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Factors Affecting Efficient Supply Chain Operational Performance of High and Low Technology Companies in Thailand[1]

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Abstract: This paper was about comparison between two groups of companies with different characteristics of technology intensity on their supply chain operational performance and potential factors that constitute efficient supply chain operational performance. Data collection was conducted for the manufacturing sector in Thailand where 407 participants evaluated themselves using an SCM Logistics Scorecard (LSC). The LSC focused on four decisive areas, namely, (i) corporate and inter-organization alignment, (ii) planning and execution capability (iii) logistics performance and (iv) IT implementation and management. The LSC score was compared between high and low technology groups to identify their strengths and weaknesses. Attempt was made to identify the potential factors leading to improvement of supply chain management for both groups of companies.
Keywords: Technology intensity; High technology industries; SCM, Supply chain operational performance; Factor analysis

1. INTRODUCTION

Business environment is characterized by unpredictability and changeability. With the growth of inter-network competition, individual business may no longer compete solely as independent company but must do as supply chains. Companies associated in the same network require efficient supply chain integration in order to optimize their collective performance. To this end, supply chain management (SCM) has been recognized as a key business competency. Moreover, numerous companies have started to

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appreciate that SCM plays a major role in building a sustainable competitive edge for their products in highly competitive markets (Jones, 1998).

Previous research works (Gunasekaran et al., 2004; Kuwaiti & Kay, 2000) have noted that measurement of supply chain performance can provide an important foundation in improving the efficiency of the entire supply chain. Performance measures can be used not only for driving continuous improvement of the business, but also for setting direction for the future strategies of the firms. Thus, appropriate and accurate performance measurement has been considered beneficial in improvement of SCM.

Supply chain performance and practices have been found to be different among companies with different supply chain characteristics. Chan (CHAN, 2003) compared supply chain performance in three different industries and found that in the electronic industry, achievement of quality, on-time delivery and cost were found to have the highest priority, whereas the logistics service industry concentrated on service accuracy and flexibility. Meanwhile, cost and visibility were found to be the main concerns in the textile industry. Similar findings were reported by Li *et al*. (LI et al., 2006) and Yaibuathet *et al*. (Yaibuathet et al., 2008) who observed that SCM performance and practices may be influenced by firms' characteristics. It can be concluded, herein, that one operational practice could not fit all supply chain characteristics. A beneficial practice in high technology group may not contribute significantly towards performance improvement in low technology group.

Thailand and other newly industrialized countries are now looking for efficient SCM as a means to enhance their competitiveness because their historical advantages of lower labor and raw material costs have faded away with progressive economic development. Accordingly, the aim of this research is to empirically measure supply chain operational performance in the Thailand manufacturing sector and to identify contextual factors which influence operational performance. In particular, the effect of technology intensity on its supply chain operational performance and its SCM approach will be examined. This study will mainly focus on the comparison between two groups of industry, namely, (i) high technology and (ii) low technology groups. The managerial approach or orientation to SCM may differ between the two groups of companies.

The findings from this study may provide insight into possible solutions for the firms who attempt to increase their operational performance via implementing SCM in their operations. Appropriate management model will be, therefore, introduced to the firms of different characteristics so as to accomplish their ambitions in improving their supply chain operational performance.

2. BACKGROUND AND RESEARCH HYPOTHESES

In this paper, an attempt has been made to analyze the level of operational performance and the performance structure which lead to improved supply chain performance in two groups of companies with different technology implementation level. High and low technology firms may convey satisfaction to customer by different approaches or they may manage their supply chain in a different direction. Carroll et al. (Carroll et al., 2000) defined that a high technology industry is a business where activities are heavily dependent upon innovation in science and technology. On the other hand, low-tech industry may involve with less advanced methods or equipment. Low-tech industry may be fabricated with a minimum of capital investment and the knowledge of the practice can be completely comprehended by a single individual, free from increasing specialization and compartmentalization. A classification of high and low-tech industry has been utilized in many research fields.

