Seoul Journal of Business
Volume 13, Number 2 (December 2007)

The Characteristics of Information Systems Utilized in Supply Chain Management

Soo Wook Kim*
Seoul National University
Seoul, Korea

Abstract

In this paper, in order to derive the utilization priority of functional information systems utilized in the process of supply chain integration and suggest a set of advisable strategies for IS utilization, the relationship analysis among three major functions (Creation functions, Connection functions, Support functions) of information systems utilized for supply chain management and supply chain management performance is carried out by means of LISREL.

As a result of the analysis, this paper derives an IS utilization strategy for supply chain integration based on the priority of (support functions → creation functions → connection functions), and, through the further analysis, discloses that, in order for the derived strategy to be implemented successfully, the establishment of proper relationship with external utilization mechanism of the system and the proper role shift of information systems under the developmental stage of supply chain is required.

Keywords: information systems, supply chain integration, creation functions, connection functions, support functions

INTRODUCTION

Supply chain management seeks to enhance competitive performance by closely integrating internal functions within a company and effectively linking them with the external operations of suppliers, customers, and other channel members.

* Associate Professor, College of Business, Seoul National University (kimsoo2@snu.ac.kr).

The proper application of information systems and technologies may change the characteristic features of the existing supply chain structure with its focus on efficient supply chain integration. Information system utilization can contribute to the efficiency improvement of supply chain structure, because it can provide product information, inventory information, shipping information, and demand-forecasting information on a real-time basis (Coleman et al. 1995; Radstaak and Ketelaar 1998; Lee and Whang 2000; O'Keeffe 2001; Klein 2007; Devaraj et al. 2007). In addition, information system utilization makes 'pull' supply chain management possible by linking each function effectively in a supply chain with the customer's demand information (Kalakota and Whinston 1997; Thonemann 2001; Treville 2004).

However, the information technologies and systems currently utilized by most companies are separate and meant to be used by such functions as procurement, production and sales, thus making it difficult to connect each functional system as well as lowering the effectiveness and efficiency of these systems themselves. Therefore, from the perspective of integrated supply chain management, it is necessary to establish a total supply chain network with an integrated database capable of supporting each function (Bardi et al. 1994; Williamson et al. 2004).

This research analyzes the characteristics of information systems utilized in supply chain management, prioritizes the utilization of functional information systems by identifying the structural relationship between those characteristics and SCM performance, and, on the basis of the derived priority, develops a set of guidelines for strategic utilization of information systems as a precondition to the construction of a total supply chain network and an integrated database.

This paper is organized as follows. First, previous research on the role of information systems for supply chain management is discussed. Next, a conceptual model and hypotheses on the relationship among functional information systems and SCM performance are developed. Third, the characteristics of information systems utilized for supply chain management are identified based on factor analysis of sample data, and structural equation models for hypothesis test are identified. A set of advisable strategies for IS utilization in supply chain management is explicated based on SEM results using LISREL.

The implication of the results is discussed in the concluding section.

LITERATURE REVIEW AND HYPOTHESIS

The introduction of information systems in supply chain management originally was limited to the automation of clerical functions. Information systems were viewed as providing infrastructural support to the value chain and they had an indirect impact on the competitiveness of a product. Companies were able to save costs through information systems, but customers did not feel the effect. With intensification of competition, firms started to utilize information systems to have a direct influence on value chain (Rushton and Oxley 1994; Williams et al. 1997; Gunasekaran and Ngai 2004). Through the utilization of the information systems, companies have been able to integrate similar functions spread all over different areas as well as to curtail unnecessary activities, thus enhancing their capability to cope with sophisticated needs of customers and meet product quality standards (Bardi et al. 1994; Frohlich and Westbrook 2002).

The works of Earl (1989) and Porter and Miller (1985) have two major points in common on the strategic utilization of information technology. First, in order for a company to enhance its competitiveness, the company has to raise the role of information systems from mere information processing to the utilization of technology to change an existing value chain and to create a new value chain. Second, in its application to the value chain, the information technology should not only automate and improve the physical aspect of value activities, but also create and adjust a structural connection of all supply chain activities.

