick retrieval and reliable restoration of data and comprehensive processing of complex sets of data.
DSP has three essential characteristics (Yasuhiko, 2007). First, it has a few useful commands. Second, it carries high powerful calculator that performs arithmetic calculation (addition, subtraction, division and multiplication) and required level of memory. Third, it has two types of buses (i.e., program and data transmission).

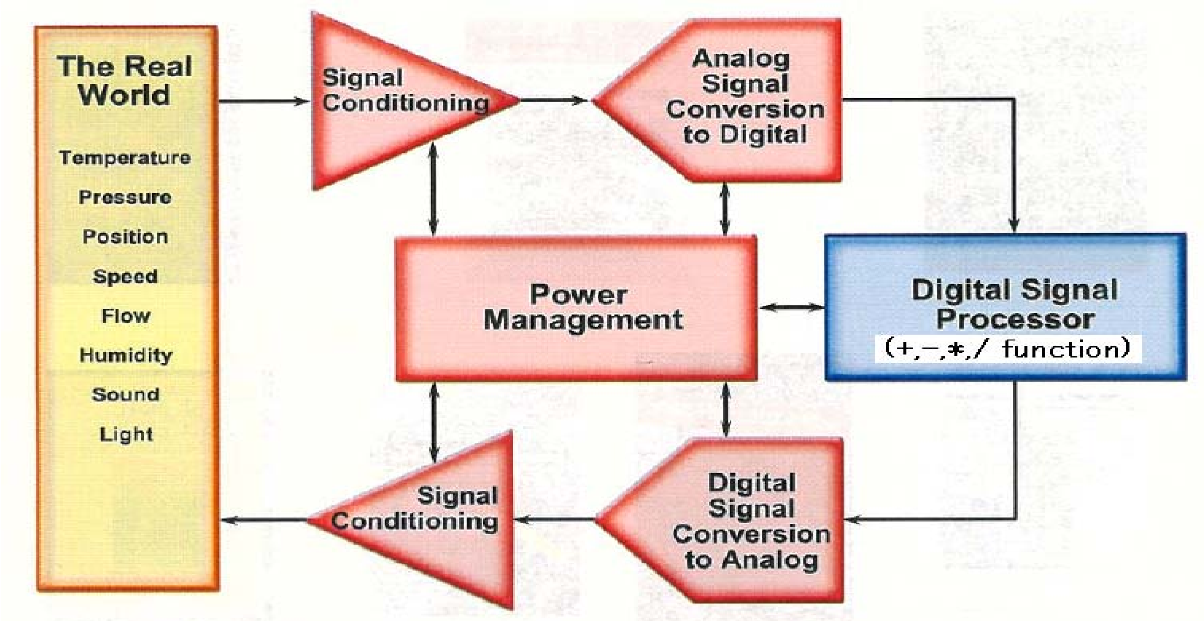

Figure 7. DSP's Functions
(Source: Texas Instruments Digital Signal Processor Overview (January 20th 2006))

In 1960s-1970s TI pursued DSP development in response to the needs of defense industry. TI was also active in the defense electronics market in the 1970s-1990s, designing and manufacturing airborne radars and electro-optical sensor systems, missiles, and laser-guided bombs. In 1978, Texas Instruments introduced the first single chip speech synthesizer and incorporated it in a product called the Speak & Spell that showed its feature in the movie E.T. the Extra-Terrestrial. In 1982, TI introduced TMS 320 that is the first pioneering version of DSP and yet it did not generate enough market interest. It was the emerging mobile phone market that gave the new light to TI. From

1994 TI became the top supplier of chips for NOKIA's cellular handsets and the No.1 producer of digital signal processor (DSP). As of 2006 TI secures 58% of 8 billion ($) cellular phone market (Digital Times, 2006.7.12).

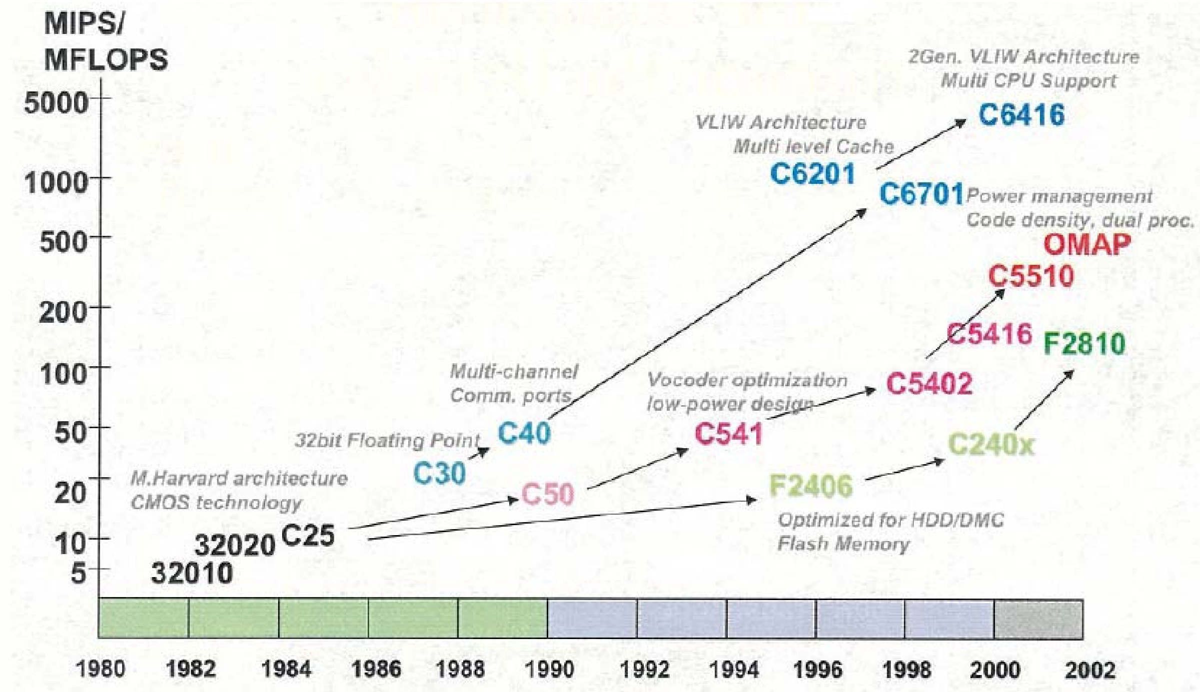

Figure 8. TI DSP history
(Source: Texas Instruments Digital Signal Processor Overview (January 20th 2006))

4.2. TI's DSP Architecture in GSM Handset of Nokia

As mentioned, although Texas Instruments (TI) engaged in DSP research since 1970s, it did not succeed in new products until 1982 when they introduced the first DSP product. In 1990s, with the tremendous growth in mobile telephones, TI secured its position as the sole supplier of NOKIA's 2G GSM phones. 2G mobile phones adopt an embedded DSP core with ARM MPU core or a multiple processor core in internally developed process core (e.g., Philips, Infineon, and Motorola)(ETNews, 2002.7.23).
TI first produced component parts (e.g., digital DSP, analogue semi-conductor, power amp) with strong interrelationships on their own and purchased core chipset processors from ARM. From the standpoint of product architecture TI used integral architecture (i.e., integration of digital and analogue parts) for their own products while it purchased the process core parts from ARM (its external strategic partner) by applying modular architecture. In the early 1990s it was focusing physical integration among integral component parts since TI could not produce single chip that integrates analogue semi-conductors including RF chip.
Afterward, in March 1994 TI developed Multimedia Video Processor (MVP) that became the key of multi-media. MVP is a single chip with RISC processor and four DSPs (total 4 million transistors). Until that time, real time compression and functional extension for video, image and audio have been dong using parallel processors and circuit base, but these works could be done using single chip by MVP (Yukio, 1995). In

2000s, with the accelerating demand in the emerging market (in contrast to the slow growth in the advanced mature market), TI's business strategy focus has been (1) to develop low cost DSP chip and (2) to integrate ARM processors and analogue component parts (e.g., RF) into single chip. In 2002 TI developed OMAP (Open Multimedia Applications Platform) chip. In 2004 with OMAP2 TI secured personal entertainment and communication functions in mobile phones (EECC, 2004.2.26).

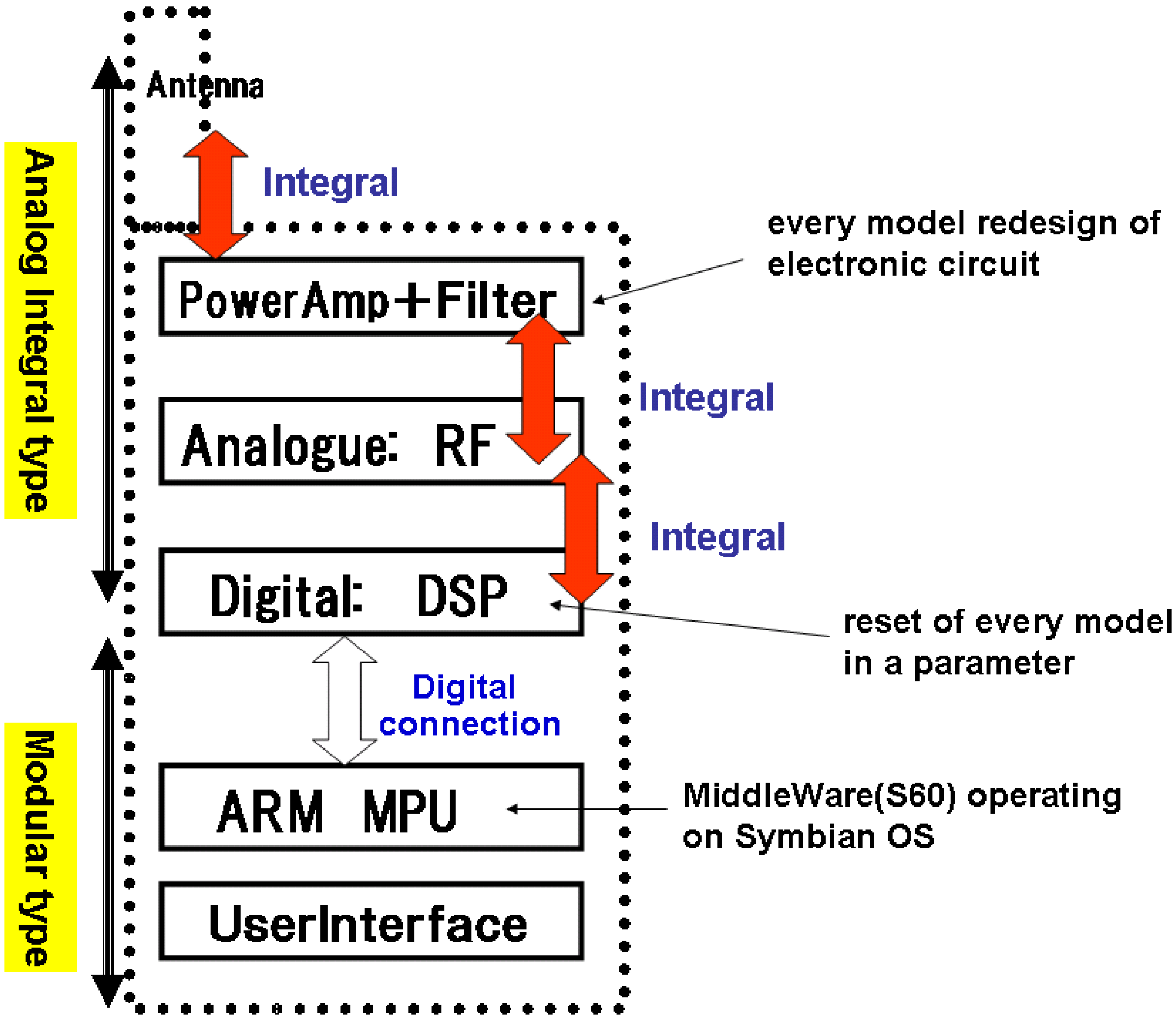

Figure 9. Product architecture of TI's DSP and ARM in Nokia Handset

OMSP2 Processor contains delicate electrical management circuit that ensures maximum performance to the users and extends the battery life as well. It also supports development platform that includes hardware evaluation module, reference design, ARM and DSP compiler, debugger and OMAP's software emulation function. Besides, TI invests its ample resources to develop next generation chip series that support GSM/GPRS/EDGE/WDCMA and integrate 3rd generation communication base band and multi-processor OMAP. TI plans to offer baseband and multi-media processor as the customer-driven products in terms of price and rich applications and therefore enhances its dominance in the market of 3rd generation mobile communication (ETNEWS, 2003.3.18).

In January of 2005, TI announced that single chip solution with digital RF processor (DRP) will be used in NOKIA's handsets. With the adoption of TI's DRP based single chip technology NOKIA upgraded its brand image in the market. Price, size, electrical battery power, and performance maximization are all important value components for mass production of new handsets. NOKIA's handset technologies and TI's single chip solution made all the above requirements possible. TI's most recent multi-media wireless communication technology includes single chip solution for mobile digital TV, and other future generation single chip solution for GPS, wireless LAN, UMTS and other wireless interfaces. From 2006 NOKIA and Motorola have marketed handsets with low cost chip to China, India, Bangladesh, and Russia (Digital Times, 2006. 7.12).

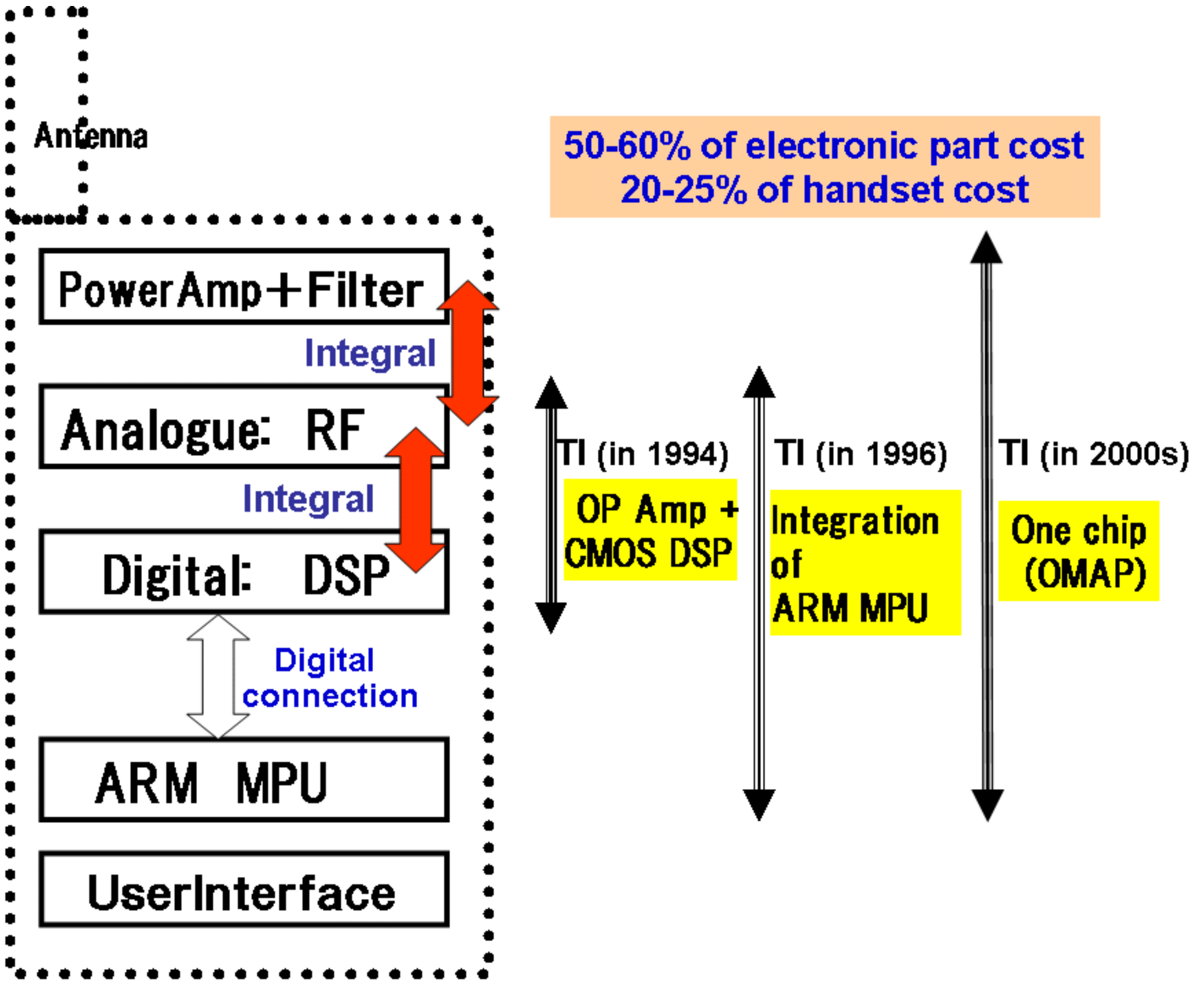

Figure 10. Historical integration stage of TI' DSP and ARM processor in Nokia Handset

For component parts, NOKIA uses ASIC products that are internally developed out of fear of overdependence on its platform core competencies on TI. But most of semi-conductor chip manufacturers lean toward ASSP products. For example, Motorola, TI, Philips, Intel, Qualcomm, and Infineon are moving toward ASSP not ASIC (ETNews, 2002. 7.23).

Particularly, total solution (that includes ASSP products) is expected to contribute to cost reduction and price competitiveness of handsets. This suggests that handsets follow the patterns of household electronics and in the existing value chain added values are transferred from small specialized developers to mass producers. This suggests that small handset manufacturers are moving toward one stop shopping through standardization efforts rather than depending on small numbers of semi-conductors.
In the other hand, in TI's OMAP, baseband, RF and application chips are integrated in single chip to maintain semiconductor in integral element in value chain of handset. Especially semiconductor manufacturers like TI, have a tendency to sell single chip as a modularized part not only to Nokia but to Asian handset firms.
In that case, discrimination between Asian ODM firms and handset manufacturers having a competitive power in a mobile market like Nokia may be narrow in the future.

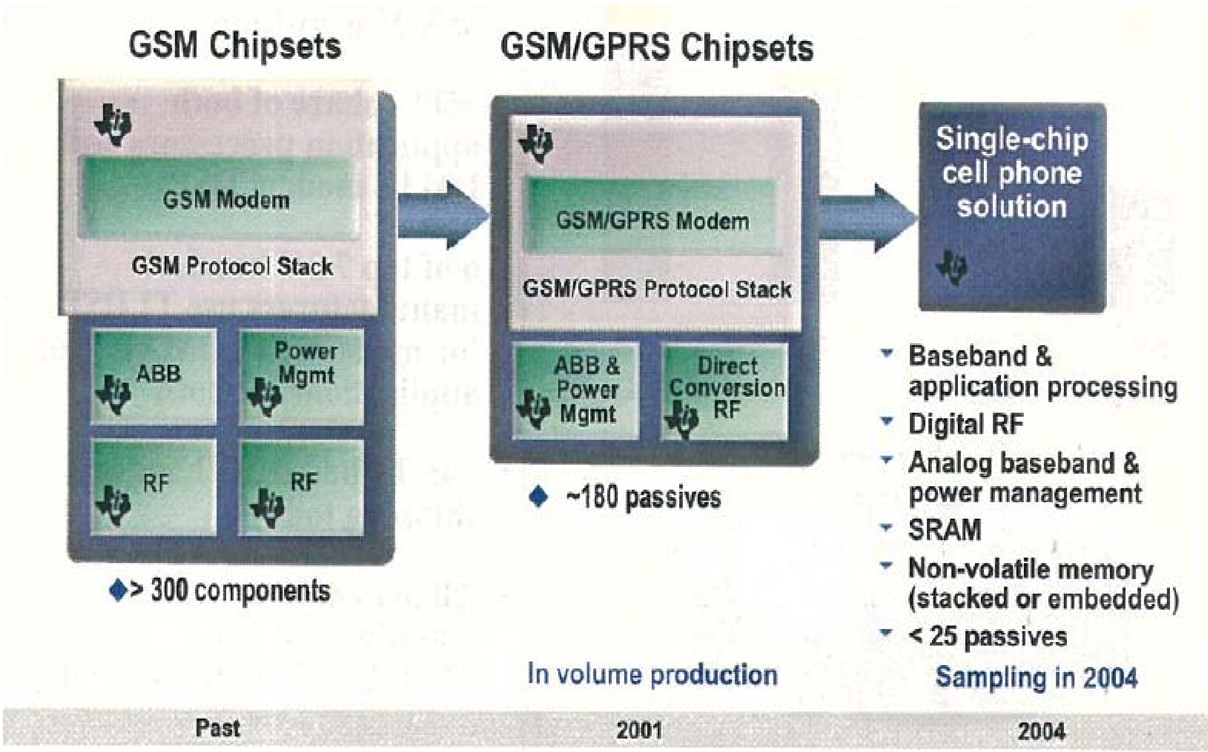

Figure 11. 2G/2.5G/3G TI chipsets
(Source: Texas Instruments Digital Signal Processor Overview(January 20th 2006))

5. Discussion

Increasingly, semi-conductor manufacturers strive to provide total solution based on core base band chip for their sustainable competitive advantages. The core of next generation handset technology is in the integration of key service functionalities in its baseband. This explains why TI is so strategically focused on integrative solutions (such as OMAP with application processors and development tools).
Positioned both in the front and backend of value chain, NOKIA and TI maintain complementary nature of strategic alliances for their mutual competitive advantages.

Fine (1996) explains such relationships as “double helix” by using the concept of product architecture. Integral products usually have vertical integration structure in value chain. However, factors (such as niche competitors, high dimensional complexity, and organizational rigidity) have disintegrating impact in the value chain. The above mentioned modular pressures change a value chain into horizontal and divisible modular products. Other factors (such as technical advances, supplier market power, and proprietary system profitability) tend to change the structure of the value chain system into more integral product architecture. In 1994 NOKIA intentionally divide the value chain structure into specialized fashion. However, in 2000s it moves toward more vertical integration in its value chain and adopts single chip strategy in response to the increasing influences of semi-conductor suppliers like TI.
In 1994, Nokia made value chain structure of a mobile phone de-integrated through outsourcing of semiconductor chips to utilize innovation of semiconductor companies such as TI and ARM, but in 2000s Nokia may change product architecture structure by reinforcement of internal development such as ASIC because of reaction for the semiconductor suppliers who seem to have big influence on value chain structure through integrated single chip rapidly.
In other words, in product architecture of a mobile phone, we can foresee recurrence to integral architecture as a reaction for power of strengthened suppliers in value chain, as handset manufacturers like Motorola kept integral architecture in the analog times.

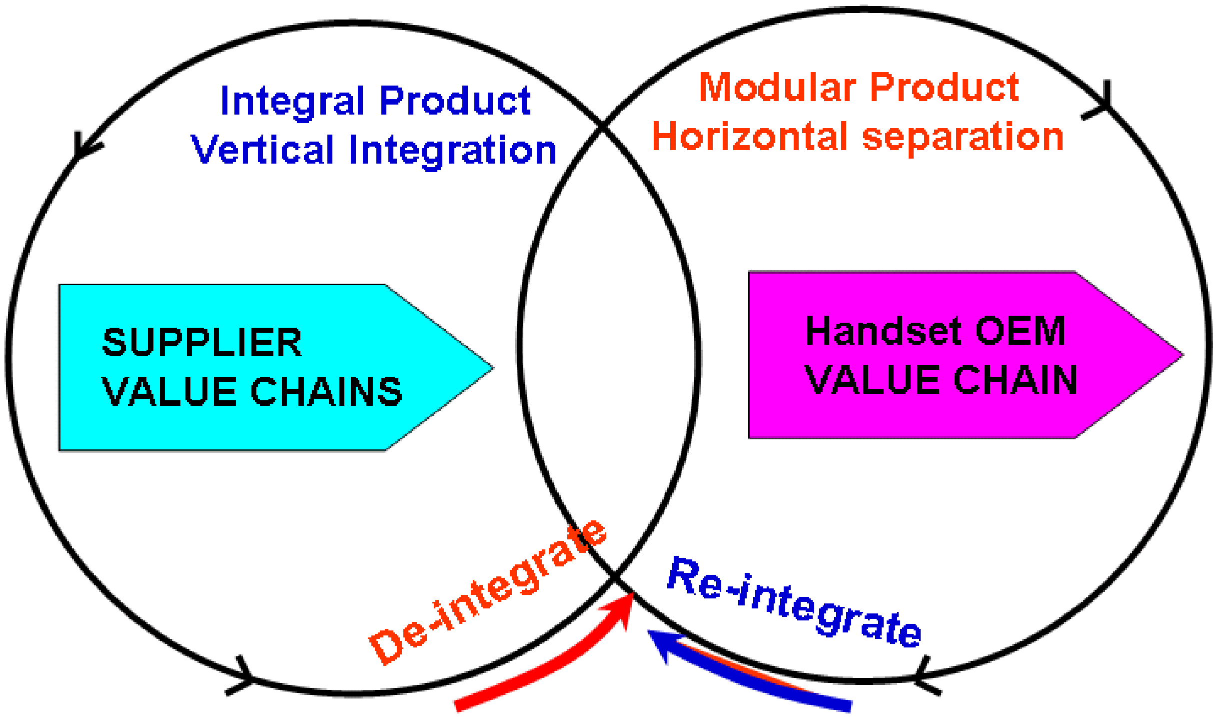

Figure 12. Change of Product Architecture
(Source: Adopted from Fine (1996))

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The Effect of Technological Platform on Global Supply Chain: Case Study of Intel's Platform Business in Pc Industry

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Abstract
Today PC products are common goods. In early 1990's, however, PC was expensive and only a business man used it. PC has great success to be widespread among the general public.
At this diffusion process, technological platform has played a key role and produced a powerful effect on global supply chain. Many researchers suggest the significant relation between the technological platform and the international division of labor(Sturgeon, 2002).
Technological platform promotes to change the structure of industries form vertical integration to vertical disintegration. As the result, it stimulates the industries in growing countries and encourages the collaboration between firms in developed countries and in growing countries.
However we have very little deep-knowledge about the mechanism for the diffusion of technological platform.
This paper examines how a leading firm commercializes and diffuses novel technologies as technological platform under vertical disintegration drawing on the case of Intel's platform business.
Intel introduced their CPU's and chipsets to Taiwanese motherboard[1] manufacture in early 1990's. They didn't only supply them. PC's technological platform includes not only CPU's and chipsets, but also manufacturing recipe, BoM(Bill of Materials) lists, reference designs and technical solution. Moreover, Intel has standardized large portion of area inside PC.
This case shows us how technological platform was accepted by firms in growing countries and had the influence on the international division of labor.
Sturgeon, J. S.(2002) "Modular production networks: A new American model of Industrial Organization", Industrial and Corporate Change, Vol.11(3).pp.451-496.

Keywords: Technological Platform, International division of labor, diffusion mechanism, Intel's platform business.

1. Introduction

1.1 Research theme

This research present here is of an international division of labor influenced by a technological platform.

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[1] A motherboard is a main component (print circuit board) of PC.

Recent interest in relation between vertical disintegration and technological platform has made researchers greatly research(Berger and the MIT Industrial Performance Center, 2005 ; Sturgeon, 2002).Modularization is widespread in the all industries, especially in the digital products areas. In the traditional industries, firms make great efforts to develop core technologies. However, modularization makes it possible that companies can obtain the even core technologies through market transactions. As a result, every companies easily becomes to participate in the competition under the vertical disintegration circumstances. At the same time, commoditization and various innovations (von Hippel, 2005) is promoted.

As the design rules of the product is decided and the modularization is widespread, the industrial structure shifts to the vertical disintegration (Baldwin and Clark, 2000). The venders supplying technological platforms which achieve the core functions of the final products are the main supporters of these industrial changes (Christensen and Raynor, 2003; Iansiti and Levien, 2004). The reason why the technological platforms promote such changes is technological platforms supply not only functional elements but also system knowledge of the final products, that is, design rules.

The appearance of a technological platform has a big influence on the relation between the industrial structure and the enterprise relationship and economic development in the country (Shintaku, Ogawa and Yoshimoto, 2006). It becomes possible for new firms to enter the final products market with technological platforms, even if they are in emergent countries. This is why international vertical disintegration is promoted (Sturgeon and Lee, 2005).

However, it is not clear what characteristics a technological platform has and how the platform influences on these industrial changes.

The purpose of this study is to examine the natures of the technological platforms and the mechanism of their influences on the international division of labor.

By drawing on the detail case study of Intel’s platform business in Taiwan, the accounts of the natures and influences of the technological platforms are generated. The platform business of Intel in the personal computer industry that happened in the 1990's is the research target.

The progress of Taiwanese economy had a big influence on the electronics industry after the 1990's. The cooperation between Intel, CPU vendor in the United States and Taiwanese motherboard or notebook PC manufactures is the typical successful case.

Therefore, this paper focuses on the collaborative economic development process between Intel and Taiwanese firms as the technological platform case.

As a result, two features of a technological platform were founded. First, a technological platform firm integrates peripheral elements and composes a technological platform from them. A technological platform is very integral system itself. Second, a technological platform has the standardized interface. Therefore, the diffusion of technological platform has increased the open-modularization of the product architecture. These facts mean the product architecture is to be integral inside the technological platform and to be modular on the outside.

Next, one fact on change of international division of labor with a technological platform was found. The open-modularization of the product architecture advances as a technological platform spreads. And, the manufacturing of the products with novel technologies becomes possible in the firms with a little technological accumulation. Therefore, the entry of the new company including the rising nation firms happens

frequently. As a result, it has been understood that the rising nation enterprise rapidly extends production using a technological platform.
It is concluded from this research that the technological platform is important as a competitive pattern of the firms under the vertical disintegration. And at the same time, the diffusion of technological platform influences on international division of labor through its natures.
In the first section, the basic objective, the method, the object, and the conclusion of the research are described. In the second section, the research framework and method are explain in detail. In the third section, the facts founded from the result of this in-depth case study are mentioned. In this case study, deep relationship between the nature of a technological platform and the cooperation of Intel and Taiwanese firms are revealed. And, the cooperation mechanism with a technological platform is discussed from the obtained facts. In the fourth section, the result of this research are compared to the past research, and generalization is tried. In the fifth section, finally, the conclusion is described.

2. Method

2.1 Method

In the present study, the nature and the influence mechanism of a technological platform are examined by focusing one typical case, and doing a detailed case study.
Intel's platform business is widely known as a typical case with a technological platform. However, few researchers are explaining it in the viewpoint of the international division of labor. Therefore, this case study investigates the process that a technological platform of Intel was accepted to a Taiwanese firms by the interviews and statistics.
The interviewees are Intel's design center in Taiwan and a Taiwanese motherboard and notebook PC manufacturers. 90 percent of the world-wide demand for motherboards is produced in Taiwan now. Intel also is supplying CPU and the chipset for a Taiwanese enterprise. Therefore, a technological platform is suitable for investigating influences the international specialization.

2.2 Research Design

The research question of this investigation is the following two.
i) What characteristic does a technological platform have?
ii) How does a technological platform influence the international specialization?
These research questions can be broke down to following two operational ones in the observational level.

Research Question 1) What characteristic does a technological platform have?

To observe the characteristic of a technological platform in a practical manner, the aspect of architecture is introduced. In the framework of architecture, the character of the system is observed by two indices. The first evaluation indicator is a dependency of the element that composes the system.
The system can be broke down in a lot of elements , and then the dependence between elements is observed. The system with a strong dependence between elements is called

Integral system, and one with a weak dependence is called Modular system.
Another indicator that explains architecture is whether the information of the interface is open or close to others . It is called open system when the interface is standardized, and it is open to all the firms. Oppositely, it is called close system when the information of the interface is accessible to only a specific firm.
In this investigation, the change of the product architecture by introducing the technological platform is observed with two indicators of "integral-modular" and "open-close".

Research Question 2) How does a technological platform influence the international specialization?

The Taiwanese motherboard industry grew up greatly in the 1990's. Intel also released a technological platform in the 1990's. Whether it related between the two is confirmed by using the statistical data. To examine the relation between diffusion of the technological platform and the growing up of the production in the growing countries, two statistical data are used.
The first statistical data is the market-share trend of the Intel's chipset, which shows the spread of a technological platform.
The second statistical data shows production in the rising nation using a technological platform. A Taiwanese firms produces motherboards by using a technological platform. The motherboard is the main print circuit board in the personal computer. And, the chipset is mounted on the motherboard. The time series data of Taiwanese motherboard production is regarded as the industrial growth in rising countries.

3. Case study and fact findings

3.1 Industrial environment

About 1990-1993 year was time that had been exposed to threats most for Intel's CPU business. The compatible CPU enterprise that competed with Intel began to appear. Cyrix is included in such an enterprise. Moreover, the enterprise that develops CPU for the minicomputer and the workstation has entered CPU market for the personal computer.
A basic strategy of Intel that dealt with this threat was "A large amount of CPU was supplied, and rival's CPU enterprise was surpassed in the scale economy". It was the maximum strategy to rival's CPU enterprise that latest CPU spreads promptly the personal computer equipped in large quantities.
Even if a large sum of development cost and manufacturing cost are invested, a large amount of supply of CPU allows Intel supply latest CPU at a low price. As a result, the complementary products such as software and hardware expands, too. It was the key for success to rotate product life cycle at very high speed.
To execute this strategy, it's not enough for only supplying CPU with limited traditional PC manufactures like IBM or Compaq etc. And these traditional companies disliked Intel's monopoly and were ardent to the adoption of Intel's competitors' CPUs.

3.2. Fact 1: A technological platform was made by the architectural integration.

Intel needed to supply a large amount of, latest CPU to upstart ventures and no brand enterprise like Dell, Gateway etc. These enterprises were generally young and their technologies were low.

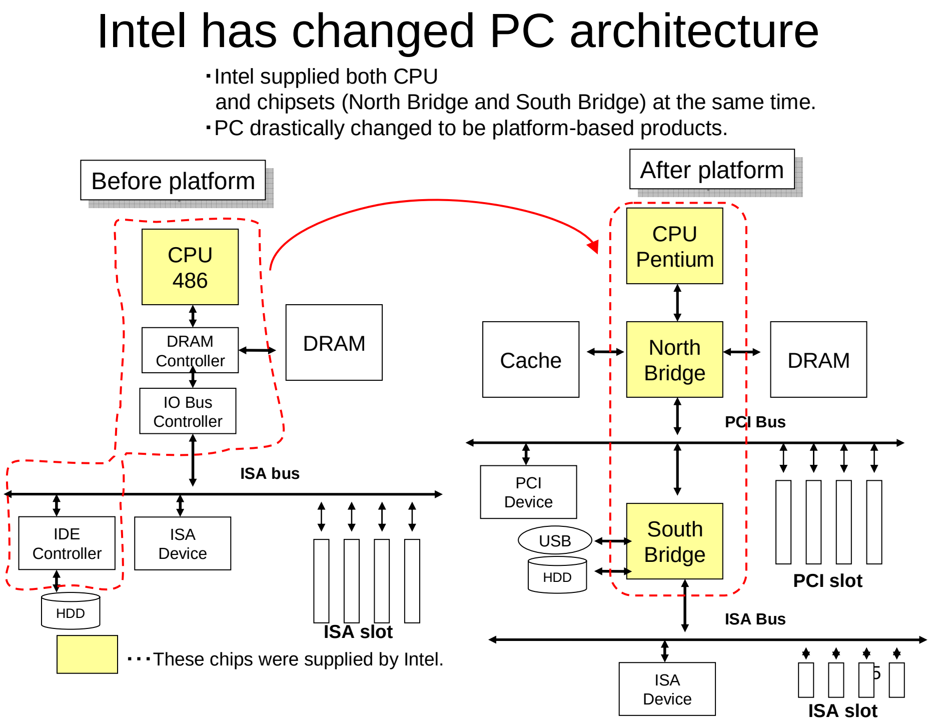


Figure1. Platform of Intel

It was not enough only by the supply of latest CPU to them. They were not able to master it deeply and to develop the final product. Not only CPU but also the circumference IC is necessary to introduce latest CPU into the market promptly. In addition, it is necessary for motherboard developers to adjust CPU and companion ICs mutually.

In the development of the motherboard, the problem of the mutual coordination happened frequently. It took the considerable time until personal computers with latest CPU were put on the sale after Intel had developed it. Adjusted chipsets ware introduced as the solution of these problems. These chipsets facilitated to develop the personal computer that uses latest CPU.

In this paper, the component of adjusted chipset and CPU is called a technological platform. In a comparison of the product architecture before Intel supplied technological platform and the one after Intel did it, Fig.2 shows the range of the elements that Intel supplies has expanded.

Intel supplied latest CPU and the chipset as a platform to the market at the same time, since Pentium CPU. It was a moment when Intel had become a platform leader. Intel supplied the chipset for Pentium from 1993. The Triton chipset put on the market in 1995 paid the big success, and Intel won the first place about the market share in the chipset market. CPU and the chipset came to be planned by the same road map as a platform since Pentium CPU.

3.3 Fact 2: Standardization of the PC

The strategy that Intel did is not only a supply of the chipset. Intel standardized an internal bus, size of components, and various interface with external peripherals. On some occasions Intel standardized it by themselves alone, on the others with other firms together. Standardization was done in most areas of the personal computer (Figure 3).
Intel initiated standardization, and at the same time they supplied a large amount of chipsets that had the standard interface. If the firm uses the chipset that Intel supplied, they can use various standardized parts. Another effect of standardization is the solicitation on the consumer. Even if it is no brand maker's PC, the consumer can buy it at ease if it has standardized interfaces such as USB and PCI.

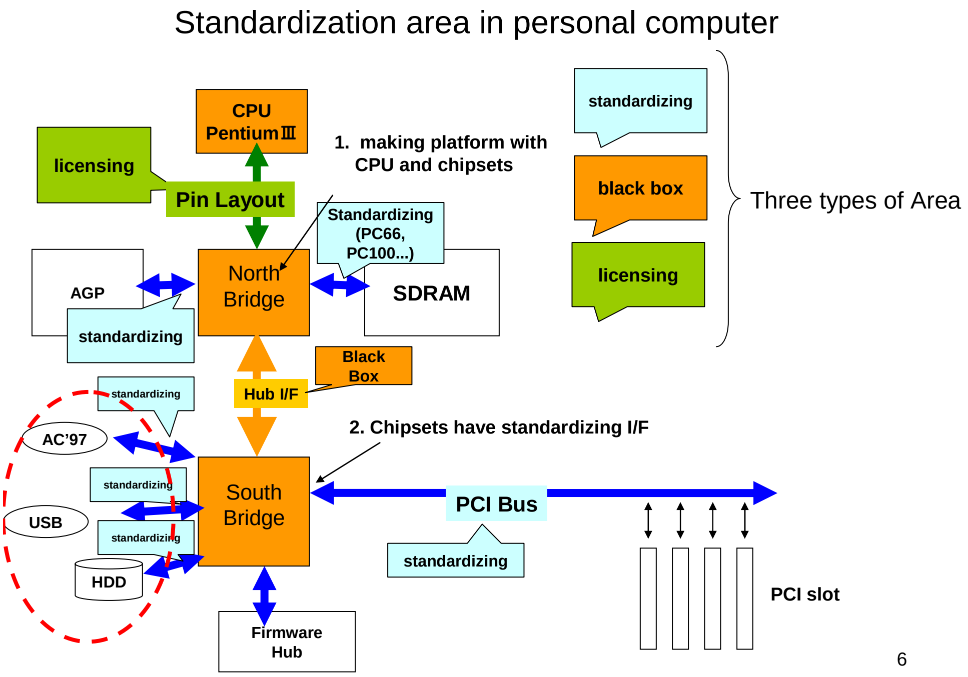
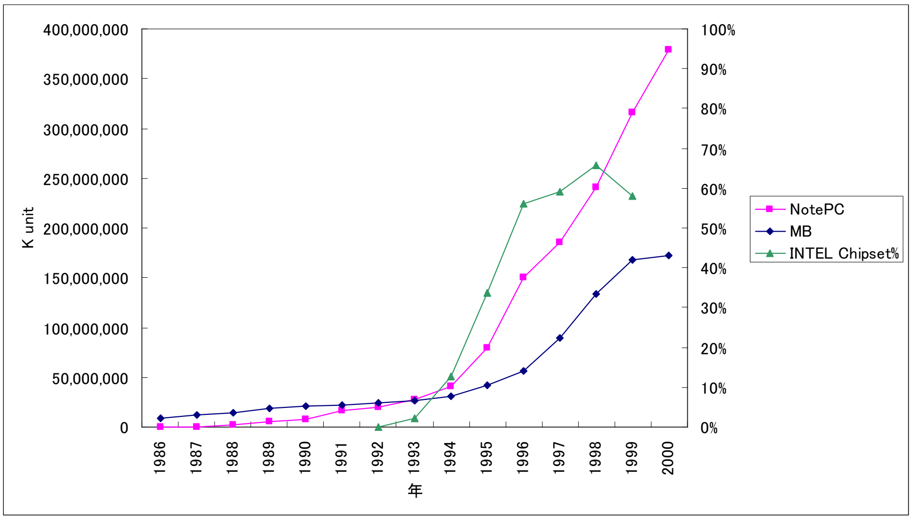


Figure2. Standardization area in personal computer

Standardization has advanced in the notebook computer as well as desktop. Changing the personal computer to modular system was rapidly promoted by a large amount of supply of the chipset which had the standardized interfaces. A huge coordination between final products manufacturers and component suppliers was necessary for the personal computer and the notebook computer before standardization. The personal computer was born to be integral system. Therefore, personal computer manufacturers and component suppliers had to coordinate mutually. However, the technological platform transformed the personal computer to complete modular system. After this conversion, any firms can produce the personal computer if they purchase the components and the technological platform. Intel changes PC's architecture from integral system to modular one by using technological platform. As a result, the focus of the competition in the personal computer industry has changed completely.

3.4. Fact3: Taiwanese firms received the technological platform, and their production was growing rapidly.

The trends of motherboard/note PC production in Taiwan and chipset market share trends



Data:Kawakami(2007), Dataquest 39

Figure3. Trends of Intel's chipset market share and production of motherboards and notebook PCs in Taiwan

On the supply side, who was the receipt hand of the Intel's technological platform? As previously stated in this paper, the traditional final product manufacturers were in the antagonism with Intel, and they were developing the latest chipsets by themselves. They were not major recipient in Intel's technological platform. The biggest recipient was Taiwanese ODM firms to which the firms in the developed countries often outsource.
The ODM market of the motherboard for the personal computer in Taiwan had already been approved in around 1990. However, the products that Taiwanese ODM manufactures had been supplying was not the latest motherboards. They mainly provided economic versions of motherboards that were obsolete functionally and not so expensive. The latest and premium motherboards were enclosed in in-house market by traditional firms such as IBM or Compaq. The technologically advanced firms had a tendency toward developing originally the latest chipsets by themselves. They differentiated their products with the chipsets.
A Taiwanese enterprise was being shut out from the premium market. It was a very attractive thing for Taiwanese firms to supply the latest and premium motherboards by using Intel's technological platform. In about 1995, their gross margin ratio of the latest motherboards occasionally exceeded about 60%.
Taiwanese firms had great success in the field of motherboards and they again achieved in the notebook PC by using the technological platform. In the field of notebook PC, the knowledge of the entire system was required for the manufactures, so traditional firms had competitive advantages.
The knowledge of the entire system here was a heat design, and a power consumption

design, etc.. It is the chipsets that control these functions. The latest chipset did not circulate. And, the traditional firms were developing them in-house. Therefore, it was difficult for Taiwanese ODM manufacturers to enter the notebook market.

