Achieving Product Quality Performance: The Roles of Supply Chain Integration and Information Technology

Sakun Boon-itt

***Abstract*—The purpose of this paper is to increase the understanding of supply chain integration implementation through a selection of appropriate types of information technology (IT). Survey response from production/purchasing managers in 111 Thai suppliers and automakers in the automotive industry were analyzed to test the effect of types of information technology on the relationship between supply chain integration and product quality performance. Univariate analysis was used to analyze the data. The results suggest an interaction effect of collaboration/decision support information technology to enhance the effectiveness of supply and customer integration. The findings of this study provide framework linking supply chain integration strategies and product quality performance leading to valuable insights into how different information technology types can be configured to enhance product quality.**

I. Introduction

In an increasingly competitive global marketplace, most firms are competing with a high level of market pressure worldwide. In the context of supply chain management, it is necessary for industry to develop supply chain networks of activities involved in producing and delivering final products from suppliers to end customers. A prerequisite for successful supply chain management (SCM) is the integration of information flow, material flow and all the business processes within a supply chain network. Effective and efficient supply chain management requires integrated business processes that go beyond purchasing and logistics activities. Effective supply chain integration among entities in a supply chain has currently come to play a major role in competitive advantages, especially in terms of product quality [1].

However, it is important to recognize that one of the primary prerequisites for successful supply chain integration is the implementation of appropriate information technology (IT). In other words, advances in information technology have had a huge impact on the integration of supply chain processes. Information Technology could improve the interconnections in the supply chain by coordinating the links to the outside and increasing product quality. Little research has been conducted to address the type of information technology involved in determining the implementation of supply chain integration. In this case, the researcher's objective is to discover whether or not product quality requires different types of information technology in implementing supply chain integration.

In the following section, the existing literature is reviewed in order to build a theoretical background for developing hypotheses. Section III describes the questionnaire design and data collection. The collected data have been examined by using univariate analysis. The results of the statistical analysis are explained in Section IV, while section V concludes the findings and contributions of this study. The implications and limitations of the study are also identified with suggestions for future research.

Manuscript received May 26, 2011; revised September 12, 2011.

Sakun Boon-itt is with the Department of Operations Management, Thammasat Business School, Thammasat University, Bangkok, Thailand (E-mail: sboonitt@tu.ac.th)

II. Literature Review And Hypotheses Development

A. Supply Chain Integration

In today's business environment, integration among organizations in the form of cooperation and coordination has been recognized for years as a problem-solving strategy for business systems. Cooperation focuses on the need to integrate business functions, and views these functions as interdependent parts in responding to customer needs. With organizational integration theory, for example, reference [2] studied contingency models of integration and found that both differentiation and integration between departments were needed for organizations to be successful in a turbulent environment.

The traditional supply chain, which relies on discrete information flows, can create three major disadvantages. First, forecast accuracy decreases with each step back in the supply chain due to the increase of demand uncertainty. This, therefore, results in excess inventory for manufacturers and retailers. Second, the traditional supply chain reacts to demand changes very slowly. If a particular item suddenly starts to sell out, replenishment orders go to retailers' distributions centers until minimum inventory levels are reached and then orders are placed with the manufacturer. As a result, the traditional supply chain does not communicate underlying customer demand trends and, therefore, tends to create under-supply. The third disadvantage is that the traditional supply chain treats all items in very much the same manner. Common material handling approaches are used across high and low volume items. Consequently, opportunities are missed for reducing supply chain operating costs. For these disadvantages, success is no longer measured by a single transaction. Rather, competition is evaluated as a network of cooperating companies competing with other firms along the effective supply chain.

Within the requirements of the new competition, an increase in the level of partnership among businesses is required. Reference [3] summarizes the development of

partnership into three stages from cooperation to coordination and then to collaboration. Cooperation, whereby firms exchange some essential information and engage some suppliers in long-term contracts, has become the threshold level of interaction. In other words, cooperation is a starting point for supply chain management and has become a necessity for businesses. However, it is not a sufficient condition. The next stage is coordination whereby specified materials and information are exchanged among partners to make seamless linkages between and among trading partners. Again, this process is important, but it is not a sufficient condition for integration due to deficient integrated information flow.

At the highest level, collaboration, known as supply chain integration, requires that all trading partners throughout the supply chain become integrated into their suppliers'/customers' processes. For example, supply chain partners cannot only plan the future production scheduling together, but they also share technology as well as future designs, product requirements and long-term strategic intentions. The movement from coordination to collaboration or integration requires high levels of trust and information sharing among partners. Reference [4] identifies two interrelated forms of integration regularly employed by manufacturers. The first type of integration involves integrating the forward physical flow of delivery between suppliers, manufacturers and customers. The second type of integration involves the backward integration of information technologies and the flow of data from customers to suppliers. Reference [5] classifies supply chain integration into three levels from functional integration to internal and external integration. However, this study focuses only on internal and external integration because the functional integration is claimed as a basic requirement all firms should implement and achieve.