From all of the above arguments, we can divide three major functional areas for the utilization of information system in supply chain management. The first is the creation function that focuses on the automation and improvement of the physical aspects of individual value chain activities (*production/process control, inventory/warehouse management, sales/price management, and consumer service/customer management*). The second is the connection function that focuses on the optimal connection among value chain activities within and outside of a corporation (*plant/warehouse location selection, resource management, order processing, distribution/ transportation management, and forecasting system*). The third is the *support function* IS which provides infrastructural support for the effective operation of value chain activities (*network planning and design system, office information system, and accounting information system*).

Closs (1994) insists that IS application for supply chain management must be extensively reviewed or reengineered to shift from a functional to a process focus. In other words, newer application must focus on the reengineering process to create competitive advantage, and the existing application should be a starting point for the reengineering process. Meanwhile, Daugherty (1994) supports the theory of Porter and Miller by an indirect method emphasizing the limitation of EDI, a representative of IS utilization for information processing. That is, she asserts that EDI provides the basis for establishing strategic linkages, but its technical aspects alone are not sufficient to achieve strategic linkage. Accordingly, IS application beyond basic EDI makes it possible to achieve strategic linkage and ultimately create discriminant competitive advantage (Huggins and Schmitt 1995; Tilanus 1997; Williamson et al. 2004; Zhu and Kraemer 2005).

The previous researches mentioned above indicate the same opinion in that support function IS for information processing including EDI provides the basis for establishing strategic linkages, and, based on support function IS, IS directly applied to value chain makes it possible to achieve strategic linkage and competitive advantage. This means that support function IS plays a role as an infrastructural supporter for direct IS utilization to supply chain functions. Thus, following hypotheses can be suggested.

H1: Support function's IS utilization has a direct influence on Creation function's IS utilization

H2: Support function's IS utilization has a direct influence on Connection function's IS utilization

However, most of the above previous researches represent the relationship among information systems indirectly based on theoretical interpretation rather than empirical verification. Accordingly, to set up unidirectional hypotheses simply on the basis of the above previous researches may be too much restrictive, and so, it may be more meaningful to analyze simultaneously the validity of the above hypotheses supported by previous researches and the existence possibility of any different types of relationship through the establishment of reciprocal hypotheses. Actually, Currie (1993) in emphasizing the role of information systems for supply chain integration asserts that synergy among and integration of logistics activities can be attained through electronic linkages by EDI and advanced network design systems. Also, Bowersox and Daugherty (1995) assert that successful opportunity of EDI can be found not in technological aspect, but in the efficient control of new IS utilization approach for internal and external strategic alliance. This suggests the necessity of analysis on the new type of relationship model in which support function IS is the center of the creation of supply chain competitiveness. The following hypotheses represent such necessity.

H3: Creation function's IS utilization has a direct influence on Support function's IS utilization.

H4: Connection function's IS utilization has a direct influence on Support function's IS utilization.

Bowersox (1989) suggests another good guide on the above question in a different perspective. That is, he asserts that the process of supply chain integration should be progressed from the integration of internal logistics process to external integration with suppliers and customers, and the internal integration and the external integration can be accomplished respectively by the continuous automation and standardization of each internal logistics function and by efficient information sharing and strategic linkage with suppliers and customers. Such assertion implies that the integration stage of supply chain may be another criteria for the derivation of priority. Actively, Stephens (1989), Byrne and Markham (1991), Hewitt (1994), Gimenez and Ventura (2003) and Arlbjorn, Wong and Seerup (2007) through the presentations of supply chain developmental stages respectively, also emphasize that the improvement of each internal function in internal integration stage should be ahead of the external connection with suppliers and customers in external integration stage, and for this, the entirely new approach of IS utilization focusing on the above integration process is required, thus supporting the assertion of Bowersox (1989).

The previous researches on supply chain integration stage emphasize that the improvement of each internal function in internal integration stage should be ahead of the external connection with suppliers and customers in external integration stage, and the above integration process also should set IS utilization strategy. However, the above previous researches are also no more than inferring the relationship among information systems indirectly by theoretical interpretation. Thus, the consideration of reciprocal relationships between variables is needed for the identification of precise causal relationship between creation function IS and connection function IS. The following hypotheses describe such reciprocal relationships.