Actually, they had started the production of notebook PC in the early 1990's.However, their production was kept to limited growth because they didn't have enough knowledge of entire system. Although their production share was about 80% in 2005, it was only about 20% in 1995.

The Taiwanese notebook computer industry faced the substantial change in the mid of 1990's.. After 1995, Intel began to provide the chipset for the notebook PC energetically. The chipset market for the notebook computer was recognized the niche market. Intel began to supply a large amount of chipsets to this market energetically. Their main target consumer was Taiwanese ODM manufacturers.

The chipset for the notebook computer was designed more carefully than desktop in respect of power consumption and heat radiation. Moreover, the chipsets for the notebook computer solved the battery life problem by standardizing the power saving control function named ACPI.

As a result, the necessity for whole knowledge has become small relatively. On the one hand, the technological platform has helped the Taiwanese production. On the other hand, Taiwanese firm, especially ODM manufactures has contributed to the diffusion of the technological platform. Taiwanese ODM manufactures has invested ardently and expanded production on a large scale. As a result, a technological platform of Intel has spread all over the world.

3.5 Fact4:fall of standardized component's price and stability of technological platform's one

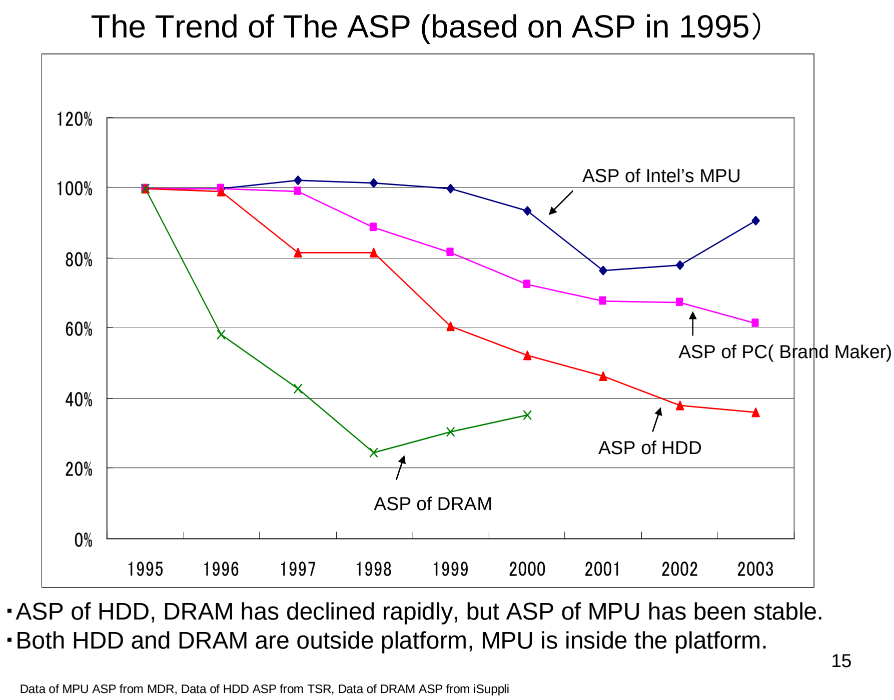


Figure4. Standardization area that Intel initiated

The personal computer converted a complete modular product from an integral product. However, Intel has made inside the technological platform a black box, and improved an integrated level. Oppositely, a technological platform has the standardized interface outside. Therefore, the more a technological platform spread, the more the price of the device connected with the standardized interface declined.

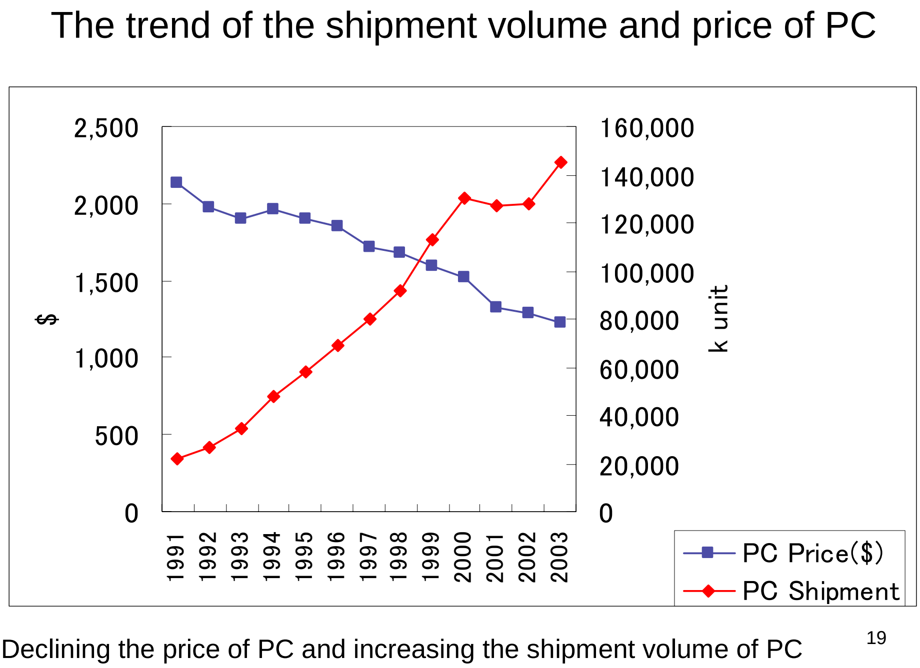


Figure5. Average selling price and shipment of PC

Because Intel had offered CPU and the chipset at the same time as a platform, the average sales price of CPU was steady. This is why the reason all inside in the platform was a Black Box. However, average sales prices of the main components such as HDD or DRAM rapidly were falling. The average sales price of HDD fell down to about 40% in 2003. DRAM was suffering from more rapider price drop. The sales average price of DRAM was about 40% in 2000 after only five years from 1995.

The architectural conversion of the personal computer brought the big influence on competition of the HDD market and DRAM market. The market share of Seagate expanded rapidly in the HDD market after 1995, and that of Samsung has also done rapidly in DRAM market. The strategic change has happened in the standardized component market such as DRAM and HDD. The large scale production and the cost leadership became a key success factor.

As main components become cheaper, the price of the final product was declining, too. Moreover, the element of the product differentiation has decreased because all the areas of the personal computer were standardized.

The commoditization has increased in the personal computer. Therefore, the strategy for competitiveness also got affected by architectural conversion of the personal computer. The enterprise that tried the product differentiation by technology like Compaq faced difficult situations. The company which focused on a circulation channel got more competition predominance than the one which invested in element technology.

A cheap personal computer came to spread all over the world as a result of converting architecture. The consumer, who couldn't obtain the personal computer before, can buy it. Open-modularization was enabled to send the personal computer to the consumer in the world.

4. Discussion

4.1 Results

The purpose of this investigation is that a technological platform has what characteristic, and how it spread was examined. Therefore, we set two research questions.
The following facts were discovered from the result of the investigation for the research questions.

1) Changing personal computer's architecture to open-modular one was promoted by the technological platform which had standardized interfaces. On the contrary, technological platform itself become more close-integral.

2) The motherboard production of Taiwan has expanded with the spread of a technological platform. The production of the notebook PCs of Taiwan has expanded rapidly similarly, too.

Moreover, we had following fact as a relating discovery.
3) A technological platform has the standardized interface. Therefore, the more the technological platform spread, the more the price of the device connected with standardized interface was falling. The commoditization of the personal computer increased radically, and the price of the personal computer declined. The more the price of the personal computer fell, the more the personal computer become widespread. The shipment of Intel's CPU has increased at the same time, too. However, the radical fall in price did not happen because it was inside the technological platform.

4.2 Comparison of present research result and past one

In the present study, the analysis began from a micro aspect of artificial system, that is, architecture, and examined the influence that the architectural change gave the international specialization.
Gawer and Cusumano(2002) is a famous research of a technological platform. By several case study, they clarified the strategy that the technological platform leader firms should take. Their discussions have concentrated on the strategy of the platform firms. Therefore, the influence on the international specialization by the architectural change with the technological platform has not been treated. It is this aspect, this research is complementary to their one.
Sturgeon(2002) is pioneer research that points out the technological platform influences the international specialization. He showed the economic model that the firms in the advanced country supply a technological platform and the firms in the rising nation produce the product with it. However, why is a technological platform accepted to the enterprise in the rising nation was not clear in his research.
In the present study, it was clarified that it had a big meaning to standardize when the

rising nation adopted a technological platform. And, the spread of a technological platform was assumed to be not an autonomous issue but a managerial one. The rising nation enterprise can produce products with standardization even if they don't have any complex know-how or marketing information.

4.3. Recommendations

This investigation took up the technological platform issue by the case study. It is necessary for further generalization to do more case studies in another products segment or to use cross-sectional statistical data.

5.Conclusions

Intel aimed at the conversion of PC's architecture by the technological platform, and Taiwanese firms acquired a huge growth chance in the new architecture. Intel and Taiwanese firms presented the model with new international specialization that based on architecture. This economic model was born from the personal computer, but, it is more important today because it's widespread to other industries. This model is seen in various products segments such as the cellular phone, the DVD player and digital cameras, even LCD panel and Photo Voltaic.

The framework of this model that "rising nation enterprise extends the achievement by using the technological platform supplied from advanced country firms" has not changed. It is just applying this model to other product fields. It is necessary to recognize the importance of the this model again.

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An Improved Order Picking System by Using the Concept of Bucket Brigades

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Abstract
This paper discusses order picking problems in warehouses. Order picking is the process by which products are retrieved from specified storage locations on the basis of customer orders. Today, as the transactions through direct sales increase, warehouses often receive a large amount of small orders to be picked, which makes fast and efficient order picking more important than ever. This paper examines a new order picking method where the concept of bucket brigade (BB) is applied. Bucket brigade is a way of dynamically coordinating workers who progressively perform a set of operations along a flow line. In bucket brigades, a worker is assigned the jobs in a dynamic way. We identify some considerations when bucket brigades are applied to order picking. A new BB picking protocol is presented. Through simulation experiments, the performance of BB order picking is evaluated.

Keywords: Order picking, bucket brigades, zone picking, warehousing, dynamic system, blocking, hand-off

1. Introduction

Warehouses carry out a variety of activities which include receiving, storing, order picking, sorting, packing, and shipping. Among these, order picking is the process by which products are retrieved from specified storage locations on the basis of customer orders. Today, as the transactions through direct sales such as electronic commerce and TV home shopping increase, warehouses often receive a large amount of small orders to be picked within tight time windows, which makes fast and efficient order picking more important than ever. The performance of order picking depends on warehouse layout, storage strategy, picking strategy, picking routing, order batching, and so on. Among these, picking strategy is related to how the orders are picked. One of the order picking systems that are widely used in industries is zone picking, which is shown in Figure 1. For zone picking, the warehouse is divided into several picking zones to each of which one picker is dedicated. After picking up an ordered item from the rack, the picker puts it into a box on the conveyor behind him and slides the box along the conveyor as he moves down the aisle. Each box is assigned to collect products for a specific order that is a list of items for a single customer or a group of customers. On reaching the end of his zone, the picker leaves the order on the conveyor for the next picker and returns to the beginning of his zone for more work. Each worker remains in his zone, moving boxes forward while picking, and is idle if there are no orders waiting when he returns to the beginning of his zone.

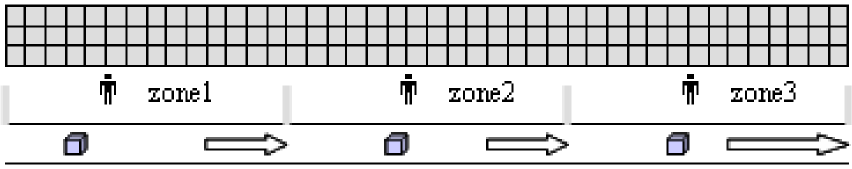

Figure 1. Zone order picking system

One of the issues in zone picking is to equalize the workload of the zones so that the pickers have balanced workloads. If the workload is not balanced, a picker keeps busy while the other pickers remain idle without the order to be filled. The unbalanced workload results in long lead time and less throughput rate. A few research works have been done to balance the workloads among zones. Jane (2000) presents a heuristic algorithm for balanced assignment in a zone picking system. Considering fluctuation in order volume over time, the algorithm adjusts the number of zones. Later, Jane and Laih (2005) propose an assignment algorithm in a synchronized zone picking system. A similarity coefficient of any two items is first presented for measuring the co-appearance of both items in the same order. Le-Duc and De Koster(2005) presents a procedure to find the optimal number of picking zones by using mixed integer programming.

The balanced workload model in zone picking has some problems in practice. Firstly, the workload is usually calculated based on historical order data. However, the demand in the past may not remain the same in the future, especially under today's fast changing market environment. Secondly, the model attempts to balance the total work over long period of time. Even though it may appear balanced on average, the allocation of work can be quite unbalanced in real operational situations because the items in each order changes from order to order. Thirdly, the static balancing method cannot adjust to uncertainties such as equipment break down, employee conditions, and other various interventions. Lastly, the work speed of each picker is not considered in assigning items to zones. This will result in lower picker utilization than expected.

A promising alternative for the zone picking system is bucket brigade order picking (BB picking). Bucket brigade is a way of coordinating workers who progressively assemble a product along a flow line. In bucket brigades, each worker performs operations on an flow line until the next worker downstream takes over the job, then goes back to the previous worker upstream to take over a new job. In this way, the line balances itself and no work-in-process (WIP) is allowed unattended in the system. This paper describes bucket brigades applied to order picking systems. We discuss distinct characteristics in order picking systems when bucket brigades are applied. Some efficiency losses under the BB picking are identified. We discuss an alternative method to improve BB picking and investigate the performance of bucket brigades. Through simulation experiments, the performance of BB picking is compared with that of zone picking.

2. Bucket brigade order picking

2.1 Introduction of bucket brigades

Bucket brigades (BB) imitate the cooperative behavior of ants when brood, food or other resources are moved (Anderson et al. 2002). Each ant carries his load along the trail until she meets an unladen ant. Direct transfer takes place between two ants and the doner ant returns back up the trail while the recipient ant carries the load further down the tail until he meets another unladen ant, and so on. Load transfer is always direct and is not a fixed location. (Anderson et al. 2002) Bartholdi and Eisenstein (1996) present theoretical studies on the bucket brigades. They start by using several simplifying assumptions and by modeling a self-balancing line as a Markov chain. Then, they enrich the initial model by relaxing some assumptions (Bartholdi et. al., 2001; 2006 and 2008). They apply bucket brigades to warehouse order picking systems (Bartholdi *et al.* 2001) and manufacturing assembly lines (Bartholdi and Eisenstein, 2005) and report many successful results. Bartholdi and Eisenstein, (1996) present normative model, which represents ideal conditions under which bucket brigades achieve the maximum possible throughput. The normative model is based on the following three assumptions.

Assumption 1. Insignificant walking time: The total time to perform a job is significantly greater than the time to walk the length of the flow line.
Assumption 2. Total ordering of workers by work velocity: Each worker i is characterized by a distinct constant work velocity v_i.
Assumption 3. Smoothness and predictability of work: The work content required by an order, which is normalized to one, is spread continuously and uniformly along the line.

In a flow line where products of a kind is produced repetitively under the normative model, there is a unique balanced partition of the effort wherein worker i performs the interval of work, $\left\lfloor \sum_{j=1}^{i-1} v_j / \sum_{j=1}^{n} v_j , \sum_{j=1}^{i} v_j / \sum_{j=1}^{n} v_j \right\rfloor$, and the production rate converges to $\sum_{i=1}^{n} v_i$ items per unit time, which is the maximum possibly attainable from the given set of workers. Since all the workers keep busy all the time under the normative model, there is no balancing loss in the line. Bucket brigades have some benefits over static workload balancing methods such as zone picking. It is a pull system, so work-in-process (WIP) is strictly controlled. It spontaneously reallocates effort in response to changes in the environment. The system becomes more flexible and agile because bucket brigades tune themselves, without cumbrous endeavors of workload balancing. Throughput can be increased because bucket brigades spontaneously generate the optimal division of work.

2.2 Bucket brigade order picking

Bucket brigade order picking (BB picking) is a method of order picking where the concept of bucket brigade is applied. The BB picking system works as follows:

> Each picker follows the rule "pick forward until someone takes over your work; then go back for more." When the last picker completes an order, he walks back to take over the order of his predecessor, who in turn takes over the order of his predecessor, and so one until the first picker begins a new order. Pickers are not restricted to zones, and so any worker can pick from any location. Pickers are sequenced from slowest-to-fastest and maintain their sequence.

The BB picking system has different characteristics from the assumptions made in the normative model: (1) Each order has different line of items to be picked. With the different order contents, we can not normalize the production time to a constant value, one. (2) The work content is not usually spread continuously in oder picking system.

Even though a picker downstream becomes available, he may wait for his predecessor to finish his current picking job for an item. In this case, there may be some hand-off losses. (3) Since the order contents are different from order to order, the picking locations change over orders. Therefore, the hand-off location will never converge. (4) Blocking may happen even though all the pickers have the same work speed. In general, no passing is allowed and so it can happen that a picker is blocked by his successor, in which case he simply waits until he can resume picking, after his successor has moved out of the way.
The characteristics in BB picking system indicate that the normative model is no longer applicable in BB picking. We have identified two kinds of efficiency losses in BB picking, blocking and hand-off losses. Figure 2 shows a situation where a blocking happens. Picker 1 is performing a picking operation for order #1 while picker 2 for order #2. Order #1 includes items a1, a2 and a3 while order #2 includes items b1, b2, b3 and b4. Suppose picker 2 finishes picking item b1 and should go forward to pick the next item, b2, while picker 1 is performing picking operation for a1 on the way to the location of b2. When passing is not allowed, picker 1 blocks picker 2 from going forward to pick item b2. The picker 2 should wait until picker 1 finishes picking both the items a1 and a2.

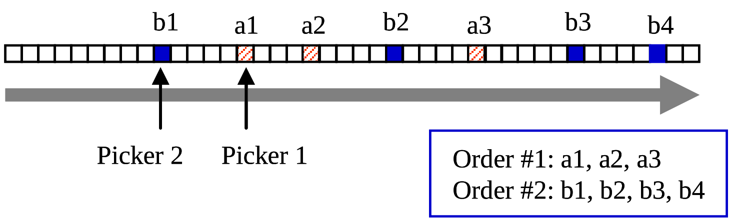

Figure 2. Blocking in BB picking

Figure 3 shows a situation where a hand-off loss happens. Picker 2 becomes available and is ready to take a new order from picker 1 at time t_2, but picker 1 is in the middle of picking an item. Then, picker 2 should wait until picker 1 finishes his current job. The waiting time of picker 2 for the hand-off is t_3 - t_2.

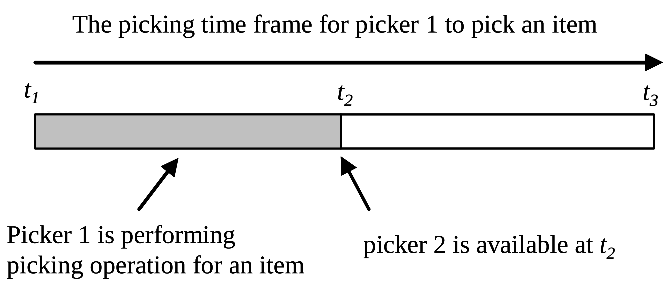

Figure 3. Hand-off loss in BB picking

We now predict the performance of workers when the hand-off times are present. Consider an order picking system that handles the orders whose pick list contains n items on average. Performing a picking operation for item j (1,…,n) takes a task time t_j. Then, the total picking time for an order is $T = \sum_{j=1}^{n} t_j$. When a picker performs all the tasks for an order, pick rate r during a unit time is $r = 1/T$. When m pickers work along the picking line (as in zone picking) and they are utilized 100%, then the pick rate of the line is $r = m/T$. Now let us consider hand-off losses. Let $\bar{t}$ be the average picking time, $\bar{t} = T/n$. Then, the average hand-off time would be $\bar{t}/2$. When there are m pickers (zones), each order experiences the hand-offs $(m-1)$ times. Then the hand-off loss time for a product is $(m-1)\bar{t}/2$. Let E_o be the efficiency of pickers. Then E_o can be calculated as follows

$$E_o = \frac{T}{T + (m-1)\bar{t}/2} \tag{1}$$

With the picker efficiency E_o, the pick rate r done by a picker during a unit time is as follows

$$r = \frac{E_o}{T} = \frac{1}{T + (m-1)\bar{t}/2} \tag{2}$$

Then, the pick rate performed by m pickers in a picking line during a unit time is mr. From equations (1) and (2), it can be seen that the system performance becomes worse due to the hand-off losses as the number of pickers increases in BB picking systems.

2.3 A new bucket brigade order picking: Zoned BB picking

The performance of BB picking may be undermined by the blocking and hand-off losses. To reduce the blocking and hand-off losses, a new BB picking protocol is introduced in which the zone picking and general BB picking are combined. We will call this protocol as ‘zoned BB picking’. In the zoned BB picking, each picker is allowed to work within an extended zone. Figure 4 shows the work areas for the pickers in the zoned BB picking. There is no work area restriction for each picker in the upstream line so that all the pickers are allowed to go back to the beginning of the flow line to take a new job. However, there is a downstream work area limit for each picker beyond which he cannot perform a picking job. There are (n-1) interface buffers each of which is located at the end of a picker’s work area. When the next picking job is located beyond the work area for a picker, the job is put in the interface buffer located at the end of his work area. When a next picker is available and there is at least one job in the interface buffer before him, he picks the job out of the interface buffer and starts performing picking operations (like in zone picking). If there is no job waiting in the interface buffer, he goes upstream and takes a new job from his predecessor (like in general BB picking).

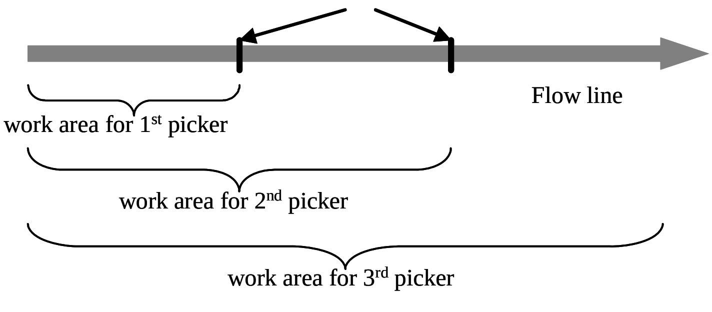

Figure 4. Work area for each worker in zoned BB picking

In the zoned BB picking, each picker follows the following protocol when he is free.

```
If (location of the next item < allowed work area)
  If (next picker available)
    Hand the job over to the next picker and then go back for another job
  Else
    If (location of the next item < location of the next picker)
       Start a picking operation.
    Else
       Blocked until the next picker goes beyond the location of the next
job
    End if
  Endif
Else
  Put the job in the interface buffer. and then go back for another job
Endif
```

With the interface buffers in the zoned BB picking, it is expected that we have less blocking and hand-off losses: When a picker downstream is available and finds at least one order in the interface buffer, he takes the order immediately out of the interface buffer and starts picking operation for the order. In this case, the picker does not experience any hand-off loss for this order. The blocking loss is also reduced because each picker has a work area limitation beyond which he can not perform picking operations. The next section examines the performance of the general and zoned BB picking systems through simulation experiments.

3. Experimental Analysis

This section examines the performance of BB picking. The warehouse under consideration stores cosmetics and daily necessities for a direct-sales company, whose original data is given in Jane (2000). There are 150 kinds of products kept in the pick area. Currently, a zone picking policy is adopted where the pick area is divided into three serial zones. Every day, about 800 orders are placed by customers. In each order, a variety of products (6 ~ 12 kinds) with a small amount (1~3 units) of each product are requested. Each zone contains 50 item types for the zone picking policy. In the zone picking system, the number of boxes waiting at the buffer area between two zones may be restricted because of the space restriction. In the simulation experiments, r different products ($6 \le r \le 12$) in an order are generated with equal possibility. The time it takes to pick an item follows an exponential distribution with a mean of 10 seconds. Since an order has 6 ~ 12 items to be picked, it takes 90 seconds in average to complete an order under an ideal condition. The simulation runs for one month (20 days). The statistics during a period of transient state (5 days) are discarded.

3.1 Performance of general BB picking and zone picking

Table 1 shows the performance of general BB picking and zone picking in terms of pick rate and lead time. The table shows that zone picking provides better performance than the BB picking in terms of pick rate while the BB picking provides better performance in terms of lead time. Here, for the zone picking systems, we assume that there are infinite buffer between zones so that a picker can put an order (box) in the buffer whenever he finishes picking the items within his zone. With the infinite buffer, there is little chance for a picker to be idle due to a shortage of orders to be filled. This makes it possible for a picker to keep busy in the zone picking system, which results in high pick rate. However, the infinite buffer leads to a very long lead time. The poor performance of general BB picking in terms of pick rate is due to blocking and hand-off losses, which have been discussed in the previous section. Picker 1 and 2 experience the blocking losses while picker 2 and 3 experience hand-off losses. The experimental results show that in our example with the general BB picking, the pickers are utilized only 73.9% in average with 10.5% hand-off and 15.6% blocking losses. The analytical model given in equation (2) estimates 11.1 % hand-off loss, which is very close to the simulation result, 10.5%

Table 1. Comparison of general BB picking and zone picking

	BB picking	Zone picking
Pick rate per (orders/day)	670.8	904.8
Lead time (minutes)	1.9	79.3

The high performance of zone picking is due to an unlimited buffer between the zones. However, the infinite buffer size is not practical in the real-world warehouse. Table 2 shows the performance of zone picking systems when buffer size is restricted. It is seen that as the buffer size decreases, both the pick rate and the lead time decrease in the zone picking systems. It is observed that that the lead time is reduced at the cost of less pick rate, compared with the results from the zone picking system without a buffer restriction.

Table 2. Effect of buffer sizes in zone picking

Buffer size	Pick rate (orders/day)	Lead time (minutes)
0	572.2	2.1
1	675.0	2.6
2	731.8	3.1
5	803.6	4.8
10	843.6	7.4
20	874.3	12.9
Inf.	904.8	79.3

3.2 Performance of zoned BB picking

The performance of the zoned BB picking has been examined through the experiments. Here, the interface buffer between pickers 1 and 2 is located just after the 50th item while the interface buffer between pickers 2 and 3 is located just after the 100th item, as in the zone picking. Table 3 shows the performance of zoned BB picking systems with various buffer spaces. As in the zone picking, both the pick rate and the lead time decrease as the buffer size decreases. It is seen that the performance improvement of the zoned BB picking over the general BB picking:

Table 3. Performance of zoned BB picking with various buffer sizes

Buffer size	Pick rate (orders/day)	Lead time (minutes)
1	720.6	2.7
2	770.5	3.2
5	830.9	4.8
10	863.1	7.4
20	883.3	12.7
Inf.	904.8	62.1

Figure 5 compares the performance of zone picking and zoned BB picking when the same buffer size is assumed. It is seen that the BB picking provides better performance than the zone picking especially when the buffer size is small.

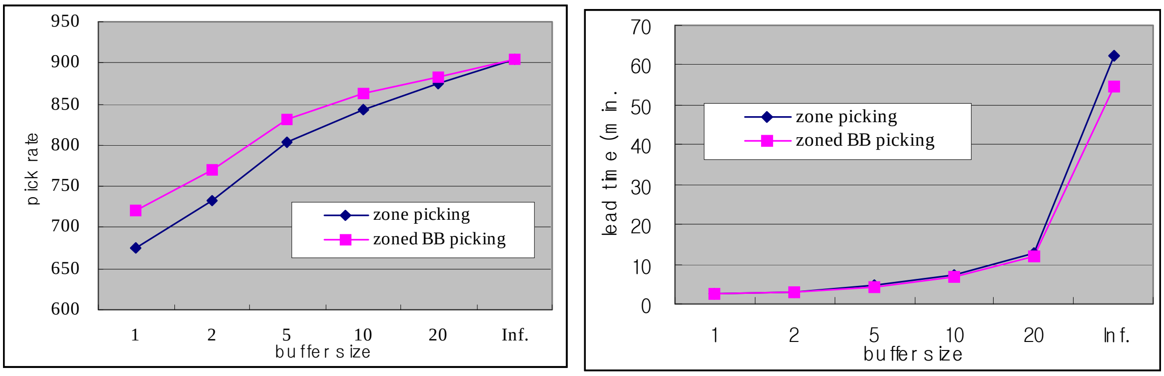

Figure 5. Performance of zone picking and BB picking over various buffer sizes

Table 4 compares the losses due to blockings and hand-offs in the general BB picking and zoned BB picking systems. It is observed that the hand-off and blocking losses are dramatically reduced in the zone BB picking system. The low hand-off and blocking losses in the zoned BB picking result in high worker utilization. The low hand-off % in the zoned BB picking indicates that the pickers downstream take the new jobs from the interface buffers in most cases, which does not require any hand-off time.

Table 4. Hand-off and blocking losses for each picker in zoned BB picking

	General BB picking	Zoned BB picking
hand-off %	10.5%	1.9%
blocking %	15.6%	6.6%

3.3 Effect of different work speed

The work speed may vary picker by picker. Figure 6 shows the results when each picker has a different work speed. Here, it is assumed that the both picking methods have the same buffer size, five. The numbers on the *x* axis mean the work speed difference. For example, 20% means that there is speed difference of 20 % among workers: i.e., the speed of the slowest picker is 0.8, the speed of the fastest picker is 1.2, and the speed of the average picker is 1.0. As in normative model, the slowest picker is located at the beginning and the fastest picker at the end of the line. The figure shows that the work speed difference affects the performance less in the zoned BB picking than in the zone picking. This result says that the BB picking works well especially for the system with different work speeds than the zone picking.

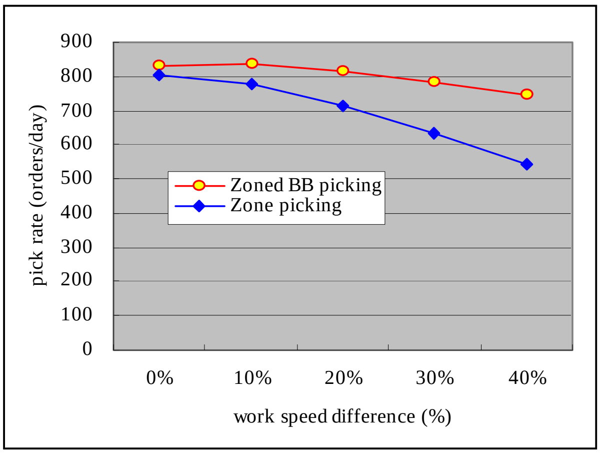

Figure 6. The effect of work speed on performance of order picking

4. Conclusions

This paper discusses an order picking system in which the concept of bucket brigades is applied. Two types of efficiency losses, blocking and hand-off losses, have been identified in BB picking. To reduce these losses, we introduced a new bucket brigade order picking protocol where zone picking and general BB picking are combined. The simulation experiments show that the general BB picking provides worse performance than zone picking in terms of pick rate but better performance in terms of lead time. The poor performance of BB picking in terms of pick rate is due to blocking and handoff losses. The experiments show that the new BB picking system provides less hand-off and blocking losses than general BB picking, resulting in higher pick rate. It is seen that the BB picking provides better performance than the zone picking especially when the buffer size is small and work speed are different from picker to picker.

There are some prerequisites that should be considered when bucket brigades are applied in order picking. Since the workers under the BB picking systems cover more work areas than zone picking, they should have knowledge about more items. Since each worker does not have his own work area, there may be some confusions and congestions in practice. In addition, there could be some other negative side effects that occur in systems that rely on flexible work assignment. These problems should be addressed before BB picking is applied.

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Session 5

Demand Planning

Chair: Dr. Young Hae Lee

1. **The impact of seasonal demand on bullwhip effect in a supply chain**
   Dong Won Cho, Hanyang University, Korea
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2. **Optimal outbound dispatch policy to consider pricing**
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4. **Supplier selection model using fuzzy–AHP**
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The Impact of Seasonal Demand on Bullwhip Effect in a Supply Chain

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Abstract
This paper deals with a simple two-stage supply chain which is made up of a single retailer with a multiplicative seasonal mixed demand process and a single supplier. There are found only a few researches on the bullwhip effect in a supply chain with the seasonal demand process. In this study the retailer employs a base stock policy and a minimum mean square error forecasting technique for demand forecast is performed via a multiplicative seasonal mixed model. It shows that the seasonal demand process has some impact on bullwhip effect. At first sight, it is anticipated that both the supplier and the retailer experience the same process. But it shows that an order quantity process experienced by the supplier reaches an unexpected result with no seasonal factor. Each order and demand process follows its time series process in spite of the effect of a seasonal demand.

Keywords: Supply chain, bullwhip effect, seasonal demand process

1. Introduction

The bullwhip effect means the phenomenon in which demand variability is amplified when one goes upstream along a supply chain. The phenomenon can has a significantly negative impact on increasing supply chain performance. Therefore, minimizing this phenomenon in supply chain has been given the attention to many of academicians and practitioners.

The phenomenon of the bullwhip effect is first recognized by Forrester (1969). The beer game (Sterman, 1989) exhibited the same phenomenon through an experiment. In addtion, Lee et al. (1997a, b) established five main sources that may lead to the bullwhip effect, including demand signal procesing, non-zero lead-time, order batching, rationaning game under shortage, and price fluctuations and promotions. They shows that the bullwhip effect may be reduced by eliminating its main causes. Among various causes of the bullwhip effect, forecasting methods are known as one of the most important causes because the inventory system of a supply chain is directly affected by the forecasting method (Duc et al., 2008). Graves (1999) quantified the bullwhip effect for an integrated moving average process, and Lee at al. (2000) consider a first-order autoregressive process and an order-up-to policy with a minimum mean square error forecasting technique is used at the retailer with simple two-stage supply chain. Chen et al. (2000a, b) shows that the simple moving average and exponential smoothing forecasts have an influence on the bullwhip effect in a two-stage supply chain with an autoregressive demand process similar to Lee et al. (1997a). Zhang (2004) also

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investigates the impact of different forecasting methods on the bullwhip effect for a inventory system with a first-order autoregressive demand process. In addition, Chen et al. (2000a, b) and Zhang (2004) prove that increasing lead-time enhances the bullwhip effect regardless of the forecasting methods employed. Disney et al. (2006) measure the bullwhip effect and the net inventory in a single-echelon supply chain with the order-up-to policy in case of first-order autoregressive, first-order moving average, and mixed first-order autoregressive-moving average demand processes. In a lot of research on the quantification of the bullwhip effect, it is proved that forecasting methods has an impact on the bullwhip effect.

It is proved that time series models of supply chains can provide very practical managerial insights about supply chain dynamics (Alwan et al., 2003; Duc et al., 2008; Gilbert, 2005; Luong, 2007a, b) . But the approach of using a non-seasonal time series models such as the first and high order autoregressive models and integrated autoregressive models may not be good for pratical application in seasonal demand process. In order to consider a seasonal demand processes, a more realistic model such as a multiplicative seasonal mixed model, SARMA (1, 0) x $(1, 0)_s$ needs to be examined. An SARMA model has characteriestics of both seasonal and non-seasonal demand processes. In general, an SARMA model often fits the time series of the seasonal demand process better than an non-seasonal autoregressive model. Seasonal demand process is known as one type of demand patterns. It goes to prove that many business such as food, apparel and tourist industries contain a seasonal demand process. In this research, therefore, we will examine the bullwhip effect in a supply chain with an SARMA demand process. In addition, we will investigate the stochastic nature of the upstream demand processes over time through analytic expressions in a two-echelon supply chain with one retailer and one supplier. It is also assumed that the retailer employs the base stock policy for replenishment.

This paper is organized as follows. In Section 2, we describe some charateristics of the SARMA (1, 0) x $(1, 0)_s$ demand process and its stationarity and invertibility in a simple supply chain model. In section 3, we develop analytical expression for important parameters of the order-up-to inventory model for the retailer. Section 4 presents some properties of replenish model as well as the stochastic nature of the upstream demand processes over time. Finally, section 5 makes a conclusion for this study.

We follow the notation in this study.

Notation

D_t customer demand quantity in period t

$\hat{D}_t$ forecast value of D_t

q_t ordered quantity at the beginning of period t

S_t order-up-to-level in period t

ϕ first-order autocorrelation coefficient

e_t forecast error in period t

Θ first-order seasonal moving average parameter

δ constant of the multiplicative seasonal mixed model

μ_d mean of the multiplicative seasonal mixed process

σ_d^2 variance of demand quantities

L order lead-time

D_t^L lead-time demand, which is the total demand of periods t through $t + L - 1$

$\hat{D}_t^L$ lead-time demand forecast that the retailer will face over L future periods

$\hat{\sigma}_t^L$ standard deviation of lead-time demand forecast error

z normal z-score

s seasonal interval

2. Two-stage supply chain model

We will consider a two-stage supply chain with one retailer and one supplier. It is assumed that a retailer places an order to supplier at the beginning of period t. The orders placed in time period t arrive after a fixed order lead-time L. The length of lead-time is assumed to be a multiple of the inventory review interval. The order policy is a base stock policy, a simple order-up-to inventory policy. The demand forecast is performed with an SARMA (1, 0) x (0, 1)$_S$, i.e., a multiplicative seasonal mixed model, by using minimum mean square error forecasting technique.

The order quantity q_t can be given as

$$q_t = S_t - S_{t-1} + D_{t-1}, \tag{1}$$

where S_t is the order-up-to level in period, i.e., the inventory position at the beginning of period. We allow q_t to be negative, in which assume, similarly to Chen et al. (2000a), that this excess inventory is returned without cost. If retailer follows the base stock policy, the order-up-to level S_t can imply that

$$S_t = \hat{D}_t^L + z\hat{\sigma}_t^L, \tag{2}$$

in which z is the normal z-score chosen by a desired service level. Note that z is also known as the safety factor. For i.i.d. demands from a normal distribution, a base stock policy of this form is optimal, under the assumption that there is no setup or fixed order cost (Nahamis, 1997). However, since it is usually difficult to estimate these costs accurately in practical situation, the approach of using the service level is often employed when the order-up-to level is to be determined. In the base stock policy, an order is placed at the beginning of each period so as to increase the inventory level up to a predetermined level. But the retailer must forecast demand because predetermined level is generally not known in practice. Note that forecasting is a main source of the bullwhip effect with creating variability in the order-up-to level as identified by Lee et al. (1997a). Given a service level, the order-up-to level S_t is determined by estimating the lead-time demand forecast $\hat{D}_t^L$ and the standard deviation of lead-time demand forecast error $\hat{\sigma}_t^L$.

$$D_t = \delta + \phi D_{t-1} + e_t - \Theta e_{t-s}. \tag{3}$$

where e_t's (t = 1, 2, …) are normally and independently distributed with mean zero and variance σ^2 (i.i.d. random variables from the normal distribution). For the multiplicative seasonal mixed process to be stationary, we must have

$$E[D_t] = E[D_{t-1}] = \mu_d. \tag{4}$$

Hence, a stationary condition can be given as

$$\mu_d = \frac{\delta}{1-\phi}. \tag{5}$$

In order to variance of demand quantities, σ_d^2, we have to use autocovariance function and is given as $\gamma_k = \text{cov}\left[D_t, D_{t+k}\right] = E\left[\left(D_t - \mu_d\right)\left(D_{t+k} - \mu_d\right)\right]$. Constant of the multiplicative seasonal mixed model, δ in (3) has no specific meaning except as a reference point for the level of the process. That is, δ makes no contributions to autocovariance function. Hence, we can abbreviate δ from (3). And we have $D_t = \phi D_{t-1} + e_t - \Theta e_{t-s}$. Then, autocovariance function at lag 0 and 1 is given as

$$\gamma_0 = \text{cov}\left[D_t, D_t\right] = \phi\gamma_1 + \sigma^2 - \Theta(\phi^s - \Theta)\sigma^2$$

where $\gamma_0 = \sigma_d^2$

$$\gamma_1 = \text{cov}\left[D_t, D_t\right] = \phi\gamma_0 - \Theta\phi^{s-1}\sigma^2$$

We can obtain

$$\sigma_d^2 = \frac{1 - \Theta\phi^2 - \Theta^2}{1 - \phi^2}\sigma^2. \tag{6}$$

From (5) and (6), it can be seen that in order to have the stationarity of SARMA(1, 0) x (0, 1)*s* model, we should also have $|\phi| < 1$. Similarly, in order to have invertibility of the demand process, we should have $|\Theta| < 1$ (Box et al., 1994).

3. Lead-time demand forecast and forecast error

As stated earlier, the retailer must forecast demand in the base stock policy. It is assumed that a minimum mean square error forecasting technique for the demand forecast is employed. Under this policy, the lead-time demand for a given period can be expressed as

$$D_t^L = D_t + D_{t+1} + \cdots + D_{t+L-1} = \sum_{i=0}^{L-1} D_{t+i} \tag{7}$$

If $\hat{D}_t$ is the forecast with the minimum mean square error, then the forecast for the lead-time demand with the minimum mean square error can be given as

$$\hat{D}_t^L = \hat{D}_t + \hat{D}_{t+1} + \cdots + \hat{D}_{t+L-1} = \sum_{i=0}^{L-1} \hat{D}_{t+i} \tag{8}$$

According to Box et al., (1994), for the SARMA (1, 0) x (0, 1)*s* process, $\hat{D}_t$ can be determined as

$$\hat{D}_{t+i} = E\left[D_{t+i} \middle| D_{t-1}, D_{t-2,\ldots}\right]. \tag{9}$$

An exact expression of $\hat{D}_{t+i}$ can be derived from the above expression. Since we have

$$D_{t+i} = \delta + \phi D_{t+i-1} + e_{t+i} - \Theta e_{t+i-s}$$

and

$$D_{t+i-1} = \delta + \phi D_{t+i-2} + e_{t+i-1} - \Theta e_{t-s+i-1},$$

We can obtain

$$D_{t+i} = (\phi + 1)\delta + \phi^2 D_{t+i-2} + e_{t+i} + \phi e_{t+i-1} - \Theta e_{t+i-s} - \Theta\phi e_{t+i-s-1}$$

By applying this procedure recursively, we have

$$D_{t+i} = (\phi^i + ... + \phi^2 + \phi + 1)\delta + \phi^{i+1} D_{t-1} + \sum_{j=0}^{i} \phi^j e_{t+i-j} - \sum_{j=0}^{i} \Theta \phi^j e_{t+i-s-j}$$

Taking the expectation, we have

$$\begin{aligned}\hat{D}_{t+i} &= E[D_{t-i} \mid D_{t-1}, D_{t-2}, \cdots] \\ &= (\phi^i + ... + \phi^2 + \phi + 1)\delta + \phi^{i+1} D_{t-1} - - \sum_{j=0}^{i} \Theta \phi^j E[e_{t+i-s-j} \mid D_{t-1}, D_{t-2}, \cdots] \\ &= \delta \frac{1-\phi^{i+1}}{1-\phi} + \phi^{i+1} D_{t-1} - \sum_{j=0}^{i} \Theta \phi^j E[e_{t+i-s-j} \mid D_{t-1}, D_{t-2}, \cdots]\end{aligned}$$

Therefore, from (4), we have

$$\hat{D}_{t+i} = \mu_d (1-\phi^{i+1}) + \phi^{i+1} D_{t-1} - \sum_{j=0}^{i} \Theta \phi^j E[e_{t+i-s-j} \mid D_{t-1}, D_{t-2}, \cdots] \tag{10}$$

It is noted that the last term in (10) can be determined with a given seasonal interval and is a modification factor for the forecast which takes account of the residual. It can be seen from (10) that $\lim_{i\to\infty} \hat{D}_{t+i}$ converges μ_d with a given seasonal interval when the SARMA(1, 0) x (0, 1)*s* process is stationary. This means that if the minimum mean square error technique is used, the forecast function can retain the so-called conditional mean reversion property of the stationary SARMA (1, 0) x (0, 1)*s* process. This property not valid in case of the moving average or exponential smoothing forecasting technique, since $\hat{D}_{t+i} = \hat{D}_t$ is a constant for any i = 1, 2, ….