1) Internal Integration

To best support customer requirements at the lowest total system costs, internal integration represents the integration of all internal functions from material management to production, sales and distribution. Internal integration is characterized by full systems visibility from distribution to purchasing, and required integration across functions under the control of the firm to achieve customer satisfaction. In practice, it means special attention must be given to the interface between functional areas, such as procurement, production, logistics, marketing, sales and distribution [6].

2) External Integration

External integration involves full supply chain integration, which extends the scope of integration outside the company to embrace suppliers and customers [5]. A review of the external supply chain integration literature reveals two major areas of focus: (1) customer integration and (2) supply integration.

For supply integration, integration back down to the suppliers represents a change in attitudes from conflict to cooperation starting with product development, supply of high quality products, process and specification change information, technology exchange and design support. Reference [7] defines supply integration as obtaining frequent deliveries in small lots, using single or dual sources of supply, evaluating alternative sources on the basis of quality and delivery instead of price and establishing long-term contracts with suppliers.

In terms of customer integration, the firm will penetrate deeply into the customer organization to understand the product, culture, market and organization so it can respond rapidly to customer needs and requirements. The important concept of customer integration is based on the improvement of demand planning and visibility in supply chains [8].

B. Strategic Information Technology in Supply Chain Integration

The benefits of information technology (IT) on supply chain integration are pinpointed in many studies [9], [10]. For instance, reference [11] suggests that the use of information technology is to share data between members in supply chain so a virtual supply chain can be formed. In addition, reference [9] outlines information technology as a key in supporting firms creating strategic advantage by enabling centralized strategic planning. Having viewed functional roles of IT in supply chain integration, the following classification can be adopted [12]: 1) *Transaction execution*: reducing the friction in transactions between members through cost-effective information flow/communication (telephone, fax, e-mail, and internet); 2) *Collaboration and Coordination*: providing a cost-efficient way to join firms and their partners in the supply chain (EDI and MRP); and 3) *Decision Support*: providing assistance in managerial decisions (e-businesses, ERP and SCM software).

C. Hypotheses Development

According to [11], product quality could result from the implementation of integrated supply chain management practices such as the sharing reliability of data both within and across firms in the production network. In addition, the adoption of different information technology tools will facilitate the implementation of demand integration practices. Reference [12] also suggests that the close relationship of IT and supply chain integration sometimes makes it hard to examine which types of IT contribute to supply chain integration. For instance, could the product quality performance have been achieved through EDI by sharing information via e-mail or fax? Therefore, the effect of supply chain integration on product quality may indeed be different under various models, depending on the type of IT. Therefore, the following hypotheses were proposed:

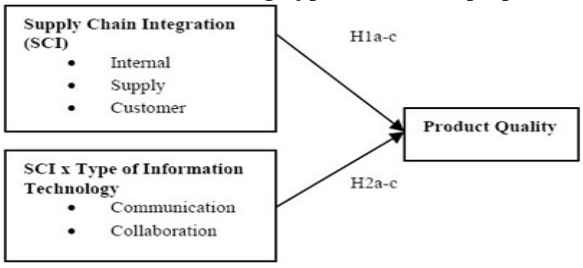

Fig 1. Conceptual Framework

Hypotheses 1a-1c: The levels of supply chain integration, (a) internal, (b) supply and (c) customer integration, will affect product quality.

Hypotheses 2a-2c: The levels of supply chain integration, (a) internal, (b) supply, and (c) customer integration and

type of information technology, will have an interaction effect on product quality.

III. Methodology

A. Constructs and Survey Instrumentation

The instrument used to test the hypotheses was a mail survey. This study used a five-point Likert scale for three constructs of main factors (supply chain integration level), one dependent variable (product quality), and interaction effect (information technology) to draft a questionnaire. This drafted questionnaire was the pre-tested with academics and practitioners to check its content validity, after which it was modified accordingly. The modified questionnaire was pilot tested to examine its suitability for the target population before large-scale mailing.

B. Data Collection

In this study, data was obtained through a mail survey to production or purchasing managers with knowledge of supply chain management practices. These respondents were asked to rate their firms relative to their understanding of supply chain integration and product quality performance in their respective plants. The unit of analysis in this study was limited to plant level. The survey was restricted to the automotive industry in Thailand because the automotive sector has been a leader in implementing supply chain management strategies in Thai industry.