H5: Creation function's IS utilization has a direct influence on Connection function's IS utilization.

H6: Connection function's IS utilization has a direct influence on Creation function's IS utilization.

Bowersox et al. (1989) and Germain (1989) verified empirically that the logistics performance of corporations more susceptible to the innovation of logistics information technology is higher. Bardi et al. (1994) asserted that IS employed by a company determines the efficiency and competitiveness of the company in the marketplace, and the ability to optimize logistics costs and service levels is affected by the IS. Also, Williams et al. (1997) insisted that the utilization of IS can make both suppliers and buyers more cost, product, and process efficient, which means a given channel can have an advantage over their competitors.

The above researches exhibit that the utilization of IS is a key to bringing supply chain competitiveness, and consequently support most of the previous researches introduced in this research which disclose that the introduction and utilization of IS applied directly to value chain process with IS for information processing would eventually enhance the company's supply chain competitiveness through the efficient linkage and integration of various supply chain activities.

Specially, the previous researches (Bowersox 1989; Stephens 1989; Byrne and Markham 1991; Hewitt 1994; Gimenez and Ventura 2005; Chen, Mattioda, and Daugherty 2007) on supply chain integration stage emphasize that the extent and method to which each of information system utilized in a supply chain affects on the performance may be different according to the integration stage of supply chain. That is, they hold the same view in that, as the stage of integration moves from independent operation to internal and external integration, the focus of IS utilization would shift from information processing to value creation and from value creation to value connection. The following hypotheses include such view.

H7: Support function's IS utilization has a direct influence on supply chain performance.

H7a: Support function's IS utilization has a relatively high influence on supply chain performance in the stage of independent operation.

H8: Creation function's IS utilization has a direct influence on supply chain performance.

H8a: Creation function's IS utilization has a relatively high influence on supply chain performance in the stage of internal integration.

H9: Connection function's IS utilization has a direct influence on supply chain performance.

H9a: Connection function's IS utilization has a relatively high influence on supply chain performance in the stage of external integration.

Figure 1 represents the research model of this study. The research model is distributed into two parts. The first part is on the relationship among the three different functions of IS utilized in a supply chain, and second refers to the relationship between IS utilization of the above three functions and supply chain performance under the integration stage of supply chain.

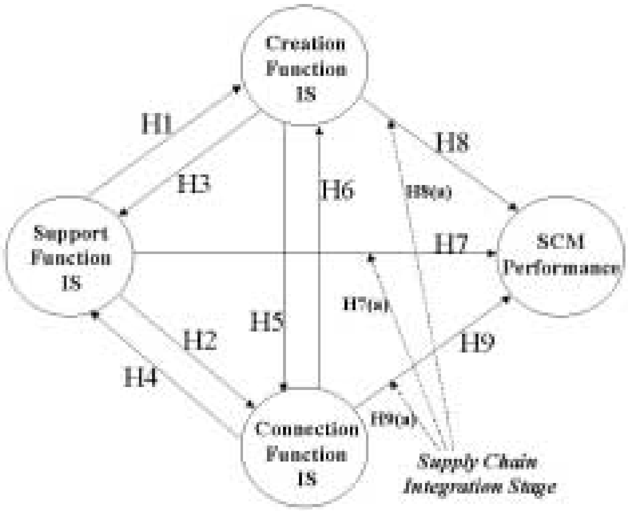


Figure 1. Research Model.

RESEARCH METHODOLOGY

Research Variables and Measurements

Functional Information Systems. The selection of functional IS variables in this research focuses on how to clearly classify the three major functional areas (Creation, Connection, Support) of IS utilization in supply chain management, the center of the research model abovementioned. Specially, the precise classification of creation function IS and connection function IS ambiguous compared to support function IS is the key success point of this research.