Using (10), we can derive the following proposition.

Proposition 1. The minimum mean square error forecast for the lead-time demand can be given as

$$\hat{D}_t^L = \mu_d (L - \frac{\phi(1-\phi^L)}{1-\phi}) + \frac{\phi(1-\phi^L)}{1-\phi} D_{t-1} - \sum_{i=0}^{L-1} \frac{\Theta(1-\phi^{L-i})}{1-\phi} E[e_{t-s+i} \mid D_{t-1,} D_{t-2,} \cdots] \tag{11}$$

Proof. From (8) and (10), we have

$$\begin{aligned}\hat{D}_t^L &= \sum_{i=0}^{L-1} (\mu_d (1-\phi^{i+1}) + \phi^{i+1} D_{t-1}) - \sum_{j=o}^{i} \Theta \phi^j E[e_{t+i-s-j} \mid D_{t-1,} D_{t-2,} \cdots] \\ &= \mu_d (L - \frac{\phi(1-\phi^L)}{1-\phi} + \frac{\phi(1-\phi^L)}{1-\phi} D_{t-1} - \sum_{i=0}^{L-1} \sum_{j=0}^{i} \phi^j \Theta E[e_{t+i-s-j} \mid D_{t-1,} D_{t-2,} \cdots] \\ &= \mu_d (L - \frac{\phi(1-\phi^L)}{1-\phi} + \frac{\phi(1-\phi^L)}{1-\phi} D_{t-1} - \sum_{i=0}^{L-1} \frac{\Theta(1-\phi^{L-i})}{1-\phi} E[e_{t-s+i} \mid D_{t-1,} D_{t-2,} \cdots]\end{aligned}$$

The following proposition gives the variance of lead-time demand forecast error.

Propostion 2. The variance of lead-time demand forecast error depends on *s* and is given as

$S > L-1$,

$$\begin{aligned}\hat{\sigma}_t^{L^2} &= \mathrm{VAR}(D_t^L - \hat{D}_t^L) \\ &= \sigma_d^2 \left(\frac{1-\phi^{L-1}}{1-\phi} - \Theta \left(\sum_{i=1}^{L-1} (L-i)\phi^i - \sum_{i=0}^{L-1} (L-i)\phi^i \right) + L(1-\Theta) \right)\end{aligned} \tag{12}$$

$2 \le S \le L-1,$

$$(\hat{\sigma}_t^L)^2 = \mathrm{VAR}(D_t^L - \hat{D}_t^L)$$

$$= \sigma_d^2 \left(\frac{1-\phi^{L-1}}{1-\phi} - \Theta \left(\sum_{i=2}^{L-1} (L-i)\phi^i - \sum_{i=L-s+1}^{L-1} (L-i)\phi^{i-1} - \sum_{i=0}^{L-s-1} (s-1))\phi^i \right) + L(1-\Theta) \right)$$

Proof. From (8) and (10), we have

$$D_t^L - \hat{D}_t^L = (D_t - \hat{D}_t) + (D_{t+1} - \hat{D}_{t+1}) + \cdots + (D_{t+L-1} - \hat{D}_{t+L-1})$$

$$= \sum_{i=0}^{L-2} \sum_{j=1}^{L-1-i} (\phi^i e_{t+j} - \Theta \phi^j e_{t-s+j}) + \sum_{i=0}^{L-1} (e_{t+i} - \Theta e_{t-s+i}) + \Theta \sum_{i=0}^{L-1} \sum_{j=0}^{L-1-i} \phi^j E[e_{t-s+i} \mid D_{t-1}, D_{t-1} \cdots]$$

Where $D_t^L - \hat{D}_t^L$ can be given from s conditions as follows:

$$S > L-1,\ D_t^L - \hat{D}_t^L = \sum_{i=0}^{L-2} \sum_{j=1}^{L-1-i} (\phi^i e_{t+j} - \Theta \phi^j e_{t-s+j}) + \sum_{i=0}^{L-1} (e_{t+i} - \Theta e_{t-s+i}) + \Theta \sum_{i=0}^{L-1} \sum_{j=0}^{L-1-i} \phi^j e_{t-s+i}$$

Therefore, we have

$$S > L-1,\ \hat{\sigma}_t^{L^2} = \mathrm{VAR}(D_t^L - \hat{D}_t^L)$$

$$= \sigma_d^2 \left(\frac{1-\phi^{L-1}}{1-\phi} - \Theta \left(\sum_{i=1}^{L-1} (L-i)\phi^i - \sum_{i=0}^{L-1} (L-i)\phi^i \right) + L(1-\Theta) \right)$$

$$S = L-1,\ D_t^L - \hat{D}_t^L = \sum_{i=0}^{L-2} \sum_{j=1}^{L-1-i} (\phi^i e_{t+j} - \Theta \phi^j e_{t-s+j}) + \sum_{i=0}^{L-1} (e_{t+i} - \Theta e_{t-s+i}) + \Theta \sum_{i=0}^{L-2} \sum_{j=0}^{L-1-i} \phi^j e_{t-s+i}$$

Therefore, we have

$$S = L-1,\ \hat{\sigma}_t^{L^2} = \mathrm{VAR}(D_t^L - \hat{D}_t^L)$$

$$= \sigma_d^2 \left(\frac{1-\phi^{L-1}}{1-\phi} - \Theta \left(\sum_{i=2}^{L-1} (L-i)\phi^i - \sum_{i=2}^{L-1} (L-i)\phi^{i-1} - (L-2) \right) + L(1-\Theta) \right)$$

$$S = L-2,\ D_t^L - \hat{D}_t^L = \sum_{i=0}^{L-2} \sum_{j=1}^{L-1-i} (\phi^i e_{t+j} - \Theta \phi^j e_{t-s+j}) + \sum_{i=0}^{L-1} (e_{t+i} - \Theta e_{t-s+i}) + \Theta \sum_{i=0}^{L-3} \sum_{j=0}^{L-1-i} \phi^j e_{t-s+i}$$

Therefore, we have

$$S{=}L{-}2,\ \hat{\sigma}_t^{L^2} = \mathrm{VAR}(D_t^L - \hat{D}_t^L)$$

$$= \sigma_d^2 \left(\frac{1-\phi^{L-1}}{1-\phi} - \Theta \left(\sum_{i=2}^{L-1} (L-i)\phi^i - \sum_{i=3}^{L-1} (L-i)\phi^{i-1} - \sum_{i=0}^{1} (L-3)\phi^i \right) + L(1-\Theta) \right)$$

This completes the proof.

Note that $\hat{\sigma}_t^L$ is needed only for computation of the order-up-to level S_t and the bullwhip effect is not affected by $\hat{\sigma}_t^L$ because the variance of lead-time demand forecast error does not depend on t. Then, it is seen from proposition 2 that the variance is different from some relation of scale between s and L.

4. Replenishment model

In general, it is known that the bullwhip effect is quantified by the ratio of the variance of order quantity experienced by the supplier to the actual variance of demand quantity

(Chen et al., 2000a, b; Duc, 2008; Luong, 2007a; Zhang, 2004). In order to understand the phenomenon for creating the bullwhip effect, we examine the variance of the order quantity.

Proposition 3. The variance of the order quantity of period t depends on seasonal interval s and is given as

$$\begin{aligned} q_t &= (\phi b+1)D_{t-1}-\phi bD_{t-2}-\theta b[e_{t-s}]-(\frac{\theta(1-\phi^{L-1})}{1-\phi}-\theta b)E[e_{t-s+i}\mid D_{t-1},D_{t-2},\cdots] \\ &-(\frac{\theta(1-\phi^{L-2})}{1-\phi}-\frac{\theta(1-\phi^{L-1})}{1-\phi})E[e_{t-s}\mid D_{t-1},D_{t-2},\cdots]-\cdots \\ &-(\frac{\theta(1-\phi)}{1-\phi}-\frac{\theta(1-\phi^{2})}{1-\phi})E[e_{t-s+L-1}\mid D_{t-1},D_{t-2},\cdots][e_{t-s+L-1}] \\ &+\frac{\theta(1-\phi)}{1-\phi}E[e_{t-s+L-2}\mid D_{t-1},D_{t-2},\cdots][e_{t-s+L-2}] \end{aligned} \tag{13}$$

Proof. From (1), (2), (8), (11) and (13), we have

$$\begin{aligned} q_t &= \hat{D}_t^2-\hat{D}_{t-1}^2+D_{t-1} \\ &= \frac{\phi(1-\phi^2)}{1-\phi}D_{t-1}-\frac{\phi(1-\phi^2)}{1-\phi}D_{t-2}+D_{t-1}-\sum_{i=0}^{L-1}\frac{\theta(1-\overset{L-i}{\theta})}{1-\theta}E[e_{t-s+i}\mid D_{t-1},D_{t-2},\cdots] \\ &+\sum_{i=0}^{L-1}\frac{\theta(1-\overset{L-i}{\theta})}{1-\theta}E[e_{t-s+i-1}\mid D_{t-1},D_{t-2},\cdots] \end{aligned}$$

From (6) and (13), the measure of the bullwhip effect can be determined with a given seasonal interval s. This shows that seasonal interval has an impact on the bullwhip effect. Most previous studies of the bullwhip effect have focused only the bullwhip ratio. Even though the issue of bullwhip effect measure is important and requires continuous research, it does not provide complete insight for the essence of the supply chain dynamics. Hence, it can prove useful to know the stochastic nature of the upstream demand processes over time.

Propostion 4. When minimum mean square error forecasting technique is used for an underlying SARMA (1, 0) x (1, 0)$_2$ demand process, the order process q_t follows ARMA (1, 2) demand process and is given as

$$q_t=\delta+\phi q_t+a_t-\theta_1 a_{t-1}-\theta_2 a_{t-2} \tag{14}$$

where

and $\theta_1=\dfrac{\phi(1-\phi^{L+1})}{1-\phi^{L+1}+\Theta(\phi-1)\phi^{L-2}}$, $\theta_2=\dfrac{2\theta(1-\phi^{L})}{1-\phi^{L+1}+\Theta(\phi-1)\phi^{L-2}}$,

$$\{a_t\}\sim IIDN\left(0,\left(\frac{1-\phi^{L+1}+\Theta(\phi-1)\phi^{L-2}}{1-\phi}\right)\right)$$

The result of this study turned out at variance with our expectations. In general, it is anticipated that supplier experience the same process of the retailer. But the supplier does not undergo seasonal demand process. That is, each of supplier and the retailer process has its process. In general, it is known that both the supplier and the retailer experience the same process with minimum mean square error forecasting technique. Duc et al. (2008) provides a similar analysis for an underlying ARMA (1, 1) in conjuction with a base stock policy and minimum mean square error forecasting technique. They shows that both order quantity process q_t and demand quantity process D_t follows ARMA(1, 1) demand process.

5. Conclusions

The results of this study provide several key insights. First, it is clear that seasonal demand process has an impact on the bullwhip effect. But the result of this study shows a variance from our expectations. At first sight, it is anticipated that both the supplier and the retailer experience the same process. But it shows that an order quantity process experienced by the supplier reaches an unexpected result with no seasonal factor. This means that it needs to conduct continuous and detailed study for the effect of seasonal demand process. Secondly, the variance of lead-time demand forecast error depends on seasonal interval s. And it shows that some relationship between seasonal interval and lead-time plays a role for the bullwhip effect. Future work in this area would include further research about how the nature of seasonal demand process affects decisions on replenishment parameters in association with bullwhip effect.

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Biographical notes

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Optimal Outbound Dispatch Policy to Consider Pricing

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Abstract
Under a VMI(Vendor Managed Inventory) system, the vendor holds a certain level of control over not only inbound replenishment decisions on stocking but also outbound re-supply decisions. Under this scenario, vendor faces a better opportunity to synchronize the inventory and transportation decision. While shipment consolidation can reduce the transportation cost, however, delivery time to the customer may increase. Thus, inventory and transportation decision must be coordinated considering both customer service requirement and transportation cost. In this study, we have developed a optimal outbound dispatch policy to maximize profits under a quantity based shipment consolidation model. A mathematical model is developed and an efficient algorithm is provided to obtain the optimal parameters for the proposed policy.

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Methods for Allocating the Costs of Quay Construction

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Abstract
A port has been considered as a major social overhead capital. Since all people benefit from the port, it has been deemed as a public goods. As a consequence, most countries, including Korea, have levied port charges which are too low to collect the investment costs. However, nowadays, since the port industry is classified as part of the service industry, it is not justified any more for the government to subsidize the port facilities. This paper will discuss why it is difficult to collect the quay construction costs when the current construction cost allocation method is applied and suggest the application of serial cost sharing rule (Moulin and Shenker, 1992). Furthermore, this paper applies the serial cost sharing rule to the Gwangyang Container Port's construction cost as an example showing a fair allocation of the construction cost.

Supplier Selection Model Using Fuzzy-AHP

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Abstract
Supplier selection is a multi-criteria decision making problem which includes evaluation factors. Recently a multi-criteria structure analysis is one of the evident areas of important points in the decision support system analysis. In order to select the best suppliers it is crucial to considering the both qualitative and quantitative factors simultaneously. In the supplier selection process, manager also has to consider multi-criteria factors related with decision. Thus the integration of multi-criteria analysis and those analysis results by multi-analysis teams has an important meaning in supply chain design. In this paper we suggest a decision analysis model for supplier selection problem considering both by Fuzzy-AHP method and integration of analysis results. First, we develop a decision analysis model using Fuzzy-AHP method. It is a three-step decision analysis model which converts the qualitative factors of suppliers into the quantitative measures, reliability. Then, we develop an integration model that integrates the results of multi-analysts so as to select the best supplier. We develop a computer program for both the Fuzzy-AHP model and for integration model. We validate this model by applying in a third party logistics problem.

Keywords: Supplier selection, Fuzzy-AHP, MCDM, Decision Analysis Model

1. Introduction

The purpose of this study is to develop a supplier's performance evaluation model for a third party logistics (TPL) in supply chain management (SCM). Recently, with the increasing trends of the study in the third party logistics system (TPL) that some of production of supply chain works are outsource to the other companies, the supplier performance evaluation model for TPL becomes one of the important research areas. The supplier performance analysis problem is one of the multi-criteria decision making (MCDM) problem considering a lot of factors in a hierarchical structure of decision analysis system (Cakravastia et al., 2002) and Cheng (1996) used the Fuzzy-AHP method in evaluating missile system.
In this study we used a MCDM method for supplier selection problem.
Recently supply center sourcing and practices have evolved significantly for the purchasing managers in the last 20 years. The research has shown that suppliers are becoming increasingly critical for the competitive success of cost reduction. This research is concerned with supplier selection problem under the condition of high service level for customers, total logistics cost saving, and supply efficiency increasing. The major researches on suppliers selection problem are done as follows: Boer (2001) reviewed the methods of supplier selection problems, Ghodsypour and O'Brien (1998) used an integrated analytic hierarchy process (AHP) to overcome the multi-criteria

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decision problem, Dulmin and Mininno (2003) used a multi-criteria decision analysis method in supplier selection problem, and also Wang and Hwang (2004) used a product-driven supply chain selection method using integrated multi-criteria decision making methodology. A great deal of studies have examined evaluation problems for the suppliers selection, but the results of these studies do not provide a basis upon which to construct comprehensive evaluation criteria in terms of suppliers performance evaluation or to identify relative weights of these criteria (Zahedi, 1986).

In this study, we proposed a method to select supplier for the third party logistics (TPL) using multi-attribute decision analysis method as; first, using the solution methodology of analytic hierarchy process (AHP) (Barbarosoglu & Yazgas, 1997) to select the supplier with lots of factors, second, applying fuzzy set ranking methodologies to integrate the special decision problems.

In this research, we developed and demonstrated a methodology for the supplier evaluation based on decision support system using its computer programs. These programs transform several individual multi-criteria rank-ordered lists of decision alternatives into one aggregated and prioritized rank-ordered list. We applied this model in supplier evaluation problem of third party logistics and compared the results with that of other methods and also show the sample outputs.

2. Conventional Suppliers Performance Evaluation and Third Party Logistics

Third party logistics is originated by the council of logistics management (CLM) of United State. For the purpose of the improvement of customer service, the logistics cost saving, and logistics management improvement, a part of supply chain works is transferred to outsourcing (Itina, 1994). Recently, there are many researches (Talluri & Baker, 1999, 2002) on the supplier selection problems using AHP, and other mathematical programming methods (Verma & Pullman, 1998). This kind of third party logistics has several advantages and disadvantages instead of working by their own companies or sub-companies. We can summarize as following:

Advantages:

- Economical advantages by outsourcing to a specialized company,
- The risk can be reduced.

Disadvantages:

- Uncertainty of services,
- The beliefs will be worse by the customers,
- Internal company information security problem,
- Labor problem by reducing the workers for outsourcing part of work,
- Difficulties of fast reply to customer claims,
- Difficulties of knowledge accumulation for outsourcing area.

Because of these disadvantages, it is very important to evaluate the supplier selection problem. We consider the most of important factors of supplier evaluation indicators.

The objectives of TPL for the outsourcing policy concern customers to get a customer centric new logistics service level with a good supplier selection, thus it has been an important evaluation in logistics decision area. The conventional approach of supplier selection process is given by Figure 1.

We evaluated this supplier selection problem considering all the related information with supplier performance indicators and using a hierarchical decision structure, while the conventional process for supplier selection didn't considered these major analysis factors. There are could be many difficulties in selecting supplier analysis such as:

- The increasing of factors to be considered,
- Difficulties for holding in common the SCM information between related industries,
- Difficulties of evaluation for the supplier's performance,
- Strategic priority of objects and weighted values.

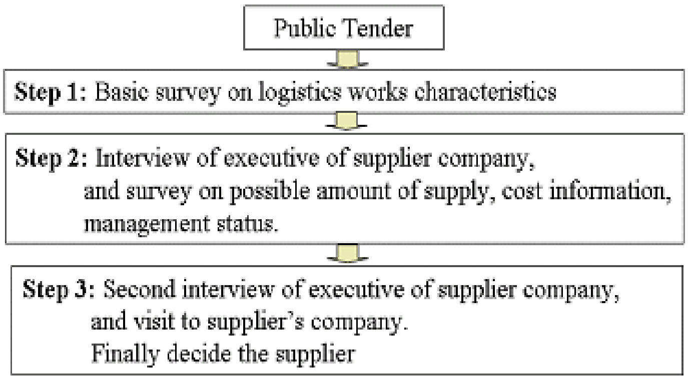

Figure 1. Conventional process of supplier selection

In this study, we proposed a systematic approach and evaluation methods using AHP (Saaty, 1980, 1981) and fuzzy-AHP methods (Blin, 1974) to consider the hierarchical decision structure considering all the related factors and also we developed computer software for proposed method. Figure 2 shows the schematic diagram of proposed model.

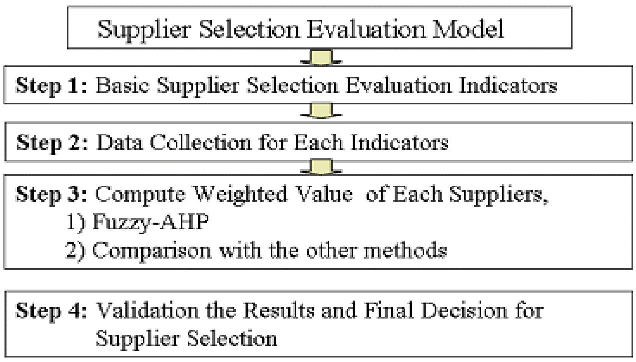

Figure 2. Supplier selection model

3. A Decision Analysis Model for Supplier Selection

3.1 Fuzzy-AHP Method

The theory of fuzzy sets has extended traditional mathematical decision theories so that they can cope well with any vagueness problem which cannot adequately be treated by probability distributions. The impacts and the relationships among the characteristics in any decision problems can sometimes be described only by vague verbal descriptions. Fuzzy decision making provides us with the necessary tools for structuring a decision from a kind of information. The model used in this study has a limited capability in studying the fuzzy set priority that can be obtained from the summed frequency matrix of Shannon (1986) method. The fuzzy priority is computed and compared with the rank order by Shannon method. The fundamental concept of fuzzy set priority relation R is derived from the result obtained by Shannon method. From the Shannon's summed frequency matrix for complementary cells, A_{ij} and A_{ji}, an additional fuzzy set matrix was made by considering $A_{ij} = 1 - A_{ji}$ for all cells. The fuzzy matrix complement cell values sum to 1 and fuzzy set difference matrix is defined as follows:

$$R - R^T = \text{U(A, B)} - \text{U(B, A)}, \quad \text{if U(A, B)>U(B, A)},$$
$$= 0 \qquad \text{otherwise}$$

Where, for U (A, B) quantifies, A is preferable to B.

To obtain fuzzy preferences, the following five steps are considered:

Step 1: Find the summed frequency matrix (using Shannon method)

Step 2: Find the fuzzy set matrix R which is the summed frequency matrix divided by the
total number of evaluators

Step 3: Find the difference matrix

$$R - R^T = \text{U(A, B)} - \text{U(B, A)}, \text{ if U(A, B)} > \text{U(B, A)},$$
$$= 0 \qquad \text{otherwise}$$

Where, for U(A,B) quantifies, A is preferable to B.

Step 4: Determine the portion of each project that is not dominated as follows:

$$A^{ND}_{ColA} = 1 - \max\,(X_{1.ColA}, X_{2.ColA}, \ldots , X_{n.ColA})$$

Step 5: The priority of the fuzzy set is then the rank order of X^{ND} values with a decreasing order.

An example is shown as follows:

$$R = \begin{bmatrix} 0.0 & 0.8 & 0.6 & 0.6 \\ 0.2 & 0.0 & 0.0 & 0.4 \\ 0.4 & 0.1 & 0.0 & 0.4 \\ 0.4 & 0.6 & 0.6 & 0.0 \end{bmatrix} \qquad R^T = \begin{bmatrix} 0.0 & 0.2 & 0.4 & 0.4 \\ 0.8 & 0.0 & 0.1 & 0.6 \\ 0.6 & 0.0 & 0.0 & 0.6 \\ 0.6 & 0.4 & 0.4 & 0.0 \end{bmatrix}$$

$$R - R^T = \begin{bmatrix} 0.0 & 0.6 & 0.2 & 0.2 \\ 0.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 0.1 & 0.0 & 0.0 \\ 0.0 & 0.2 & 0.2 & 0.0 \end{bmatrix}$$

$$X^{ND}_{A} = 1 - \text{Max}\,(0.0) = 1 - 0.0 = 1.0, \qquad X^{ND}_{B} = 1 - \text{Max}\,(1.0) = 1 - 1.0 = 0.0$$
$$X^{ND}_{C} = 1 - \text{Max}\,(0.2) = 1 - 0.2 = 0.8, \qquad X^{ND}_{D} = 1 - \text{Max}\,(0.2) = 1 - 0.2 = 0.8$$

Thus, the fuzzy set priority score is given by 1.0 > 0.8 > 0.8 > 0.0 and the alternative priority is given by A > C > D > B.

3.2 Evaluation for Supplier Selection (Example)

Step 1: Basic supplier selection indicators and AHP structure

To construct the hierarchy structure of AHP decision process, we used the integrated decision analysis model by Hwang (2004) which can drive out the indicators by web-based brainstorming and can find a reasonable result. The resulting brainstorming ranking of the 3 major indicators and 11 most important and easily assed sub-indicators are shown in Table 1. Four supplier candidates are considered in this example.

Table 1. Supplier Selection Indicators

Major indicators	Sub-indicators	Rem.
1. Serviceability	Meet the lead time	
	Inventor rotation rate	
	Lead time	
	Customer satisfaction	
	Market share	
2.Supply capability	Production flexibility	
	Multi-item production capability	
	New item development/production capability	
3. Quality	Quality assurance	
	Return penalty	
	After service level	

These indicators can be transferred to AHP structure as Figure 3 and 4 which show the sample output of alternative generation and construct the decision structure of the example of supplier selection problem.

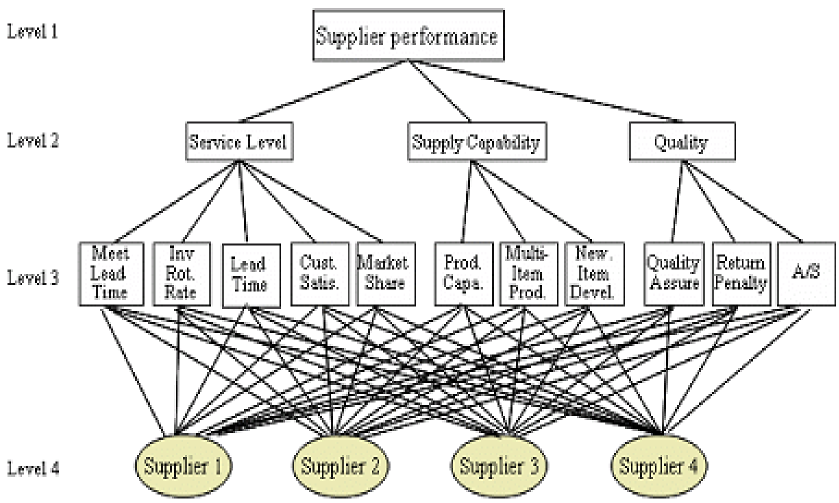

Figure 3. AHP structure of example problem

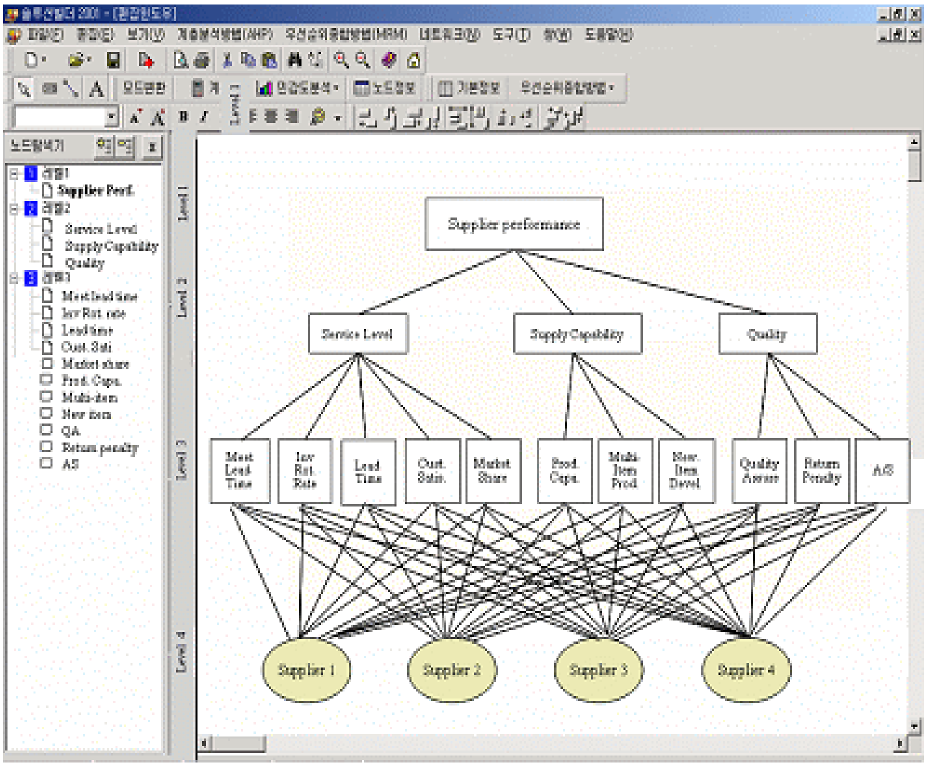

Figure 4. AHP structure of example problem by web-program

Step 2: Data collection by basic evaluation indicators

In this step we have to collect the detail data related with supplier selection. These data can be used in evaluating the selection of supplier performance. Table 2 shows supplier data collected for the sample problem.

Table 2. Supplier data for evaluation indicators

Indicator	Supplier 1	Supplier 2	Supplier 3	Supplier 4
Meet the lead time	91%	80%	85%	90%
Inventory rotation rate	15 times	12 times	16 times	13 times
Lead time	15 days	17 days	16 days	143 days
Customer satisfaction	42	48	52	55
Market share	12%	18%	19%	15%
Production flexibility	20 days	27 days	16 days	18 days
Multi-item Prod. Capa.	2 ea	4 ea	3 ea	1 ea
New item dev./ prod.	1 ea	2 ea	1 ea	1 ea
Quality assurance	ISO9001	ISO9001	ISO9001	none
Return penalty	12%	3%	1%	4%
A/S	3 days	6 days	2 days	5 days

Step 3: Compute the weighted values of each supplier using fuzzy-AHP

Using fuzzy-AHP method we found the weighted value of each evaluation factors as summarized in Table 4, also performances of each supplier candidates were developed and shown in Table 3 where supplier candidates are the lowest level. In Table 4, we can see that supplier candidate #1 (Supplier 1) is the best candidate. For the detail out sourcing policy has to be more analyzed so as to maximize the supplier selection factors weighted values and lower cost of logistics operations. For the comparison purpose, we summarized the sample results of this problem both by AHP and fuzzy AHP as Table 5. To validate the final results of supplier selection problem we have to collect more real data and analysis the supplier selection problems with various areas of industries and compared with several methods. This work will be done in further study.

Table 3. Results of Integrated Priority

Evaluation Factors		Weighted Value	
1.Serviceability 0.48	Meet the lead time	0.190	0.091
	Inventory rotation rate	0.315	0.151
	Lead time	0.120	0.058
	Customer satisfaction	0.301	0.145
	Market share	0.074	0.035
2.Supply capability 0.25	Production flexibility	0.160	0.040
	Multi-item Prod. Capa.	0.499	0.125
	New item dev./ prod.	0.341	0.085
3. Quality 0.27	Quality assurance	0.591	0.160
	Return penalty	0.211	0.057
	A/S	0.198	0.053

For this example problem we compared the two results using AHP and fuzzy-AHP. Both methods are theoretically similar each others except the fuzzy relation functions. We have developed a computer program and applied it to an example problem. Table 5 shows these results for the comparative purpose. By the results of fuzzy-AHP, Supplier 1 is selected as the reasonable supplier, while in case of the result of AHP the supplier 3 is selected as the best one. Some of the other methods and more example problems are needed to validate this problem. Any how, the AHP method gives a multi-criteria decision making structure considering all the related factors in a hierarchical decision structure.

Table 4. The weighted value for each supplier candidates for sub-factors

Indicator	Weighted Value	Supplier 1	Supplier 2	Supplier 3	Supplier 4
P_1: Meet the lead time	0.091	0.26, 0.024	0.23, 0.021	0.25, 0.023	0.26, 0.024
P_2: Inventory rotation rate	0.151	0.36, 0.054	0.21, 0.031	0.29, 0.044	0.14, 0.021
P_3: Lead time	0.058	0.58, 0.034	0.09, 0.005	0.08, 0.005	0.25, 0.015
P_4: Customer satisfaction	0.145	0.32, 0.046	0.25, 0.036	0.27, 0.039	0.18, 0.026
P_5: Market share	0.035	0.19, 0.007	0.28, 0.010	0.30, 0.011	0.23, 0.008
P_6: Production flexibility	0.040	0.25, 0.010	0.33, 0.013	0.20, 0.009	0.22, 0.009
P_7:Multi-item Prod. Capa.	0.125	0.20, 0.050	0.40, 0.05	0.30, 0.038	0.10, 0.013
P_8: New item dev./ prod.	0.085	0.20, 0.017	0.40, 0.034	0.20, 0.017	0.20, 0.017
P_9: Quality assurance	0.160	0.48, 0.077	0.11, 0.018	0.30, 0.048	0.11, 0.018
P_{10}: Return penalty	0.057	0.60, 0.034	0.15, 0.009	0.05, 0.003	0.20, 0.011
P_{11}: A/S	0.053	0.19, 0.018	0.38, 0.020	0.12, 0.006	0.31, 0.017
Total	1.000	0.368	0.180	0.243	0.179

Table 5. Results of Sample problem by both AHP and fuzzy-AHP method

Evaluation method	Priority of Suppliers and Weighted Values of factors	Selected Supplier
1. Fuzzy Set Ranking Method	S_1 (0.368), S_3 (0.243), S_2 (0.180), S_4 (0.179) P_9 (0.160), P_2 (0.151), P_4 (0.145), P_7 (0.125), P_1 (0.091), P_8 (0.085), P_3 (0.058), P_{10} (0.057), P_{11} (0.053), P_6 (0.040), P_5 (0.035)	S_1: Supplier #1
2. AHP Method	S_3 (0.342), S_1 (0.330), S_2 (0.180), S_4 (0.148) P_2 (0.170), P_9 (0.141), P_1 (0.140), P_5 (0.125), P_4 (0.101), P_3 (0.090), P_{10} (0.062), P_8 (0.060), P_9 (0.041), P_7 (0.040), P_5 (0.030)	S_3: Supplier #3

4. Conclusion

In this study, we proposed a supplier selection method using a multi-criteria decision making method which includes analysis method and also its programs. We used fuzzy-AHP method for the purpose of multi-attribute characteristics of supplier selection problems. In the third party logistics system, some of works are done by outsourcing and the supplier selection problem becomes one of the most important works which can save much budget. In this study, we used a three-step approach based on web-based decision model for multi-structured decision support systems program (Hwang, 2002, 2004) in the view of multi-attribute evaluation. Those steps are: 1) brainstorming to define the alternatives and performance evaluation factors, 2) individual evaluation of the alternatives using fuzzy-AHP, heuristic and fuzzy set reasoning methods, and 3) integration of the results of individual evaluations using majority rule method.

We applied this method in supplier selection problem for a third party logistics considering 11 evaluation factors and 4 supplier candidates. Also we developed a GUI-type computer program for proposed method of supplier selection problem. We applied the proposed model to a third party logistics system in Taoyuan area of Taiwan. By the sample results of both AHP and fuzzy set reasoning method, it is known that the proposed model is a good method for the performance evaluation of multi-attribute and multiple goals.

The computational results showed that the proposed method is very effective on a set of test problems. For the academic users, we would provide this software and user manual for educational purposes. For the problems of data collecting and its analysis in hierarchical decision structures, the DHP (Delphic Hierarchy Process) method can be used in the future study for a more efficient model.

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Session 6

New Product Development

Chair: Dr. Shuo-Yan Chou

1. **Antecedents of customer involvement and success of new product development in competitive global market**
   Abdullah Aldakhil, University of Toledo, USA
   Paul Hong, University of Toledo, USA

2. **Product development of Japanese electronic manufacturers and computer aided design usage patterns**
   Youngwon Park, University of Tokyo, Japan
   Takahiro Fujimoto, University of Tokyo, Japan
   Paul Hong, University of Toledo, USA

3. **Concurrent impacts of competitive design competence on manufacturing and supply chain and customization capability**
   James Roh, University of Toledo, USA
   Erika Marsillac, University of Toledo, USA
   Paul Hong, University of Toledo, USA

Antecedents of Customer Involvement and Success of New Product Development in Competitive Global Market

Abdullah Aldakhil* **and Paul Hong**

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Abstract
Customer involvement has been identified as an essential factor to enhance new product development performance. While there has been considerable progress in the success of new product development research, very limited attention has been given to the antecedents of customer involvement and its outcomes. We present a research model, construct hypotheses that define these interrelationships and examine the nature of interactive dynamics. Based on the previous studies, we have developed a research model and the relevant variables which include, design coordination, operational priorities, competitive priorities and the use of Information technology as antecedents of customer involvement. We develop five hypotheses relating customer involvement to the new product development performance, and relating the antecedent variables to the customer involvement.
This exploratory study is based on the empirical data from the International Manufacturing Strategy Survey (IMSS IV). MISS is global researchers' network in more than 20 countries that carried out the survey. We use generally accepted statistical analyses for this exploratory study: reliability, unidimensionality, convergent and discriminant validity of the scales. We perform structural equation modeling for the measurement model and structural model. Our findings suggest that most of the antecedents have impacts on the customer involvement. To the extent that an organization utilizes customer involvement, the performance outcomes of new product development are affected. Based on these findings, this research discusses several theoretical and managerial implications.

Introduction

The success of manufacturing organizations depends heavily on the success of new product development. Successful product development increases profit, sales, and competitive strength for most organizations. According to Booze et al 1982, a study of 700 Fortune 1000 organizations showed that product development would provide almost a third of their profits over the next five years. Also, about 50 percent of the new products introduced in the markets each year are failed. This fail cause a significant financial loss and embarrassment to the new products' promoters (Business Week 1993; Zirger and Maidique 1990). For example, Ford Motor Co. lost $250 million with the Edsel in 1958 and RCA's failed Video Disc player launched in 1981 cost them $500 million (Salmans 1984).

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New markets and opportunities of growth can be created by the innovation and the product development. The increases in the global competition emphasize the importance of the product development process. Customer involvement has been identified as an essential factor to enhance new product development performance. While there has been considerable progress in the success of new product development research, very limited attention has been given to customer involvement and the possible antecedents to enhance customer involvement. We present a research model, construct hypotheses that define these interrelationships and examine the nature of interactive dynamics.
The current trend and development of the global market have caused significant challenges for most manufacturing organizations around the world to enhance the product development performance because the demand for better quality products with lower costs forces the manufacturers to be more customer driven and innovative, to make their manufacturing operations leaner to be internationally competitive. There is confusion in the literature about the benefits of customer involvement in the new product development. While Von Hipple (1986) suggested that users are a significant source of generating product development ideas, other researchers have argued that being too close to customers might be harmful to the innovation and the business performance. (Macdonald, 1995). Therefore, this study discusses the relationship between the customer involvement and the new product development performance or success in order to increase the level of understanding the impact of customer involvement on the product development performance.
A customer orientation allows organizations to carry superior value to customers and assist to continuously improve the marketplace performance (Webster, 1988; Narver and Slater, 1990). In order to provide contribution on the subject, this paper empirically studies the antecedents of customer involvement and the impact of customer involvement on the success of product development in terms of time to market, product innovativeness, and customization. The purpose is to identify the possible antecedents of customer involvement available to managers to better shape the manufacturing strategy of their companies, and to provide them with an assessment of the possible consequences for product development success. This exploratory study is based on the empirical data from the International Manufacturing Strategy Survey (IMSS IV) to answer the following research questions

Research Questions

In this paper we explore the following research questions:

- What are the meaningful antecedents of customer involvement from strategic, organizational and operational aspects?
- To what extent does customer involvement impact on the success of product development?

Research Model

We have developed a research model and the relevant variables which include design coordination, operational priorities, competitive priorities, and the use of Information technology as antecedents of customer involvement. We developed five hypotheses relating customer involvement to the new product development, and relating the antecedent variables to the customer involvement see research Model Figure 1.

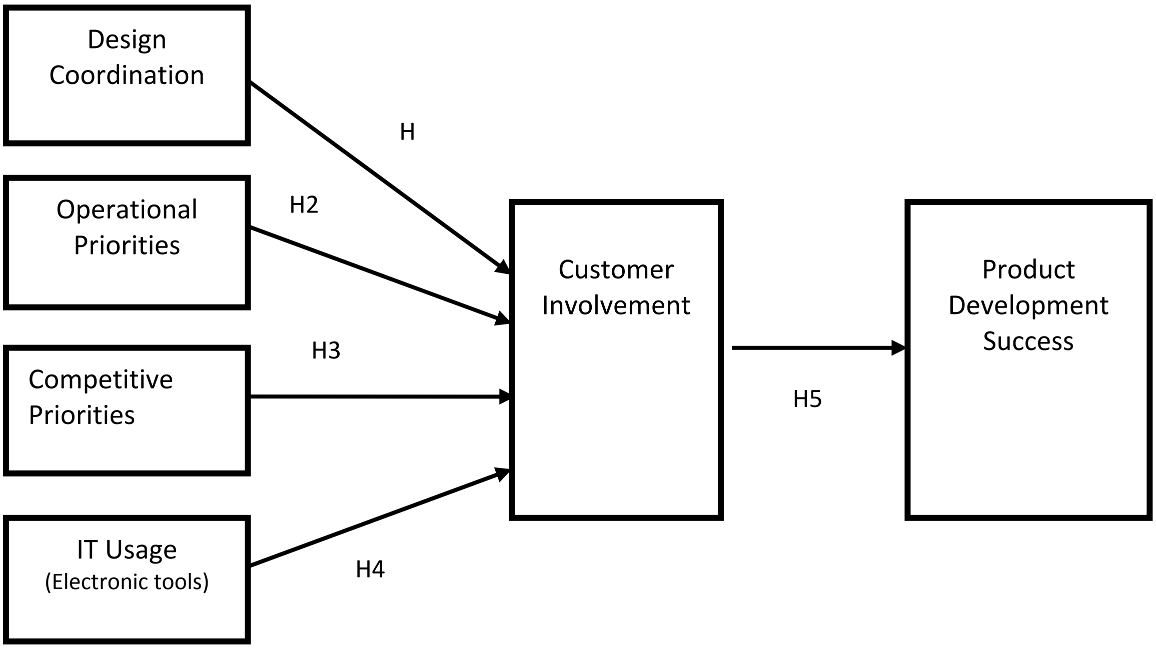

Figure 1: A Research Model

Table 1 is the summary of the constructs, definition and literature base. This shows that definition of each construct reflects adequate examination of literature base and they are consistent with the item measures as shown in Table 2.