In the data collection process, the questionnaire was forwarded to 403 qualified first-tier suppliers and automakers in Thailand with a cover letter indicating the purpose of the study. After six weeks, 91 completed responses were received followed by another 20 questionnaires returned in the second wave. A total of 111 responses were returned for a response rate of 27.5 %.

IV. Data Analysis

A. Data Reduction

The objective of the data reduction process is to bring all six dimensions, in which each dimension consists of two to four items, to be employed in the composite scores for the study. However, it is important to ensure that all dimensions have satisfactory results in terms of construct validity and reliability. For this reason, factor analysis with principal components and Varimax rotation was used to test validity and reliability which were assessed by using Cronbach's alpha.

B. Supply Chain Integration

As the independent variable, the internal integration factor explained 66.3% of the variance with all four items loaded on a single factor with loads ranging between 0.778 and 0.854. The scale for Cronbach's alpha was 0.83. In addition, the factor of supply integration explained 72.2% of variance with all three item loads ranging from 0.814 to 0.882. The scale for Cronbach's alpha was 0.808. Apart from internal and supply integration, the factor of customer integration explained 68.85% of the variance with all three items loading between 0.768 and 0.880. The Cronbach's alpha for this factor was 0.765.

C. Information Technology

Based on the results of the factor analysis, there are two factors for types of information technology in this study. First, the *"communication/information flow"* factor explained 48.23% of the variance with two items (e-mail and internet) loaded on a single factor with loads ranging from 0.892 to 0.919. The scale for Cronbach's alpha was 0.87. Second, the dimension of *"collaboration/decision support"* explained 26.32% of the variance with five items (EDI, MRP, MRPII, ERP, and SCM software) loading between 0.601 and 0.903. The Cronbach's alpha for this factor was 0.774.

D. Product Quality

The dependent variable in this study was product quality. According to the same recommended value for testing scale validity and reliability used in the previous constructs, the cumulative percentage of variance explained that the delivery construct was well in excess of 50% with a showing of 71.87%. In addition, reliability was tested using Cronbach's alpha for each factor. The reliability of product quality construct showed a satisfactory score at 0.899.

E. Hypothesis Testing

To investigate whether or not product quality depends upon the level of supply chain integration and the interaction effect of information technology, the Analysis of Variance (ANOVA) technique was used with internal integration, supply integration and customer integration as the main effects in addition to types of information technology as the interaction effects. Mean splits were used to classify all independent variables into higher and lower levels. ANOVA is an appropriate technique for avoiding the problem of multicollinearity in regression analysis and is used to measure the differences among dependent variables based on a set of categorical independent factors [13]. Table 1 summarizes the ANOVA results for product quality performance as the dependent variables, along with the F-test results and significance level for the main effect and interaction effect.

V. Results and Discussion

It was noted that only internal integration turned out to be a highly significant main effect (statistical significance level: 0.01) on product quality performance. Therefore, the findings demonstrated support only for Hypothesis 1a. However, when firms use information technology (IT) in implementing external integration, the findings indicate an interaction effect that hypothesizes between supply integration and IT in "collaboration/decision support" (statistical significance level: 0.05), but not for IT in "communication/information flow". In the same way, the findings also show an interaction effect between customer integration and IT in "collaboration/decision support" (statistical significance level: 0.05), but not for IT in "communication/information flow". Therefore, Hypotheses 2b and 2c are supported.

Several interesting findings resulted from this study. These findings provide a confirmation of previous studies in that firms operating in highly collaborative internal practice are likely to have excellent performance in product quality.

One explanation may be that, since firms can share essential information within their own units, they are able to reduce their non-value added activities (waste) among departments, thereby leading to increased product quality. However, it is interesting to note that implementing external integration (either on the supply side or customer side) does not affect product quality performance. A more plausible explanation may be that external integration levels alone are insufficient for reaching a higher level of product quality performance in the Thai automotive industry and should be accompanied by other facilitating factors, such as information technology.

The findings also support the use of information technology (IT) based on different levels of information technology in facilitating supply chain integration. As shown in Table 1, product quality performance is not influenced by the interaction effect between supply chain integration and IT in terms of "communication/information flow". Rather, IT needs to be able to collaborate on supply chain processes with suppliers or customers. In other words, firms may require IT for "collaboration/decision support" to maintain collaborative planning and information sharing within the supply chain network. These findings support the work of reference [14] by indicating that the adoption of an advanced IT for supply chain integration can improve product quality due to the interconnectedness enabled by collaboration and decision support from IT. As a result, the isolated decision making process from upstream suppliers to downstream customers is becoming more intertwined. In fact, reference [15] indicates that the purpose of IT used in supply chain is to facilitate integrated and/or coordinated decision-making in supply chains. Moreover, collaboration/decision support from IT can help firms reduce transaction costs in the supply chain with increased responsiveness to customer needs [10], [11].