In this research, based on the previous researches mentioned in literature review, which classify logistics activities in integrated supply chain management and functional information systems for logistics management, nine traditional functions utilizing information systems in supply chain management (*plant and warehouse location selection, order processing, resource management, production plan and process control, inventory and warehouse management, distribution/ transportation management, sales and price management, consumer service and customer management, forecasting*) were identified, and, by adding three more sub-functional information systems(network planning and design system, office information system, and accounting information system) that provide infrastructural support for the effective utilization of information systems in the above nine major functions, a total of 12 functions were identified. In order to measure IS utilization level in each of these 12 functions more accurately and objectively, a seven-point scale was set up as follows by combining Nolan's research (1982) on the growth stage model of information systems and Stephens' research (1989) on the integration stage model of supply chain management.

● --------- ● --------- ● ----------- ● ----------- ● ---------- ● ---------- ●

No Response	Planning Stage	Initialization Stage	Extension Stage	Functional Integration Stage	Internal Integration Stage	External Integration Stage

The IS utilization level in each of these 12 functions was measured at two different time frames: three years ago and current time period. Comparing data for these two time frames derived growth level in the utilization of information systems.

SCM performance. As mentioned previously, the gain of competitive advantage in the era of supply chain integration can be guaranteed by the fulfillment of both cost reduction and differentiation. Accordingly, in this research, multi-dimensional indices have been used ranging from financial factors reflecting the level of cost reduction to non-financial factors reflecting the level of differentiation to give a comprehensive analysis of supply chain management performance. The method measuring performance by dividing into financial and non-financial indices has been generally used and also this is suitable for the purpose of this research in that the linkage of information system utilization with different performance measures can be studied.

This research set up *purchasing cost, operation cost, inventory cost, warehouse cost(storage cost), sales cost, and distribution/transportation cost* as financial indices related to supply chain management, according to general accounting principle. Non-financial measures consisted of *on-time delivery of materials from suppliers, percent of acceptable materials, the speed of suppliers' order processing, the reduction degree of* *response time in processing requests for materials returns, product innovation level, process innovation level, flexibility (responsiveness), the accuracy of order processing for customers, the reduction degree of product return ratio, the speed of order handling, and the reduction degree of response time in processing requests for product returns or after-service*. The reduction in each of the financial indices was derived by comparing the costs of three years ago to the current level, according to each company's annual financial data. In the case of non-financial indices, in order to measure more objectively and concretely, the improvement over the last three years in on-time delivery, acceptable material, order processing accuracy, and return ratio was measured by a seven-point scale: ← *no effect* ↗ *below 5%* →*5-10%* ↙ *10-15%* ° *15-25%* ± *25-50%* ” *above 50%* * *if the improvement was above 50%, the companies were requested to indicate the percent improvement*. Also, the improvement degree over the last three years of suppliers' order processing speed, suppliers' response time reduction for requests, order handling speed for customers, and response time reduction for customers' requests was measured by a seven-point scale: ← *no effect* ↗*twice speed up* → *four times* ↙ *six times* ° *twelve times* ± *twenty times* ” *sixty times* * *if the improvement was above 60 times, the companies were requested to indicate your company's magnification (if the work of which the time required was 1 hour in the past take a 30 minutes currently, that is twice speed up*). The improvement degree over the last three years of product innovation level, process innovation level, and flexibility was measured by seven-point likert scale.

Developmental Stage of Supply Chain Management. According to the trend of integrated supply chain management, this study employs the integration model of supply chain management as the theoretical background of supply chain developmental stage. Some previous researches (Stephens 1989; Heskett 1989; Byrne and Markham 1991; Ellram 1992; Hewitt 1994) on the integration of supply chain management emphasize that the integration of supply chain management should be accomplished stepwise from internal integration to external integration. In particular, Stephens' research presents the integration process of supply chain management developing from the integration of related functions to internal integration and external integration most concretely and practically. Therefore, this research measures the supply chain developmental stage of sample corporations according to the following four integration stages of supply chain management discussed by Stephens: (1) Stage 1: Independent operation of each function-Complete functional independent stage where each business function such as production, purchase and sales is operated on a completely separate basis. (2) Stage 2: Functional integration-Integration within limited range between adjacent functions such as shipping and inventory or purchase and raw material management. (3) Stage 3: Internal integration-All internal functions from raw material management through production, shipping, and sales are connected and integrated realtime. (4) Stage 4: External integration-Integration with external suppliers and consumers.