Table 1: Summary of Constructs, Definitions and Literature Base

Construct	Definition	Literature Base
Successful product development	Successful NPD refers to a product's successful production, launch, and market acceptance	Brand, 1998 Sivadas & Dwyer 1998
Customer Involvement	the level to which the customer is engaged as a participant in business operations	Largrosen,2005 Wells et al 1998
Design Coordination	Interactive actions between designers' input including customers' input.	(Eastman, et. al.1998) (Riley, Horman,2001)

Operational Priorities	The manufacturers' selection of the key competitive capabilities which drive some or all of the four classifications of manufacturing strategy (quality, cost, delivery, and flexibility)	Skinner (1969)
Competitive Priorities	The focus areas that reflect the future trends and address the interest of the manufacturing firm (Leong et al., 1990).	(Leong et al., 1990). (Hoehn, 2003) (Phusavat & Kanchana, 2008)
IT (E-tools usage)	The level to which a firm deploys IT (electronic tools) to support operational and strategic customers' tasks.	(Cagliano et al, 2005) (Boynton et al., 1994) (Ives and Arvenpaa, 1991)

Literature Review and Hypotheses

In this study, we consider customer involvement in the context of product development. Manufacturers may operationalize customer involvement in the product development process by designing products with consideration to customers. According to Brockhoff (2003), customer involvement has been proved to be a successful strategic initiative in new product development. Customer involvement is an important factor for the enhancement of product development processes to make a comprehensive evaluation. The comprehensive evaluation of all aspect of product development has been called Design for Supportability (DFS-II) by Goffin 1998.To achieve DFS-II, engineers should include the experience of customer input in the product development stages (Hull and Cox, 1994)

Design Coordination. Design coordination can improve customer involvement process by organizing and facilitating the process of transforming the customer input into new ideas to improve the product development. While the relationship between coordination and customer involvement is understood, there is little empirical evidence that quantifies the linkage. This paper explores the effects of design coordination on customer involvement, and demonstrates that investments in design coordination can typically lead to successful product development. In order to be competitive manufacturers must listen to their customers. Through close contact with customers, designers can be more accurate in identifying the market requirements, faster in refining product specifications, and thus reduce time to market and improve the manufacturing performance (Riley, Horman,2001) However, excessive customer input may cause confusion and replication of effort, which ultimately increases time to market. In other words, some organizations take the risk of over-listening to their customers.
Design coordination is the management of commitments. Design coordination includes coordination in both process and product design. For example, selection of materials,

decisions when to order components a, sizing (Eastman, et. al.1998). An unreleased design may include information on which others depend. In this study we define design coordination as interactive actions between designers' input including customers' input. Based on that our first hypothesis is,

Hypothesis 1: Design coordination will enable the firm to involve customers in the product development

Operational priorities In strategy literature, researchers can divide their investigations into two broad classifications: content and process. This study addresses the content of operations priorities and their influence on customer involvement. Operational priorities have been classified in manufacturing strategy as quality, reliability, and cost, and we will use some of those classifications in this study. Skinner (1969) identified the important role of "operations priority" in the process of formulating and implementing the corporate strategy, and argued that management must recognize tradeoffs in the development of the appropriate operations priority. As mentioned above, "operations priority" refers to the manufacturers' selection of the key competitive capabilities which drive some or all of the four classifications of manufacturing strategy (quality, cost, delivery, and flexibility) therefore, our second hypothesis is,

Hypothesis 2: operational priorities will enable the firm to involve customers in the product development

Competitive priorities According to Hoehn (2003), competitive priorities represented the future trend of an organization for the next five years and beyond. In this study, competitive priority is defined as the focus areas that reflect the future trends and address the interest of the manufacturing firm (Leong et al., 1990). In other words, competitive priority perceived as a requirement for determining manufacturing strategies (Chen, 1999). For the action plans, competitive priority dealt with how to achieve manufacturing objectives (Kim and Arnold, 1996). Also according to (Carpinetti, 1999), competitive priorities are also defined based on additional investigation about customer expectations and performance against competitors.
Competitive priorities in general included selling price, flexibility, quality, and dependability (Phusavat & Kanchana, 2008). According to Phusavat & Kanchana, (2008), there are some studies indicated that customer service represented an emerging priority to maintain the firms' competitiveness. In addition, time to market and responsiveness for the new product development could be regarded as significant competitive priorities because of the shorter life cycle of a typical product (Leong et al., 1990; Chen, 1999). In this study, competitive priorities focused mainly on satisfying and fulfilling customers' requirement and expectations such as offer wider product range and offer more innovative products. Therefore our third hypothesis is,

Hypothesis 3: Competitive priorities will enable the firm to involve customers in the product development

IT use (Electronic tools Use) The use of electronic tools that links between organizations has been considered as a significant tool for more than 20 years. Malone et al. (1987) argued that the electronic tools or communication along with supply chain enables the organizations to reduce the cost of coordinating the production and the transactions. For example, EDI (Electronic Data Interchange) was the first tool that was widely deployed. The current technology and communication development and the role of web-based technologies to support company operations (e-business) are widely recognized by practitioners and academicians (Cagliano et al, 2005). There are many benefits of using electronic tools to support supply chain integration such as the information transfer efficiency, the information availability timeliness (Cagliano et al, 2005). According to Steven,1989, e-business is significant for the supply chain literature as a result of the increasing need to integrate activities as well as information flows and to enhance the processes in both single and inter-organizational levels. In our study we defined IT use (electronic use) as the level to which a firm deploys IT (electronic tools) to support operational and strategic customers' tasks. Therefore, we consider IT use as the application of IT within a firm's operational and strategic activities. (Boynton et al., 1994 & Ives and Arvenpaa, 1991). This will lead us to the fourth hypothesis is,

Hypothesis 4: Electronic tools (IT) use will enable the firm to involve customers in the product development

New product Development Success of product development is not only involved with pure innovation, but also customer input, thoughtful collaboration, objective analysis, and deliberate testing. The determinants of the development success are the process of the development, and the features of the product itself (Brand, 1998). One of the most important aspects in the product development process is the customer involvement. In this study successful product development refers to a product's successful production, and market acceptance. Third hypothesis is:

Customer Involvement An important aspect in recent marketing literature is the evolution from a limited focus on transactions to a focus on the relationships that organizations have with their customers and other actors (Bruhn, 2003; Gummesson, 1999). According to Priluck 2003, previous studies have indicated that well managed relationships can moderate the effects of inadequate product performance. The management of product development that involves customers is related to the process of organizations' customer relationship management (Tollin, 2002). Developing products based on the customers' wants and needs has been promoted. On the other hand, customer involvement is one of the most important sources for market knowledge (Gummesson, 1999). This indicates that we should see the product development as an interactive process that involves both customers and suppliers. Products carry a huge number of meanings which are individually perceived (Martin, 1998). In this study customer involvement is defined as the level to which the customer is engaged as a participant in business operations (Lagrosen, 2005). This will lead us to the fifth hypothesis is,

Hypothesis 5: Customer Involvement will lead to Successful product development

Research Methods

The Sample

This study is based on survey data collected within the fourth edition of the International Manufacturing Strategy Survey (IMSS IV), a research carried out by an international network aimed at exploring performance in manufacturing and supply chain management. Data were collected during 2005 by the national research groups using a standard questionnaire, developed by a group of experts, exploiting also the experience of the previous editions of the research. In countries where English is not used, the questionnaires were translated into the local language by professors in OM familiar with manufacturing strategy. This exploratory study is based on the empirical data from the International Manufacturing Strategy Survey (IMSS IV). MISS is global researchers' network in more than 20 countries that carried out the survey. We use generally accepted statistical analyses for this exploratory study: reliability, unidimensionality, convergent and discriminant validity of the scales. We perform structural equation modeling for the measurement model and structural model.
This study is based on the European, Asian, North American, South America and other countries. In the sample of IMSS- IV; the average response rate in the various countries was 18%. Overall, the final database used for the analysis consists of 711 companies.

The Measurement Model

The analysis was based on six sets of variables: design coordination, operational priorities, competitive priorities, IT use (Electronic use), customer involvement, product development success. List of the variables, Items, Description, Factor Loading and Reliability are illustrated in Table 2.

Table 2: Variables, Item, Description, Factor Loading and Reliability

Constructs	Item	Description	Factor Loading	Reliability
Customer Involvement	CI1	Share inventory level knowledge (level of adoption 1-none, 5-high)	**0.75**	0.7
	CI2	Share production planning decision and demand forecast knowledge (level of adoption 1-none, 5-high)	**0.75**	
	CI3	Order tracking/tracing. (level of adoption 1-none, 5-high)	**0.78**	
Operational priorities	O1	Improving product quality and reliability (1-not important, 5-very important)	**0.80**	0.6
	O2	Reducing unit manufacturing cost (1-not important, 5-very important)	**0.83**	
Competitive Priorities	CP1	Wider product range (1-not important, 5-very important)	**0.77**	0.8
	CP2	Offer new products more frequently (1-not important, 5-very important)	**0.86**	
	CP3	Offer more innovative products (1-not important, 5-very important)	**0.80**	
IT Usage (to what extent your customers use electronic tools	T1	Auctions (1-none, 5 high)	**0.77**	0.9
	T2	RFx request for quotation, proposal, information (1-none, 5 high)	**0.82**	
	T3	Access to catalogues	**0.73**	

with you)	T4	Order management and tracking	**0.84**	
	T5	Content and knowledge management	**0.83**	
Design Coordination	D1	Early involvement of the manufacturing function in product design (1-no use, 5 high use)	**0.84**	0.7
	D2	Overlapping of product and process design (1-no use, 5 high use)	**0.82**	
	D3	Prototyping and testing at early stages of product design (1-no use, 5 high use)	**0.67**	
NPD Performance (success)	N1	How has your manufacturing performance (Time to market) changed over the last three years? (1-deteriorated more than 10%, 5-improved more than 50%)	**0.80**	0.6
	N2	How has your manufacturing performance (Product innovativeness) changed over the last three years? (1-deteriorated more than 10%, 5-improved more than 50%)	**0.72**	
	N3	How has your manufacturing performance (product customization ability) changed over the last three years? (1-deteriorated more than 10%, 5-improved more than 50%)	**0.64**	

The Structural Model

Our findings suggest that most of the antecedents have impacts on the customer involvement. To the extent that an organization utilizes customer involvement, the performance outcomes of new product development are affected. An exploratory factor analysis using SPSS 15 was conducted to test the measurement model. Six common model-fit measures were used to assess the model's overall goodness of fit: the ratio of x2 (Chi-square) to degrees-of-freedom (d.f.), goodness of fit index (GFI), adjusted goodness-of-fit index (AGFI), normalized fit index (NFI), comparative fit index (CFI), and root mean square error of approximation (RMSEA). As shown in table 3, all the model-fit indices very close to the respective common acceptance levels suggested by previous research, demonstrating that the measurement model exhibited a good fit with the data collected. Therefore, we proceeded to evaluate properties of the measurement model in terms of reliability, convergent validity, and Discriminant validity. Reliabilities for all items is shown in table 2. The average extracted variances were more than 65%, which meant that more than 65% of the variances observed in the items were accounted for by their hypothesized factors. Following Hair et al.'s (1992) suggestions, factor loadings higher than 0.50 were considered to be significant. All of the items in our research model had factor loadings greater than 0.70 (except two items N3 D3 0.64, and 0.67 respectively).
Using AMOS, fit indices was used to examine the structural model. Comparison of all indices of fit, with their corresponding recommended values, provided support of a good model fit (x2/d.f. = 4.3, GFI = 0.91, AGFI = 0.89 NFI = 0.85, CFI = 0.88, RMSEA = 0.06). Therefore, we could proceed to examine the path coefficients of the structural model. Properties of the causal paths, including standardized path coefficients and t-values, are illustrated in table 4. The effect of design coordination on customer involvement was significant. Thus, H1 was supported. As expected, operational priorities impact on the customer involvement was significant. Therefore, H2 was also supported. However, competitive priorities were negative and not significant. IT use (the use of electronic tool) was found to be a significant factor in determining customer involvement, supporting hypotheses H4. Finally, customer involvement appeared to be a significant factor of product development success, supporting H5.

Table 3 : Summary of Model Fit Results

Fit Index	The Value
Chi-square/ DF	4.3
GFI	0.91
AGFI	0.89
NFI	0.85
CFI	0.88
RMSEA	0.06

Table 4: Summary of Hypotheses Results

Hypotheses	Supported?	Est.	S.E	C.R.	P
H1: Design Coordination → Customer Involvement	Yes	0.16	0.044	3.7	***
H2: Operational Priorities → Customer Involvement	Yes	2.2	0.368	6.04	***
H3: Competitive Priorities → Customer Involvement	No	- .087	0.063	-1.4	0.16
H4: E-tools (IT)usage → Customer Involvement	Yes	0.45	0.038	11.8	***
H5: Customer Involvement → NPD	Yes	0.10	0.040	2.7	.006 **

Conclusions

The contribution of this research is that this exploratory study examines meaningful antecedents of customer involvement from strategic, organizational and operational aspects. It shows that design coordination, operational priorities, and IT use are important drivers for customer involvement in the context of product development. Also, the study suggests that effective customer involvement will lead to successful product development. This research has significant implications for practitioners (managers) involved with product development. It has confirmed the nature and value of customer involvement for product development success. Effective customer involvement requires diverse strategic, organizational, technological considerations. In this sense, this paper defines the concept and scope of customer involvement for the effective product development performance.

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Product Development of Japanese Electronic Manufacturers and Computer Aided Design Usage Patterns

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Abstract
Increasingly, effectiveness of product development depends on how firms utilize their product architecture in achieving their internal organizational collaboration and external supply chain network. Besides, the usage patterns of Computer-Aided Design (CAD) have serious implications in the ways firms utilize their product architecture. Very few studies have ever examined diverse issues in these areas.
In this paper we first present a research framework about product architecture in electronic products. In this paper, we extend our inquiry by comparing the product architecture and CAD usage patterns of electronic products. We then further explore Computer Aided Design (CAD) usage patterns. To analyze our research model, we apply “integral architecture index,” which has a dozen specific measures of architectural characteristics of each product.
We then present our research methods and findings of survey questionnaires collected from selected Japanese electronic manufacturers. These integrative and comparative analyses suggest that product architecture and CAD usage patterns between two products (i.e., auto-mobile products and electronic products) quite differ and product development of Japanese electronic manufactures tends to be near integral architecture. In conclusion, we discuss practical implications of these findings.

Keywords: product architecture, Computer Aided Design, electronic products, integral architecture

1. Introduction

Increasingly, use of information system is essential for new product development. Since products delivered to customers are regarded as “design information embedded in media”(Fujimoto, 2005), IT system such as Computer-aided design (CAD) has a very important function as design information transformation media in new product development (Ueno et al., 2007). Over the years Design tool have evolved from hand drawing, 2D (second dimension) CAD, and 3D CAD. In Japan, 2D CAD was being widely available in 1980s. By the middle of 1990s most of large equipment manufacturers adopted it and at the same time period more firms also accelerated their adoption of 3D CAD (Nobeoka, 2006).
Although 3D CAD adoption time and its implementation speed is somewhat slower than those of 2D CAD, the implementation impact is quite substantial. Various researchers reported the effects of 3D implementation (Fitzgerald, 1987; Velocci and Childs, 1990; Robertson and Allen, 1992; Baba and Nobeoka, 1998; Kappel and Rubenstein, 1999; Aoshima et al., 2001; Ku, 2003; Tan and Vonderembse, 2006). Their

findings suggest that to the extent that electronic information transformation process is simplified and concurrent development is done, and engineering design steps and development time are drastically reduced. Enhancement of product quality is possible through substantial reductions of transformation loss. By sharing 3D images product development teams engage in new product development from diverse perspectives and accordingly they experience rich product innovation. In the early stage of product development product development teams adequately consider key concerns of back-end design engineering and therefore reduce the scope of design changes that can be occurred in the later stages (Aoshima et al., 2001).

3D CAD and CAE contribute to both front loading (i.e., early problem solving effort) and decline of development time through shortening design changes (Fujimoto, 1997, Thomke and Fujimoto, 2000). Particularly, 3D CAD facilitates concurrent engineering activities and links product design and process design electronically. Concurrent usage of 3D also enhances design processes (Koufteros et al., 2001). Product information flexibility with 3D CAD usage also helps greater extent of integration of mechanical design, electrical design and detail design analysis and therefore promote simultaneous and concurrent interpretation of product concepts.

In spite of adoption of this outstanding functionality, not all firms utilize its capability in the same way. It is important to consider differences in firm capabilities that use IT system (Fujimoto, 2006). A study of 240 US firms suggests that CAD usage affects more on cross-functional information sharing and therefore indirectly affect product development performance than it affects directly to product development performance (Tan and Vonderembse, 2006). In other words, unless firms may utilize CAD for greater sharing of cross-functional information, CAD usage itself may not directly impact product development success. In this sense, integration of CAD-related data base is critical for wider application of CAD generated information (Park et al., 2007). Organizational capabilities are unique competencies that have been developed for a long period. Building cross-functional data base is regarded as one way of expanding organizational capabilities.

Another factor that determines the extent of CAD utilization is product architecture. Compared to automobile products, electronic products are closer to modular architecture (Fujimoto, 2001). Differences in product architecture impact on the degree of CAD usage in product design. Even among the same electronic products, product architecture is not necessarily the same (Fujimoto, 2003; Nobeoka et al., 2006; Park et al., 2007).

This paper examines the relationships between product architecture of electronic products (close to modular architecture) and CAD usage. This research is based on our survey results using product architecture questionnaire items initially developed by Oshika and Fujimoto (2006).

Based on the theory of comparative advantage of product architecture, Oshika and Fujimoto (2006) empirically validated that products that is close to integral architecture tends to have more comparative advantage in Japanese industry. Yet, they did not clearly explain why electronic products close to modular architecture show declining competitive advantage. Compared to auto industry, Japanese electronic industry shows weak competitiveness in new product development performance and the reasons have not yet been explored. This paper intends to fill this research gap by focusing on the

CAD usage in electronic products and further explores the relationships between CAD usage and electronic product architecture.

2. Relationships between Product Architecture Measures and CAD Usage

2.1. Design Idea and Product Architecture Measure

Product architecture may be classified into multiple patterns. Two important types of classification are (1) modular and integral (2) open and close (Ulrich, 1995;Fine, 1998;Baldwin and Clark, 2000;Fujimoto, 2001). In reality the larger issues may be too complex to understand by such simple classification. Even for the same products, different characteristics of product architecture are noticeable depending on their product position and the extent of product complexity (Fujimoto, 2003). Product architecture can be classified on the continuums between two extremes--integral and modular.

Oshika and Fujimoto (2006) evaluated a few characteristics of architecture by using Likert scale and derived integrality index. The results indicate that the automobile and its component parts showed the highest integrality index while the lowest one was in electronic products. Other researchers also conclude that digital household goods are close to modular architecture (Ueno et al., 2007).

In general, integral products involve the maximum structural design under the serious constraints of requirement function and tradeoff of structural functions. For example, with given market demands analogue type of products requires consistent expression of structural design and functional design of small size of mechanical products in terms of weight, intensity and volume and therefore, they usually show strong integral tendency (Nishimura, 2004).

Besides, such integral products are not predetermined from the beginning; rather, modular products may become integral products depending on changes in market, technology and competitive environment. According to the analysis of integral processes, the degree of integrality of products is determined by the extent of interdependency among design elements (e.g., components, unit and parts) in terms of product attribute elements and other external factors (e.g., market, technology and competitive characteristics) (Fujitsu, 2007).

The elements from product attribute are (1) products that do not have one-to-one relationship between functionality and component parts; (2) compact and high functionality products; (3) newly devised component parts during design processes; (4) critical characteristics of products rely on total products; (5) interdependency between electrical design and mechanical design; (6) reduction in design margin, (7) products emphasizing design aspects. The factors from market, technology and competitive environment are (1) reduction in time-to-market, (2) new model from reused designs; (3) pursuit of design for users (4) technological progress and rapid changes (5) product development from new concept (6) new product development through technological integration.

Therefore, integral assembly products tend to show high ratio of specially customized design components, analogue products and mechanical components (Ueno et al., 2007). Modular products in contrast are from industry standard commodity parts, internally-used common parts, digital parts, and electrical and electronic products. The cost proportion of electrical and electronic components is about 50% in PC and digital

household goods and 30% in premium automobiles, and 10% in low cost automobiles. The cost proportion of commodity products is 50% in PC, 30% in white household electronics (refrigerator and washer/dryer) and less than 10% for premium automobiles.
Classification (as either integral or modular) requires in-depth interviews and analysis of internal product structure; however, access to firms' private data base is not realistically feasible. Therefore, it is reasonable to use survey methods to compare product architecture of firms.
In general, three approaches are available in assessing product architecture. First, "functionality structure relationship approach" is to examine the extent of integral architecture (or the opposite continuum of modular architecture) based on technological interrelationship between functionality elements and structure elements for each product. Second, by focusing structural elements (component parts) and connective elements (interface) of component parts, interface approach measures the degree of product particularity or standardization/ commonality component parts (Fujimoto 2002). These two approaches require tremendous time because they involve interviewing specialists for each product for the purpose of validation of functionality structure relationship or interface characteristics in the areas of multiple functionality elements and component part processes. These two approaches are appropriate for in-depth case studies but not for large sample data gathering or statistical empirical studies (Oshika and Fujimoto, 2006).
The third approach is subjective evaluation approach that Oshika and Fujimoto (2006) used. This involves subjective judgment on the visible patterns of product process architecture that is close to integral (or modular). This method evaluates if specialists for particular products demonstrate the adoption of such design mindsets.
This study measures questionnaire items of Oshika and Fujimoto (2006) in order to quantify the degree of architecture. Detail items are shown in the attached appendix.

2.2. Product Architecture and CAD Usage

This section explains the relationships between product architecture and CAD. Studies show that CAD system usage patterns are different between automobile industry and electronic industry in Japan (Park et al., 2007). Since Japanese automobile firms adopt integrated manufacturing, suppliers of component parts are required to use the same CAD system as their OEMs use. On the other hand, since more than 70% of household electrical and electronic products are common parts, CAD systems of suppliers and their assemblers are not necessarily the same.
For better understanding of product architecture differences, we compare product design patterns of automobile and electronic products in terms of their usage of CAD (Ueno et al., 2007). Let's consider first integral architecture of automobile products. During initial product design, structure design is subject to total functional design. Since design aspects are so important in determining the value of automobile products, functional design and structural design are implemented through sequential processes. Functionality of products is too often determined in the structural design stage in somewhat reverse order manner.
Traditionally, automobile emphasized mechanical component parts and therefore electronic parts and their embedded software have been usually subordinate to the design processes of mechanical components. With the rapid electronic transition, the

scope of electronic components in automobile (e.g., addition of ECU and other electronic component parts) has expanded and naturally electronic design and software design are becoming more important. For example, the source code requirement of car navigation exceeds 5 million lines which is beyond what the source code of other electronic components is allowed. In automobile manufacturing, to the extent diverse electronic component parts are used, the importance of software further increases.

For electronic products, electronic components are more important than mechanical parts. With the increasingly short product life cycle in electronic products, reduction in time to market is becoming an expected norm. For example, as of May 2006, life span of mobile phone and digital camera of CASIO is four to six months (Toritani, 2006). By applying typical modular architecture, electronic industry has not used CAD for the design of products with short product life cycle (PLC). As requirements for product innovation become more complicated, the focus is becoming more on information control, not on actual prototype completion. In this environment 3D CAD is more widely applied (Ueno, 2005;Park et al., 2007).

In contrast to analogue age, electronic components are becoming more important in the digital age. Many other global firms with their low cost strategy have successfully challenged Japanese competitive advantages in the segments of DVD player and low pixel digital camera. With commoditization of electronic products any firm could produce electronic products with appropriate assembly of component parts (Shintaku et al., 2004;Nobeoka, 2006;Ueno et al., 2007).

Recently, electronic products (with their market maturity) show strong pressures for differentiation and display minimization trend, energy efficiency and feature/image design. Naturally mechanical design in electronic products regains its importance. Because of mechanical design matters in the environment of integrating all the complex components parts in the very small space, high degree of image minimization and energy efficiency is required. With accelerating expectations of fast design upgrade and appearance appeal, component materials are switched from plastics to magnesium alloy and from aluminum to titan alloy. Accordingly, rule changes in existing mechanical design are required (Fujitsu, 2007).

Such trend is quite noticeable in the products where minimization is the key of differentiation strategy for premium values. Design has been an important competitive factor not in electronic products, but in automobiles for a long time. In view of little room for differentiation in technological performance in most consumer electronic products, design is becoming an important competitive factor.

For example, design in mobile products (such as mobile phone, MP3 Players and digital camera) impact the sale volume, the actual design is not finalized even at the last stage. As design is related to minimization and flat tendency, space layout design is more challenging for design components (mostly external) and functional components (mostly PCB assembly, electronic components). In this environment, CAD for external design is becoming important more seriously (Ueno et al., 2007).

This study intends to examine the relationships between product architecture and CAD usage and assess product architecture measures and mechanical electronic CAD usage in the context of mechanical electrical software development. Particularly, we first examine product architecture of mobile products (e.g., mobile phones and digital camera) and then we further analyze product development practices of Japanese electronic manufactures and their CAD usage patterns.

3. Research Model and Framework

A previous case study compared the product development practices of electronic firms with those of automobile manufacturers in terms of product architecture (Park et al., 2007). This study reported that integral product development patterns also exist in electronic products.

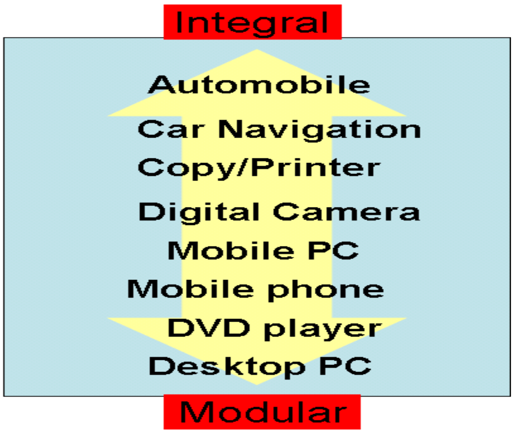

Figure 1. Product Classification by Product Architecture
(Source: adopted from Park et al. (2007), Nobeoka et al.(2006))

This study, as an extension of the previous one, focuses primarily on product development practices of electronic products that follow integral product architecture patterns. In the previous paper, we presented two parameters (i.e., integral-modular and open-close). For the purpose of this paper, we will focus on integral-modular axis, not open-close one. Nobeoka (2006) classified products in terms of integral-modular continuum. Figure 1 shows that automobile products are on the top of integral side and desk top computer is on the other opposite modular side. In between these two extremes, car navigation, printer, digital camera, mobile PC and mobile phones are positioned. In this paper, we focus primarily on product architecture of electronic industry. This paper also examines electronic products that are more close to modular than integral. Based on the findings of the previous study (Park et al., 2007), we assume that new product development heading for high functionality in electronic products adopts integral product architecture.
Figure 2 shows that in case of derivative product development common parts are used more and interfaces among component parts are highly standardized. They adopt modular product architecture.

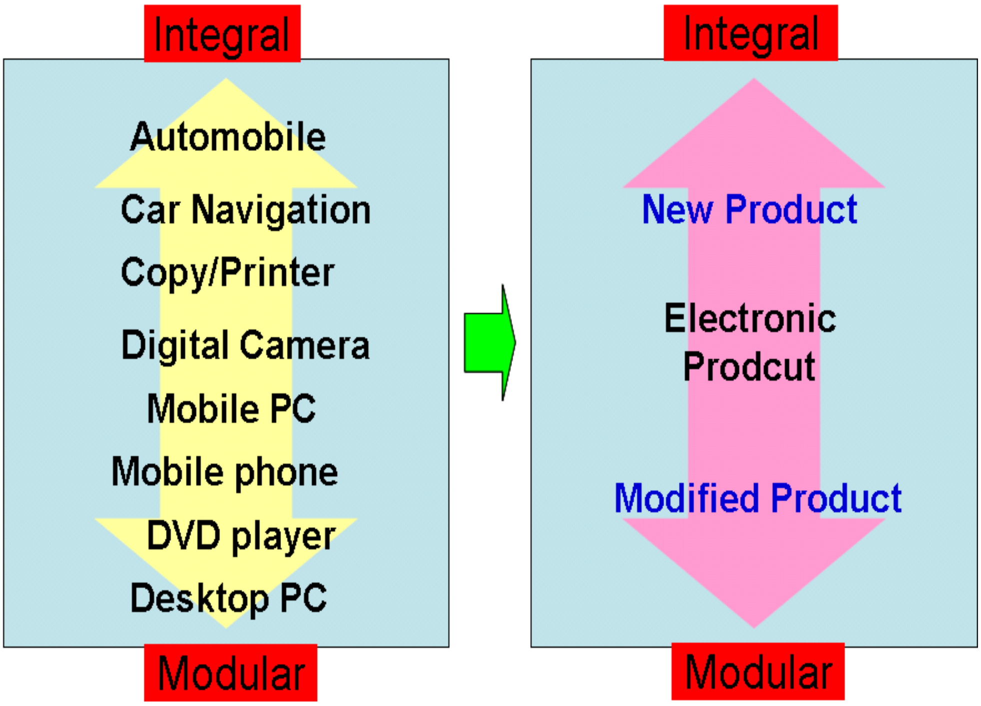

Figure 2. A Research Framework

4. Analytical Methods

4.1. Research methods

Manufacturing Management Research Center (MMRC) of University of Tokyo has been conducting interviews in the areas of product development and CAD usage in Japanese electronic industry. From the latter part of 2007 the research team conducted the questionnaire survey on product development practices and CAD usage of electronic products that are classified as one of assembly product families (Oshika and Fujimoto, 2006). This is the first pioneering study of CAD usage of the electronic industry in Japan.

We have adopted the instruments developed by Oshika and Fujimoto (2006) for the analysis of the content of product architecture. These measures examine (i) component parts design in terms of product specificity (4 items), (ii) connective parts in terms of internally restricted standards(4 items), (iii) design parameters in terms of mutual modifications (4 items), (ⅳ) comprehensive five-step subject evaluation by product leaders(1 item). Oshika and Fujimoto (2006) assessed the degree of integral architecture by adding the scores of all variables based on principal analysis. On the other hand, our focus was on small numbers of products and therefore for this analysis purpose we have used the total score of only 13th item. More details about this comprehensive instrument are available in Oshika and Fujimoto (2006). In Appendix, the items used for our research are disclosed.

4.2. Product Architecture and Measurement Results

This study analyzes four types of electronic products (i.e., mobile PC, liquid crystal projector, digital camera, and mobile phones). The simple average score of product architecture of these four products is 3.8. This suggests that even though they are electronic products, they are quite close to integral architecture.

However, as we classify them in terms of high performance product development and derivative model, the results are somewhat different. Figure 3 shows that the products reported as integral architecture are high pixel digital camera and new mobile phones with complex functionality. Product development of Mobile PC is also reported as close to integral architecture. On the other hand, liquid crystal project and derivative model of mobile phones are somewhat close to modular architecture. These conflicting results reveal the different product architecture between highly performance and derivative product models.

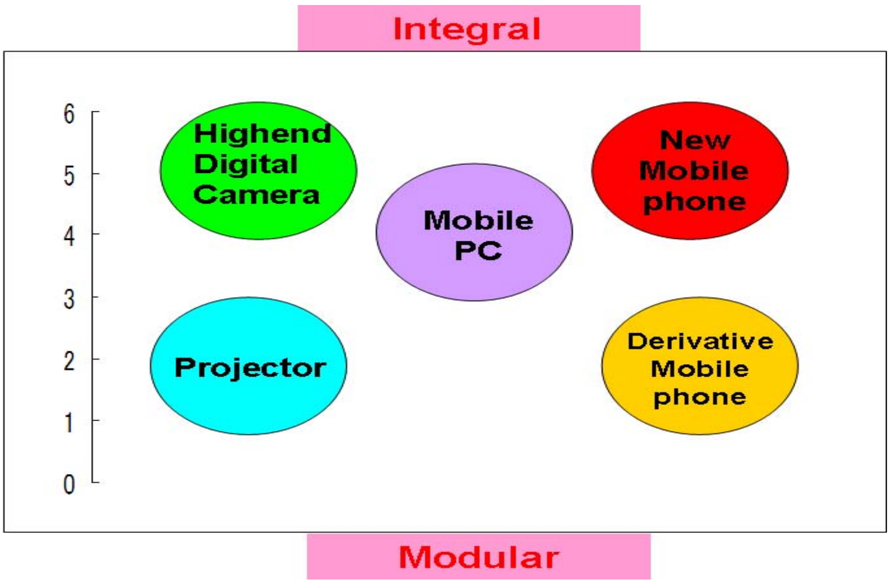

Figure 3. Classification of Product Architecture by Four Products

These differences in product architecture reflect the impact of differentiation by minimization of mobile products. It shows that for consumer electronic products the primary way of differentiation is in design features (Park et al., 2008). Particularly, sales volume of all mobile products such as mobile phones, digital camera and mobile PC depend on outstanding design expression which includes minimization and flatness of products. As a lot more complex component parts are squeezed into smaller available space, the degree of integral architecture increases in electronic product designs.

Of course, product differences among Mobile PC, digital camera, mobile phones and liquid crystal projector need to be carefully considered as well. In our study, multiple evaluators participate and therefore with the presence of perceptive biases it is not quite possible to compare the absolute differences of product architecture. Yet, the differences in product architecture are observed among high performance products and their derivative products.

The implications of these results are useful for engineers involving in product development in that (1) effective product development requires careful examination of each product architecture; (2) the impact of product architecture on the CAD usage patterns need to be examined; (3) in view of excessive product quality issues, the extent of premium functionality is to be carefully considered.

4.3. Electronic Product Development and CAD Usage

This section examines CAD, CAM and CAM usage patterns of electronic products. The types of CAD for component parts design are 2D, 3D Wire Frame, 3D Surface, 3D Solid. Our study shows different characteristics between case (mechanical design focus) and PCB base (electrical circuit design focus). Table 1 shows that Case (Housing) design uses mostly 3D Solid while PCB base design limits to 2D. 3D Solid is used for core components (e.g., digital camera lens). In other words, besides PCB base, it is not surprising to see that almost all component part designs use 3D CAD, CAM and CAE.

Table 1. Types of CAD According to Component Parts Design

Component Parts	Type of CAD in Design of Component Parts (%)				
	2D	3D Wire Frame	3D Surface	3D Solid	CAD No use
Case	2.8	0.0	0.4	96.9	2.5
PCB board	86.3	0.0	0.0	13.8	0.0

The number of CAD operators per design engineers indicates that in most cases (except a few cases of CAD operators) design engineers themselves input CAD data. The percentage of CAE experts in the process is a little higher than that of design engineers (55.7% vs. 44.3%).

Table 2. Ratio between CAD Operators and CAD Experts

Number of CAD Operators that Support Design Engineers (Unit: Number of people)	% of Total Processes In Terms of CAE	
	CAE Experts	Design Engineers
0.8	55.7	44.3

After the middle of 1990s, the changes have occurred from 2D CAD to 3D CAD usage. We have examined more in detail of the processes in terms of (1) product planning, (2) design, (3) mechanical design. (4) electrical design (PCB design), (5) equipment design,

(6) interpretative design, (7) prototype. Table 3 shows the usage percentage of 2D CAD and 3D CAD in terms of seven different processes.
For product planning 3D CAD is used (32.5%) and for the majority 3D CAD is not used (66.9%). In design, 3D usage is definitely large (65%) and then the 3D usage portion increases in mechanical design (93.8%), equipment design (66.9%) and interpretative design (93.1%). In view of the continuity from equipment design to interpretative design, 3D usage probably enhances the concurrent aspects of process management.

Table 3. Ratio of 2D CAD and 3D CAD Usage in Design Processes

Design Process	2 D CAD	3 D CAD	CAD no use
(1) Product Planning	0.6	32.5	66.9
(2) Design	20.0	65.0	15.0
(3) Mechanical Design	6.3	93.8	0.0
(4) Electrical Design (PCB Design)	86.3	13.8	0.0
(5) Equipment Design	18.1	66.9	15.0
(6) Detail Design	6.3	93.1	0.6
(7) Prototype	18.1	56.9	25.0

But 2D usage is heavy in electrical design (PCB design). Although some electronic firms try 3Dization in electrical design, still 2D CAD usage is more common. Increasingly, the effectiveness of 3D usage will be more obvious in all aspects of design processes the years to come.
Table 4 shows the effect of 3D CAD implementation in terms of (1) number of development processes, (2) number of design changes (3) development time, (4) total cost changes. The base line is 100% prior to the usage of CAD and the ratio after the CAD usage is assessed.

Table 4. The Effect of CAD Implementation

Development Processes (%)	Design Process (%)	Development Time (%)	Total Cost (%)
100->102.5	100->68.6	100->63.6	100->90.0

Although some firms reported decrease in their development processes, most of the firms reported the increase in the number of development processes after 3D CAD usage from 100 to 102.5.
This shows that the impact of 3D CAD usage shows in the increased number of processes through (1) realization of front-loading; (2) effect of division of labor by concurrent engineering; (3) development process changes. In 2000s many firms effectively use 3D and yet some firms (with the lack of organizational capabilities) instead increase the number of processes with 3D usage.
Increase in actual number of processes suggests that although the simplification of processes through 3D usage is attained, many firms still use 2D drawing as well (Park et

al., 2007). Some firms experienced the double work volume increase for design engineers with the adoption of 3D CAD without changing organizational process capabilities (e.g., routines, functional roles, work processes and design rules). However, with their achievement of improving the above mentioned organizational capabilities, they were able to reduce the number of work processes. Even so, many firms still use 2D drawing after their adoption of 3D CAD because of lack of check measures for acceptance evaluation and other relevant measures for prototypes. This might be the reason for increase in number of processes with the adoption of 3D CAD.

With the adoption of 3D CAD, the number of design changes and development time is substantially reduced. The average reduction of design changes is more than 30% and development time is also reduced by 40%. These reductions are mainly due to the time reduction of prototype preparation. However, these progress in design changes and improvement of development time have not resulted in substantial total cost reduction. This indicates that maximization of the effect of 3D CAD requires overall reduction of total processes through process redesign and internal organizational capability enhancement.

Firms (with or without their improvement of organizational process capabilities) make huge differences to the extent of reaping the benefits of 3D CAD usage. This suggests that successful implementation of new technologies (e.g., 3D) must include corresponding improvement of organizational capabilities.

5. Product Development Patterns of Japanese Electronic Firms

Our research findings suggest the interesting managerial implications. First, the high level of product development capabilities of Japanese electronic firms need better strategic business orientation. The integral architecture of high functional digital camera and mobile phones indicates that Japanese firms make significant efforts in applying innovative product development. Their commitment to outstanding product development (notice that they used to sustain competitive advantages in 1990s) is clear and strong. The problem is that their high level of product development capabilities is not necessarily translated into global competitiveness. A critical issue is their pursuit of excessive product quality in 2000s without responding to the global market requirements.

Compared to Korean mobile phone firms, Japanese counterparts are not inferior in terms of technologies (Park et al., 2008). In fact, technologies in camera modules and component parts are much superior. Yet, except Sony Ericsson no other Japanese electronic firms are global market players. Instead, Japanese firms pursue excessive product quality for their domestic market needs without resolving global communication methods and standardization issues. They have narrowly focused on Japanese domestic market with a slogan “one model for 500,000”. In the meantime they somehow have failed to adapt to the changing global market reality. For example, European GSM segment that covers 80% of its global market, most customers do not demand high functional mobile phones; rather they expect appropriate functionality for business. In reality, Nokia and Samsung have successfully focused on rapid product development and design-based product strategy. However, Japanese firms have been slow to respond to global market demands while directing their attention for domestic customer requirements in terms of diverse entertainment and leisure features. Their

longer product development time and high cost somehow have not been so appealing to the global customers.
Second, firm's organizational process capabilities affect the extent of benefits of 3D implementation. 3D usage may improve front loading and concurrent engineering and therefore enhances product development capabilities. Full realization of 3D technologies requires corresponding application of organizational process capabilities. This should include process innovation of the entire organization (Park et al., 2007). 3D technologies are related to all organizational processes. Without organizational structure that integrates all product development processes, 3D technologies become merely a process tool. Without proper organizational process innovation, the net results of heavy IT investment and CAD technology adoption are no more than mere increase of work processes.
In this sense, building organizational process capabilities is becoming more important for the sustainable competitive advantages in the context of strategic fit and IT system implementation (e.g., adoption of 3D CAD technologies). This study also addresses the current state of Japanese electronic firms and the realistic possibility for their competitive advantages. This requires their strategic product development priorities toward design excellence through integral product architecture and organizational process capabilities. In this context, successful adoption of 3D technologies is a realistic option for enhancement of design excellence and organizational process capabilities toward their long term global prominence again.

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Appendix: Questions of Product Architecture

The survey analysis gained responses based on five-step Likert-scale evaluation by employees who are in charge of those products in question. It asked those company personnel in charge of products for their subjective evaluations of 12 items as elements of “integrative/modular architecture indicators”; these items included “Is part design conducted specially for the specific product?” and “Do inter-component interfaces use company-specific designs?”

The 12 question, plus 1 (overall evaluation 13) items are shown as follows.

＜Questionnaire＞

1. This product mainly consists of parts or materials with customized (product-specific) design.
2. Interfaces that link the components of this product are custom-designed (product-specific).
3. Interfaces that link the components of this product are firm-specific (used only in this company).
4. In order to achieve total performance of this product, design parameter of its components must be precisely fine-tuned (mutually adjusted).
5. Total quality of this product cannot be achieved by mix-and-match of pre-designed components (e.g. generic parts, common parts, carry-over parts).
6. The product faces strict constrains in terms of size and weight, which results in inter-dependence between design parameter of the components, (e.g. parts interference and weight balance).
7. The product requires close collaboration of component design or material design between the assembler and the suppliers.
8. In order to satisfy its customers, the product needs to achieve more than one performance requirement at the same time.
9. The product needs precise adjustment of process design parameters to the change and variance of its materials or upstream products.
10. The product cannot achieve high total product quality by mix-and-match of the standard production equipment (it requires customization of the equipment).
11. The main production process of this product is designed or manufactured by this company (in-house equipment).
12. In order to achieve the required performance, this product needs precise mutual adjustment of control parameters between its production processes.
13. Overall evaluation of product/process architecture based on questions 1-12

（Note.1) Scale 5: Very true, 4: Rather true, 3: Neutral, 2: Not so true, 1: Not true at all

（Note.2) Assembly-industry products are answered from Questionnaire1 to Questionnaire13,
Process-industry products are answered from Questionnaire7 to Questionnaire13.
The results were aggregated by multi-variable statistical analysis (e.g., principal component analysis), then indicators that express the level of “integral-ness” (or, conversely, level of modularity) of the products’ architecture were prepared.

Concurrent Impacts of Competitive Design Competence on Manufacturing and Supply Chain and Customization Capability

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Abstract
Previous operations research has focused on the individual relationships between product and process and product and supply chain, but significantly less research has explored the simultaneous influence of product design on manufacturing process and supply chain. There has also been sparse research on the influence of the manufacturing system on collaborative supply chain practices. This paper seeks to develop a conceptual model that explores the impact of competitive design capability on flexible manufacturing technologies and collaborative supply chain practices, which enhances flexible manufacturing outcomes and firm performance. The integrative model and research hypotheses are presented for review. To test the research model, empirical evidence was drawn from the International Manufacturing Strategy Survey (IMSS), a worldwide research project involving 751 manufacturing units in twenty four countries. Data were collected during 2005 by international research groups within the global network using a standard questionnaire. The exploratory study suggests that competitive design capability plays a critical role in determining flexible manufacturing technologies and collaborative supply chain practices. However, flexible manufacturing technologies do not affect flexible manufacturing performance, indicating that advanced flexible manufacturing technologies do not work alone but require collaborations from both internal suppliers and external customers. This study sheds lights on the significance of competitive design competence in shaping manufacturing and supply chain design and its impact on customization capability and firm performance.

Key Words: Competitive design competence, advanced manufacturing technologies, collaborative supply chain practices, customization capability, concurrent impacts

1. Introduction

Child et al. (1991) highlighted an emergent importance of product design, and suggested that the product design is a large determinant of the total cost of producing and delivering a product. With the competitive and dynamic requirements of today's business environment, the strategic role of design is significant, often determining the direction and competitive advantage of a manufacturing firm for years to come.
Hayes and Wheelwright (1979a, 1979b) first formulated a product process matrix to illustrate how product design can influence and even determine manufacturing processes. Since then, many firms have used this theoretical matrix to support the

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integration of product design with manufacturing process selection, and to encourage cross-functional cooperation among marketing, finance and engineering areas. Product design has also been shown to significantly affect supply chain type (Fisher 1997; Mason-Jones et al., 2000; Christopher & Towill 2001; Lee, 2002; Christopher & Peck, 2004; Vonderembse et al., 2006). Complementary research has also shown strong correlations between product characteristics and supply chain strategy (Fisher, 1997; Vonderembse et al., 2006; Selldin & Olhager, 2007).

Integrative approaches to designing product, manufacturing and supply chains are rather recent in literature, possibly due to the extensive scope of the theoretical framework required to comprehensively conceptualize a product/process/supply chain model. Some methodologies, such as concurrent engineering, have been developed that focus on the product as the source of many manufacturing and supply chain decisions (Sohlenius, 1992). Complementary perspectives such as those of green and/or lean manufacturing or strategies such as Design for Environment (Chen, 2001) may also apply an integrative product, process, supply chain perspective working towards an emphasis on waste elimination. Based on a similar product-source integrative perspective, this paper will explore the simultaneous influence of product design characteristics on the design of manufacturing systems and supply chains, as well as the impact of the manufacturing design on the design of the supply chain.