Several attempts have been made to classify the industry into high- and low-tech categories. One of the most well known concepts was provided by the Organization for Economic Co-operation and Development (OECD). OECD classified industries by technology implementation intensity, based on the level of different technology and knowledge intensity implemented in supply chain operation (2001). OECD classified industry types into four main categories by the level of technology/knowledge intensity, as shown in Table 1.

The classification concept of OECD has been employed as input for several researches. Carroll *et al*. (Carroll et al., 2000) use the classification concept of OECD (2001) to further categorize industries into high- and low-tech using the integration of R & D expenditure, R & D intensity, innovation rate, and technology endowment of the final product. It was further concluded (Carroll et al., 2000) that technology intensive sectors are more growth- inducting than low-tech sectors, therefore, policy emphasis should be placed on high-tech industries because they have a greater impact on growth. Anantana *et al*. (Anantana et al., 2009) applied the OECD classification concept to study the level of new product development (NPD) operational performance for different industrial category. It was revealed from this research that high-tech group performed better in terms of new product development. However, those high- and low-tech groups have different approaches that led to successful NPD.

Table 1: The categorization of industry by technology/knowledge intensity[6]

High-tech industries - Pharmaceutical - Office, accounting and computing machinery - Radio, television and communication equipment - Medical, precision and optical instruments - Aircraft and spacecraft	**Medium-Low tech industries** - Coke, refined petroleum products and nuclear fuel - Rubber and plastics - Basic metals - Fabricated metal products
Medium-High tech industries - Electrical machinery and apparatus - Motor vehicles, trailers and semi-Trailers - Chemicals excluding Pharmaceuticals - Railroad and other Transport Equipment - Machinery and Equipment	**Low-tech industries** - Food products, beverage and tobacco - Textiles, fur and leather - Wood, paper, printing and publishing - Furniture, other manufacturing and recycling

Furthermore, previous researches have attempted to compare high and low technology groups in many aspects. Hatzichronoglou *et al*. (Hatzicgronoglou, 1997) argued that firms which are technology-intensive innovate more, win new markets, and use available resources more productively. Some researchers proposed about the role of technology in supply chains management, namely, Autry *et al*. (Autry et al., 2010) identified that supply chain technologies could be implemented as the tools or techniques in order to effectuate integrated supply chain management within or across organizational boundaries. The range from low-level operational technologies such as bar coding, through mid-range tactical technologies (i.e., warehouse management systems, transportation management systems) are designed to enhance logistics and supply chain functionality through strategic level. These technologies and systems could further establish long-term supply chain process integration and planning, and inter-firm relationships (Autry et al., 2005).

Assessing the impact of specific information technology (IT) usage is important for improving plant operations because building IT-based competence is an ongoing process that requires incremental investments in new IT applications in order to improve the effectiveness and efficiency of operational processes at different levels (Heim & Peng, 2010). Moreover, Wilbon (Wilbon, 2002) suggested that technology literacy at the executive level is not only critical to increase operational efficiency but also to firm survival.

As far as previous researches concerned, none of those findings mentioned about supply chain operational performance between high-tech and low-tech industry. This research has attempted to rectify the limitation of previous work by exploring high-tech and low-tech groups in terms of their supply chain operational performance and approaches to successful SCM.

[6] Organization for Economic Co-operation and Development. . (2001). STI Scoreboard, Paris.

From the previous definitions and findings, it can be observed that high technology intensity group may tend to focus their supply chain operations on precision information sharing, knowledge management, and a personnel training more than the low intensity group does. Therefore, the first hypothesis is derived.

Hypothesis 1*: The LSC score from high intensity group is higher than that obtained from low intensity group in terms of average total score and four assessment area score.*

It has been further revealed (CHAN, 2003; LI et al., 2006; Yaibuathet et al., 2008; O'Regan & Sims, 2008) that supply chain performance and practices have been found to be different among companies with different supply chain characteristics and SCM performance and practices may be influenced by firms' characteristics. In addition, Anantana *et al.* (Anantana et al., 2009) proved that high and low technology group has different approaches leading to successful new product development based on their NPD scorecard framework. Similar finding should be observed in the context of successful supply chain management. Second hypothesis has been derived herein;