Sampling

Consistent with the purpose of this study, target corporations to be sampled were large manufacturing corporations carrying out all of value chain activities in a supply chain, and utilizing

Table 1. Sample Characteristics

		Type of Industry*						
		Consumption Industry	Basic Industrial Material Industry	Electronic and Machinery Industry	Total			
No. of Firms		99 (40.7%)	81 (33.1%)	64 (26.2%)	244			
		Organization Size						
		Below 50 million $	50-100	100-200	200-500	500-1000	Above 1000	Total
No. of Firms	Sales	18	50	52	70	30	24	244
	Assets	14	34	60	64	38	34	244

* consumption industry: food processing, sweetmeats, pharmaceuticals, footwear, clothes, wood, furniture basic industrial material industry: textile, organic chemical, inorganic chemical, petrochemical, cement, paper, tire, fertilizer, fabric, pulp, metal electronics and machinery industry: computer, home appliances, communication equipment, electronic parts, automobile, automobile parts, machinery

information system in supply chain management. Therefore, the necessary data were collected through 1000 questionnaires sent to supply chain managers in large manufacturing corporations among Korea's listed and registered corporations. Of these, 265 completed responses were received, representing a response rate of 26.5%. Of 265 questionaires, 21 incomplete responses were discarded. Accordingly, the analysis that follows and all reported statistics were based on a sample of 244 manufacturing organizations.

Table 1 summarizes the sample characteristics according to industry type and size. The generalizability of a study is determined by the representativeness of the respondents. As shown in the table, sample corporations in this study have diversified industry types and scales. The diversity of the sample should strengthen the external validity of this study results.

Results

The Classification of the Characteristics of IS utilized for Supply

Table 2. Factor Analysis

Measurement Item \ Factor	*Connection Function IS* (α = 0.8356)	*Creation Function IS* (α = 0.9050)	*Support Function IS* (α = 0.8111)
Transportation Management System	**.860**	.141	.093
Forecasting System	**.797**	.183	-.017
Automatic Ordering System	**.733**	.362	.048
Resource Management System	**.685**	.312	.216
Plant & Warehouse Location Selection System	**.655**	.103	.086
Production Plan and Process Control System	.279	**.829**	.105
Sales and Price Management System	.284	**.790**	.007
Consumer Service and Customer Management System	.187	**.760**	.108
Inventory and Warehouse Management System	.371	**.688**	.274
Network Plan and Design System	-.196	.093	**.786**
Accounting Information System	.287	.103	**.666**
Office Information System	.394	.174	**.623**
Eigenvalue	**3.6347**	**2.7042**	**1.6126**
Pct of Var	**.3029**	**.2253**	**.1344**

* Factor loadings below 0.5 were not presented

* α: the result of Cronbach α test

Chain Management. Factor analysis by Varimax rotation were implemented to assess the constructs of the above 12 measured items indicating IS utilization degree by function. Table 2 shows the result of factor analysis after Varimax rotation of factors.

As shown in the table, the 12 functions identified can be divided into three major functional areas. The above classification into three clusters of functional areas can be interpreted as having a conceptual validity in the light of the previous researches (Ballou 1985; Bowersox 1989; Mentzer et al. 1990; Cooper and Ellram 1993; Gustin 1994) on the classification of logistics activities. And at the same time the functional information systems bound with the same factor shows a high level of factor loadings for the factor, thus reflecting high construct validity.

The values of mean for the IS utilization of three functional areas and SCM performance under the integration stage of supply chain are summarized in table 3.

As shown in the table, current functional utilization degree as well as growth degree in utilization over the past three years increases as supply chain developmental stage moves from independent operation to external integration. Also, the levels of

Table 3. Mean Values of Research Variables

Research Variable		Integration Stage	1st (n=40)	2nd (n=62)	3rd (n=88)	4th (n=54)
Functional IS Utilization Degree	Present Level	Primary Function	1.27	3.47	4.84	6.44
		Connection Function	1.56	2.89	4.55	5.88
		Support Function	1.56	3.62	4.74	6.11
	Growth Degree (over the last three years)	Primary Function	-0.68	1.25	1.73	2.89
		Connection Function	0.02	1.13	1.74	2.96
		Support Function	-0.10	1.56	1.93	2.85
SCM Performance	**Cost Reduction Rate (over the last three years)*		-4.5(%)	13.22(%)	14.68(%)	30.06(%)
	The Improvement Degree of Discrimination Level (over the last three years)		2.66	2.34	2.67	3.17

* In case of cost reduction rate, (-) corresponds to an increase in cost and (+) corresponds to a decrease of cost.