Both researchers and practitioners have recognized the importance of careful consideration of product design in the development of both manufacturing and supply design processes, especially with a focus on the product development stage (Ellram et al., 2007). Despite this recognition and acceptance of the individual associations between product and manufacturing and product and supply chain, however, there has been little research completed on investigating the *simultaneous* impact of product design on manufacturing process design and supply chain design. This paper attempts to answer three research questions: (1) How does product design competence influence the design of manufacturing systems (process) and supply chains? (2) How does manufacturing design influence the design of the supply chain? (3) What kind of organizational performance does product design competence result in?

This study aims at developing and discussing a research framework that describes the relationships among the competitive design competence, advanced manufacturing technologies, collaborative supply chain practices and their impact on customization and firm performance. A discussion of research methodology and data analysis and discussion follows the theory development section.

2. Theory development

The recent research outlines a strong impact of product design on manufacturing process and supply chain design, as well as inferring possible links between process and supply chain design. Indeed, there has been much discussion, if little empirical work, regarding extending the Design for Manufacture (DFM) conceptual underpinnings to those of the Design for Supply Chain (DSC). Integration decision supports methodologies, especially as conceptual pieces such as the Product Chain Design Model (PCDM), have already been proposed by Blackhurst et al. (2005). Optimal configuration models have also been proposed by Huang et al. (2005). And at the theory level, some integrative approaches of the three areas, such as Three-Dimensional

Concurrent Engineering (3DCE), have already been proposed by Ellram, Tate and Carter (2007).

Based on previous research, theory and nomological analyses, this paper proposes a conceptual model which suggests the impact of competitive design capabilities on flexible manufacturing technologies, and collaborative supply chain practices. The competitive design capabilities eventually materialize flexible manufacturing performance and firm performance. Figure 1 presents the research framework. The research framework portrays the hypothesized impact of competitive design capability on flexible manufacturing technologies and collaborative supply chain practices. These all enhance competitive advantage of the firm, leading to better firm performance.

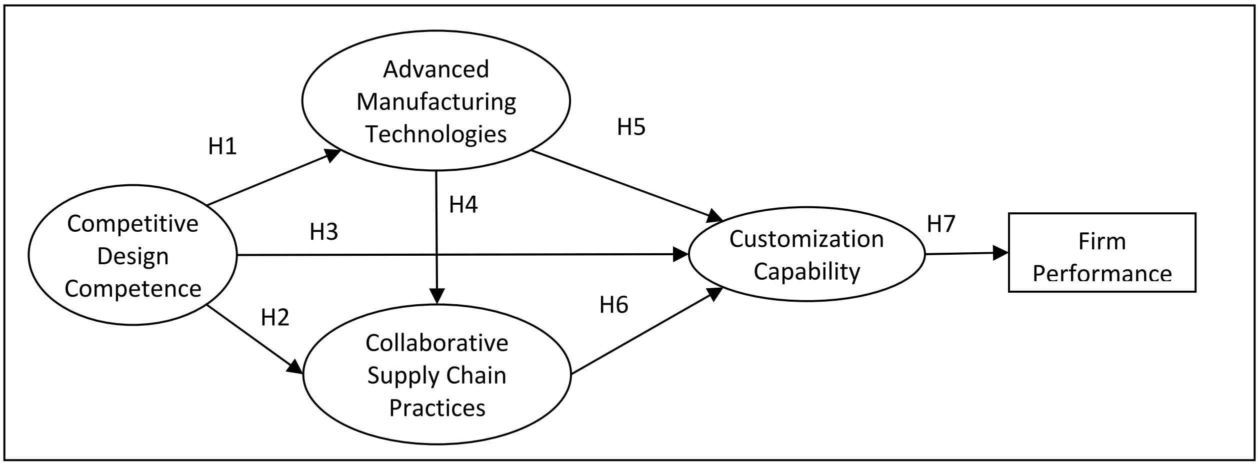

Figure 1. The Research Model

2.1. Competitive Design Competence

Product development has been defined as "a deliberate business process involving hundreds of decisions" (Krishnan & Ulrich, 2001). Product development can focus on the development of a tangible, physical product, or the development of an intangible service product. Krishnan & Ulrich (2001) recognized this service product facet and developed suggestions that would apply to products as services or goods, but focused their attention primarily on the development of a tangible, physical product.

Spanning such a broad range of decision areas, multiple perspectives of product development exist. This paper will focus on the operations management perspective of product development, as suggested by Krishnan & Ulrich (2001). The operations management perspective of product development include a definition of "…a sequence of development and/or production process steps", critical success factors of "supplier and material selection (and) design of production sequence", and decision variables that may include "development process sequence and schedule (and) point of differentiation in production process" (Krishnan & Ulrich, 2001, pg. 3). Important to note here is that the critical success factors and decision variables span and impact both the manufacturing design process and the supply chain design process. The critical success factors and decision variables are also specifically based on product development processes and could be directly influenced by specific product characteristics.

The turbulent market environment and frequent customer preferences change demand firms to acquire capability to deal with this dynamics. The best way is to take a proactive approach rather than a reactive one because reaction to competition would be slower and costly. Preventive actions begin with product and process design stage. In this sense acquiring competitive design competence enables firms to cope with uncertain environment better. This competitive design competence could be defined as the extent to which a firm could respond to market dynamics by increasing product customization, variety, and innovativeness.

Table 1: Variable definition and literature base

Construct	Definition	Reference
Competitive design competence	The aptitude of a firm to increase product customization, variety, and innovativeness to proactively confront market dynamics	(Zhang et al., 2003)(Iversen & Buur, 2002)(Chastain & Elliott, 2000)
Advanced manufacturing technologies	A group of technologies that enables firms to produce a variety of products with less costs such as automated parts loading/unloading, automated guided vehicles (AGVs), Flexible manufacturing/assembly systems (FMS/FAS/FMC), computer-aided inspection, integrated design-processing systems (CAD-CAE-CAM-CAPP)	(Lei, Hitt, & Goldhar, 1996) (Dean, Se Joon Yoon, & Susman, 1992)(Lowe, 1995) (Small & Chen, 1995)
Collaborative supply chain practices	Practices of manufacturers with their suppliers and customers in sharing planning decisions, demand, delivery knowledge in order to increases collaboration among them.	(Barratt, 2004) (Chan, Chung, & Wadhwa, 2004)(Holweg et al., 2005)
Product customization capability	The ability of a firm to incorporate customers' needs and wants by producing a variety of customized products.	(White, 1996)(Pine, Victor, & Boynton, 1993)(Vickery, Droge, & Germain, 1999)(Klein, 2007)
Firm performance	The extent to which a firm increases sales or market share	(Yamin, Gunasekaran, & Mavondo, 1999)

2.2. Advanced Manufacturing Technologies

Manufacturing process design has changed over time as production itself has evolved from craft systems to modern industrial manufacturing (Skinner, 1985). Through this evolution, appropriate and efficient manufacturing process design has taken on greater and greater importance as investments have become larger, time lines have become longer, production volumes have grown, and technological advances have arrived more swiftly. Manufacturing or process design involves significant, long-term, capital intensive decisions which can determine the direction of a firm for years to come, develop sustainable competitive or first mover advantages, or alternatively shackle a firm to inappropriate, or worse, unprofitable manufacturing direction. Successful manufacturing design demands coordinated strategies and integration with multiple areas of the firm (Hayes & Wheelwright, 1979a, 1979b).

As manufacturing processes and customer needs have changed, so have manufacturing goals: changing from those of high volume to faster time, from those of standardization to increased flexibility and product variety, from those of secondary roles to primary roles, and from those of silo mentalities to integrative approaches. As manufacturing goals evolved, researchers recognized that the manufacturing design expectations of the past were no longer effective, and they had to be adapted. Part of this adaptation includes a growing recognition of the importance of the product design on the manufacturing process.

Amidst these changes, flexible manufacturing technologies have arisen as an alternative solution because it enables firms to produce products with less cost but high variety, increase strategic flexibility (Lei et al., 1996). Flexible manufacturing technologies denote machines or technologies such as automated parts loading/unloading, automated guided vehicles (AGVs), Flexible manufacturing/assembly systems (FMS/FAS/FMC), computer-aided inspection, integrated design-processing systems (CAD-CAE-CAM-CAPP). These technologies open wide window for firms to exploit faster speed, greater product variety and increased productivity (Lei et al., 1996). Manufacturing system equipped with flexible manufacturing technologies increases production speed thanks to reduced set up time and relative easiness to adopt product variants into the system. Product variety stems from their capabilities to accommodate more design quickly, resulting in the increase in productivity.

2.3. Collaborative Supply Chain Practices

Supply chains are complex mechanisms based on the particular product they are designed to support. In recent decades, the supply chain has received increasing attention from both researchers and practitioners. Beginning in the 1980s and early 1990s, researchers and practitioners focused on analyzing the general principles of supply chain management as an offshoot of interest in Toyota's successful application of the "lean" paradigm (Womack et al., 1990; Womack & Jones, 1996). The core concept of lean supply chains is to eliminate waste from the entire supply chain process from production to delivery (Womack et al., 1990).

Starting in the late 1990s, researchers realized that supply chains strategies worked best when they were market-specific and that certain types of supply chain better fit an "agile" paradigm. Agile supply chains refer to the ability of the supply chain to respond to a rapidly changing market by being flexible (Mason-Jones et al., 2000). Consequently, much effort focused on finding the right supply chain for the right product, industry, and product life cycle. Fisher (1997), for example, suggested a typology of products/supply chains, and emphasized that a mismatch between product type and supply chain strategy could result in negative performance consequences.

Collaborative supply chain emerged as a choice to implement in order to stay vital amongst rapid technological change and hyper-competition. Industries and researchers widely recognize that supply chain collaboration brings transparency, efficiency and synergy to a supply chain (Holweg et al., 2005). It takes a variety of forms such as vendor management inventory (VMI), collaborative forecasting planning and replenishment (CPFR), and continuous replenishment (CR). Collaboration in a supply chain is a very amorphous term, but this study defines it as practices of sharing planning decisions, demand, delivery knowledge between a hub-manufacturer and suppliers and customers.

2.4. Product customization capability

Customization plays a critical role in achieving manufacturing flexibility (Gerwin, 1993). To remain competitive in a changing environment, there is a need to develop flexible system. In this regard, attaining product customization capability gives essential competitive advantage to firms. Researchers initially identified product customization as product flexibility, a key competitive priority in the operations literature (Krajewski & Ritzman, 1999; SKINNER, 1969; D'Souza & Williams, 2000). Later, the concept of product customization has been associated with product flexibility and product variety that lead to financial and marketing performance (Vickery et al., 1999). This study defines product customization capability as the ability of a firm to incorporate customers' needs and wants by producing a variety of customized products.

2.5. Firm performance

Firm performance refers to the extent of organization's achievement in terms of sales and market share. Market and financial performance should increase as firms implement the right strategy across its organization and supply chains. Researchers has taken firm performance as one of the measures of firms' effectiveness and efficiency (Stock, Greis, & Kasarda, 2000; Yamin et al., 1999).

2.6. Hypotheses Development

2.6.1. Competitive design competence and advanced manufacturing technologies

There have been many research attempts made to link product design to the manufacturing process. A primary example is from Hayes and Wheelwright's seminal HBR articles (1979a, 1979b) describing the product-process matrix which matches a product's process life cycle stage to its product life cycle stage, and includes various dependency levels between product and process. For instance, high volume and standardization product requirements characterize commodity or functional products such as sugar, which then entails the use of continuous flow production. In contrast, low volume and standardization product requirements exemplify the features of innovative products, which then entail the use of jumbled flow production. According to Hayes and Wheelwright's matrix (1979a, 1979b), product characteristics are strongly associated with manufacturing processes and as such, product design should be actively considered when mapping out or designing the manufacturing process.

Supporting these integrated design practices, design methodologies have been developed which propose guidelines for design practices and scope. One of these design methodologies is Design for Manufacture (DFM), which is "the practice of designing products with manufacturing in mind" (O'Driscoll, 2002, pg.318). DFM emphasizes process cost reduction and the simultaneous improvement of production processes (O'Driscoll, 2002). While conventional design methods focus on sequential product development, DFM highlights a more concurrent and integrated design process which modifies and restructures conventional design methods, creating and inserting manufacturing integration checkpoints into the new product development process. These checkpoints, by sharing information earlier across the new product impacted areas, can help reduce component and material costs and reduce lead time from product design to full scale production, leading to significant cost savings for the firm (O'Driscoll, 2002). Based on this previous literature and theory, one could infer a logical relationship between product design characteristics (such as product variety, product nature, or platform usage) and the selection of certain manufacturing process types.

Nomologically, a manufacturing system should be designed based on a product's characteristics and specific design, or else the system would not be able to meet production needs. However, practically speaking, it would be impossible to design and build a manufacturing facility for each and every new product design. Therefore, firms face essential needs to increase product customization competence in every way. One of the important ways is to acquire advanced manufacturing technologies. The need to manufacture multiple product varieties with less costs and faster speed compels firms to equip itself with advanced manufacturing technologies.

In a similar vein, products with innovative features or designs may require more sophisticated manufacturing processes. These sophisticated processes will likely require the manufacturing system be able to change rapidly. In addition, if a market or industry requires a rapid time to market for its products, i.e. small electronics, manufacturing processes would be required to have short set up times and the flexibility to adapt quickly. It is expected that products which require high levels of innovation and rapid speed to market are positively related to manufacturing flexibility. Therefore, a company that strives to acquire competitive design capability will make every effort to acquire flexible manufacturing technologies. Therefore,

Hypothesis 1: The more competitive design competence a firm seeks for, the more flexible manufacturing technologies it will acquire.

2.6.2. Competitive design competence and collaborative supply chain practices

Current supply chains taxonomies are heavily based on product types and the product life cycle (Mason-Jones et al., 2000; Christopher & Towill, 2002; Goldsby et al., 2006; Vonderembse et al., 2006). These supply chain classifications suggest a strategic association between product characteristics and supply chain types. With the nature of competition changing from firm vs. firm to supply chain vs. supply chain, it is imperative for manufacturing firms and their suppliers to align visions, expectations and costs, in order to optimize performance.

However – if in fact striving for greater product variety, some researchers suggest different strategic alignments of supply chain with product characteristics. For example - extending Fisher's framework, Selldin and Olhager (2007) reported significant relationships between product types and supply chain types, suggesting a positive influence of alignment on performance. Although empirical research is still sparse in evaluating many of these proposed relationships, it is expected that higher levels of product variety will require and relate to higher levels of supply chain flexibility.

In order to accommodate expected increases in levels of product variety, supply chain designers should anticipate and plan for the changes and challenges involved in managing a variety of products. Similar anticipatory logic may apply for the influence of platform strategy on supply chain design. If an original equipment manufacturer (OEM) utilizes a platform strategy, its supply chain might incorporate more flexibility in providing components. Given innovative product designs, supply chains might be required to be more flexible because the supply chain would be required to consistently produce relatively new components and models. Additionally, products which require a high speed-to-market, i.e. the small electronics industry, should require a highly responsive supply chain (Fisher, 1997; Selldin & Olhager, 2007), which demands supplier and customer collaboration. Based on these logical arguments, the following research proposals are suggested.

Hypothesis 2: The more competitive design competence a firm seeks for, the more a firm will implement collaborative practices with its suppliers and customers.

2.6.3. Competitive design competence and customization capability

Competitive design competence is a firm's aptitude to increase product customization, variety, and innovativeness to proactively confront market. As firms endeavor to develop competitive competence, they tend to acquire more capability to customize products that satisfy customers. One example could be found recent case of LG, a Korean electronic company that excels in cellular phone market (Moon, 2008; Business Week, May 19, 2008, pp. 30). The global cell-phone business amounts $ 142 billion a year and the thee major players are Nokia, Samsung, and LG. LG takes the most advantage of Motorola's stagnant performance. Its exports grew to 54% from January to March, 2008 and increased market share from 6.4% to 8.6%. The main contributor to this success lies in design competence. As LG endeavors to achieve higher design competence, the firm presents more attractive and various products that appeal to customers. Therefore,

Hypothesis 3: The more competitive design competence a firm seeks for, the more a firm will achieve customization capability.

2.6.4. Advanced manufacturing technologies and collaborative supply chain practices

As the manufacturing process is heavily dependent on the product it produces, the supply chain of a firm is likely to be heavily dependent on the manufacturing process providing the product to the supply chain. In fact, the supply chain is likely dependent on both the product and the manufacturing process producing it, although the product is likely a more heavily weighted relationship. The links between product, process and supply chain are inevitable, and manufacturing has been described as highly influenced by both the product development process and supply network efficiency (Saad & Gindy, 2007). In today's highly dynamic market environment, manufacturing design has a challenging role to fill, that of designing responsive, agile, yet cost-effective production which can be moved by the supply chain to meet consumer needs.

Several broad frameworks for manufacturing models have been developed in previous research. One of these frameworks is the Responsive Manufacturing Model (RMM), which seeks to integrate a range of manufacturing areas of concern into one model. The model specifically incorporates impacts from the product development process, adaptability, supply network efficiency, and organization characteristics. The model heavily weights the influence of the product on the manufacturing design, but also notes the important influence of the supply chain (Saad & Gindy, 2007).

As the need for dynamic manufacturing processes grows ever greater, new manufacturing systems have developed which combine flexibility, reconfigurability, and rapidity. Mansfield defines flexible manufacturing systems as "…production unit(s) capable of producing a range of discrete products with a minimum of manual intervention" (Mansfield, 1993, pg. 149). This flexibility allows a firm to support the production of a wide range of products or a larger span of product variety, and may impact the supply chain design due to the increased span of product types that must be accommodated.

Reconfigurable manufacturing systems focus on more than just flexibility and manual intervention in manufacturing. Reconfigurable manufacturing systems emphasize production that is "rapidly designed", requiring quick conversion to new product production, with quick capacity adjustments, integrated with technology and able to "produce an increased variety of products in unpredictable quantities" (Mehrabi et al., 2000, pg. 403). In essence, the reconfigurable manufacturing system is one which is designed to meet a product's dynamic needs, especially in providing as-needed functionality and capacity, which can 1) minimize lead time and 2) support a firm's first mover advantage manufacturing strategy or firms in highly dynamic industries (Mehrabi et al., 2000). These rapid changes and reconfigurations can result in an ever changing product mix, requiring supply chain adaptations with regard to transportation types or routes, changing partners and/or customers, and changing volumes.

In addition, companies which implement flexible and time-based manufacturing expect their suppliers to support and align with these practices by implementing similar strategies (Zhang et al., 2003; Koufterous et al., 1998). It has been stated that top global firms are moving towards the alignment of processes and information flows throughout the value-added network (Spekman et al., 1998). Fine (1998) suggests that product design characteristics, manufacturing system design and supply chain design should be coordinated together to improve congruency and coherence. Forza et al. (2005) also supports this school of thought that manufacturing design and supply chain design should be aligned. Since it is usually the focal manufacturing company which implements its supply chain strategy, the design of the supply chain should be considered as compatible to the design of the process (Hayes & Wheelwright, 1979a, 1979b).

Since advanced manufacturing technologies enable firms to more product variety, at varying production levels, more responsively than ever before, the new types of supply chains which follow production must either adapt or be redesigned to meet these changing 'manufacturing customer' characteristics.

Researchers have recognized the relationship between advanced manufacturing technologies and organizational design. For instance, Lei et al. (1996) said, "The full exploitation of advanced manufacturing technologies, however, requires a flexible organization design that allows quick responses to take advantage of the capabilities of the technology" (p. 502). Flexible organization in his research refers to loosely coupled systems, modular structures, open systems and learning laboratories. Extending this flexible organization to supply chain context, the flexibility cannot come without increasing collaboration with suppliers and customers. To make the advanced manufacturing works seamlessly, a hub-manufacturers has to be able to collaborate with suppliers and customers and coordinate their activities in higher level. Therefore we present hypothesis 4.

Hypothesis 4: The more advanced manufacturing technologies a firm uses, the more collaborative supply chain practices it will implement.

2.6.5. Advanced manufacturing technologies and customization capability

Customization typically incurred high cost. With the advent of advanced manufacturing technology, firms could offer more customized products to customers with cheaper prices. It was because advanced manufacturing technologies overcame the trade-offs between customization and costs. As technology develops more and more with inexpensive computing power, customization would become less and less expensive, leading firms to higher level of customization capability. Therefore,

Hypothesis 5: The more advanced manufacturing technologies a firm achieves the higher level of customization capability a firm will acquire.

2.6.6. Collaborative supply chain practices and customization capability

Supply chain collaboration with strategic suppliers and customers increases responsiveness to market changes (Holweg et al., 2005). It is because supply chain collaboration brings more customization capability to the supply chain. A hub-manufacturer can more flexibly deal with market dynamics when supported by its suppliers and customers, thus giving it a leeway to deal with various changes. For instance, to accommodate a customer's needs, a firm often has to procure different sets of components and materials from suppliers. From customers' standpoint, a firm has to know what their needs are and what kind of demand it is facing. This information keeps a firm updated about the market situation and enables it to customize in the right way and in the right time. For instance, Business Week (May, 2008) reports that GM is happy with $3 billion loss in the first quarter of 2008 because it could have been even worse. One main reason stems from a major supplier's decision to go strike. The strike caused the several important plant to come to a halt, yielding that much loss. This example shows what a significant impact a key supplier could bring to a company. Therefore,

Hypothesis 6: The more a firm collaborates with its strategic suppliers and customers, the higher level of customization capability a firm will achieve.

2.6.7. Customization capability and firm performance

Customization has long been known for a key antecedent for firm performance (White, 1996; Pine, Victor, & Boynton, 1993; Vickery, Droge, & Germain, 1999; Klein, 2007). Firms that provides customers with well-customized products exceeds customers' expectation. Many researchers have found the positive association between customization capability and firm performance (Zhang et al., 2003; Tu et al. 2005). Therefore,

Hypothesis 7: Firms that exhibit high level of customization capability will achieve high level of performance in terms of sales and market share.

3. Research Methods

In order to examine the research model presented in figure 1, empirical evidence was drawn from the International Manufacturing Strategy Survey (IMSS), a worldwide research project involving 751 manufacturing units of twenty-four countries that covers Asia, Europe, North and South America and Autrailia. Data were collected during 2005 by national research groups within the global network using a standard questionnaire. Industries ranges in various 9 manufacturing industries. The questionnaire was sent to plant managers or manufacturing executives in a sample of manufacturing units with more than 100 employees. Initially, firms were contacted for their willingness to participation and the response rate varied across countries--with the minimum response rate of 25%. Works by Voss and Balckmon (1998), Frolich and Westbrook (2001) and Silveria (2006) and Cagliano et al. (2006) present the credential and detailed methods of IMSS research.

4. Analysis and results

The quantitative analysis centers on measurement validation and hypothesis testing. Measurement validation starts with the assessment of the reliability (*Cronbach's α*) and appraising various validity. After confirming these reliabilities and validities, the data analysis employed structural equation modeling (SEM) in order to test hypotheses. SEM is known for testing the relationships between latent variables and validating structural models (Chin, 1998). Table 2 provides detailed construct measures and factor loadings and reliability. *Cronbach's alpha* for collaborative customer practices, customization capability, and firm performances esceeds .7, showing the adequacy of reliability scores (Fornell nad Larcker, 1981). Although that for competitive design competence, advanced manufacturing technologies and collaborative supplier practices are less than 0.7, they display reasonably good fit for composite reliability. 6 factors emerged with principal component method. Absolute coefficient values were suppressed at less than .4 because it indicates no cross-loadings between items (Hair et al., 2006). Some factor loadings are under 0.6, but all of them are under acceptable range for exploratory study (Nunally, 1978).

Table 2 - Factor Analysis Results

		Loadings
Competitive design competence *Cronbach's alpha: .626*		
How important are the following improvement goals for your manufacturing function for the next 3 years? (1-not important; 5-very important)		
CPC1	Increasing product customization ability	0.596
CPC2	Increasing volume flexibility	0.741
CPC3	Increasing mix flexibility	0.81
CPC4	Increasing product innovativeness	0.489
Advanced manufacturing technologies *Cronbach's alpha: 0.678*		
To what extent is the operational activity in your plant performed using the following technologies: (1-no use; 5-high use)		
AMT1	Automated parts loading/unloading	0.688
AMT2	Automated guided vehicles (AGVs)	0.693
AMT3	Flexible manufacturing/assembly systems--cells (FMS/FAS/FMC)	0.633
AMT4	Computer-aided inspection/testing	0.592
AMT5	integrated design-processing systems (CAD-CAE-CAM-CAPP)	0.565
Collaborative supplier practices *Cronbach's alpha: .0.665*		
How do you coordinate planning decisions and flow of goods with your key/strategic suppliers? (Level of adoption: 1-none; 5-high)		
CSP1	Share inventory level knowledge	0.775
CSP2	Share production planning decisions and demand forecast knowledge	0.798
CSP3	Collaborative planning, Forecasting and Replenishment	0.567
Collaborative customer practices *Cronbach's alpha: .0.785*		
How do you coordinate planning decisions and flow of goods with your key/strategic customers? (Level of adoption: 1-none; 5-high)		
CCP1	Share inventory level knowledge	0.789
CCP2	Share production planning decisions and demand forecast knowledge	0.788
CCP3	Agreements on delivery frequency	0.731
CCP4	Collaborative planning, Forecasting and Replenishment	0.689
Customization capability *Cronbach's alpha: .0.744*		
CC1	How has your product customization ability changed over the last three years?	0.685
CC2	How has your volume flexibility changed over the last three years?	0.755
CC3	How has your mix flexibility changed over the last three years?	0.800
CC4	How has your time to market changed over the last three years?	0.675

Firm Performance Cronbach's alpha: .0.730		
FP1	What is the current business unit performance in terms of sales compared to three years ago?	0.749
FP2	What is the current business unit performance in terms of market share compared to three years ago?	0.701

The results for structural equation modeling are presented in this section. First, measurement model validates instrument for it spells out the association between the observed variables and latent variables (Igbaria et al., 1995). AMOS 5 was chosen to analyze the measurement models. Note that collaborative supply chain practices, a second-order construct consists of two first order constructs: collaborative supplier practices and collaborative customer practices. Table 3 presents the measurement model results. Model 1 uses sales as firm performance while model 2 market share. Model 1' stands for the model that correlated CSP3 (CPFR usage for strategic suppliers) with CCP4 (CPFR usage for strategic customers). If CPFR is used for strategic supplier side, it is likely to be used for strategic customers. For this reason the two items were correlated. The measurement results show that the hypothesized models are pretty credible.

Table 3. Summary of SEM Measurement Model Fit

Index	X^2/df	CFI	GFI	NFI	RMSEA
Model 1	3.252	0.886	0.929	0.844	0.054
Model 1'	2.940	0.902	0.936	0.860	0.051
Model 2	3.306	0.884	0.927	0.843	0.055
Model 2'	2.994	0.900	0.934	0.859	0.051

Table 4 reports the hypothesized structure model results. Competitive design competence positively impacts (1) usage of advanced manufacturing technologies (H1), (2) collaborative supply chains (H2) and (3) customization capability (H3). Advanced manufacturing technologies positively affect collaborative supply chain practices (H5) but do not affect customization capability directly, failing to support hypothesis 4. Collaborative Supply Chain practices positively influence acquiring customization capability, supporting hypothesis 6. The analysis also support hypothesis 7 that the higher customization brings the higher firm performance.

Table 4. Summary of Hypothesis Testing

Hypotheses	Path	Model 1	Model 1'	Model 2	Model 2'
H1	CDC → AMT	0.28 *	0.28 *	.28 *	.28 *
H2	CDC → CSC	0.18 *	0.18 *	.18 *	.18 *
H3	CDC → CC	0.34 *	0.34 *	.34 *	.34 *
H4	AMT → CSC	0.53 *	0.52 *	.53 *	.52 *
H5	AMT → CC	n/s	n/s	n/s	n/s
H6	CSC → CC	0.20 **	0.19**	.20 **	.19 **
H7	CC → Sales (M1) CC → Market Share (M2)	0.27 *	0.27*	.32 *	.32 *

* significant at .001 level (two-tailed); ** significant at .05 level (two-tailed); n/s:non-singnificant

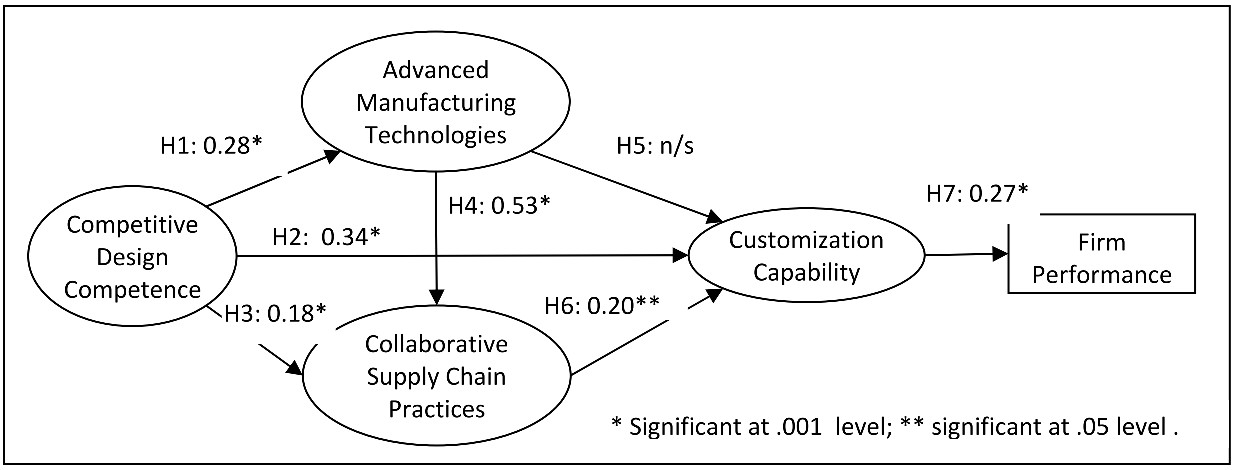

Figure 2. Hypothesized Structure Model

5. Discussion

Despite the implied and expected benefits of matching and integrating product, process and supply chain design (such as economies of scope, leveraging scarce resources, etc.), many firms lag behind in actual practical implementation (Ettlie, 1995). Ettlie's analysis of US firms described a broad range product and manufacturing design integration, however early mover firms emphasizing integration efforts reported higher sales per employee, leading to an expected and eventual improved firm performance. Later research results by the same author suggested that the success of new products was indeed related to integrating at least product and process design (Ettlie, 1997). The integration of product and process design was found to be related to first-mover firm strategies and benchmarking best practices, indicating that firms at the highest levels of their respective industries were beginning to apply integrated design practices across the firm (Ettlie, 1997).

It is possible that the practical implementation and application of integration efforts lag due to the broad span of areas which may be impacted by product design decisions or characteristics. In many cases, manufacturing processes and supply chain designs may be significantly disrupted by product changes such as increased variety, differing customization levels, the number of platform components, and changing market conditions or changing manufacturing goals. Firms choose to focus on or stabilize short-term goals by minimizing the longer-term consequences of product design changes. However – firms would likely experience significantly better results if able to balance the short-term 'pains' with the long-term 'gains'.

The managerial implications of applications from this conceptual model are several and could be significant. The primary implication to managers would be in the recognition and prioritization of product design as a precedent variable to supply chain and manufacturing design. This study shows that competitive design competence significantly affects three design aspects from manufacturing process (advanced manufacturing technologies), supply chain design (collaborative supply chain practices) and manufacturing outcomes (customization capability) and firm performance.

Product design has significant impacts and influence on supply chain efficiency and thus entire supply chain performance, going beyond product functionality, performance, and manufacturability. Product design also has significant impact and influence on the design of the manufacturing process. The manner in which manufacturing systems are designed has long-term consequences, usually associated with large sunken costs. These costs make the prioritization of product to process design extremely critical. Once finalized, the designs of the supply chain or manufacturing process are relatively concrete, and the associated structural and infrastructural decisions are difficult to modify. If managers would consider product design as a priority and integrate it across other areas, firms might be precluded from incurring additional supply chain and manufacturing costs.

If managers were also to consider the manufacturing process when designing the supply chain, it is likely that supply chain efficiency would be improved, as well as manufacturing outputs. When a firm's managers design its supply chain, in addition to product considerations, manufacturing process variables can have an impact. Although the managers' primary considerations for the supply chain should be the product, the manner in which the product is processed or the suppliers chosen to provide the component materials, can influence the supply chain. For example – if a product is produced via batch processing, resulting in large, but sporadic volume, the managers preferred choice for supply chain transportation methods may be influenced. Thus, it is recommended that managers actively consider both the impact of the product and process when organizing the supply chain.

In addition, the recognition of interdependences among product design, manufacturing process and supply chain design should lead managers towards integrating product development efforts with those of manufacturing and logistics efforts. Managers should intensify efforts to gather and align key stakeholders from respective departments and suppliers to develop the most efficient and relevant products, which can be best supported by the interrelated areas. Encouraging cross-departmental collaborations (from marketing to engineering to suppliers) would facilitate these efforts. It is suggested that greater alignment, facilitated by greater cross-departmental collaboration among product, process and supply chain designs, would be associated with greater firm performance.

Given the importance of product design on the dependent areas of process and supply chain, it is suggested that managers specifically assess the impact of product design changes when considering improvements to either supply chain or manufacturing system or both. With its precedent status, product design has long-term impacts on supply chain and manufacturing designs, efficiency and value. Since a flawed product design can result in significant process misalignment or supply chain inefficiency, managers should review and evaluate the current product design to determine if product re-designs could be incorporated which could ease parallel improvement efforts in the process or supply chain. Although it would be most efficient to develop these integrated design considerations at the onset of product development, even later improvements could prove beneficial and position firms to better exploit their manufacturing and supply chain processes.

Lastly, Hypothesis 5, "the more advanced manufacturing technologies a firm achieves the higher level of customization capability a firm will acquire" was not supported. This was a surprising result. This finding, however, gives us an important implication, that is, technology itself may not be sufficient to create customization capability. This research find that advanced manufacturing technology has rather a indirect impact on customization capability (Hypothesis 4 → Hypothesis 6). To take the full advantage of advanced manufacturing technology, management should implement the right management practices such as supply chain collaboration.

6. Conclusion and future research directions

Much previous research has been completed on the individual associations between product design and manufacturing design, and product design and supply chain design. Limited research has been performed which investigates the potential associations between manufacturing design and supply chain design, or the simultaneous interactions among product design, manufacturing design and supply chain design. These research gaps may result from the difficulty in conceptualizing the broad interactions involved.

This paper seeks to explore certain expected associations between product design, manufacturing design and supply chain design. Its contribution is that of finding the significant impact of competitive design competence on manufacturing design, supply chain design and organizational performance such as customization capability and firm performance. While confirming the importance of flexibility and customization in firm performance, this study highlights the vital aspect of competitive design competence.
This study provides a more comprehensive and international evidence of operations activities (product, process and supply chain), their interdependencies, and potential impacts on firm performance. Although domestic empirical research would prove valuable, international empirical testing would contribute much more to the operations research base. This study is one of such rare international study that covers 24 countries operational practices.

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Practitioner's Session

Chair: Dr. Hokey Min

Trends of advanced operation systems in container terminal
Hyun Sook Shin, Total Soft Bank Ltd., Korea
Kap Hwan Kim, Pusan National University, Korea

Panel Discussions Session

Future of Supply Chain Research

Chair: Dr. Seung-Chul Kim

Panelists: Prof. Youngwon Park, University of Tokyo, Japan
Prof. Shuo-Yan Chou, National Taiwan University of Science & Technology, Taiwan

Trends of Advanced Operation Systems in Container Terminals

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Abstract
Because container vessels spend a significant amount of transportation time in ports, it is essential to improve the productivity of various handling activities at port container terminals. Further, in order to modernize container terminals, automated container handling facilities have been recently developed and installed. This trend has introduced various new handling facilities and provided new requirements for terminal operation systems (TOSs). This presentation introduces basic functions of TOSs and new features required for the next generation TOSs. Also, it is introduced how scientific researches can contribute to improve the performance of TOSs. The second half of the presentation will introduce one of the most famous TOSs in the world. Detail functions of the TOS, new concepts applied to the TOS, and the future direction of the TOS will be discussed.

Keynote Speech

Chair: Dr. Gyewan Moon

Creating an International Research and Education Panel for Supply Chain Management

Dr. Mark Vonderemse, University of Toledo, USA
Dr. Paul Hong, University of Toledo, USA

Creating an International Research and Education Panel for Supply Chain Management

Mark Vonderemse and Paul Hong

University of Toledo, USA

The address describes the purpose and objectives for creating an International Research and Education Panel, outlines what has been done, and what remains to be accomplished. It describes the need for a strong working relationship with practitioners. In addition, it describes how funding was secured from the U.S. Department of Transportation to support these efforts, and how we can work together to secure funding from the governments of other countries.

Session 7

The Use of Information Technology in Supply Chain Management

Chair: Dr. Young Ku Kim

1. **The effects of interactivity of Internet shopping malls on trust and repurchase intention of fashion products**
   Eun Ju Kim, Youngdong University, Korea
   Myung Sun Chung, Chonnam National University, Korea
   Soon W. Hong, Youngdong University, Korea

2. **Antecedents of E-business technology use: the impact on supply chain integration and firm performance**
   Ki-Hyun Park, University of Toledo, USA
   Paul Hong, University of Toledo, USA

3. **Simulation study of RFID based air cargo process**
   J.Y. Kim, Korea Aerospace University, Korea
   S.H. Jung, Korea Aerospace University, Korea
   H.C. Choi, Korea Aerospace University, Korea
   M.K. Sohn, Korea Aerospace University, Korea
   J.H. Yang, Korea Aerospace University, Korea
   Y.S. Chang, Korea Aerospace University, Korea

The Effects of Interactivity of Internet Shopping Malls On Trust and Repurchase Intention of Fashion Products

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Abstract
Internet brings new problems to Internet Shopping mall marketers. It is the most important task that how Internet Shopping mall operators obtain their customers trust and repeat buying. The purpose of this study was to identify the effect of interactivity of internet shopping malls on trust and repurchase intention of buying fashion products. The results were as follows. First, the interactivity was categorized into two factors (interactivity of shopping mall with consumer and interactivity of consumer with another consumer). Second, interactivity of internet shopping malls influenced trust in the following ways: interactivity of consumer with another consumer had a greater influence on trust in the case of group buying, while interactivity of shopping mall with consumer had more influence on trust in the case of individual buying. Third, for fashion product purchases through internet shopping malls, interactivity of shopping malls had indirect effects mediated by trust more than direct effects on repurchase intention. The results of this study will be useful data for strategy establishment leading to e-store loyalty and a decline in the perceived risks of purchasing fashion products at Internet shopping malls.

Keywords: fashion product, interactivity, trust, repurchase intention

1. Introduction

Recently, internet shopping malls have been spreading out as standard model of Electronic Commerce, resulting in increasing competition.
People are therefore concerned in how to manage internet shopping malls, rather than how to set out. In this regard, many internet shopping malls begin to take advantage of interactivity which is essential for continuing relationship with customers by preventing from switching to another mall. Despite the importance of interactivity in the practical level, theoretical research on this issue is not much found. In Korea, little research is also found regarding the marketing effects of the interactivity, however, a few studies address classification of interactivity and scale adaptation in order to use in the local situation (Lee and Koo, 2001; Song and Sin, 1999).
The purpose of this study is to show how the interactivity affects repurchase intention on internet shopping malls where people buy fashion related goods. In addition, we

analyze two kinds of shopping patterns, namely, individual vs. group buying. We also use trust as a mediating variable which links interactivity and repurchase intention.

2. Theoretical Framework

2.1. Interactivity

The concept of interactivity has been stemmed from the field of human communication studies (Rafaeli, 1988). Later, this concept has been used for representing the communication between personnel and machine (Hoffman and Novak, 1996). Doney and Cannon (1997) pointed out that a lot of interactions between customers and sellers could form trust between them. Kim (2001) also found that the various features of interactivity, for example, interactivity range, interaction convenience, interaction reactivity, have impacts on shaping the trust.

On the other hand, through enhancing the interactivity, the internet shopping malls were able to make customers feel that they are served personally and lead to repurchase (Lee and Koo, 2001). Sin (2003) supported their perspective by discussing that the customer-customer interactivity also makes customers visit the mall more frequently and stay longer, which lead to repurchase. In sum, these findings indicate that the interactivity should influence to a customer′s purchasing behavior when shopping on the internet malls.

2.2. Trust on internet shopping malls

Trust is a major factor that on-line sellers must provide to the customers since they cannot see the real things they are going to buy and the seller as well. For instance, Ryu (1999) pointed out the trust customers have on internet shopping malls would be more important variable than others in repeated purchase in particular items such as clothing, jewelry, accessories. Similarly, according to Sharma and Patterson (1999), people who effectively communicate with a company likely to have trust which in turn lead to raising repurchase rate. Thus, trust seems to be a significant factor that enables people to have confidence about internet shopping malls by removing uncertainty that might come up in their transaction.

2.3. Repurchase Intention

Repurchase intention means the intention a customer purchases again from the same shop at which he or she has bought before (Oliver, 1980). Mohr and Sohi (1995) and Rafaeli (1988) emphasized the concept of interactivity in explaining the idea of repurchase intention.

2.4. Hypotheses

To test the relationship between interactivity, trust and repurchase intention, this study provides the following hypotheses.

1. Interactivity of internet shopping malls has a positive effect on trust.
2. Customer trust on internet shopping malls has a positive effect on repurchase intention.

3. Interactivity of internet shopping malls has a positive effect on repurchase intention.
4. Trust mediates the positive influence of interactivity on repurchase intention.

3. Research Methods

We obtained data consisting of 505 cases all that came from consumers who were at 20s to 30s at their age and have purchased more than five times at any internet shopping malls. The respondents live in Gwang ju, one of six largest cities in Korea. The data were analyzed using factor analysis, regression analysis, path analysis.

4. Results and Concluding remarks

Results from regression analysis and path analysis are summarized in Table 2, Table 3, Table 4 and figure 1 in appendix, which indicate that all hypotheses are supported.
This study demonstrates the interactivity that lies in shopping mall-customer and customer-customer in order to figure out the relations of shopping malls interactivity, and trust, repurchase intention. However, this study has some limitations such as confining our sample to a specific area, Gwang ju, thereby require replicating study across nations or different cultures for generalization of our findings. Future study should also include other variables such as customer characteristics that was not considered in this study.