TABLE 1: ANOVA RESULTS

	Product Quality	
	F	**Sig.**
Supply Integration	2.15	0.15
Internal Integration	6.80**	0.01
Customer Integration	0.79	0.38
Supply Integration x IT (Communication)	0.37	0.54
Internal Integration x IT (Communication)	1.09	0.30
Customer Integration x IT (Communication)	0.02	0.89
Supply Integration x IT (Collaboration)	5.35*	0.02
Internal Integration x IT (Collaboration)	0.28	0.60
Customer Integration x IT (Collaboration)	3.45*	0.05

** $p < 0.01$; * $p < 0.05$

In terms of research contributions, this study highlights the importance of information technology and supply chain integration on product quality. Furthermore, the findings provide managerial insights about specific integration practices and types of information technology that are effective in product quality. Managers can, therefore, ask about the types of information technology implemented in their firms in order to focus on the right supply chain integration-information technology strategy. The findings also provide additional support by building on previous literature about the value of supply chain integration and information technology mostly conducted in Western countries. The findings of the present study offer confirmation from a different context as an empirical study of the effects of information technology and supply chain integration in the Thai automotive industry.

REFERENCES

[1] Basnet, C., Corner, J., Wisner, J. and Tan, K.C., "Benchmarkingsupply chain management practice in New Zealand," *An International Journal of Supply Chain Management*, vol. 8, no.1, 2003, pp. 57-64

[2] Lawrence, P. & Lorsch, J., Organization and environment: managing differentiation and integration, 1967, Irwin, Illinois

[3] Spekman, R.E., Kamauff, J., and Myhr, N., An empirical investigation into supply chain management: a perspective on partnerships, *An International Journal of Supply Chain Management, vol.*3, no.4, 1998, pp. 53-67

[4] Morash, E.A. and Clinton, S.R., "Supply chain integration: customer value through collaborative closeness versus operational excellence", *Journal of Marketing Theory and Practice*, vol. 6, no.4, 1998, pp. 104-120.

[5] Steven, G.S., "Integrating the supply chain", *International Journal of Physical Distribution and Material Management*, vol. 19, no. 8, 1989, pp. 3-8

[6] Birou, L.M., Fawcett, S.E. and Magnan, G.M., "The product life cycle: a tool for functional strategic alignment", *International Journal of Purchasing and Materials Management*, vol. 34, no.2, 1998, pp. 37-51.

[7] Handfield, R.B., "A resource dependence perspective of just-in- time purchasing", *Journal of Operations Management*, vol. 11, 1993, pp. 289-311.

[8] Fisher, M.L., Hammond, J.H. & Obermeyer, W.R., "Making supply meet demand in an uncertain world", *Harvard Business Review*, vol.72, no.3, 1994, pp.83-93.

[9] Bowersox, D.J. & Daugherty, P.J., "Logistics paradigm: the impact of information technology", *Journal of Business Logistics*, vol.16, no.1, 1995, pp. 65-80.

[10] Muller, M. & Seuring, S., "Reducing information technology- based transaction costs in supply chains", *Industrial Management& Data Systems*, vol. 107, no.4, 2007, pp. 484-500.

[11] Lin, F., Huang, S. & Lin, S., "Effect of information sharing on supply chain performance in electronic commerce", *IEEE Transactions on Engineering Management*, vol. 49, no.3, 2002, pp. 258-268.

[12] Auramo, J., Kauremaa, J. & Tanskanen, K.,"Benefits of IT in supply chain management: an exploratory study of progressive companies", *International Journal of Physical Distribution and Logistics Management*, vol.35, no.2, 2005, pp. 82-100.

[13] Hair, J., Ronald L. T., Anderson, R.E., & Black, W. . *Multivariate Data Analysis*, Prentice-Hall, 1998, USA.

[14] Wu, F., Yeniyurt, S., Kim, D. & Cavusgil, T., "The impact of information technology on supply chain capabilities and firm performance: A resource-based view", *Industrial Marketing & Data Systems*, vol. 107, no.4, 2007, pp. 484-500.

[15] Vakharia, A.J. 2002, "E-business and supply chain management", *Decision Science*, vol.33, no.4, pp. 495-504.

Dr Sakun Boon-itt received his PhD in Management of Technology (Operations Management) from Asian Institute of Technology. He is currently an Assistant Professor at the Department of Operations Management, Thammasat Business School, Thailand. He has published many papers in international journals, including conference papers.