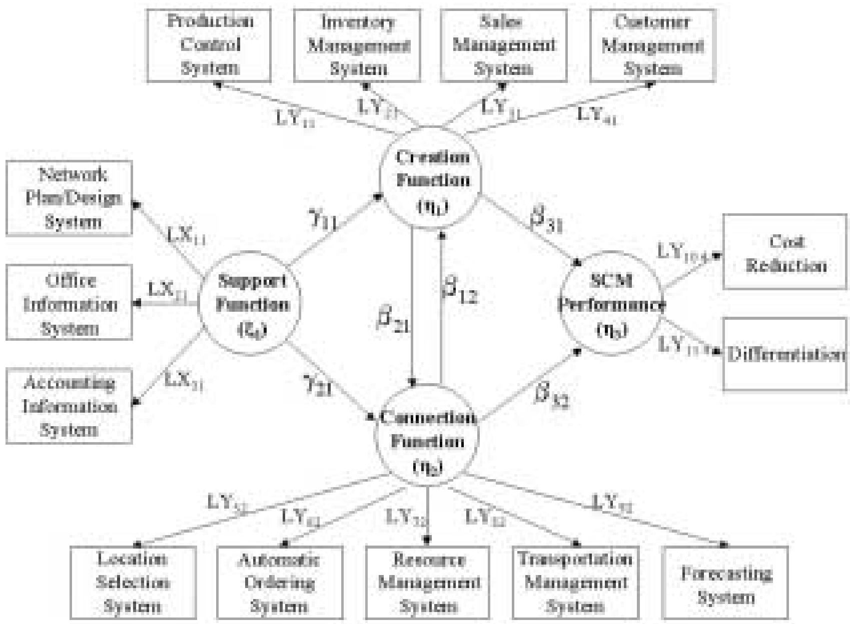
cost reduction and differentiation, which indicate the trade-off relationship at independent operation and functional integration, the prior stage of supply chain integration, are improved together at internal and external integration, the posterior stage of supply chain integration. These results means that supply chain integration can be likened to the old saying of killing two birds such as cost reduction and differentiation with one stone, and also, the successful utilization of information systems having significant correlation with the integration stage of supply chain can make great contributions to that end. This provides more than enough validity of IS strategy derived from the analysis of relationship with SCM performance.

Structural Equation Model. As mentioned in the introduction of research model, this research is assuming the reciprocal relationship between functional information systems. However, to analyze all of reciprocal relations between systems based on a single model not only is a lengthy process for searching an optimal model, but also might lose the validity of random sample due to repeated use of data, ultimately tarnishing the validity of the final model. Accordingly, this research analyses simultaneously all the possible models between variables in order to enhance the statistical validity of causal relations between variables (Bagozzi 1991).