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Appendix

Table 1. Factor Analysis of interactivity

factor	item	factor1	factor2
Factor 1 shopping mall-customer interactivity	· This shopping mall sends an apology e-mail for products that have not been sent on time.	.75	
	· The mail that this shopping mall sends shows what the company is concerned of and gives the reader the informations that has to be sent.	.80	
	· This shopping mall uses its bill board in order to hear customers dissatisfactions and questions.	.81	
	· This shopping mall reads the suggestions made from the customers and tries hard to apply them within the system.	.76	
Factor 2 customer-customer interactivity	· This shopping mall uses its bill board for feedbacks about the product.		.81
	· This shopping mall allows customers to interact with other customers about product information.		.81
	· This shopping mall allows customers to read other users feedbacks and comments about the product experience.		.84
	· This shopping mall answers questions made from you or other customers about the product.		.76
EigenValue		2.65	2.40
% of variance explained		33.12	30.05
Cumulative % of variance		33.12	63.17
Cronbach's Alpha(α)		.78	.82

Table 2. Regression results for hypothesis 1

independent variable		dependent variable	B	β	t	F	Adjusted R^2
Interactivity	shopping mall-customer interactivity	trust	.32	.43	11.01^{***}	77.63^{***}	.24
	customer-customer interactivity		.17	.25	6.27^{***}		
Interactivity(total)			.47	.46	11.64^{***}	135.59^{***}	.21

$^{***}p<.001$

Table 3. Regression results for hypothesis 2

independent variable	dependent variable	B	β	t	F	Adjusted R^2
Trust	Repurchase Intention	.65	.52	13.73^{***}	188.59^{***}	.27

$^{***}p<.001$

Table 4. Regression results for hypothesis 3

independent variable		dependent variable	B	β	t	F	Adjusted R^2
Interactivity	shopping mall-customer interactivity	Repurchase Intention	.30	.32	7.75^{***}	36.58^{***}	.13
	customer-customer interactivity		.14	.16	3.93^{***}		
Interactivity (total)			.42	.33	7.90^{***}	62.32^{***}	.11

$^{***}p<.001$

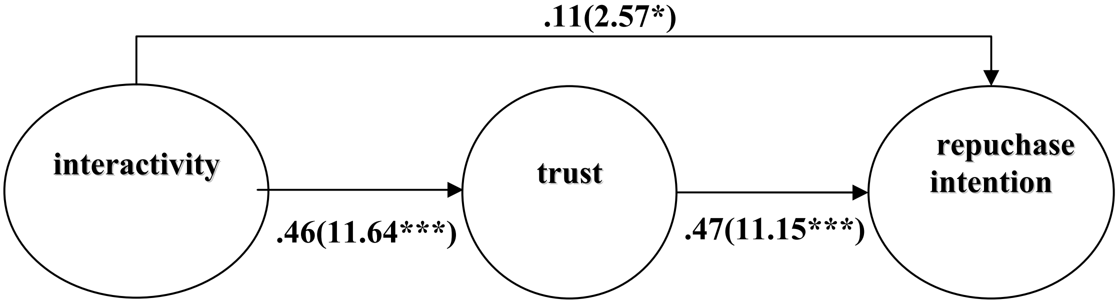

Figure 1. Path analysis results for hypothesis 4

Table 5. Regression results for shopping partterns

	independent variable		dependent variable	B	β	t	F	Adjusted R^2
group buying pattern	interactivity	shopping mall-customer interactivity	trust	.16	.23	4.03^{***}	34.62^{***}	.23
		customer-customer interactivity		.33	.42	7.30^{***}		
	Interactivity(total)			.47	.46	7.74^{***}	59.89^{***}	.21
Individual Buying pattern	Interactivity	shopping mall-customer interactivity		.31	.44	8.27^{***}	43.62^{***}	.24
		customer-customer interactivity		.17	.26	4.88^{***}		
	Interactivity(total)			.48	.47	8.80^{***}	77.40^{***}	.22

$^{***}p<.001$

Antecedents of E-business Technology Use: The Impact on Supply Chain Integration and Firm Performance

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Abstract
Increasingly, E-business technology has been regarded as important to enhance supply chain integration. Despite many relevant studies about this issue, a research on antecedents of E-business technology adoption for supply chain integration is rare. Based on literature reviews, this paper presents a model that indentifies the antecedents of E-business technology use along supply chain and investigates its impact on supply chain integration. Data is analyzed through exploratory factor analysis. Using International Manufacturing Strategy Survey (IMSS IV) data, we develop Structural Equation Model (SEM). Our empirical results suggest that market intensity and competitiveness, and information communication technology readiness are important antecedents. E-business technology has a positive and significant impact on the integration of information and physical flow upstream and downstream in supply chain. Also supply chain integration enhances operational manufacturing performance.

Keywords: E-business technology, Supply Chain Integration, Firm Performance

1. Introduction

The development of IT and internet enabled diverse electronic tools such as EDI and ERP to streamline business process. Increasingly, these tools have been adopted to coordinate business activities and facilitate collaboration between entities in the entire supply chain (Zhu and Kramer 2005, Devaraj et al. 2007). E-business technology has been regarded as a key determinant to integrate business process along supply chain. The existence of supply chain practice using E-business technology means that firms already adopted innovative technology to improve performance. The implementation of E-business technology characterizes its capability and competitiveness (Rosenwig et al. 2003, D'Avanzo et al. 2007). Through adopting E-business technology, firms are more likely to gain the benefits of supply chain integration such as are reduced costs, increased flexibility and faster response times (Lee and Whang 2001).
Through existing theories and literature reviews, we initiate two research gaps. One is the lack of study on antecedents of E-business technology use and its impact on the firm performance. Although until now there have been a large number of studies which deal with E-business strategy and its impact, the research on the antecedents of E-business technology use is very rare. Another is the lack of comprehensive and integrated supply

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chain integration framework. Many papers defined supply chain integration and developed scales for measuring it. However, most are not sufficient to specify integration. These two points reveal research gaps and suggest that supply chain integration framework requires more holistic view to assess the impact on supply chain. In this paper, we consider the supply chain integration regarding physical and information flows in both customer and supplier side along the whole supply chain.

2. Theoretical background

As a general theory of technology diffusion, the TOE (Technology Organization Environment) framework can be used for studying types of innovations and has an empirical support in IS area (Zhu et al. 2002). Tornatzky and Fleischer (1990) developed the TOE framework and identified firm's three contexts which influence adoption and implementation process of technological innovation. They are technological, organizational and environment contexts. Iacovou et al. (1995), based on TOE framework, formulate three major factors to influence EDI adoption. They are technological factor (perceived benefit), organizational factor (organization readiness), and environmental factor (external pressure). We adopted some constructs among them to indentify the antecedents of E-business technology.

According to RBV, firms can enhance performance based on its unique resources and capabilities (Barney 1991). The main point in RBV is that those who have valuable resources at their disposal have competitive advantages among industry and competitors (Devaraj et. al 2007). RBV provides the theoretical base for developing E-business technology constructs which are able to explain the value creation procedures through influencing supply chain integration and performance, because through E-business technology use, firms can improve business process including commerce, procurement and operation and gain competitive advantage against competitors.

3. Conceptual model

Using TOE and RBV, we developed a conceptual model to assess E-business technology use and its impact on supply chain integration and operational performance. Figure 1 explains our conceptual model. We identified the three antecedents of E-business technology use based on technological, organizational and environmental context (Zhu and Kramer 2005). We present consequences of E-business technology adoption which are supply chain integration and performance at the right side of our model. To capture the holistic integration effect precisely, we form the second order constructs for E-business technology and supply chain integration. Each scale was developed to measure the degree of technology adoption and coordination in both customer and suppler side. According to Rosenwig (2003), supply chain integration is expected to have a mediating effect between E-business technology and operational performance.

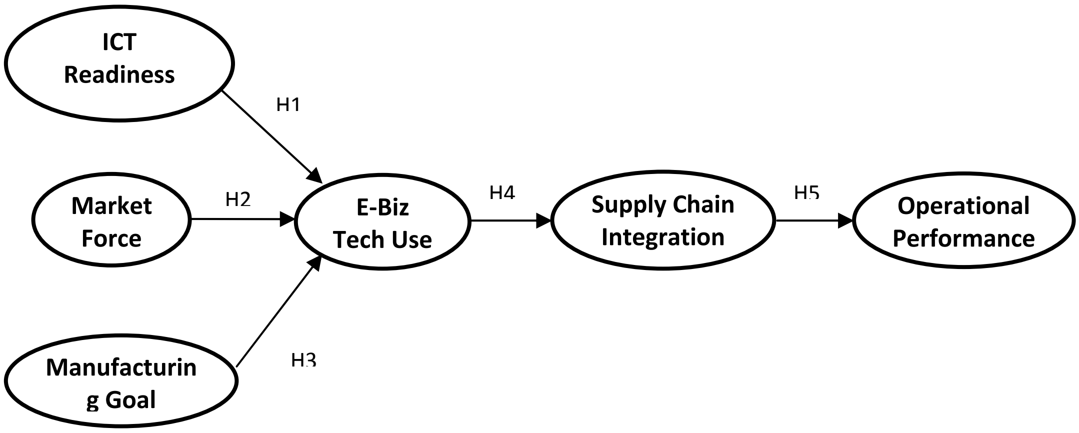

Figure 1. Conceptual Model

4. Hypotheses

4.1. Antecedents of E-business technology use

Based on TOE, we identified thee antecedents in technology, organization, environment context. First, technological competence is conceptualized as a firm's technical capability resulting from specific technology implementation (Zhu 2004). Yet this paper follows the category which was identified by Iavocou et al. (1995). They focused on the perceived benefit that technology offers. Perceived benefit is defined as anticipated advantages that IT can provide the organization. We adopt this construct and apply it to manufacturing context. We name it manufacturing goal. In the technological level, manufacturing goal can be achieved by the E-technology usage. Perceived benefit does not exactly mean goal, however we reason that achieving manufacturing goal through E-business technology can realize the perceived benefit and competitiveness which can be obtained from technology use. Namely, the more manufacturing goal is achieved, the more perceived benefit will be realized and it will increase E-business technology use. Table 1 explains the definition and references of each construct.
Hypothesis 1: Manufacturing goal has a positive influence on the degree of E-business use

Table 1. Variable definition and literature base

Construct	Definition	Reference
Market force	The extent to which external environment is competitive and intensive, forcing firms to plan for new business strategies	Lin (2006), Iacovou et al. (1995), Sillince et al.(1998)
Manufacturing goal	The extent to which improving manufacturing function concerning delivery and responsiveness is important	Frohlich and Dixon (2001), Ward and Duray (2000)

Information communication technology readiness	The extent to which firms are intended to use and implement information and communication technologies	Cragg and King(1993), Lacovou et al. (1995)
E-tool usage	The extent to which electronic tools (Internet or EDI based) are used with regard to supply chain management	Soliman and Youssef (2001), Cagliano et al (2003), Graham and Hardaker (2000)
Supply chain integration	The extent to which information and physical flows are integrated along the whole supply chain to enhance business process	Romano (2003), Lee et al. (1997), Cagliano et al. (2006)
Operational performance	The extent to which operating process along with quality, delivery, flexibility and customization is improved	Buzzell and Ortmeyer (1995), Chen and Paulraj (2004), Devaraj (2007)

Second, many papers identified antecedents of technology in organizational context. Dewan et al. (1998) found out that firms who have larger scope tend to have greater demand for IT investment. Chwelos et al. (2001) categorized organizational factors into financial resources, technological resources and partner readiness. Among those, we chose technological resources. The more technology resources are ready, the more firm can implement E-business technology into each business activities. We measure this construct with the degree of ICT and ERP software use during past 3 years and planned effort within next 3 years.
Hypothesis 2: ICT readiness has a positive influence on the degree of E-business use
Third, many existing studies identified competitive pressure as an important driver in technology adoption (Crook and Kumer 1998, Iacovou et al. 1995). We consider environmental context as market force. Market force refers to the extent to which external environment is competitive and intensive, forcing firms to plan for new business strategies. Firm can be influenced to adopt technology from external environment such as competitor, industry and government. As a market is becoming more competitive and intensive, a firm is likely to be forced to adopt and use innovative technology to remain in competitive advantage. Thus, based on above argument, we propose the following hypotheses.
Hypothesis 3: Market force has a positive influence on the degree of E-business use

4.2. E-business technology use and supply chain integration

E-business has been classified by the level of adoption and implementation in a firm's business activities concerning commerce, procurement, operation and collaboration (Brynjolfsson and Smith 2000, Lee and Whang 2002). Devaraj et al. (2007) categorized E-business technology into three: customer side, supply side and collaboration between them. We identify E-business technology use as the extent to which E-business technology are used to conduct and support business activities in supply chain. We developed the second order construct to capture the degree of E-business technology use in supplier side and customer side. E-business technology use in supplier side relates to find and qualify suppliers, purchase resources through on-line auction, collaboration support services with suppliers through internet-based EDI. Customer side refers to the use of E-business technology to handle sales and customer services in downstream relationship (Cagliano et al. 2006). It includes order management, status check through tracking system, access to catalog and collaboration support services.

Internet-based technologies are often cited as critical integration tools among many studies. When these technologies are integrated, they can support a firm's business and efficient use can take place in supply chain (Cagliano et al. 2006). In this paper, we developed the second order construct for supply chain integration which consists of information sharing and physical flow in customer and supplier side (Frohlich and Westbrook 2001). Information sharing includes exchanging information about inventory knowledge, collaborative planning, forecasting and replenishment. In physical flow, integration takes place through the adoption of practices such as Vendor Managed Inventory, Consignment Stock, cross-docking and collocation (Sauders 1997, Trent and Monczka 1998). So, we expect that the more e-business technology is used, the more these technologies are likely to integrate information as well as physical flows among customer and supplier in supply chain

Hypothesis 4: E-business technology use has a positive influence on supply chain integration

4.3. Operational performance

Many studies in OM area found out that firm performance cannot be realized by supply chain integration unless operational performance is mediating both. Armistead and Mapes (1993) show that higher level of integration increases operating performance in quality, cost and delivery. Frohlich and Westbrook (2001) investigated the direct relationship between integration intensity and sales growth. However, they could not find any evidence. Our paper defines operational performance as the extent to which operating process along with quality, delivery, flexibility and customization is improved (Buzzell and Ortmeyer 1995, Chen and Paulraj 2004). As supply chain is more integrated, we expect that operational performance will be more improved.

Hypothesis 5: Supply chain integration will improve operational performance

5. Methodology

5.1. Data

In order to investigate the relations between supply chain integration and performance outcomes, we test the conceptual model empirically using the fourth edition of International Manufacturing Strategy Survey (IMSS) which is research carried out global network aimed at exploring practice and performance in manufacturing and supply chain management (Linberg et al. 1998, Cagliano et al. 2006, p. 287). 709 manufacturing units from 23 countries are included and data were collected during 2005.

5.2. Measures

Table 2 provides scale items and the exploratory factor analysis (EFA). Factor loadings and Chronbach's alpha are presented. Next, we test the reliabilities by Cronbach's alpha of each factor. The reliability of the scale for 4 factors is below than 0.7 which is common threshold (Nunnally 1978). Yet, since IMSS comprises international data, they are acceptable. If items are loaded into a single factor with factor loading over 0.6, each construct can be considered unidimensional. In Table 2, the Cronbach's alpha of some constructs is not exactly over 0.7 which is common threshold, but still acceptable. It is because IMSS data gathered from many different countries. That kind variance is shown in the international data (Cagliano et al. 2006). In Table 3, there are no cross loading of any items and all items loaded on their own factors separately. This table can be used to demonstrate that construct measurements yield same results and all construct differ from each other assessing convergent and discriminant validity (Monge et al. 2006, Hair et al 2006)

6. Results

After measures are developed, we test Structural Equation Model (SEM) using AMOS5. In table 4, model fit indices are used to assess how well the proposed model fits the theoretical framework. They are all above the threshold value. Then through SEM methodology, the relationship between constructs was specified.

Table 4. SEM Model fit

Index	Norm Chi-square	CFI	GFI	NFI	RMSEA
Value	2.67	.92	.905	0.849	0.049

Figure 2 shows the path analysis coefficient and statistical significance. The results display that all proposed hypotheses are supported by data. Hypotheses 1, 2 and 3 which represent the antecedents of E-business technology use are supported. Specifically, ICT readiness, Market Force and Management Goal have positive and significant impacts on E-business technology use. It means that these three variables are able to explain firms' motivation to adopt and use E-business technology. The coefficients are 0.38, 0.26 and 0.17 respectively. All the antecedents are significant at the level of 1%. It shows that among antecedents, ICT readiness influences E-business technology use most. Manufacturing Goal is still significant, yet the explaining power for the reason to use E-business technology is a quite low. It is because items were selected in the context of firm's general manufacturing goal not for the purpose in E-business adoption.

Table 2. Properties of the measurement model

Constructs	Item	Explanation	Factor Loading	Reliability
Information Communication Technology	T1	Indicate degree of implementing Information and Communication Technology and/or ERP software last 3 years (1-not use, 5-high use)	.847	0.666
	T2	Indicate degree of planned effort of implementing Information and Communication Technology and/or ERP software within next 3 years	.786	
Market Force	M1	How do you describe the external environment (Competition intensity)? (1-low intensity, 5-high intensity)	.846	0.625
	M2	Market concentration	.840	
Manufacturing Goal	G1	How important are the improvement goal (increasing delivery speed) of your manufacturing function for the next 3 years? (1-not important, 5-very important)	.651	0.667
	G2	reducing manufacturing lead time	.831	
	G3	reducing procurement lead time	.784	
E-business technology use (Supplier)	ES1	Indicate to what extent do you use electronic tools (Internet of EDI based) with your key/strategic customers for Scouting/pre-qualify? (1-not adoption, 5- high level of adoption)	.769	0.85
	ES2	Auctions	.618	
	ES3	RFx (request for quotation, proposal, information)	.760	
	ES4	Access to catalog	.639	
	ES5	Collaboration support services	.619	
E-business technology use (Customer)	ED1	Indicate to what extent do you use electronic tools (Internet of EDI based) with your key/strategic customers for access to catalog? (1-not adoption, 5- high level of adoption)	.735	0.866
	ED2	Order management and tracking	.765	
	ED3	Collaboration support services	.737	
Supply chain Integration (Supplier)	IS1	How do you coordinate planning decisions and flow of goods with your key/strategic suppliers for sharing inventory level knowledge? (1-not adoption, 5-high level of adoption)	.490	0.616
	IS2	Require supplier(s) to manage or hold inventories of materials at your site (e.g. Vender Managed Inventory, Consignment Stock)	.783	
	IS3	Physical integration of the supplier into the plant	.764	
	IS4	Collaborative Planning, Forecasting and Replenishment	.675	
Supply chain Integration (Customer)	ID1	How do you coordinate planning decisions and flow of goods with your key/strategic customers for sharing inventory level knowledge? (1-not adoption, 5-high level of adoption)	.756	0.703
	ID2	Require supplier(s) to manage or hold inventories of materials at your site (e.g. Vender Managed Inventory, Consignment Stock)	.712	
	ID3	Physical integration of the supplier into the plant	.666	
Operational Performance	OP1	How has your operational performance (product quality and reliability) changed over the last three years? (1-deteriorated more than 10%, 5-improved more than 50%)	.725	0.711
	OP2	Volume flexibility	.611	
	OP3	Customer service and support	.748	
	OP4	Delivery dependability	.766	

Table 3. Summary of factor analysis

	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8
ES1	.769	.011	-.029	.055	.066	.116	.078	.070
ES2	.760	.028	.058	.140	.005	.092	.100	.060
ES3	.639	.079	-.036	.350	-.118	.089	-.159	.002
ES4	.619	.229	.128	.332	.065	.011	.079	.097
ES5	.618	.116	.064	-.036	.267	-.010	.177	.080
IS1	.024	.783	.061	.125	.147	.046	.039	.019
IS2	.014	.764	.058	.224	.021	.107	.121	.071
IS3	.213	.675	.180	-.034	.222	-.012	-.026	.002
IS4	.125	.490	-.042	.029	.291	.064	.210	.041
OP1	.026	.052	.766	.080	.053	.052	.076	.029
OP2	.089	.136	.748	.075	-.080	.012	.017	.044
OP3	.014	.025	.725	.035	.176	-.023	-.002	-.035
OP4	-.008	.022	.611	.036	.126	.220	.049	.003
ED1	.131	.069	.102	.765	.228	-.037	.168	.023
ED2	.236	.123	.130	.737	.207	-.036	.082	.097
ED3	.161	.129	.035	.735	.059	.132	-.025	-.022
ID1	.051	.062	.041	.202	.756	.047	.117	.033
ID2	.034	.230	.103	.124	.712	.049	-.010	-.012
ID3	.134	.352	.216	.118	.666	.018	-.057	.044
G1	-.022	.016	.019	.068	.082	.831	-.010	.036
G2	.083	.063	.063	-.002	.014	.784	.041	.078
G3	.183	.080	.142	.008	.001	.651	.083	-.077
T1	.093	.092	.021	.063	.058	.014	.847	.019
T2	.120	.117	.111	.092	.015	.098	.786	.012
M1	.100	.015	-.019	.023	-.015	.033	.149	.846
M2	.118	.085	.054	.048	.067	.007	-.115	.840

There is a support for hypothesis 4 that E-business technology use contributes the degree of integration of information and physical flow along supply chain. E-business technology positively influences the supply chain integration. Interestingly, the relationship between E-business technology and supply chain integration is highly significant. The coefficient is 0.72 which is very high and statistically significant at the level of 1%. It reveals that E-business technology is an important determinant to increase supply chain integration. Those who adopt and use E-business technology can be expected to gain a higher level of integration for physical and information flow.
Finally, hypothesis 5 is supported by data. Our analysis indicates that supply chain integration had an important impact on the operational performance. The coefficient for hypothesis 5 is 0.49 and it is highly significant at the level of 1%. This means that operational performance can be improved by 49% through the integrated business process. According to operational performance definition, this results seem to indicate that supply chain integration will increase flexibility, product quality and delivery dependability.

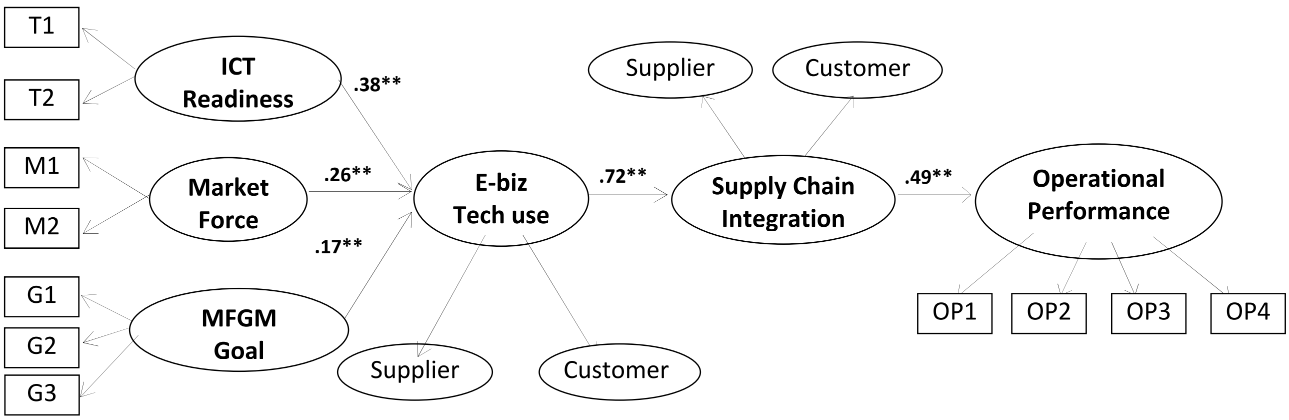

Figure2. Empirical Results

Note: ** indicates that all the coefficients are significant at p<0.01 level.

7. Conclusion

This paper provides a theoretical rationale for E-business technology use and its impact on supply chain integration. We indentify three antecedents of E-business technology use based on TOE framework. We consider determinants in technological, organizational and environmental context. So, manufacturing goal, ICT readiness and market force are identified. To capture the holistic effect, the second order constructs for E-business technology and supply chain integration are developed. Using IMSS data, we specify the structural equation model to assess the impact of E-business technology on supply chain integration and operational performance. After measurement models are assessed, we test structural equation model and examine path coefficient between each coefficient.
In this paper, there are some limitations. Manufacturing goal has much less power to explain why firms adopt and implement E-business technology. It is because items were measured in the general manufacturing context. Future research should be able to

capture the purpose to adopt E-business technology in supply chain context. Further, manufacturing capability can be included in the research framework of this study. Cagliano et al. (2006) studied on the linkage between supply chain integration and manufacturing improvement programs. They showed that two manufacturing programs which are ERP and lean manufacturing have a close relationship with supply chain integration. Future research could explore the internal coordination by manufacturing capabilities and its impact on external integration with customers and suppliers. Finally, comparative studies can be done based on different business unit, ownership and external environment.

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Simulation Study of RFID Based Air Cargo Process

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Abstract

Radio Frequency Identification (RFID) is considered as one of potential identification technologies in Logistics today. Many companies have established requirements to use RFID technology and according to many market research organizations, the size of RFID market will be growing rapidly because of huge expected benefit. However, from management point of view, rather than such a promising market analysis, clear Return on Investment (ROI) may be more important factor for new investment. In this paper, we introduce a new RFID based air cargo process and a simulation study which has been developed lately.

1. Introduction

Nowadays, though it charges high transport cost, air transport is preferred in many business users. One of advantages of air cargo transport is fast delivery which can reduce shippers' inventory level and costs, cover dispersed manufacturing locations, and shorten delivery time. Due to higher cost of air transportation than other methods, many studies and challenges have been investigated to maximize its process efficiency. As a part of it, various information technologies, especially RFID system, are tested and implemented to support and improve air cargo processes.

RFID is a technology which allows remote interrogation of objects using radio waves to read data from RFID tags which are at some distance from an RFID reader. Using this method avoids most problems of orientation, obscuration and reading many at a time that dog barcodes, magnetic stripes, written information and other traditional alternatives. In the near future, RFID technology is expected to take the place of bar-codes and there will be no exception in air cargo control. Following four characteristics of RFID system are accelerating this phenomenon.

Uniqueness: enable unique product identification, distinguish every single product by its ID

Timeless: reduce/eliminate time for every step of checking ID like scanning, typing etc.

Accuracy: eliminate error of ID checking, possible to establish correct information database, especially for inventory handling like location and volume of the inventory

Completeness: ensure availability of relevant product information

From these characteristics, following benefits can be expected for air cargo ULD process. They are benefits in mainly 3 areas of cost savings. Each is related to air-cargo process, asset management, and automatic data collection.

- Cost saving related to the operation of air-cargo process: elimination of manual data entry, searching for lost ULD, shipping error reduction, normal operations;

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- Cost saving related to asset management: physical ULD counting, ULD write-off reduction, reduction in ULD carrying cost;
- Benefit related to automated data collection: quantity of ULD transported increase due to intangibles through batter management decision and decreased processing down time.

Moreover, these 3 benefits could bring pervasive effects. Table 1 shows its potential advantages in detail.

Table 1. Potential benefits

Potential benefit area		**Benefits**
Reduce WIP	Reduced WIP	Benefit in terms of increase cash flow due to the decrease WIP
	Utilization of Asset	Utilized benefit of asset(ULD)
Asset Management	Capacity Utilization	Reduction of the number of required existing assets which can be resold Reduction in the number of annual new asset purchases
	Asset Tracking	Reduction in shrinkage of ULD asset inventory Reduction in replacement expenditures due to damage
	Yard Control	Reduction of labor costs in ULD yard location
Damage or Loss Insurance	Reduction Claim Cost	Reduction in claim costs due to decrease in misplaced & delayed packages Reduction in claim costs due to more accurate value determination using RFID
	Reduced Insurance Cost	Reduction in insurance premium costs by reducing total number of claims

2. Cargo Process and Performance Indicator

In ULD process point of view, there are few problems. Table 2 shows current problems in ULD process and expected advantages of using RFID for those problems.

Table 2. Current problems and expected advantages from RFID

Area	Problems	Expected advantages of using RFID
ULD process	◆ Need to check several times for loading according to loading plan ◆ Hard to detect mis-loading ◆ Input data by labor at every process	◆Information checking from RFID system automatically ◆Automatic input of correct information ◆Paperless work process
Movement Management	◆ Movement management according to an paper document 'work order' ◆ Input related data after movement ◆ Incorrect ULD number checking by labor ◆ Problems of security and safety ◆ Impossible to track and trace of ULD	◆Paperless work process ◆Real time track and trace ◆Real time management ◆Improve security problems ◆Decrease human error
Asset Management	◆ Impossible to real time inventory management ◆ Inventory check by labor, 2-3 times a month ◆ Record history of washing/repairing of ULD on paper document ◆ Impossible to manage the ULD turnover ratio	◆Real time inventory control ◆Real time ULD condition control ◆Computerized ULD history management

Air cargo operations (ULD process) and system consists of the following steps:

- Booking & receipt documentation: step for booking & check in by document (S/R-Shipping Request, HAWB-House Air Way Bill, MAWB-Master AWB, etc);
- Truck dock: Unloading transported cargo;
- Security Check Point: Dangerous cargo check. Except ULD unit entering cargo;
- B/U (Build-up): Loading cargo in ULD according to the MAWB;
- Storing (ETV): Storing ULD into ETV according to the flight schedule, in case of dangerous cargo which should be stored for 24hours;
- Weighting Scale: Before loading in airplane, weight a ULD for airplane's weight and balance;
- Apron : Before loading in airplane, ULD located in this place for a while;
- Loading/Unloading: Loading or Unloading ULD from airplane;
- Empty ULD control: Empty ULD keeping or supplying and demanding empty ULD;

- ULD Repair shop: Cleaning or repairing ULD.

Generally it takes 4~24 hours (emergency cargo: 1.5hours) from entering of ULDs into the terminal to loading them to flight. All the baggage in the truck dock should be loaded 4 hours before the departure time; in case of animal and perishable, cargo should be entered terminal before 2.5 hours; and dangerous cargo should be stored 24 hours in terminal.

In order to develop RFID based air cargo ULD system successfully, we reviewed actual processes in air cargo terminal in one of international airport, in Korea. Figure 1 shows a ‘activity diagram’ of ULD process in air cargo used for simulation study.

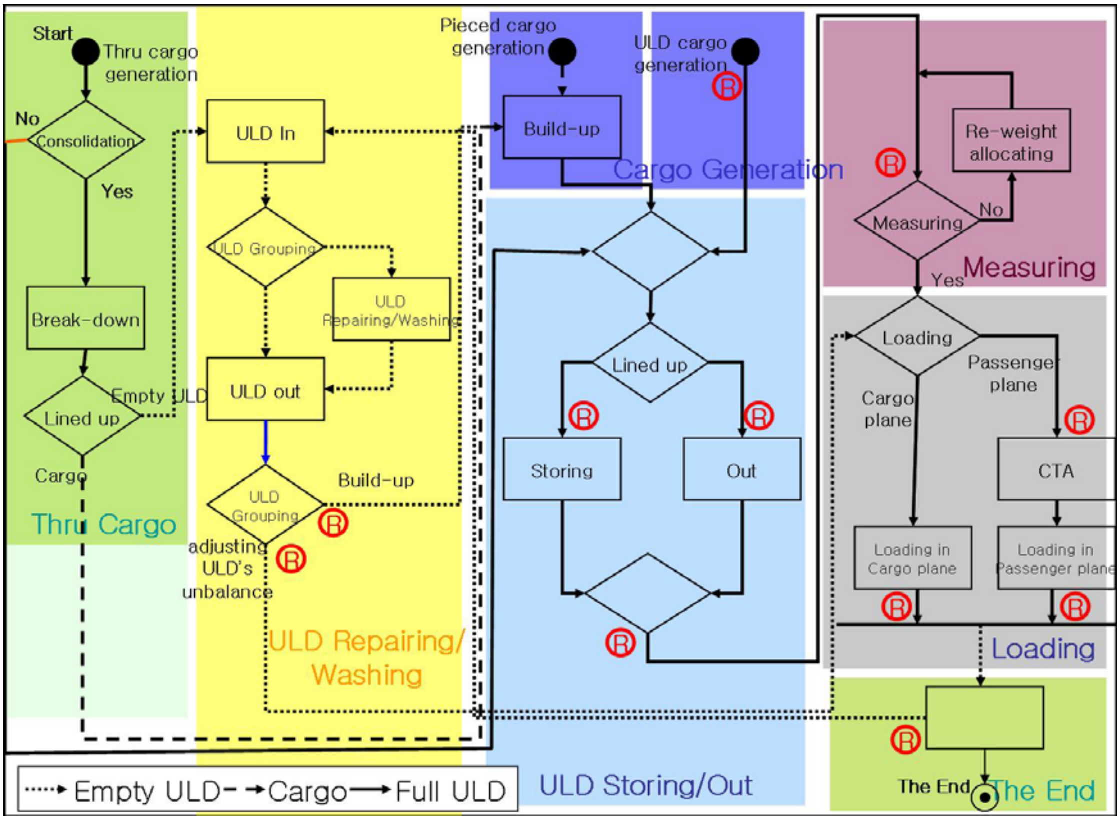

Figure 1. Activity diagram of ULD process

In many RFID researches, reading accuracy is not considered carefully and this may create misunderstanding of RFID technology. In our study, we consider difference in reading accuracy. Figure 2 shows difference in cycle time when considering different reading accuracy. In this simulation we considered kind of penalty when misreading (i.e. not read) is occurred (Misreading creates extra action for operators). As in the figure, it is considered that benefit could be achieved when reading accuracy is over 90%.

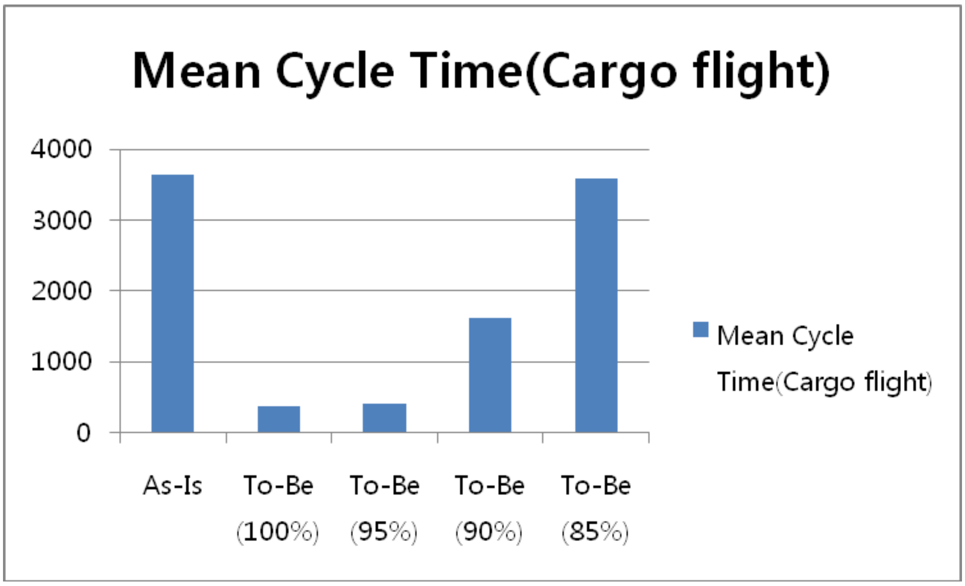

Figure 2. Mean cycle time considering different reading accuracy

3. Conclusion

In this research, we analyze the practical benefits for implementing RFID technology using simulation. We also provide scenarios for RFID based air cargo process including scenario of different reading accuracy of RFID system. RFID could bring the benefits with respect to the data entry time reduction, data accuracy increase, real time location management and asset management. It could also bring better process utilization, better ULD turnover ratio, better cycle time and better throughput compared to current bar-code system. Even though we did not analyze here, if these benefits are connected to cost then it could show more particular benefits and be realistic solutions.

Session 8

Global Sourcing

Chair: Mr. Melvin Williams

1. **Supplier selection strategy and supply chain integration for innovation: an international study**
   David D. Dobrzykowski, University of Toledo, USA
   Paul Hong, University of Toledo, USA

2. **Role of Korean SMEs in global supply chain management: case study illustrations**
   Soon W. Hong, Youngdong University, Korea
   Paul Hong, University of Toledo, USA
   Maga Yang, University of Toledo, USA

3. **A study on the practical use of standby letters of credit**
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4. **The Indian automotive supply chain network: implications for the global automobile industry**
   Melvin Williams, University of Toledo, USA
   Paul Hong, University of Toledo, USA

Supplier Selection Strategy and Supply Chain Integration for Innovation: an International Study

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Abstract

A rapidly changing international business environment is leading many firms to develop business strategies intended to improve performance through higher levels of innovation. In implementing these strategies, firms often invest in technology to integrate with suppliers. This is owing to the suggestion that supply chain integration enables firms to be more responsive in the marketplace through improved manufacturing outcomes. As such, scholars and practitioners have come to believe that better performance can be expected when business and manufacturing strategies and objectives are consistent or aligned. Yet, many firms struggle to realize innovative outcomes. This research suggests that supplier selection may represent a strategic activity in achieving innovation.

In doing so, this study examines data from the International Manufacturing Strategy Survey (IMSS), analyzing data from 711 firms located in 23 countries to reveal that a more strategic view of supplier selection can not only enhance, but mediate supply chain integration and as such indirectly influence a firm's innovation performance. Therefore, these findings illuminate the scholarly understanding of the relationship between strategy and innovation to suggest that the Resource Based View (RBV) may be used to explain a firm's ability to strategically select and integrate with its suppliers (as resources of the firm) to achieve higher levels of innovation.

Keywords: Innovation, Strategy, Supplier Selection, Supply Chain Integration, Resource Based View, Configurational Strategy

1. Introduction

The pace of change facing firms today is enormous and felt internationally. In fact, in studying the external environment, scholars have coined terms such as 'hypercompetition' to describe an environment characterized by new and continually changing product or geographic markets, frequent and unexpected changes in competition, substantial redefinition of market boundaries, rapidly evolving technologies, and shortened product life cycles (D'Aveni, 1994). In response to an increasingly challenging external environment, firms seek to establish competitive

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capabilities focused on product innovation as a means of differentiation from the competition (Koufteros, et. al., 2002 a,b; Koufteros, et. al., 2007).

In pursuit of innovation, firms develop business strategies intended to establish competitive capabilities in the areas of product development and flexibility. Miles, et. al., (1978) have developed the Prospector strategic type to describe such firms. Prospectors perform well in highly dynamic markets as they develop competencies to exploit new product and market opportunities (Miles, et. al., 1978). In their efforts to explore the relationship between strategy and performance, scholars often employ configurational theory suggesting that firms achieve their highest effectiveness, innovation in the case of Prospectors, when alignment exists (among a firm's resources and strategies) (Doty, et al., 1993). Consistent with this notion, research suggests that firm performance is highest when structures and processes are internally complementary (Bozarth and McDermott, 1998), as can be achieved when a firm effectively develops and implements a manufacturing strategy. Owing to this notion, "manufacturing strategy is one of the most important contributions to a business strategy," (Taps and Steger-Jensen, 2007; pg. 476).

However, many desirable resources increasingly reside outside of the firm, as innovation requires the concurrent use of a variety of skills and knowledge from supply chain partners (Koufteros, et., al., 2007). Therefore, the pursuit of innovation is causing firms to integrate their supply chains to leverage information sharing and ultimately market orientation (Malhotra, et. al., 2005). This supply chain integration can be realized through first achieving internal integration of the manufacturing function (Tan and Tracey, 2007), a potential consequence of the alignment of a firm's business and manufacturing strategies.

Unfortunately however, many firms fail to achieve innovation even in the face of the extant recognition of the importance of resource and strategy alignment. Griffin (1997) finds that 6.6 ideas are required to generate one success, while only 59% of those products which make it to market are successful. Such disappointing performance contributes to the scholarly interest in exploring alternative antecedents of supply chain integration for innovation (see also Gerwin and Barrowman, 2002). Supplier selection is one such antecedent, representing strategic value to the firm, as Koufteros, et. al., (Pg. 851; 2007) suggests that "choosing the "correct" or most appropriate partner is paramount," to a firm's innovation performance.

Considering this, the present exploratory research study makes an important contribution to the extant body of literature concerning supply chain integration in that it explores supplier selection as a strategic antecedent to supply chain integration for innovation, illuminating the relationships between business and manufacturing strategy alignment, and supply chain integration for innovation. Configurational and Resource Based View (RBV) theories are explored in a juxtaposed state to reveal the strategic importance of supplier selection on supply chain integration for innovation.

Given the preliminary stage of this research, section two of this article briefly discusses theory development and the hypotheses under study. This is followed by section three, a discussion of research methodology and section four, data analysis. Section five provides a discussion of potential implications of the findings and conclusions. Finally, section six concludes the article with a discussion of research limitations and future research opportunities.

2. Theory development

Figure 1 illustrates the proposed research framework, depicting hypothesized relationships between business and manufacturing strategy, supplier selection, supply chain integration for innovation, and ultimately manufacturing outcomes for innovation. This section provides construct definitions in Table 1, as well as the theoretical foundation for the hypothesized relationships under study.

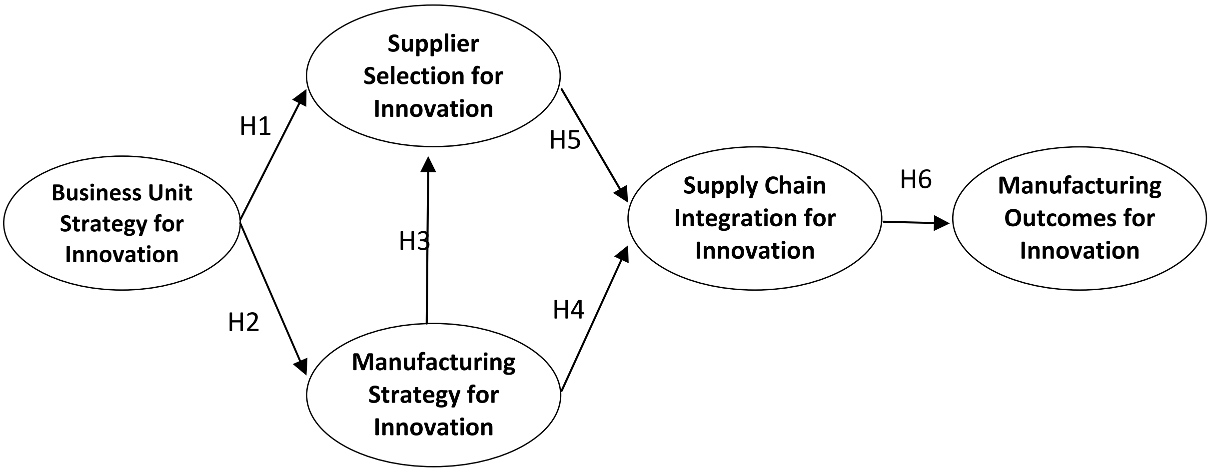

Figure 1: Research framework

Table 1. Construct definitions

Construct	Definition	References
Business unit strategy (Prospector) for innovation	degree to which a firm seeks to meet the rapidly changing needs of customers by developing competitive capabilities such as new product development and flexibility.	Miles, et. al. (1978)
Manufacturing strategy (agility) for innovation	degree to which a firm seeks to establish production capabilities characterized by inventory (mix) flexibility and speed (lead time or time to market).	Taps and Steger-Jensen (2007)
Supplier selection for innovation	degree to which a firm selects it suppliers based on their product development capabilities.	Koufteros, et. al. (2007)
Supply chain integration (agility) for innovation	degree to which a firm uses electronic tools/information systems (i.e., EDI) to integrate with suppliers in the design of new products.	Vonderembse, et. al. (2006)

Manufacturing outcomes for innovation	degree to which operational performance demonstrates high levels of improved performance in (1) time to market, and mix flexibility.	Koufteros et al. (1998)

2.1 Configurational theories

Scholars have developed and employed configurational theories as a means of explaining the alignment or consistency that can exist among the patterns of contextual, structural, and strategic factors influencing a firm (Doty, et. al., 1993). These theories have suggested that such consistency or alignment (of resources and strategies) leads to enhanced firm performance in that it can both create and maintain competitive advantage (Porter, 1996). In this way, a firm's business strategy is posited to influence its manufacturing strategy, the result of strategy alignment. Likewise, the linkage between a firm's strategy and its approach to integration with supply chain partners can be explained in this way. As such, grounded in configurational theory, this exploratory study posits and tests the following hypotheses.

H1: Higher levels of business strategy (Prospectors) for innovation are positively associated with higher levels of supplier selection for innovation.