Hypothesis 2*: Performance structures in building successful SCM are expected to be different between high and low intensity groups due to their characteristic dissimilarity.*

3. RESEARCH METHODOLOGY

3.1 Data collection process and tools

The SCM logistics scorecard (LSC) was employed in this research as a data collection tool. The scorecard was developed by the Tokyo Institute of Technology in collaboration with the Japan Institute of Logistics Systems (Arashida et al., 2004). The element of LSC and its superiority over other scorecard were previously discussed (Yaibuathet et al., 2007). The LSC involves 22 assessment items based on four fundamental areas: (1) Corporate strategy and inter-organization arrangement (2) Planning and execution capability (3) Logistics performance and (4) IT implementation and management. Each assessment item is allocated into five-level rating from 1-5. A detailed description of each level is given, with the 5^{th} level indicated the best practice for each item. This approach could reduce bias among survey respondent and simplify self-assessment process to be more precise, since clear information has been provided at each level in the scorecard.

The LSC was adopted in many researches; (i) to compare supply chain operational performance and influential factors for manufacturing sectors in Japan, China and Thailand (Yaibuathet et al., 2007), (ii) to analyze the impact of institutional environment towards the development of supply chain management (Yaibuathet et al., 2008), and (iii) to identify impact of information technology and SCM organization strategy on corporate financial performance (Yaibuathet et al., 2010). The context of previous published reports only offer the general idea of the Thai manufacturing sector but not for the detailed classification of the company using technology intensity like this work.

The LSC has been introduced to the Thai manufacturing sector and to logistics service providers since 2006, as a result of expanding LSC research to international comparison (Yaibuathet et al., 2007). Since then, data collection has been carried out and continuously updated on a yearly basis to detect changes and improvement of participants. Two approaches of data collection were conducted; direct interview of high leveled managers by the research team and self-assessment by each company. Therefore, the total score with a maximum of 110 from 22 assessment items were collected. In using the LSC, feedback reports were conveyed back to the companies as an incentive for data provision. The report was used to inform company's status of competitiveness over its rivals. This process could possibly maintain the reliability level of the data achieved.

3.2 Data analysis

Data analysis was carried out after the data collection process. Initially, companies were categorized based on technology intensity according to the definition of industry classification of OECD (2001). To simplify matters, we merge 'medium high-tech industries' and 'high-tech industries' into high-tech group and 'medium low-tech industries' and 'low-tech industries' into a low-tech group.

Reliability analysis was then conducted to verify the reliability of the LSC as a data collection tool for this research. After that, initial comparison was made on total score, area score and assessment item score. This approach could identify the level of operational performance and indicate the strengths and weaknesses of each group.

A factor analysis was subsequently undertaken to clarify performance structure of both groups. The result from this analysis could indicate the significant operations required for each group to increase their supply chain operational performance.

4. RESULTS AND DISCUSSION

4.1 Comparative results: high and low intensity category

The initial comparison in this section was performed in this section with the purpose of verifying hypothesis 1, that the LSC score from high intensity group is higher than that obtained from low intensity group in terms of average total score and four assessment area score.

In this research, 407 participating companies have been classified into two main groups, based on their technology intensity characteristic, namely, high technology and low technology. The classification was conducted in accord with the definition of industry classification of OECD (2001). High technology category consisted of pharmaceutical, office, accounting and computing machinery**,** radio, television and communication equipment**,** medical, precision and optical instruments**,** aircraft and spacecraft**,** electrical machinery and apparatus**,** motor vehicles, trailers and semi-trailers**,** chemicals excluding pharmaceuticals**,** railroad and other transport equipment**,** machinery and equipment. Low technology included coke, refined petroleum products and nuclear fuel, rubber and plastics, basic metals, fabricated metal products, food products, beverage and tobacco, textiles, fur and leather, wood, paper, printing and publishing, furniture, other manufacturing and recycling. According to the classification, 116 companies were categorized as high intensity and 291 companies were in the category of low intensity. The data attributed of total score between high and low intensity groups are given in Table 2 and Fig. 1. The results indicated that the total score of both groups are markedly different, however, the degree of variation between two groups was slightly different. Reliability analysis of the LSC was conducted after company classification. The results are shown in term of Cronbach's coefficient alpha for 22 items at 0.931 and 0.928 from high and low intensity groups, respectively. These results indicate high reliability of the LSC as a data collection tool for this research.

Table 2: Data attributes of total score between high and low technology group

	High technology	Low technology
Number of data	116.00	291.00
Mean	68.14	61.61
Median	69.23	61.50
Mode	52.00	66.00
Standard Deviation	14.44	14.28
Variance	208.57	203.92
Range	66.00	73.00
Minimum	37.00	28.00
Maximum	103.00	101.00

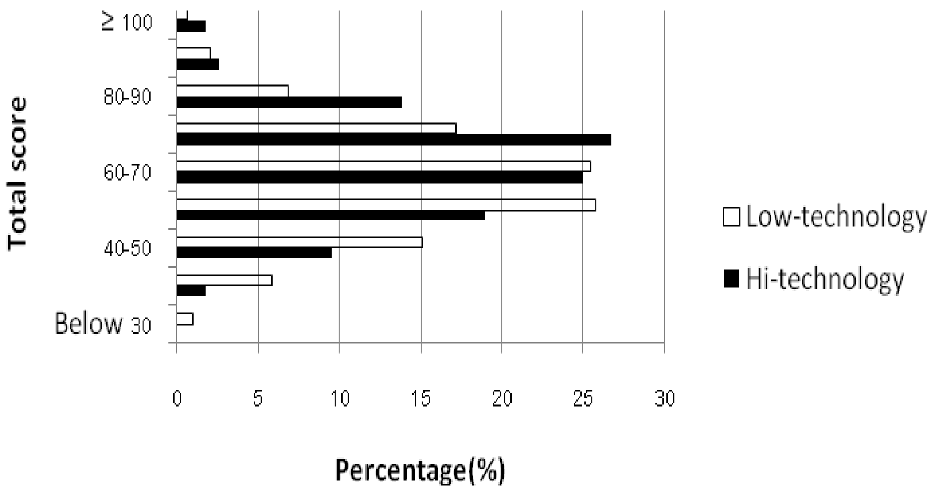

Fig. 1: Distribution chart of total score between high and low intensity categories

Initial comparison of four assessment areas between high and low intensity groups revealed that high technology group performed better than low technology group in most areas which are; area 1) Corporate and inter-organization alignment, 2) Planning and execution capability, 3) Logistics performance and 4) IT implementation and management. The results of assessment area comparison on LSC score are again displayed in Table 3.

Further analysis has been conducted to investigate 22 assessment items which affected the overall area scores, shown in Fig. 2. Considering corporate and inter-organization alignment (area 1), It was observe that the data of high technology industries have a higher score than low technology industries in any view of comparison. In view of area 2, high technology group focuses significantly better on nearly all items except for the item 2-4; the control and tracking of inventory, the score of high-tech is slightly better than low-tech group. Considering area 3, notably higher score have been detected in only 4 items which are (Item 3-1) Just-In-Time, (Item 3-4) Delivery performance and quality, (Item 3-5) Supply chain inventory visibility & opportunity costs, and (Item 3-6) Environmental activities. For IT implementation and management (area 4), high technology group outperformed low technology group in the following assessment items; (4-3) Effective usage of computers in

Table 3: Average scores of four areas between high and low intensity groups

Assessment Area	High Technology		Low Technology		p-value
	Average	S.D.	Average	S.D.	
1) Corporate and Inter-organization alignment	3.300	0.681	2.897	0.749	0.000**
2) Planning and execution capability	3.190	0.710	2.861	0.765	0.000**
3) Logistics performance	3.010	0.787	2.771	0.702	0.003**
4) IT implementation and management	2.930	0.806	2.685	0.787	0.006**