H2: Higher levels of business strategy (Prospectors) for innovation are positively associated with higher levels of manufacturing strategy (agility) for innovation.

H3: Higher levels of firm manufacturing strategy (agility) for innovation are positively associated with higher levels of supplier selection for innovation.

H4: Higher levels of manufacturing strategy (agility) for innovation are positively associated with higher levels of supply chain integration (agility) for innovation.

2.2 The Resource Based View (RBV)

Gagnon (1999) suggests that RBV is advantageous to the firm and can be used to explain its ability to acquire, develop, and exploit resources at opportunistic times to achieve goals (Dangayach and Deshmukh, 2001). These resources are considered tangible such as human, informational, technological, and financial in nature as well as intangible such as decision making processes and organizational structures (Dangayach and Deshmukh, 2001). Given this, RBV is a very appropriate perspective for supply chain study (Miles and Snow, 2007). RBV is of particular interest in the present study owing to the facts that; (1) supply chain partners represent tangible resources, and (2) their selection (firm decision making) can be considered as an intangible resource.

Considering RBV, as well as the notions that firms can develop abilities to; (1) recognize strategic interdependencies between one another (e.g., Hage and Aiken, 1967; Levine and While, 1961; Whetton, 1977), and/or (2) identify complimentarity of potential partner resources (Arora and Gambardella, 1990; Richardson, 1972; Koufteros, et. al., 2007), this study posits a positive relationship between firm behavior related to supplier selection and subsequent supply chain integration.

> H5: Higher levels of supplier selection for innovation are positively associated with higher levels of supply chain integration (agility) for innovation.

2.3 Manufacturing outcomes for innovation

The desire for innovation has led to a shift in the basis of completion to that of time. As a result, time-based competition is now a recognized source of competitive advantage (Johnson and Busbin 2000). Further, Gerwin and Barrowman (2002) suggests that time-based manufacturing outcomes (characteristics) can represent a innovative product of supply chain integration (in product development). Therefore, the present study employs proxy measures for key elements of time-based competition, mix flexibility and time to market, to posit a relationship between supply chain integration and manufacturing outcomes for innovation.

> H6: Higher levels of agile supply integration (for innovation) are positively associated with manufacturing outcomes for innovation.

3. Research Methods

Data were collected from 711 plant managers or manufacturing executives from twenty-three countries throughout the Asian Pacific, European, North American and South American regions. The respondents were all participants in the 2005 International Manufacturing Strategy Survey (IMSS). The response rate varied by county, however, all exceeded 25%, which is commonly considered as adequate for research of this type. Industries varied, but included; (1) fabricated metal products, (2) machinery and equipment, (3) office, accounting, and computing equipment, (4) electrical machinery, (5) radio, television, and communication equipment, (6) medical, precision, and optical instruments, (7) motor vehicles, trailers, and semi-trailers, (8) other transportation equipment, and (9) other miscellaneous manufactured products.

4. Data analysis

While the present research is exploratory in nature, a literature review provided a theoretical basis for the proxy measures (or items) of the variables under study. See Table 1. Further, the purpose of the study served to direct the selection of appropriate items (see Cagliano, et. al., 2006). Exploratory Factor Analysis (EFA) was used to identify factors among the variables (Hair, et. al., 2006).

4.1 Measures

The items provided in Table 2 were analyzed using SPSS 15.0. Principle Components Analysis and Oblimin rotation method techniques were employed to identify factors (Hair, et. al., 2006). The analysis filtered factors with Eigenvalues > 1.0, while the absolute coefficient values were suppressed at < 0.4. These values are considered small by Hair, et. al., (2006) and evidence of the absence of cross-loading. The Structure Matrix was used to assess factor loadings for convergent and discriminant validity, as Hair, et. al., (2006) suggest that this is a more difficult test than that of the Pattern Matrix.

Table 2. Factor Analysis Results

	Loadings
Business unit strategy (Prospector) for innovation Cronbach's alpha: .76	
BS1- Consider the current importance of offering new products more frequently to win orders from your major customers.	0.875
BS2 - Consider the current importance of offering more innovative products to win orders from your major customers.	0.826
BS3 - Consider the current importance of offering a wider product range to win orders from your major customers.	0.759
Manufacturing strategy (agility) for innovation Cronbach's alpha: .69	
How important are the following improvement goals for your manufacturing function for the next 3 years?	
MS1 – Increasing mix flexibility	-0.880
MS2 – Reducing time to market	-0.859
Supplier selection for innovation Cronbach's alpha: .65	
What criteria do you use for selecting your key/strategic suppliers?	
SS1 - Evaluation of supplier potential (development programs or past performance record)	-0.784
SS2 - Willingness to disclose cost/other information	-0.776
SS3 – Ability to provide innovation and co-design	-0.739
Supply chain integration (agility) for innovation Cronbach's alpha: .76	
SCI1 - Indicate to what extent do you use electronic tools (Internet or EDI based) with your key/strategic suppliers for RFx (request for quotation, proposal, information)?	0.801
SC2 - Indicate to what extent do you use electronic tools (Internet or EDI based) with your key/strategic suppliers for scouting/pre-qualifying?	0.778
SC3 - Indicate to what extent do you use electronic tools (Internet or EDI based) with your key/strategic suppliers for content and knowledge management?	0.738
SC4 - Indicate to what extent do you use electronic tools (Internet or EDI based) with your key/strategic suppliers for access to catalogues?	0.737
Manufacturing outcomes for innovation Cronbach's alpha: .70	
How has your operational performance changed over the last three years?	
C1 - Mix flexibility	0.878
C2 - Time to market	0.874

* Five-point Likert scale measures were used with anchors of 1 representing low (unfavorable) support, and 5 representing high support (favorable) responses.

Five factors resulted, all displaying loadings > 0.7, suggesting convergent validity and well defined structure (Hair, et. al., 2006). See Table 2. Factor loadings also demonstrated adequate discriminant validity among the factors as no cross loadings exceeding 0.4 are present. Three of the factors demonstrate a reliability value > 0.7 when assessing Cronbach's alpha. Two of the factors, Manufacturing Strategy and Supplier Selection for Innovation scored 0.69 and 0.65 respectively. While these values are below the generally accepted thresholds for confirmatory research, their shortfall is not substantial and is well within the standards of exploratory research of this type (Nunnally, 1978; also see Cagliano, et. al., 2006; Koufteros, et. al., 2007). Three of the constructs are measured using three or more items, while the Manufacturing Strategy and Manufacturing outcomes for innovation constructs employ two items each. While the authors recognize the disadvantages associated with two item measures, the factor loadings are high for each of the variables in question and two items constructs have been employed to investigate supplier selection by previous authors (see Koufteros, et. al., 2007).

4.2 Measurement model

The measurement model was tested and validated using Analysis of Moment Structures (AMOS 5), employing one absolute fit index, one incremental fit index, and the chi-squared result (Hair, et. al., 2006). Goodness-of-Fit (GFI), Adjusted Goodness-of-Fit (AGFI), and Root Mean Square Error of Approximation (RMSEA) were employed to assess absolute fit, while the Comparative Fit Index (CFI) assessed incremental fit. All of the model fit indices are displayed in Figure 2, and fall well within acceptable ranges for scientific investigation.

4.3 Structural model

The structural model analysis was performed using structural equation modeling (SEM) to test the relationships posited in the study. The results are displayed in Figure 2. All hypothesized relationships are empirically supported as statistically significant at $p < 0.001$, with the exception of two. Hypothesis four which posits a relationship between Manufacturing Strategy for Innovation and Supply Chain Integration for Innovation is not significant and thus, not supported. Therefore, these findings suggest that a relationship does not exist between Manufacturing Strategy for Innovation and Supply Chain Integration for Innovation. Hypothesis six posits a positive relationship between Supply Chain Integration for Innovation and Manufacturing Outcomes for Innovation which is statistically significant at $p < 0.05$ resulting in a beta coefficient value of 0.11. These results suggest that a positive relationship does exist between Supply Chain Integration for Innovation and Manufacturing Outcomes for Innovation.

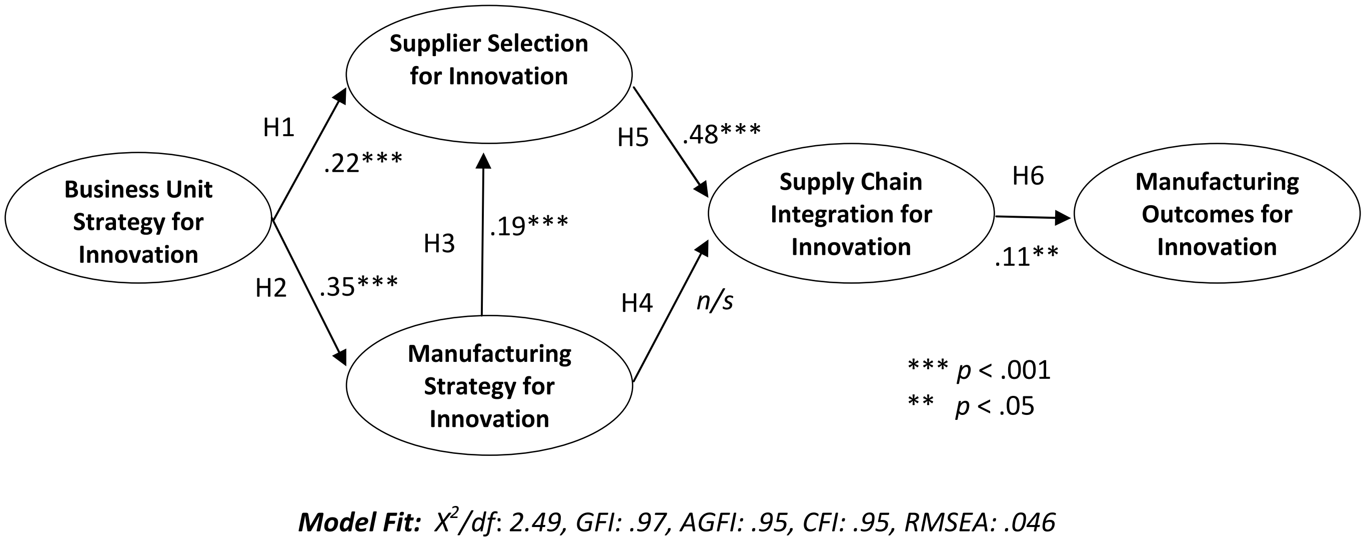

Figure 2: Structural Model Results

5. Implications and conclusion

The findings illuminate the scholarly and practical understanding of supply chain integration for innovation in a number of ways. First for scholars and practitioners, the support for hypotheses one and three suggests that supplier selection is of strategic importance to the firm, not only at a manufacturing level but it is also integral to the implementation of business unit strategy. This contributes to the notion that supplier selection is well deserved of elevation to the strategic level of decision making with in the firm. Second for scholars, the validation of hypothesis two provides strong support for configurational theories as a means of explanation for the alignment of a firm's business unit and manufacturing strategies and further supports the notion that manufacturing strategy is directly influenced by business unit strategy.

The usefulness of configurational theories breaks down however, when explaining supply chain integration for innovation. The results provide overwhelming support for hypothesis 5, (beta coefficient of 0.48 significant at $p < 0.001$) suggesting a positive relationship between supplier selection for innovation and supply chain integration for innovation, while the proposed relationship between manufacturing strategy for innovation and supply chain integration for innovation (hypothesis four) was not supported. This suggests that supply chain integration may not simply result from aligning strategies and resources as posited by configurational theories, but rather is much more likely to occur when suppliers are selected carefully. This is consistent with RBV which suggests that performance is enhanced by the purposeful selection and management of firm resources. This notion is further supported by the findings related to hypothesis six, as the management of resources per se can be considered in the present study as supply chain integration for innovation which is demonstrated in these results to positively influence manufacturing outcomes for innovation. This is of interest to scholars and practitioners alike as the findings illuminate theoretical beliefs regarding supply chain integration, while emphasizing the important role supplier selection plays in innovation for practitioners.

6. Limitations and future research opportunities

While the large-scale, multi-industry, international sample examined in this study reduces concerns regarding generalizability, the study is not without limitations. First, although the findings expand the scholarly understanding of the relationships between strategy, supplier selection, and supply chain integration, opportunity abounds to further explore and explain the notions put forth herein. Second, an international comparison is clearly warranted given the vast extant cultural differences related to relationship management that have been posited to exist between many of the countries included in this study. Finally, a confirmatory study would be useful in further validating the novel and important findings of this exploratory research.

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Biographical notes

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Role of Korean SMEs in Global Supply Chain Management: Case Study Illustrations

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Abstract
Traditionally, Small and medium enterprises (SMEs) work as suppliers of dominant Original Equipment Manufacturers (OEM) or large conglomerates. Their market positions are fairly limited in domestic markets only. As Korean firms expand their operations in global arenas, Korean SME's role is also becoming increasingly important in two ways: (1) providing reliable and solid supply base for OEM's global operations; (2) handling pioneering work in the overseas plants.
As many Korean global firms (e.g., Samsung, Hyundai, POSCO, and LG) enlarge their operations in the global markets, these SMEs also enlarge their operations as global suppliers. Some SMEs go together with these global firms and facilitate the building of necessary supplier networks in various countries. They also pioneer global markets quite independent from other global Korean firms. This paper examines the role of Korean SMEs in global supply chain. This paper is organized as follows: (1) context of Korean SMEs; (2) a research model that describes the organizational processes and outcomes of SMEs; (3) case illustrations of different patterns of Korean SMEs in this global supply chain environment. Future research issues and managerial implications are also discussed.

Keywords: Innovative SMEs, Korean economy, Globalization

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A Study on the practical use of Standby Letters of Credit

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Abstract
Standby is a term used for LCs that function like insurance. These types of LCs are "passive". That is, they are not to be drawn upon by the beneficiary unless a delinquency/default of some form takes place in a business transaction. It is purely a financial instrument used to guarantee a performance obligation of the bank's customer.
Since the end of World War II, standby letters of credit have been widely used in the international transactions as surety devices, serving as performance bonds and guarantees, etc. in the world. The purpose of this study is to make practical use of the standby letter of credit.
First, what are the differences in the international transactions rules of standby letters of credit among Uniform Rules for Demand Guarantees(URDG), Uniform Customs and Practice for Documentary Credits(UCP), International Standby Practice(ISP98), and United Nations Convention on Independent Guarantees and Standby Letters of Credit(Convention).
Second, what are the benefits of standby letters of credit in the business transactions.
Third, how to improve the practical use of standby letters of credit in the various business transactions in Korea.
Standby letters of credit have been used in the limited fields in Korea, but advanced countries like America have been used it in the diverse fields.
We are faced with international competition with global companies in the world, so it is needed to make practical use of various payment methods or guarantee instruments, etc. in the diverse business transactions.
It would be considered recommendable that standby letters of credit should be used in global commercial transactions, because standby letters of credit are equivalent to guarantees in function and standby letters of credit have also stable governing rules like URDG, UCP 600, ISP 98, and United Nations Convention on Independent Guarantees and Standby Letters of Credit.

Keywords: Standby Letter of Credit, Transaction, URDG, UCP, ISP98, Convention,

1. Introduction

Letters of credit have other uses besides supporting commercial transactions. One example is the standby letters of credit, which differs from a commercial letter of credit because it is not used in trade transactions. It is purely a financial instrument used to guarantee a performance obligation of the bank's customer[1].
Standby L/Cs are primarily used to provide security to the beneficiary if the applicant or the designated person fails to perform his contractual obligations. Unlike with a commercial L/C, when the beneficiary draws on a standby L/C, it usually involves a default situation.[2]

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[1] Kathlyn L. Farrell•David Buzzell, Law and banking, American bankers association, 2005, pp.363
[2] King T. F., Leading court cases on letters of credit, ICC The world business organization, 2004, pp.139

As the title suggests, these credits are often issued to back up open account trade as a safeguard in case the buyer fails to settle the amounts according to the schedule of payments. Experiences exporters usually agree to receive payments on an open account basis against standby credits. Standby credits are usually irrevocable credits, and these are to be opened by the importer. The bank which agrees to issue such a credit provides an undertaking that in the event of any non-payment, a claim may be made under it(the credit). If a default takes place, the exporter concerned is required to submit an invoice along with a declaration that payment has not been received according to the schedule. Thus, a failure to pay by an importer would require the bank agreeing to honour this credit to pay it. This will have an adverse effect on the commercial relationship between the importer and the bank; thus the latter has the right to accept or reject an application made by an importer for such credits.[3]

Standby letters of credit insure a customer's performance of a contract. A common example exists in construction work. The company posts a guarantee in the form of a standby letter of credit that assures compensation to the party commissioning the work if the company fails to perform. These arrangements are similar to performance bonds which have historically been provided by bonding companies or insurance companies. Such performance contracts have been used for a wide range of purposes, including the guarantee of commercial paper.[4]

In contrast to a documentary letter of credit, the standby letter of credit does not necessarily have anything to do with foreign or domestic trade. It is instead a type of guarantee whereby an issuing bank undertakes on behalf of its customer (account party) to pay specified sums on the default or non-performance of its customer. Unlike the documentary letter of credit, there is neither presentation of proper trade documentation involved nor an exchange of goods; rather, the beneficiary must merely evidence the default or non-performance by the account party. A standby letter credit is not self-liquidating and is ordinarily riskier than a documentary letter of credit, particularly if uncollateralized.[5]

The standby letter of credit and the documentary credit differ in the types of documents that need to be presented for payment. For payment under a standby letter of credit the beneficiary needs to provide a payment demand stating that the applicant has met his obligations under the secured transaction and possibly some supporting documents to substantiate the claim.[6]

There are three significant differences between commercial and standby credits. First, commercial credits involve the payment of money under a contract of sale. Such credits become payable upon the presentation by the seller-beneficiary of documents that show he has taken affirmative steps to comply with the sales agreement. In the standby case, the credit is payable upon certification of a party's nonperformance of the agreement. The documents that accompany the beneficiary of a commercial credit must demonstrate by documents that he has performed his contract. The beneficiary of the standby must certify that his obligor has not performed the contract.

Second, commercial and standby credits differ in that the commercial credit issuer expects to pay the seller's drafts. Payment is consistent with normal performance of the underlying sales agreement in a commercial credit situation. The issuer of the standby credit, however,

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[3] C. Chatterjee, Legal aspects of trade finance, Routledge, 2006, pp.41-42

[4] Duane B. Graddy•Austin H. Spencer•William H. Brunsen, Commercial banking and the finance services industry, Reston publishing company. Inc., 1985. pp.249

[5] Jonathan Golin, The bank credit analysis handbook, John wily & sons (Asia) Pte Ltd, 2001, pp.723

[6] Rolf A. Schütze•Gabriele Fontane, Documentary credit law throughout the world, ICC The world business organization, 2001, pp.17

usually does not expect to pay; the presentation of drafts or demands under a standby credit is an indication that something has gone awry. Because the standby credit operates when the parties to the underlying contract are not in harmony, the standby credit issuer can be virtually certain that its customer does not want to see the beneficiary paid, whereas the customer of a commercial credit nearly always wants the seller to be paid.

Third, the standby and commercial credit settings differ in that the commercial sale tends to follow a pattern, with the same documents accompanying the draft in case after case. The standby credit transaction, however, can arise out of any number of industries, and frequently the documents are unique. That is not to suggest that letter of credit law charges issuers with knowledge of industry practices and customs. It does not, and it specifically insulates the issuer from liability for not knowing such practices and customs. Any party issuing a standby credit, however, must evaluate its risks and must understand the nature of the customer's undertaking. A bank that issues a standby credit is making a loan to its customer, for all practical purposes, and it may not be able to determine whether that loan is bankable without understanding the performance called for by the customer's contract with the beneficiary.[7]

A standby letter of credit can be used to guarantee invoice payments to a supplier. It promises to pay the beneficiary if the buyer fails to pay as agreed. Internationally, standby L/Cs often are used with government-related contracts and serve as bid bonds, performance bonds, or advance payment guarantees. In an international or domestic trade transaction, the seller will agree to ship to the buyer on standard open account terms as long as the buyer provides a standby L/C for a specified amount and term. As long as the buyer pays the seller as agreed, the standby L/C is never funded. However, if the buyer fails to pay, the exporter may present documents under the L/C and request payment from the bank. The buyer's bank is essentially guaranteeing that the buyer will make payment to the seller.[8]

Standby is a term used for LCs that function like insurance. These types of LCs are “passive”. That is, they are not to be drawn upon by the beneficiary unless a delinquency/default of some form takes place in a business transaction. Standby LCs are usually substituted for a guarantee or bond in the United States.

The term standby letter of credit is also used in two different meanings. American terminology refers to a guarantee, i.e. the contract of (independent) guarantee between bank and beneficiary, as a standby letter of credit in order to avoid confusion with the American concept of guarantee(or guaranty) which is the accessory type of security. The term is further used as a synonym for a particular type of guarantee, namely the payment guarantee, which is a variant of a documentary credit.[9]

2. The rule & practice in standby letter of credit

Standby is a term used for LCs that function like insurance. These types of LCs are "passive". That is, they are not to be drawn upon by the beneficiary unless a delinquency/default of some form takes place in a business transaction. Standby LCs are usually substituted for a guarantee or bond in the United States.

Standby letters of credits issued by U.S. banks are subject to federal law, specifically, Regulation H(12 CFR 203). Under section 208.8 (d), a standby LC is defined as follows :

[7] John F. Dolan, The law of letters of credit, commercial & standby credits, As. Pratt & sons, 2005, pp.1-23~25

[8] Jeff Madura•Roland Fox, International financial management, Thomson, 2007, pp.658

[9] Roeland F. Bertrams, Bank guarantees in international trade, Kluwer law international, 2004, pp.19-21

"Standby letters of credit include every letter of credit (or similar arrangement, however named or designated) which represents an obligation to the beneficiary on the part of the issuer (1) to repay money borrowed by or advanced to or for the account of the account party, or (2) to make payment on account of any evidence of indebtedness by the account by the account party, or (3) to make payment on account of any default by the account party in the performance of an obligation."

Even though standby letters of credit are covered under federal law, in practice, U.S. banks apply the UCP600 and/or the International Standby Practices(ISBP) to the issuance of standby letters of credit for the support of international trade transactions.[10]

Under ISP 98, demands can only be made electronically if it has been agreed between the parties, or the issuer consents to such a presentation, or the beneficiary is a S.W.I.F.T.(Society of Worldwide Interbank Financial Telecommunication) member of a bank. In all other cases electronic presentations are excluded and do not trigger payment obligations under standby letters of credit governed by the ISP 98. Where electronic presentations are allowed, the ISP defines which form the documents have to be presented to fulfil the requirements.[11]

There are currently three major sets of rules governing credit transactions, all of which have been adopted by the international

Chamber of Commerce(ICC) : (1) Uniform Customs and Practice for Documentary Credits (UCP 500)[12]; (2) Uniform Rules for Demand Guarantees(URDG)[13]; and (3) International Standby Practices ISP98(ISP98)[14]. The ICC adopted three separate sets of rules to govern three distinct situations: the UCP 500 to govern commercial letters of credit; the URDG to govern independent demand guarantees; and the ISP 98 to govern standby letters of credit. In practice, however, the UCP 500 enjoys widespread use, while the other two sets of rules are infrequently used. In addition to these three sets of rules, there is also the United Nations Commission on International Trade Law (UNCITRAL) Convention on Independent Guarantees and Standby Letters of Credit(Convention)[15]. The Convention is a treaty and has the force of law for those countries that adopt it.[16]

Taking the view that the American standby letter of credit represents unique features which require coverage separately and distinctly from independent guarantees, the American Institute of International Banking Law & Practice adopted in 1998 a new set of uniform rules known as International Standby Practices(ISP98). The ISP98 are also published as ICC Publication No. 590. A detailed commentary on the rules('The Official Commentary on the International Standby Practices')has been written by Professor James E. Byrnes, the chairman of the ISP Working Group. Bearing in mind that the American standby letter of credit is functionally the same type of security as the independent guarantee, it has been doubted whether there was any real need for a separate set of rules. This may be true, but the

[10] Alan J. Beard•Richard M. Thomas, Trade finance handbook, Thomson, 2006, pp.23

[11] Norbert Horn, Legal issues in electronic banking, Kluwer law international, 2002, pp.303-304

[12] ICC Uniform Customs and Practices for Documentary Credits, ICC Publication No. 500 (1993) [hereinafter UCP 500], recently amended as ICC Publication No. 600 (2007) [hereinafter UCP 600]

[13] ICC Uniform Rules for Demand Guarantees, ICC Publication No. 458 (1992) [hereinafter URDG]

[14] International Standby Practices : ISP98, ICC Publication No. 590 (1998) [hereinafter ISP98]

[15] Convention on Independent Guarantees and Standby Letters of Credit, Dec. 11, 1995, 2169 U.N.T.S. 190 [hereinafter The Convention]

[16] James E. Byrne•Christopher S. Byrnes, 2006 Annual survey of letter of credit law & practice, The institute of international banking law & practice, Inc., 2006, pp.36-37

ultimate answer depends on the point of reference. In the absence of any other uniform rules, American banks used to routinely incorporate the UCP in standby credits, although it is commonly accepted that the UCP are not appropriate for standby credits. From this perspective the ISP98 are to be welcomes as they are specifically and exclusively drafted for standby credits. The ISP98 contain a vast number of rules and subrules (most of them with further subdivisions)which, taken together, are exceptionally complex and detailed and which contrast with the concise provisions of the URDG. In addition, several provisions of the ISP98 would surprise the commercial parties and/or are rather peculiar, while some of them display a certain bias in favor of the banks. Beneficiaries and account parties, but also banks, which are not sufficiently familiar with the ISP98 should, therefore, be cautious with accepting them. Nonetheless, the ISP98 contain many useful provisions, certainly when contrasted with the UCP if used in relation to standby credits.[17]

3. Benefits of standby letters of credit

3.1. Transnational/national use

Since one of the objectives of formulating the URDG and ISP98 was to provide a uniform set of rules, they are primarily intended for use in connection with cross-border transactions and guarantees or standby with parties established in different countries. There is, however, no reason why they should not also be applied in respect of domestic transactions. This is consistent with the fact that national law also does not distinguish between transnational and national guarantees and standbys.

3.2. All payment mechanisms

It is perhaps unfortunate that the ICC 1992 uniform Rules are called the Uniform Rules for Demand Guarantees. Demand(or first demand) guarantees are commonly understood to refer to independent guarantees which do not require any kind of real evidence concerning the account party's default.

Demand guarantees are often subject to the ICC Uniform Rules for Demand Gurantees. Under these rules, banks and issuing guarantors will only make payment against presentation of proper documents. The beneficiary of such a guarantee could obtain payment without having to prove any breach of contract, do or establish that it had suffered any damages. The use of demand guarantees under the ICC Uniform Rules provides the beneficiary with an instrument similar to an irrevocable letter of credit pursuant to which it can, at any time, up to the expiry date of that instrument, draw down a sum up to the bond amount without any further proof or condition - and despite any contestation or dispute on the part of the principal - merely upon presentation of a demand in the correct form accompanied by such documents as may be specified.[18]

Contrary to what its name suggests, the URDG do, however, also relate to guarantees with different payment mechanisms which require real or substantive documentary proof of default, such as a certificate by an architect or engineer, or a judgment or arbitral award, as is expressly stated in Art. 2(a) URDG. Rules 4.19 and 4.20 ISP98 also allow for standbys with

[17] Roeland F. Bertrams, Bank guarantees in international trade, Kluwer law international, 2004, pp.30-31

[18] United Nations Conference on Trade and Development, Legal aspects of international trade, United Nations, 1999, pp.39-40

such different payment mechanisms. Apart from this, both the URDG and ISP98 permit the insertion of all kinds of other terms and conditions, provided they are formulated in a documentary fashion.

As far as the United States is concerned, all 50 states have adopted Art. 5 of the Uniform Commercial Code(UCC). This Article deals with letters of credit and it encompasses both the traditional (commercial) letter of credit (documentary credit) and the standby letter of credit. The text of Art. 5 was revised in 1995.[19]

Standby Letters of Credit have been used for many years to support payments, both when due and after default, in case of repayments of money loaned and advanced, or upon the occurrence or non-occurrence of an event in relation to financial or commercial transactions. This document originated and has been widely used outside Europe for many years, but is now recognized worldwide.[20]

Standby letters of credit are much useful and available financing tools in both international and domestic commercial transactions.

Since the end of world War II, standby letters of credit have been used as a surety device, serving as a performance bond and guarantee in the world.

The standby letters of credit was also introduced by Anglo-American banks and is a result of the earlier prohibition to issue guarantees imposed on American banks. It is therefore not surprising that the standby letter of credit has the function and commercial effect of a guarantee. Objections resulting from the underlying transaction are not permitted, and consequently the standby letter of credit has many of the characteristics of a first demand guarantee.

Standby letters of credit provide a secondary or back-up payment for a particular trade transaction under a bank's full coverage. In case the exporter is unable to collect funds from the importer, such funds may be claimed under the standby letter of credit from the issuing bank as per Uniform Customs and Practice for Documentary Credits. Therefore, the standby letter of credit is usually only activated in the importer's default.

On the other hand the standby letter of credit has been widely used in the international transactions as a performance bond, guarantee and the diverse forms, we can expect the use of standby letter of credit will be expanded at any business contract.

There has been a gradual expansion of the grounds upon which payment of a letter of credit or bank guarantee may be restrained. When one looks at the particular headings (unconscionable conduct, termination of the underlying contract, nullity or non-existence of the underlying contract, illegality or violation of public policy), it is arguable that the law has always been like that and that the so-called expansion of the exceptions to the autonomy principle is more noteworthy because the courts have had opportunity to articulate views on these issues. Support for this argument can be found in the UN Convention on Independent Guarantees and Standby Letters of Credit which provides for some of these grounds. While not all the cases which have propounded the new exceptions should be applauded, the trend towards the recognition of more exceptions to the autonomy principle is undeniable. It is also arguable that some of the exception, particularly under the limb of "fraud in the transaction" in those jurisdictions which recognise that limb. English law does not recognise such an exception and, for that reason, may from time to time witness a case which tries to carve out a new exception or push the frontiers of the current definition of the fraud exception. As the

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[19] Roeland Bertrams, Bank guarantees in international trade, Kluwer law international, 2004, pp.33-34

[20] Anders Grath, International trade finance, The institute of export, 2005, pp.105

courts pronounce more exceptions, we can expect more litigation on the same and other exceptions, thus making it necessary to develop a framework for analyzing the litigation.[21]

3.3. The present state of standby letters of credit

The standby letter of credit made in U.S.A. and has used widely in the international and domestic contract because of its simple, convenient and economic characteristic, and advanced countries like U.S.A. have been used it in the various fields.

For US banks, there are longer term trends worth noting for the years 1997-2007. During that time, outstanding commercial credits dropped in value by 6.2% whereas standbys increased by 125.4%. As a result, the standby-to-commercial LC ratio for US banks has gone from 5.6:1 to 13.5:1. As of second quarter 2007, standbys accounted for 93.1% of total outstanding credit value, up from 84.9% in 1997.[22]

Table 1. Statistics U.S. banks(2007)[23]

Unit : US$1,000.

	net financial standby LCs	net performance standby LCs	net standby LCs	commercial & similar LCs	net letters of credit
3rd quarter 2006	349,482,564	55,726,457	405,209,021	28,874,026	434,083,047
4th quarter	362,244,946	80,358,070	442,603,016	27,792,182	470,395,198
1st quarter 2007	375,753,568	54,331,459	430,085,027	26,490,724	456,575,751
2nd quarter	371,654,700	58,165,921	429,820,621	31,804,081	461,624,702
3rd quarter	391,228,313	60,408,066	451,636,379	30,694,688	482,331,067

DCW reports the most current data on top US commercial banks in terms of LC activity. Net financial LCs and net performance LCs reflect net after subtracting respective amounts conveyed to others. Net LCs reflect totals for net financial LCs, net performance LCs and commercial & similar LCs.

The purpose of this study is to make practical use of standby letter of credit.

In Korea, it is not published an official statistics on standby letter of credit, so it could be estimated approximately 5%(US$ 5 billion) in total letters of credit amount in the

[21] Agasha Mugasha, Enjoining the beneficiary's claim on a letter of credit or bank guarantee, The journal of business law, September 2004, pp.524

[22] James E. Byrne, Overview of letter of credit law & practice in 2007, Documentary Credit World Volume 12 number 2, February 2008, pp.18

[23] Anonymous, Statistics U.S. banks : 3rd quarter 2006, Documentary Credit World Volume 11 number 2, February 2007, pp.32-37
Anonymous, Statistics U.S. banks : 4th quarter 2006, Documentary Credit World Volume 11 number 4, April 2007, pp.30-35
Anonymous, Statistics U.S. banks : 1st quarter 2007, Documentary Credit World, Volume 11 number 7, July/August 2007, pp.33-38
Anonymous, Statistics U.S. banks : 2nd quarter 2007, Documentary Credit World, Volume 11 number 9, October 2007, pp.24-29
Anonymous, Statistics U.S. banks 3rd quarter 2007, Documentary Credit World Volume 12 number 1, January 2008, pp.27-32

international transactions, and the use of it is unsatisfactory.

Table 2. Korea Exports and Imports by Payment Terms(2007)

Unit : US$1000, %

Terms of Payment	Exports		Imports	
	Value	Share	Value	Share
At sight L/C	52,789,443	14.2	44,213,407	12.4
Usance L/C	16,023,725	4.3	56,456,126	15.8
Deferred & Concurrent Remittance	56,258,688	15.1	41,882,618	11.7
D/A Terms	25,759,984	6.9	9,073,960	2.5
D/P Terms	4,840,604	1.3	4,568,206	1.3
Others, Free of Charge	4,982,981	1.3	15,673,561	4.4
Other Terms of Payment	29,467,017	7.9	1,072,146	0.3
Installment Payment	1,505,812	0.4	133,326	0.0
P/T	22,781,947	6.1	7,532,309	2.1
Simple Remittance	156,803,987	42.2	175,968,833	49.3
Open Account	274,896	0.1	271,241	0.1
Total	371,489,086	100.0	356,845,733	100.0

(Source: Korea International Trade Association, www.kita.net)

This study is to clarify differences between standby letters of credit and documentary letters of credit and also between standby letters of credit and guarantees.

Second, this study is carrying out to point out problems in effective use method of standby letters of credit and to suggest the solutions for the problems.

Standby letters of credit resembles documentary letters of credit to the extent that both of them involve three different contracts and that both are governed by the rule of strict compliance with documentary terms of credits and by the rule of independence, but there exist several differences between them.

Third, standby letters of credit create a contingency element not present in documentary letters of credit. While documentary letters of credit contemplate payment on performance of the underlying contract on the part of the beneficiary, standby letters of credit are operative only when there are nonperformance or default on the part of customers. A second one is the nature and purpose of the documents against which a demand is paid. Documentary letters of credit requires presentation of the third party documents such as bills of lading. However, usually standby letters of credit requires only a self-declaration by the beneficiary that the customer has failed to perform. Certificates of default are not documents of title while the bill of lading is a document of title. A third one is the reaction of the payment for the draw. Parties concerned in documentary letters of credit expect the prices to be paid for the draw. However, parties concerned in standby letters of credit expect the prices not to be paid for the draw.

Since standby letters of credit typically contemplate payment by the issuer when the customer himself defaulted, they are functionally equivalent to guarantees. Despite such functional overlaps between guarantees and standby letters of credit, the distinctive features between them are that the issuing bank in standby letters of credit has a primary obligation, but no liability on the underlying transaction. In contrast, the bank or the guarantor in a guarantee bears the secondary liability on the underlying transaction with the obligation to look beyond the documents presented to verify that the primary obligor has actually defaulted. Next, standby letters of credit are independent of the underlying contract. But the guarantee is dependent of the underlying contract. Finally, standby letter of credit is more economical than the guarantee.

4. Conclusion

The International Standby Practices(ISP98) reflects generally accepted practice, customs, and usage of standby letters of credit. It provides separate rules for standby letters of credit in the same sense that the Uniform Customs and Practice for Documentary Credits(UCP) and the Uniform Rules for Demand Guarantees(URDG) do for commercial letters of credit and independent bank guarantees.

The formulation of standby letter of credit practices in separate rules evidences the maturity and importance of this financial product. The amounts outstanding of standbys greatly exceed the outstanding amounts of commercial letters of credit. While the standby is associated with the United States where it originated and where it is most widely used, it is truly an international product. Non-U.S. bank outstandings have exceeded those of U.S. banks in the United States alone. Moreover, the standbys is used increasingly throughout the world.[24]

We are faced with international competition with global companies in the world, so it is needed to make practical use of various payment methods or guarantee instruments, etc. in the diverse business transactions.

In the same meaning, we need to use the standby letters of credit in the diverse business fields as follows; guarantees, substitute of documentary letters of credit, the contracts of sales goods, liquidated damage clause, counter plan of the bill of lading crisis, the method of saving bank commissions and any other business.

It would be considered recommendable that standby letters of credit should be used in global commercial transactions, because standby letters of credit are equivalent to guarantees in function and standby letters of credit have also stable governing rules like URDG, UCP 600, ISP 98, and United Nations Convention on Independent Guarantees and Standby Letters of Credit.

And it could be suggestible to establish one integrated governing rule of Standby Letters of Credit instead of concerned rules in the future.

Besides, it would be convenient to use together in a standby or a commercial letter of credit by stipulation, governing rules like ISP 98, UCP etc..

Finally, in amended UCP 600(2007), the term of bank includes not only traditional bank but also other financial institution, and so standby letter of credit can be also issued by enterprise. It could be expected that the enlarged application of banks caused issuing standby letters of credit to rapidly increase in standby letters of credit in the future.

In conclusion, I hope that enterprises etc. use wisely the benefits of standby letters of credit for achieving the desired goal in global competitions.

[24] United Nations commission on international trade law, Yearbook volume XXXI : 2000, United Nations, 2001, pp.580

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The Indian Automotive Supply Chain Network: Implications for the Global Automobile Industry

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Abstract
With rapid growing Indian economy the local demand for automobile are growing. Global firms use India as the basis of their market strategy for South East Asia and the world. Indian automotive manufacturers go through the stages of growth of growth. They start as small suppliers of original equipment manufacturers. With their acquisition of manufacturing and business capabilities they move up the layers of supply chain network. This paper discusses how Indian automotive companies evolve into original equipment manufacturers for small scale of passenger cars and expand their supplier base. In a sense they take the similar paths of many Japanese and Korean automotive firms. This involves rapid organizational learning and innovative capabilities. A research model is presented to show a typology for organizational learning and absorptive capacity that describes the relevant learning and growth patterns for Indian automotive manufacturers. From this simple typology an expanded model also describes more complex configurations of Indian supply chain network. Case illustrations of three Indian automotive companies present practical growth issues and related managerial implications.

Keywords: Indian Automotive Manufacturers, Typology of Organizational Learning and Growth, Innovative Capabilities and Absorptive Capacity

1. Introduction

In today's knowledge economy organizations are finding that they must be able to create new knowledge through a complementary approach of internal research and development and external sourcing if they are going to be able to improve a firm's innovation performance (Cassiman and Veugelers 2006). It is important that companies balance their internal R&D with external knowledge acquisition strategies, such as outsourcing R&D, hiring skill researchers from outside the organization, and acquiring companies. Combining internal and external information sourcing, or "complementarity", gives companies a competitive advantage (Rigby and Zook 2002) if the company is able to assimilate and exploit new ideas for competitive gain.
Organizations must apply their technological and administrative skills for competitive advantage. Given the rising cost in research and development, this process involves not only the capability to innovate, but also the capability to imitate where appropriate. The company must be able to manage its technological innovation and imitation and execute

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successfully in these areas in order to not get locked out technologically (Schilling 1998).

Companies are finding that they must continuously engage in organizational learning through absorptive capacity (Cohen and Levinthal 1990) where they must acquire and assimilate knowledge, and possess the capabilities to transform and exploit new knowledge that they have assimilated (Zahra and George 2002). Innovation and imitation strategies are not managed in a vacuum but have assumptions about decision making (Du et al. 2007), organizational knowledge and learning, and innovative capability (Parashar and Singh 2005) that must be objectified. See *Figure 1* for a theoretical framework for absorptive capacity and organizational learning in accumulating and exploiting new and existing knowledge.

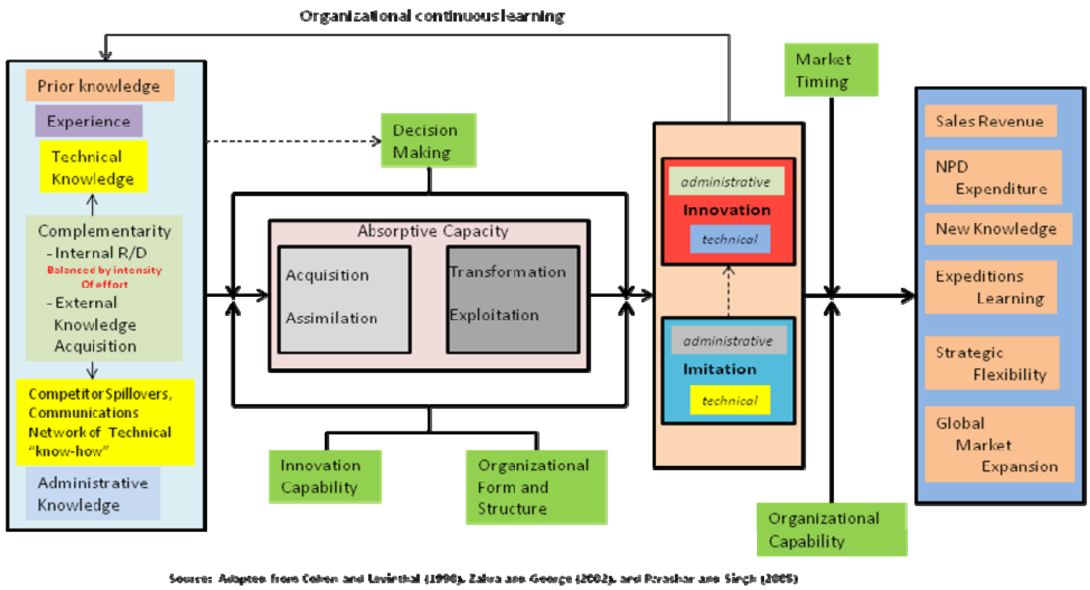

Figure 1. Conceptual Model for the Adoption of Knowledge for Innovation and Imitation

Figure 1 shows how a company applies prior knowledge. It can acquire knowledge through internal research and development (R&D) and external sources to develop technical knowledge. The company's experience, such as specializations in particular areas and its intensity of effort (Damanpour 1987) goes into determining the company's ability to continuously learn through absorptive capacity. Decision making plays a role in determining the absorptive capacity and whether a company will transform and exploit the acquired and assimilated knowledge through imitation, innovation or a hybrid of the two leading to new innovations. Organizational practices from absorptive capacity may diffuse slowly and yet lead to superior performance (Rivkin 2000). As a firm seeks to grow by replication of its technologies, its own successful replication encourages imitation (Kogut and Zander 1992).

Organizational form and structure plays a significant role in the institutional practices that companies develop toward innovation and imitation. Neo-institutional research or "new" institutional research in the social science on isomorphic organizational processes holds that though organizations may exist in different regions in the world, they still offer an abstract level of form that is relatively identical for given practices (Fligstein 1985). For example, large firms seeking to mimic the product development of their competitors will alter their structure when other large firms in the industry alter their structure. This allows them to learn and test organizations against their competitors' success and failure which will enable the mimicking company to more effectively manage and exploit technology. Isomophism in this case allows firms to structure their organizations for imitation and similar patterns of innovation of other organizations in the industry while minimizing their risks in structure regardless of their geographical location (Guler et al. 2002).