[1] *= 5% significant, **= 1% significant

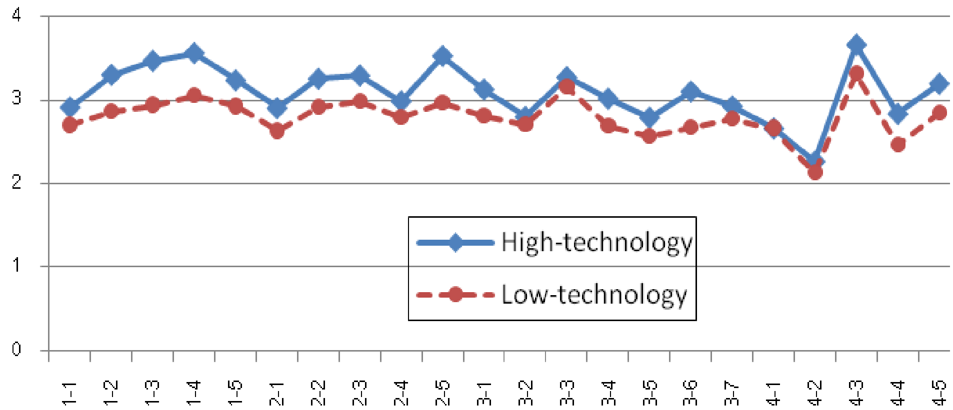

Fig. 2: Average score in each assessment item between high and low technology groups

operations and decision-making, (4-4) Open standards and unique identification codes and Decision-making systems and (4-5) Support to supply chain partners. The result from initial comparison on LSC average score appeared to support Hypothesis 1 in most assessment areas.

4.2 Performance structures

A factor analysis was carried out during this study in order to verify Hypothesis 2, that companies with different level of technology implemented should have different factor structure that constitute efficient supply chain operational performance. The factor analysis was conducted separately with the data from two groups categorized by technology implementation intensity, 116 samples from high technology and 291 from low technology firms.

The initial solution was determined using principal axis factoring with the constraint of an eigen-value of more than one. Result from the first group signified that four factors were extracted with the cumulative contribution rate of 49.67% while three factors were obtained from high technology group with the cumulative contribution rate at 46.68%. In order to simplify the factor for comparisons between the two groups, the number of extracted factor from the low technology group was limited to three during the principal axis factoring analysis. Therefore, the contribution rate of this group was reduced to 44.08% and three factors were obtained, being equal with the result from high technology group.

Promax rotation was then employed because the correlations among three factors were assumed and this method was capable of simplifying the factor analysis. As a result, the pattern matrixes of high and low intensity groups are given in Table 4. The larger factor loading of more than 0.4 indicated strong relationship between each item and factors as highlighted in the pattern matrix table. From the high technology group, three factors were determined as followed:

Factor 1: SCM flexibility & logistics performance

Factor 2: IT utilization

Factor 3: Logistics strategy and information sharing

With respect to the results from low technology group, three factors were also discovered:

Factor 1: IT utilization and logistics cost

Factor 2: SCM flexibility and responsiveness

Factor 3: Information sharing with upstream and downstream partners

Table 4: Pattern matrix of 116 high technology and 291 low technology companies

	High technology			Low technology		
	Factor			Factor		
	1	2	3	1	2	3
1-(1) Corporate strategy regarding logistics and its importance	-0.0397	0.2179	0.5996	0.1909	0.1938	0.3834
1-(2) Definition of supplier contract terms & degree of information sharing	-0.0442	0.0714	0.6961	0.0625	-0.0020	0.6945
1-(3) Definition of customer contract terms & degree of information sharing	-0.0270	0.0166	0.6965	0.0627	-0.0361	0.6003
1-(4) System for measurement and improvement of customer satisfaction	0.4986	0.0464	-0.1106	-0.1639	0.4827	0.3465
1-(5) System for employee training and evaluation	0.4070	0.0416	0.0787	-0.0247	0.3690	0.3534
2-(1) Strategies for optimizing logistics system resources based on design for logistics	0.0842	0.1096	0.5877	0.0595	0.3501	0.3529
2-(2) Understanding of market trends & accuracy of demand forecasting	0.6063	-0.2659	0.2550	-0.0462	0.5855	0.2083
2-(3) Accuracy and adaptability of SCM planning	0.6547	-0.0444	0.1755	-0.0179	0.8002	-0.0701
2-(4) Control and tracking of inventory (product/parts/WIP): accuracy and visibility	0.6694	-0.0560	0.1071	0.1963	0.5741	-0.0206
2-(5) Process standardization and visibility	0.5626	0.1289	-0.0405	-0.0330	0.5737	0.2652
3-(1) Just-In-Time	0.5479	-0.0821	0.3186	0.3750	0.4204	-0.1211
3-(2) Inventory turnover & cash-to-cash cycle time	0.5177	0.2889	-0.0733	0.4296	0.2617	-0.0499
3-(3) Customer lead time (from order placement to receipt) and load efficiency	0.4850	-0.0123	0.2761	0.4238	0.3021	-0.1257
3-(4) Delivery performance and quality	0.7535	0.0132	-0.0686	0.4064	0.4199	-0.1530
3-(5) Supply chain inventory visibility & opportunity costs	0.5057	0.2771	-0.1431	0.5213	0.1702	0.0354
3-(6) Environmental Activities	0.6645	0.0430	-0.0340	0.2483	0.3390	0.0782
3-(7) Total Logistics Cost	0.5086	0.4016	-0.0641	0.6675	0.0928	-0.0290
4-(1) Electronic data interchange (EDI) coverage	0.1571	0.6309	0.0351	0.6751	-0.1159	0.1397
4-(2) Usage of bar coding / automatic identification and data capture (AIDC)	-0.0843	0.5035	0.2297	0.5526	-0.1740	0.3167
4-(3) Effective usage of computers in operations and decision-making	0.0723	0.6118	0.0139	0.4402	-0.0124	0.2207
4-(4) Open standards and unique identification codes	-0.1383	0.7957	0.0333	0.4727	-0.0511	0.2344
4-(5) Decision-making systems and support to supply chain partners	0.0897	0.4591	0.2062	0.3190	0.1240	0.2822

The factor analysis results appeared to support Hypothesis 2 that the performance structures of companies with different technology intensity level were different. The observation from high technology group implied that they considered SCM flexibility issue and responsiveness issue at the most important level. However, similar finding was found in the low tech group with the second hierarchy.

In terms of IT utilization, high-tech group considered this issue separately, while the IT utilization seemed to affect logistics cost in low-tech group. Elucidation could be made to explain the findings in high-tech group that IT only played a role independently as an enabler firms to achieve higher SCM performance. The result also indicated that low-tech firms placed IT utilization and its logistics cost at the first priority. It could be further explained that low-tech group may start to realize that appropriate IT implementation could positively influence SCM operations including reducing overall logistics cost for the firms.

Considering information sharing with upstream and downstream partners, appropriate strategies seemed to be placed to efficiently perform information sharing with supplier and customer in the high-tech cluster. However, similar connection was not observed in low-tech group.

5. CONCLUSIONS

In this work, two groups of firms with different level of technology intensity have been compared. The LSC has been utilized as a data collection tool. Accumulated data from both high and low technology groups were compared for each assessment item. It was found that the average scores were markedly different in most areas. Therefore, it was clearly seen that high intensity group performed significantly better than low intensity group. The "performance structure" of both groups was determined from factor analysis. The finding revealed that those potential factors which constitute the efficient supply chain operational performance in the both high and low technology intensity groups were different in terms of IT utilization, SCM flexibility and responsiveness.

With respect to low intensity group, they believed that the SCM responsiveness could strengthen and improve customer satisfaction. The elucidation could be made that when the company has a good performance in SCM responsiveness the related system such as customer satisfaction measurement and collaboration level is also established to complete the supply chain system. From the observation of both groups, it was conclusive that high and low technology companies may develop different practices to achieve what they aim for.

Since this paper only examined the performance structure of each group, it was recommended that future work should include the financial data of participated companies in the analysis to identify which SCM factors have positive contribution on the financial indicators. This may provide implication to different industry classification such as product complexity where two groups of companies with different levels of product complexity are compared. Companies with different business characteristics may wish to implement appropriate supply chain practices to improve their financial performance.

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