The company's organizational capabilities along with market timing play a mediating role in the performance outcome after the imitation/innovation stage. Technical innovations have been linked to administrative innovations for different types of organizations as shown in Figure 1 above. Almost nowhere is the nature of exploiting imitation and innovation more apparent than in the global automobile manufacturing industry which dates back to the early 1900s. For example, by the mid 1950s, Ford Motor Company's mass production assembly line dominated the way that automobiles were produced (Survey of The Car Industry 1992).

Much has been written about the Toyota Production System and how innovations at Toyota are now being diffused around the world. Like other automakers of the time, Toyota first imitated mass production practices of Ford while experimenting with new technical and organizational practices of just-in-time/Kanban (Sugimori et al. 1977) and lean manufacturing (Womack, Jones, and Roos 1990).

Toyota's ability to continuously learn through imitation and innovation has enabled the company to become the third leading auto-manufacturing company trailing only Daimler AG and General Motors Corporation in worldwide automobile sales in $US. Imitation and innovation can be linked to company performance for weak property rights, technological interdependence, rapid technological change, access to rich knowledge base, and high technology with market uncertainty (Bolton 1993 Winter). Toyota has applied an imitation/innovation strategy for competitive advantage where the leading U.S. automakers have over the last decade imitated Toyota's lean manufacturing practices (Womack, Jones, and Roos, 1998). The global automobile manufacturing industry is becoming one of imitation and innovation.

2. The Gap In Economic-Based Studies On Imitation and Innovation

Prior studies on the relationship between imitation and innovation in auto-manufacturing have generally relied upon economic modeling and analysis as *a priori* with some notable exceptions. One study in particular bridges the gap between imitation and innovation through absorptive capacity and organizational learning (Kim 1998). But, this model looks back to the past to make the case for crisis construction of imitation to innovation in a learning orientation. In this case, imitation and innovation are stages within a continuous learning environment with absorptive capacity at the heart of adoptive capabilities. The potential of absorptive capacity (PCAP) leads to acquisition and assimilation of existing ideas leading to imitation. In contrast, realized absorptive capacity (RACAP) leads to the creation of new ideas that exploits and transfers technology in the marketplace for competitive advantage (Zahra and George 2002). Many studies that undertake the relationship of imitation and innovation approach it from an industry perspective at an aggregate level, showing the effects on the overall economy, the industry, and firms that operate in the particular industry (Braguinsky et al. 2007, Iwai 2000). It is no doubt that this approach draws from many proven economic theories and models. This approach, however, makes it all but impossible to begin a dialogue on developing an imitation-innovation theory that is generalizable and easily recognized from patterns exhibited by the companies who engage in imitation and innovation. Yet, through careful deliberation in a literature search on the subject of innovation and imitation, we began to see a pattern that leads us in the direction of attempting to establish a parsimonious explanation for everyday phenomena found in the global automobile industry. The motivation behind the research for this article is recognition of a gap in the research of the explanatory power of imitation and innovation configurations for technology management. In particular, we examine the acquisition, assimilation, transfer, and exploitation of technology which is in progress by relatively new entrants seeking to compete with well-entrenched leaders in a mature industry – namely, domestic Indian automakers. Specifically, this article presents 27 imitation/innovation configurations from a technological perspective in combination with administrative transformation and examines how a select case study group of domestic automobile manufacturers fall into these configurations as they seek to gain entry into and become top-tier players in the global automobile manufacturing market. The parsimonious explanations are built upon a theoretical base of absorptive capacity and organizational learning. Using the imitation/innovation configurations for interpretation of the state of companies within developing nations in a knowledge economy is both practical and complementary to academic research in management and economic theories.

3. Why Study Imitation and Innovation For Absorptive Capacity Of Indian Automakers?

India has long been a leader in the knowledge economy as perhaps the most respected and well-known information technology outsourcing destination in the world. India’s outsourcing industry began with remediation of legacy application systems support imitating the IT systems development approaches of its customers, but quickly turned to providing full-service innovative solutions for its impressive list of global clients. India has capitalized upon its knowledge of computer and engineering technology, global capital markets and investing through mergers and acquisitions and participating in global supply chain networks.

India has received increasing attention over the last decade from a global supply chain management perspective in the production of major consumer goods and services because of its important economic role in the knowledge economy (Ollinger 2007). Much of India’a manufacturing base came from spillovers and foreign direct investment in technological innovations (Joseph 2007). India is now turning its attention to the global economy of automobile sales and manufacturing.

An expanding Indian economy continues to build upon the strength of its entrepreneurial-minded highly-educated knowledge-base of engineers, scientists, computer professionals, investment bankers, and financial analysts. India has experience in minority and majority government-ownership in highly-innovative and imitative home-grown automotive companies. This in turn has ignited economic prosperity in the Indian middle- and upper-classes that are fueling consumer demand for standard and luxury automobiles in the domestic market. At the forefront of meeting this demand are both global auto-manufacturers who operate under various strategic partnerships, such as brand licensing, company affiliation, joint ventures, and subsidiaries with domestic automakers in conjunction with the Indian government. In some instances, automakers in India – domestic and foreign – serve as supply chain hubs for the exporting of passenger vehicles made by well-known global automakers operating in India.

In other instances, domestic OEMs (original equipment manufacturers) export their own low-priced, low to high quality brands to industrialized and developing nations. While economic reports and academic studies on India's manufacturing in general and IT in particular are available, very few research-oriented academic studies have focused on Indian auto-manufacturing and its foundation.

A dearth in the research are missed opportunities to explore imitations and innovations of technologies that are being assimilated, developed, and exploited across all industries in India. Absorption capacity of Indian domestic automakers is integrated with advanced manufacturing processes and the use of advanced technologies such as computers and other digital devices. India's economy is surging as the country seeks to evolve from the stymied reputation of sources for systematized IT development and financial call center support into manufacturers who can match world-class producers in style, creativity, imitation, and innovation found in global automobile manufacturing.

There are some differences in the way that Indian service managers acquire information and those in the United States which is a major outsourcer of IT and call centers to India (Motwani 2006). In general, there is greater support for knowledge sharing – a big part of knowledge creation through knowledge management – in the United States compared to India. But, the Indian government is implementing changes to encourage innovation through knowledge sharing. Like Japan, where the government instituted a national innovation system (Mowery 1995), the Indian government encourages innovation through highly selective and focused Indian Institutes of Technology and Management.

4. Research Approach and Methodology

A literature search is conducted to derive and develop 27 configurations that fall into the absorptive capacity domain leading to technological imitation, technological innovation, and administrative configurations ranging from low to high in each category. The configurations are placed into a table for descriptive content characteristic assessment and generalized assignments. The characteristic traits are later applied to three domestic Indian automobile manufacturers in a content-oriented fashion based upon assessment and analysis of the companies through third-party data acquired from the Society of Indian Automobile Manufacturers 2006-2007 fiscal year directory and the companies' websites.

5. The Literature on Innovation, Imitation, and Administrative Transformation

The literature on innovation is well developed where researchers accept the notion of a dual-core organizational innovation model (Daft 1978). Innovation can be defined as consisting of four essential steps: (1) conceiving an idea, (2) propose the idea for specification to achieve a desired outcome, (3) make a decision to adopt the idea that has now been formed into a more meaningful and measurable outcome, and (4) implement the concepts around the innovation. In dual-core, two innovative proposal patterns emerge: technical innovations are generally from the bottom and administrative ideas for new innovations are orchestrated from the top of the hierarchy. The diffusion of innovation (Rogers 1993) notes that the best practices and technological knowledge once available will find its way across the globe, thanks in large part to the roles played by countries and multinationals trade relations (Guler et al. 2002). Diffusion of administrative knowledge is just as important as diffusion of technical knowledge although there is no barrier to imitation of superior organization and management methods (Teece 1980).

Researchers found that early adopters benefited from innovations that are not imitable (Teece 1980). In the growing knowledge economy, that knowledge is reaching across the globe at an ever-increasing pace as new entrants not only seek innovation, but may opt to simply imitate the market leaders, adding small increments of innovation to distinguish their product offerings. Early adopters benefit from innovations that are not imitable (Teece 1980) Even with this thesis, there are surprisingly few academic studies that approach imitation from a theoretical base of absorptive capacity with a model that examines and explains various imitative/innovative configurations for management of technology as is found with the automobile manufacturing and the companies that operate in that sector. The model in Figure 1 builds upon the notion that a new idea is not an innovation until it is implemented and that its implementation and that there is an adoption of three types of innovation: technological, administrative, and ancillary (Damapour 1987). This also holds true for imitation as applied in this research and discussed in the following paragraphs. Innovation is related to a company's ability to transform itself and exploit new knowledge. For example, the more a company knows, the more it can learn and transfer to the marketplace or exploit for market gain (Damanpour 1987).

Imitation is driven by a desire to meet customer demands through providing similar or complementary products because the consumer benefits as competitors imitate and improve upon existing innovations (Levin et al. 1987). Three types of imitation traits have been identifies (Haunschild and Miner 1997): (a) frequency imitation where common practices are copied, (b) trait imitation where the imitator only copies practices of other organizations with certain features, and (c) outcome imitation where the imitator copies a certain trait based upon its impact on others. Innovators can benefit from an innovation as long as the innovator does not fall into complacency and institutionalizes innovation so late adopters have no cost deterrents against imitator the innovation (Bolton 1993 February). For example, as early as the mid-1980s, researchers recognized that Japan was applying an integrated imitation/innovation strategy in quality management – incremental enhancements to the U.S. innovations – along with its own innovations in automobile, electronics, and machinery manufacturing sectors (Rosenberg and Stienmuller 1998).

6. Innovation and imitation strategies based upon organization type

Technical innovations have been linked to administrative innovations for different types of organizations (Damanpour 1989). The type of imitation that each organization is likely to engage in relative to type of organization is illustrated in Figure 2 below.

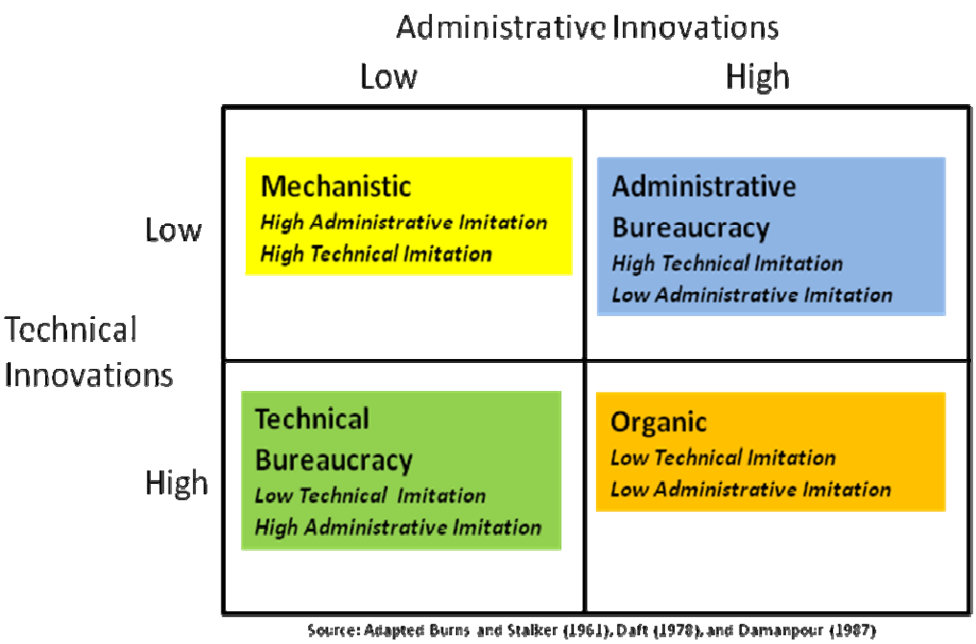

Figure 2. A Typology for Organizational Innovative Capabilities

Definitions of the various organizations:

(i) A mechanistic organization – one with stringent rules and rigid hierarchies – will typically have low administrative innovations and low technical innovation and likely engage in copying other companies in its industry. One way would be to engage in imitating the administration and the technological innovations of its rivals.

(ii) An administrative bureaucracy – one that has well-defined delineations between its officers and its labor force – will typically have low technical innovation and high administrative innovation – and will be more incline to engage in imitating the technological innovations of other companies in its industry.

(iii) A technical bureaucracy – one that has well-established technological innovative capabilities – will be more incline to engage in copying the administrative techniques and methods of its rivals for higher performance.

(iv) An organic organization – one that is more flexible and values outside knowledge – will more likely have high administrative innovations and high technological innovations and seek innovation over imitation in order to use its strength to secure a market leadership position in the businesses where it participates.

7. Innovation and imitation strategies based upon adoption strategy

Technical innovations have been linked to administrative innovations for early and late adopters of technology. The type of imitation strategy that each organization is likely to engage in relative to an adoption strategy is illustrated in Figure 3 below.

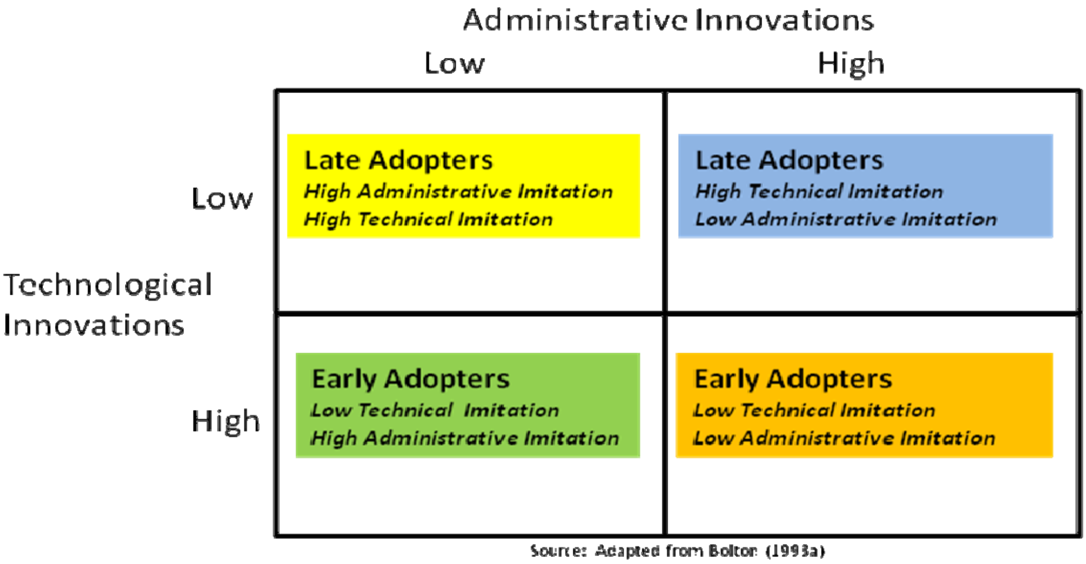

Figure 3. Typology of Innovation Adoption Strategies

Various adoption strategies for innovation and imitation consideration:

(i) Late adopters with low technological innovations and low administrative innovations will wait to see for the innovators to define the direction and then engage high administrative and high technological imitation.

(ii) Late adopters with low technological innovations and high administrative innovations will engage in high technological imitation to try to match their competitors in the field, offering incremental improvements to market-accepted products of competitors.

(iii) Early adopters with high technological innovations and low administrative innovations will wait seek to minimize risk in organizational structure and management by seeking to imitate the administrative innovations of others in the industry.

(iv) Early adopters with high technological innovations and high administrative innovations will seek an innovative strategy for growth as opposed to imitating their rival if they have the expertise in-house or that can be acquired to implement this strategy.

8. The affect of imitation on innovation

The literature on imitation while empirically studied, has not received the same attention and excitement as has the literature on innovation in management research, nevertheless, imitation is an important factor in understanding competitive shifts in the markets requiring advanced manufacturing technologies. Companies actually search for knowledge which is influenced by the firm's scanning capabilities that assist the firm in identifying useful knowledge (Almeida et al. 2003). Knowledge can sometimes be revealed from observations that are incidental on other activities (Arrow 1969). But, if mimicking firm can imitate an innovation at substantial cost below the cost of the original innovator, then there is no incentive to innovate. Companies have little incentive to innovate if competing firms can imitate an innovation at substantially lower costs for developing and introducing the imitated product compared to innovating (Arrow 1969, Mansfield et al. 1991). However, imitation is not free especially in the capital intensive automobile manufacturing industry. A company must still invest in a pilot plant, prototype construction, manufacturing equipment, and marketing startup (Mansfield et al., 1991).

9. Organizational learning relative to imitation

Uncertainty leads companies to increase communication and information sharing where they often learn from each other (Kraatz 1998). These companies may choose to examine the knowledge and technology available in their market sector or other sectors, and imitate the practices of market leader to avoid costly missteps. Companies actually search for knowledge which is influenced by the firm's scanning capabilities that assist the firm in identifying useful knowledge (Almeida et al. 2003). Once useful knowledge is identified, the company can then go about its business of assimilating, acquiring, transferring the knowledge to members of the organization who can apply it toward imitation/innovation strategies.

Two theories approach learning and imitation from different dichotomies. The theory of informational cascades supports uniform behavior where firms imitate each other (Bikhchandana et al. 1998). This makes sense when we examine the components of the automobile and its parts and assembly supply chain network of automotive companies who supply standardized items across the industry. On the other hand, differentiation through the features and services and production process such lean manufacturing provides a competitive advantage, if only short-lived until the feature and process is copied.

10. Moving from imitator to innovator

Some of the early work on imitation addressed how companies move from imitator to innovator (Currie et al. 1999) as their rate of assimilation of new knowledge increases. There is equilibrium, especially for a company seeking growth in a global market, where it no longer makes economic sense for the company to simply imitate. The company is able to substantially grow its market through an imitation/innovation strategy (Iwai 2000). Companies often mimic each other in their hiring practices, choosing to hire top management talent from their social networks (Williamson and Cable 2003). Therefore, as companies move into competitive positions against certain rivals, they began to develop social networks with those in that sector. The imitator/innovator can then hire talent from its competitors which provides evidence of how companies with strong imitating capabilities are able to transform their organizations to exploit existing knowledge that exist in the marketplace.

11. Balancing Imitation, Innovation, and Administrative Transformation

Companies may choice to imitate, innovate, and a combination of the two when seeking meet its absorptive capacity needs. For example, the company can simply acquire, assimilate, adapt, and then exploit knowledge that it does not have (imitate), or create new knowledge from its own internal research and development that can be exploited and transformed in the marketplace for competitive gain (innovate). The company may also find that where it is weak in innovation as well as imitation, it compensates in its administrative capabilities, such as vision, leadership, planning in marketing and sales, and flexible organizational transformation to meet changing market needs. The company may simply choose to exploit the technological knowledge that it has already acquired or developed and focus more on improvements in its organizational structure and practices.

The “complementarity” between the three is described in more detail in Tables 1, 2, and 3 for various imitation/innovation configurations that are the core of discussion in this paper. The table allows us to separate technological innovation/imitation for impact of administrative capabilities with identifying characteristics. These characteristics are broken out into 9 innovation/imitation configurations with low, medium, and high administrative considerations encompassing 27 configurations in total.

12. Propositions and Discussion

From the 27 configurations, we draw 9 propositions related to the global automobile industry. The discussion is centered upon Indian domestic automobile manufacturers, but pulls from a broad array of knowledge in the public domain about automobile manufacturing in general. For the following discussion, some parallels are naturally drawn between various descriptive characteristics that identify a company as falling within a certain mixed state of innovation and imitation with low to high degree of administrative capabilities for its organizational transformation skills. This does not imply that this is a true representation of the company’s sales, marketing, management, and manufacturing capabilities. Nor does it indicate that Indian automobile manufacturers cannot or will not change their competitive strategies that will affect their state of configuration as classified in the tables for explanatory research purposes. The opposite is in fact true given the forecast for growth and industry trends in automobile manufacturing according to the Indian Automotive Component Industry.

In following the research approach and methodology, the goal here is to take a snapshot of the state of a company given the information known and available today about the company and match the information to the set of configurations described in Tables 1, 2, and 3 for literature-supported postulations that are conjectural, yet practical. Suitability for generalization to other companies and industries will be explored under the “Managerial Implications” section.

The first set of propositions (1, 2, and 3 as outlined for Group 1 in Table 1) – *low innovation and low to high imitation* – relates to how companies with low innovations in automobile design, development, and manufacturing can apply low to high imitation. Obviously, companies with low to average administrative capabilities will find it difficult to capitalize upon existing knowledge even if they are very good at imitating the field of competitors in the automobile manufacturing and related industries. On the other hand, companies with high administrative capabilities can draw upon their excellence in administrative skills in transforming their organizations to position themselves in niche markets within the global automobile manufacturing industry, especially with medium to high imitation capabilities.

These companies will not immediately seek leadership, but instead will settle for establishing, maintaining, and perhaps even growing their position in the market under the radar of competitors.

The second set of propositions (4, 5, and 6 with the general characteristics as outlined Group 2 in Table 2) – *medium innovation and low to high imitation* – describe how companies that are able to make incremental innovations in the automobile sector can apply those innovations to low to high levels of imitation for expansion in the global automobile manufacturing industry for better yields. These companies may demonstrate low to excellent administrative skills in transforming their organization to add incremental value to existing automobile technologies. They imitate the market leaders in carving out market opportunities for themselves. Companies in this group may be able to distinguish themselves from the pure imitator status demonstrated by Group 1 companies. Group 2 companies will be able to capitalize upon innovation (and imitation based upon the level of imitation and administrative capabilities) where both are dependent upon the company's administrative transformation skills – for example, "medium" or "high".

The third and final set of propositions (7, 8, and 9 as outlined in Group 3 in Table 3) – *high innovation and low to high imitation* – describe companies that are able to acquire, assimilate, and exploit knowledge to excel in technological innovations. These companies, depending upon their level of imitation, can add low to high value that complements existing products by imitating the market leaders and leaders in other related industries, given their administrative abilities in transforming their organizations for excellence in automobile design, development, and manufacturing. Companies at high innovation and high imitation levels are able to innovate and imitate at the same time, and where they possess high administrative abilities, can utilize both for competitive advantage. For example, those with high imitative abilities and high administrative transformation abilities may seek to transform their organization into a leadership role through acquisition and assimilation coupled with internal and/or external R&D for innovation.

13. An Analysis of Innovation Adoption Patterns for Competitive Advantage

A company with high innovation and high imitation could use its position to surpass the market leader(s) as was the case of Toyota surpassing Chrysler and Ford in the volume of automobiles sold annually.

13.1 Group 1 – low innovation and low to high imitation

Proposition #1: A company with *low innovation and low imitation* desiring top-tier status or seeking entry in the global automobile industry can find a small niche in the market as long as the company is able to transform its organization to exploit the knowledge that it already possesses for competitive gain through medium, but preferably high administrative capabilities.

Proposition #2: A company with *low innovation and medium imitation* desiring top-tier status or seeking entry in the global car market can find opportunities in a broader, but limited segment of the larger market as long as the company has medium to high administrative capabilities to transform its organization to follow match one or market leaders in similar product offerings.

Proposition #3: A company with *low innovation and high imitation* desiring top-tier status or new entrance into the established global automobile industry can find opportunities on a broader scale in the industry as long as the company possesses medium to high administrative capabilities to transform its organizations to match several market leaders in similar product and service offerings.

Hindustan Motors falls into the category of *Low Innovator_Low to Medium Imitator* with *low to medium administrative capabilities*. Hindustan was the first Indian domestic car company. The company established itself as a provider of sturdy automobiles that can handle the India countryside. Hindustan has not been particularly adept at innovating and only moderately successful in imitating the market leaders. The company's long-tested brand of sturdy vehicles are not known for being particularly stylish in design and special features compared to the leading global automakers and has cost the company in the domestic market share. The company is applying its knowledge of other national markets through the sale of trucks and earth-moving equipment as possible targets for its newer car models. The company's performance of $273 million (US$) as measured in car sales revenue places the company far behind Tata Motors and Mahindra. Hindustan is penning its growth in the global car market on incremental innovations of its primary product line and collaboration with other global automakers, namely Mitsubishi at present.

13.2 Group 2 – Medium innovation and low to high imitation

Proposition #4: A company with *medium innovation and low imitation* desiring top-tier status or entry into the established global automobile industry can find opportunities in a niche market that values innovation at a lower price that the average available in the market segment as long as the company possesses medium, but preferably, high administrative abilities to transform its organization to distinguish itself product offerings and service offerings from the competing firms in its market segment.

Proposition #5: A company with *medium innovation and medium imitation* desiring top-tier status or entry into the established global automobile industry can find opportunities on a broader scale of niche markets that value innovation at lower prices with matching quality of available alternatives as long as the company possesses medium to high administrative abilities to transform its organization to distinguish itself from the market leaders within the segment while offering complementary products to those of the market leaders by adding value to existing products on the market.

Table 1. Configurations of Innovation Adoption Patterns by Groups

Group 1	**#1**	Administrative Transformation	General Characteristics	Practical Examples
Technological Innovation LOW	Technological Imitation LOW	Low (1)	The company is poor at innovating and is poor at imitating the market leaders and lacks in innovative capabilities. The company is incapable of transforming its organization to capitalize upon the knowledge that it already possesses.	Hindustan Motors Hindustan has not been particularly adept at innovating and only moderately successful in imitating the market leaders.
		Medium (2)	The company is poor at imitating the market leaders and lacks in innovative capabilities. The company has mediocre to average ability to transform its organization to capitalize upon the knowledge that it already possesses.	
		High (3)	The company is poor at imitating the market leaders and lacks in innovative capabilities. However, the company is able to transform its organization to take advantage of the knowledge that it already possesses even though it is weak in innovation and imitation.	

Group 1	**#2**	Administrative Transformation	General Characteristics	Practical Examples
Technological Innovation LOW	Technological Imitation MEDIUM	Low (4)	The company is poor at innovating and but yet mediocre to average at imitating the leaders in the industry through acquiring and assimilating new knowledge. However, the company is incapable of transforming its organization to exploit the new knowledge that it now possesses.	Hindustan Motors The company's long-tested brand of sturdy vehicles are not known for being particularly stylish in design and special features compared to the leading global automakers and has cost the company in the domestic market share.
		Medium (5)	The company is poor at innovating and is mediocre to average in imitating the leaders in the industry. The company is mediocre to average in transforming its organization to exploit the new knowledge that it has acquired and assimilated.	
		High (6)	The company is poor at innovating, and is mediocre to average in imitating the market leaders through acquisition and assimilation of new knowledge. However, the company is excellent in	

			transforming its organization to exploit the new knowledge that it has acquired and assimilated.	
Group 1 Technological Innovation LOW	#3 Technological Imitation HIGH	Administrative Transformation	General Characteristics	Practical Examples
		Low (7)	Although the company is poor at innovating, it is extremely good at technological imitation from the knowledge that it has acquired and assimilated. But, the company is unable to maximize upon its imitation capabilities because it lacks the ability to transform its organization to do so.	
		Medium (8)	Although the company is poor at innovating, it is extremely good at technological imitation from the knowledge that it has acquired and assimilated, and mediocre to average in exploiting its imitation capabilities.	
		High (9)	Although the company is poor at innovating, it is extremely good at technological imitation from the knowledge that it has acquired and assimilated, and is able to transform its organization to take advantage of its imitation capabilities.	

Table 1. Configurations of Innovation Adoption Patterns by Groups (--continued--)

Group 2 Technological Innovation MEDIUM	#4 Technological Imitation LOW	Administrative Transformation	General Characteristics	Practical Examples
		Low (10)	The company is mediocre to average at innovating, but it is poor in imitating the leaders in the industry. The company has been unable to transform its organization to exploit its innovative capabilities to their fullest potential.	
		Medium (11)	The company is mediocre to average at innovating, but it is poor in imitating the leaders in the industry. The company is, however, mediocre to average in transforming its organization to exploit its innovative capabilities.	Mahindra & Mahindra Mahindra draws upon its own acquired knowledge in developing rugged vehicles for rough terrains in India and other parts of the world.
		High (12)	The company is mediocre to average at innovating, but it is poor at imitating the leaders in the industry. Yet, the company is able to transform its organization to exploit its mediocre to average innovative capabilities.	

Group 2 Technological Innovation MEDIUM	#5 Technological Imitation MEDIUM	Administrative Transformation	General Characteristics	Practical Examples
		Low (13)	The company is mediocre to average at innovating and mediocre to average at imitating, but it has been poor in transforming its organization to exploit either its innovative or imitative capabilities.	
		Medium (14)	The company is mediocre to average at innovating and mediocre to average at imitating, and is mediocre to average in transforming its organization to exploit its innovative or imitative capabilities.	Mahindra & Mahindra Mahindra draws upon its own acquired knowledge in developing rugged vehicles for rough terrains in India and other parts of the world.
		High (15)	The company is mediocre to average at innovating and mediocre to average at imitating. However, the company excels in transforming it organization to exploit its innovative or imitative capabilities.	
Group 2 Technological Innovation MEDIUM	#6 Technological Imitation HIGH	Administrative Transformation	General Characteristics	Practical Examples
		Low (16)	The company is mediocre to average at innovating, but excellent at imitating the market leaders. But, the company has been unable to transform its organization to take full advantage of its innovative and imitating capabilities.	
		Medium (17)	The company is mediocre to average at innovating, but excellent at imitating the market leaders. The company is mediocre to average at transforming its organization to take full advantage of its innovative and imitating capabilities.	Mahindra & Mahindra Mahindra draws upon its own acquired knowledge in developing rugged vehicles for rough terrains in India and other parts of the world.
		High (18)	The company is mediocre to average at innovating, but excellent at imitating the market leaders, and is able to transform its organization to take full advantage of its innovative and imitating capabilities.	

Table 1. Configurations of Innovation Adoption Patterns by Groups (--continued--)

		Administrative Transformation	General Characteristics	Practical Examples
Group 3 Technological Innovation HIGH	#7 Technological Imitation LOW	Low (19)	The company is poor at imitating others, while excellent at innovating. However, the company has been unable to transform its organization to exploit its own technological innovations.	.
		Medium (20)	The company is poor at imitating others, while excellent at innovating. But, it is mediocre to average in transforming its organization to exploit its own technological innovations.	
		High (21)	The company is poor at imitating others, while excellent at innovating. The company is also excellent in transforming its organization to exploit its own technological innovations.	Tata Motors Tata capitalized upon automotive, information technology, and engineering capabilities to innovate in product design and tooling services
Group 3 Technological Innovation HIGH	#8 Technological Imitation MEDIUM	Administrative Transformation	General Characteristics	Practical Examples
		Low (22)	The company is mediocre to average at technical imitation, yet excellent at innovating. However, the company has been unable to transform its organization to exploit its own technological innovations and technological knowledge pioneered or exploited by others.	
		Medium (23)	The company is mediocre to average at technical imitation, yet excellent at innovating. The company is mediocre to average in transforming it organization to exploit its own technological innovations and technological knowledge pioneered or exploited by others.	
		High (24)	The company is mediocre to average at technical imitation, yet excellent at innovating, and is excellent in transforming it organization to exploit its own technological innovations and	Tata Motors The company used its knowledge to

			innovations pioneered or exploited by others.	enter into the automobile industry and its vast organizational and technological skills to convince the Ford Motor Company that Tata Motors was the best company to sustain high-
Group 3 Technological Innovation HIGH	**#9** Technological Imitation HIGH	Administrative Transformation	General Characteristics	Practical Examples
		Low (25)	The company is excellent at innovating and excellent at imitating, yet the company has been unable to transform its organization to exploit its own technological innovations and technological innovations pioneered and/or exploited by others.	
		Medium (26)	The company is excellent at innovating and excellent at imitating, yet the company is only mediocre to average at transforming its organization to exploit its own technological innovations and available market innovations.	
		High (27)	The company is excellent at innovating and excellent at imitating, and excellent at transforming its organization to exploit its own technological innovations and available market innovations.	Tata Motors The company used its knowledge to enter into the automobile industry and its vast organizational and technological skills to convince the Ford Motor Company that Tata Motors was the best company to sustain high-

Proposition #6: A company with *medium innovation and high imitation* desiring top-tier status or entry into the established global automobile industry can find opportunities on a broader scale across target market segments as long as the company possesses medium to high administrative abilities to transform its organizations to distinguish itself from the market leaders through incremental innovations and the ability to exploit of market knowledge in producing products that are almost identical in design and features to those of the leaders in market segment.

The automotive sector of Mahindra & Mahindra, Ltd. of the Mahindra Group falls into the category of *Medium Innovator_ Low to High Imitator* with *medium to high administrative capabilities*. Mahindra Group is a $6 billion Indian company that is among the top three tractor manufacturers in the world. Mahindra is the only tractor company in the world to have won the prestigious Japan Quality Award through high-level technical and administrative skills. Mahindra holds a leading position in the financial, electrical, steel, automotive, and information technology sectors of the Indian economy, giving the company key access to market sectors that are important for the development and distribution of automobiles. This has enabled Mahindra to build a strong base in technology, engineering, marketing, and distribution that it has successfully exploited. Mahindra's strength passenger car manufacturing comes in the development and production of highly-rugged sports utility vehicles. Here, Mahindra draws upon its own acquired knowledge in developing rugged vehicles for rough terrains in India and other parts of the world. It applies a combination of its own innovations for manufacturing to develop imitations in design and style of leaders in the SUV global market. Mahindra is entering other sectors of the passenger car market, but has been slow in matching the market leaders in style and design.

13.3 Group 3 – High innovation and low to high imitation

Proposition #7: A company with *high innovation and low imitation* desiring top-tier status or entry into the established global automobile industry can find opportunities in a niche market that puts a premium on innovation as long as the company possesses medium, but preferably, high administrative abilities to transform its organization to distinguish its product and service offerings from the leaders within its market segment.

Proposition #8: A company with *high innovation and medium imitation* desiring top-tier status or entry into the established global automobile industry can find opportunities on a broader scale within a targeted market segment where premium is placed on innovation as long as the company possesses medium to high administrative abilities to transform its organizations to distinguish its product and service offerings from the leaders in the market segment while offering products that are close to those of the leaders in design, features, and quality.

Proposition # 9: A company with *high innovation and high imitation* desiring top-tier status or entry into the established global automobile industry can find opportunities on a broader scale within the a targeted market segment with a premium on innovation as long as the company can apply superior organizational and management methods that will enable it to transform itself in such a way that the company is able to distinguish its product offerings in design, style, features, and quality from the market segment leaders while adding value to product and service offerings that are almost indistinguishable from leading competitors in the market segment.

One Indian home-grown company stands out above among its peers and falls into the category of *High Innovator_Low to High Imitator* with *high administrative capabilities*. This company is the Tata Group, owner of Tata Motors. Tata Group, through two of its companies, offers automotive services to the top players in the global automobile industry. Tata capitalized upon automotive, information technology, and engineering capabilities to innovate in product design and tooling services. The company used its knowledge to enter into the automobile industry and its vast organizational and technological skills to convince the Ford Motor Company that Tata Motors was the best company to continue to provide the design, quality, manufacturing, and marketing capabilities required to maintain and sustain high-end brands. Ford recently sold two of its top-end brands, Jaguar and Land Rover, to Tata which will carry those brands along with its others.

14. Managerial Implications

Global companies from newly industrialized nations like India that enjoy a robust innovative economy could benefit from applying the typology and the innovation adoption patterns presented in this paper. The above 27 complex configurations further detail options of imitation/innovation configurations in determining the nature of the strategic approach of competitors from emerging economies.

This conceptual framework also provides some practical managerial implications. First, automotive manufacturers go through steps of business growth. This growth occurs in terms of organizational learning and innovational capabilities. It is too easy for an ambitious firm to focus on growth in terms of economies of scale or financial aspects. Sound growth strategy requires careful consideration for growth strategies through learning and innovation. Our case illustrations suggest the vital importance of growth in organizational learning and innovation capabilities. Second, growth occurs not only through the expansion of a single organization but also through the expansion of its supply chain network. As an individual organization requires learning growth, so does supply chain network requires growth in terms of network learning and innovation capabilities. Therefore, supply chain growth strategy should include the strategic enhancement of network learning and innovative capabilities. It was beyond the scope of this paper to discuss fully in this aspect. However, the future paper will further examine this dynamic growth process of network learning and innovative capabilities.

The theoretical foundation provides an incubation in the study of Indian automakers that have practical implications for domestic automakers in emerging economies seeking entry into global markets where standards and open market knowledge increases organizational learning and make imitation and innovation competitively attractive and desirable. Establish market leaders operating in foreign countries can apply the configuration tables to better and more easily comprehend how potential domestic partners learn and later compete with the market leaders through various imitation and innovation configurations.

15. Summary and Conclusion

A research descriptive case study has been conducted that produced 3 tables consisting of a total of 27 variations in imitation-innovation-administrative configurations with 9 propositions in studying the opportunities of Indian automobile manufacturers seeking to match the leaders in the global automobile manufacturing industry. A theoretical framework was conceptualized for examining imitation and innovation through absorptive capacity within an organizational learning environment. The framework served as the foundation for studying the interrelationship between imitation and innovation impacted by administrative capabilities with emphasis on the movement from technological imitator to technological innovator. Propositions were derived to illustrate various states of existence within the imitation/innovation/administration transformation plane of existence. The study applied the diffusion of innovation theory of global practices supplemented by acquiring, assimilating, transforming, and exploiting technological knowledge through absorptive capacity within an organizational learning environment. Nine propositions are postulated from the configurations. There is the very low end of little existing knowledge where a company with low technological innovation, low technological imitation, and low administrative transformation is unable to transform its organization to capitalize upon the knowledge already available to the automobile manufacturing sector and lacks innovative capability. There is a high end where a company with high technological innovation, high technological imitation, and high administrative transformation capabilities is positioned to completely transform its organization.

Using the configurations a company can design a strategy that exploits its own technological knowledge and that its competitors in propelling itself to the top and with the potential to surpass established leaders. Companies can apply the configuration tables as a foundation for future work on building barriers that make it too costly for competitors and startups to imitate the company’s manufacturing products and practices (Rivkin 2000). A downside of this approach is that it could also slow industry growth and greatly inhibit organizational learning and creativity needed for innovation. Future work should focus on developing variable-based innovation/imitation hypotheses for empirical studies of companies within high-technology manufacturing industries in emerging economies.

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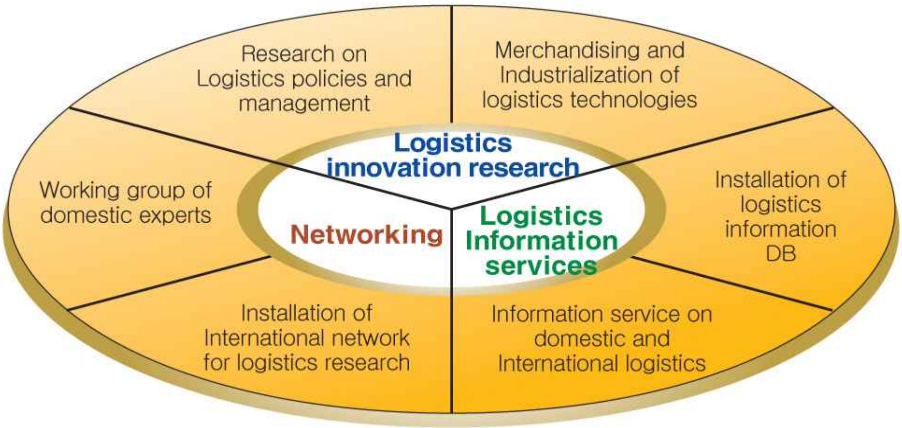
Institute of Logistics Innovation and Networking

Background of LIN Establishment

The center of economic gravity for maritime & port logistics has been shifting to Northeast Asia, especially to China which is one of the world's leading vast market and production center.
This rapidly changing environment may make Korean logistics industry suffering from tough challenges by Chinese logistics industry or provide it a new opportunity to jump up to a global level of logistics service providers. With this globalized trend, the challenge is beyond just national borders but needs the global network and cooperation between related parties and countries.
To break through this common challenge, LIN try to provide the opportunities for networking among various organizations and experts across all over the world for exchanging ideas and discussing about global logistics problems. LIN also seek to suggest future visions for Korean logistics industry based on diverse opinions collected from scholars and experts in all over the world. For that purpose, LIN try to form a working partnership within the network for interdisciplinary research and information sharing.

LIN Objectives & Functions



LIN Research Area

Maritime/ Port Policies

- Development of policies for efficient logistics in North-Eastern Asia
- Research on policies for improving competitiveness of maritime industries

Logistics System

- Research on design and operational methods for international logistics networks
- Research on manufacturng logistics including ship building industry, electronic industry, automobile industry, steel indusry, etc.
- Research on management technology for global logistics service providers

Logistics IT and Port Automation

- Methods for logistics innovation by using advanced IT including RFID and RTLS
- Technologies for automation of handling equipment
- Technologies for automated container erminals
- Industrialization and merchandising developed technologies

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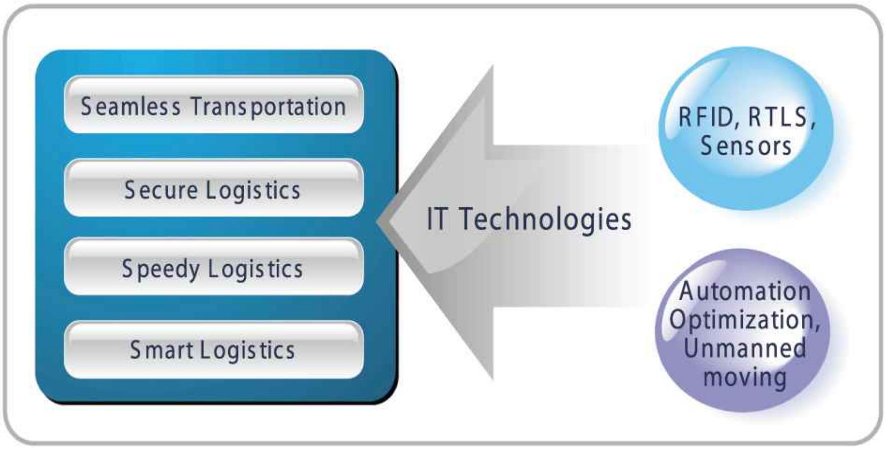
Institute of Logistics Information Technology

The Institute of Logistics Information Technology (LIT) is organized within the Pusan National University for doing the national research projects to develop the next generation of logistics information technology in Korea. Since 2004, the center has become one of the nation's leading institute dedicated to port and logistics's research and development.

LIT focuses on developing new technologies of port and logistics services in terms of IT-based technologies such as ubiquitous computing, RFID, RTLS, sensor networking, mesh-networking, optimization, automation, and intelligent logistics system. We will achieve a seamless transportation of logistics with smart and secure services.

Vision for LIT



Major Research Topics/Projects

RFID/RTLS/Sensors Middlewares

- RP, ALE, EPCIS, Reader Manager, EPCIS DS, stream data processing, BPM

- RP, LLRP, RM, ALE, EPCIS, EPCIS DS
- RTLS mIddleware
- Context-aware middleware for business
- Business process based on RFID middleware

Active Readers and Tags

- 433MHz active readers and tags, RTLS, mesh-networking

- 433MHz active readers and tags
- 2.45GHz RTLS readers and tags
- Mesh networking for RFID/RTLS readers
- smart tag for tag-to-tag communication

Smart Containal and Logistics Network

- Port operating system and logistics network

- Optimizing operation of container terminals
- Design evaluation of new container terminals
- Optimization of car carrier shipping
- Optimization of logistics network design and evaluation

Unmanned Navigation Vehicles

- Unmanned autonomous forklift

- Unmanned navigational moving vehicles
- Unmanned navigation lifting vehicles

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