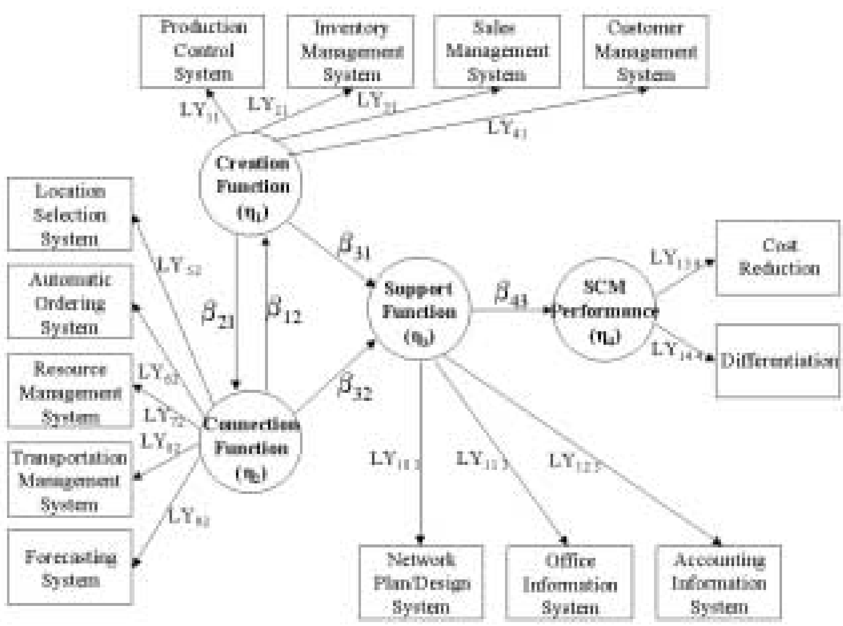
Structural equation model has been constructed on the basis of the research model shown in figure 1. As shown in the figure 2, this research suggests two contradictory models according to the type of relations between functional systems.

The first model has been constructed on the assumption that the IS utilization of support functions can bring about a change in the IS utilization level of creation or connection functions, but not vice versa. This assumption is based on the fact that support function information system is an initial type of the information system and plays an indirect role as an infrastructural supporter for direct IS utilization in supply chain. In other words, IS utilization in support functions have an indirect impact on SCM performance by backing up IS utilization in creation or connection functions.

The second model has been established assuming that the active IS utilization of creation or connection functions can



(a) First model



(b) Second Model

Figure 2. Structural Equation Model

improve the IS utilization level of support functions, thus enhancing SCM performance. This assumption is based on the interpretation that the unsuccessful contribution of supporting function IS to SCM performance is due to the lack of overall control ability, and accordingly, the construction of information systems directly utilized in value chain activities can strengthen the overall controlling ability through the improvement of IS utilization level in support functions.

This research has used the maximum likelihood method for the estimation of unknown parameters as it is generally

Table 4. The Goodness of Fit of this research's SEM Models

Overall Fit Measure							
	χ^2 *Value*	*Degree of Freedom*	*GFI*	*AGFI*	*RMSR*	*NNFI**	*NFI**
Model 1	76.42 (P=.457)	71	.966	.950	.069	.99	.93
Model 2	287.49 (P=.000)	72	.792	.697	.295	.75	.76

* χ^2 Value of Null Model = 1174.74, Degree of Freedom of Null Model = 91

Focused Measures of Goodness Of Fit		
	Model 1	*Model 2*
Normalized Residuals	The Largest Value is 1.523 (The Slope of Q-plot ≥ 1)	The Largest Value is 5.928 (The Slope of Q-plot ≤ 1)
Modificatio Index	The Largest Value is 3.120	The Largest Value is 59.749
SMC or COD of Measurement Model	Every Variable is over .3	Every Variable is over .3
SMC or COD of Structural Model	Proper (not very high and not very low)	Proper (not very high and not very low)

* *GFI*: Goodness of Fit Index, *AGFI*: Adjusted Goodness of Fit Index, *RMSR*: Root Mean Square Residual, *NNFI*: Non-Normed Fit Index, *NFI*: Normed Fit Index, *SMC*: squared multiple correlations, *COD*: coefficient of determination

recognized as being superior (Boomsma 1982; Bagozzi 1991), and also employed the matrix of covariance between observed variables as input data for LISREL analysis.

Goodness of Fit (GOF) of the models. Table 4 is the results of the analysis and comparison of GOF for the two established structural equation models.

As shown in the table, the model 1 and model 2 show a distinct difference in GOF for all the indices except for SMC and COD of the measurement and structural models. In the case of the model 1, most indices except RMSR satisfy the standards of GOF, showing a high GOF of the model. Also, the model leaves nothing to be desired for the modification indices. In case of RMSR, consequently, it (0.069) does not meet the standard (0.05) established in this research. However, this value is considerably significant compared to that of model 2, and also RMSR in this research cannot be decisive factor in judging the GOF of model because the matrix of covariance is employed as input data for LISREL analysis.

On the other hand, in case of the model 2, when compared to the model 1, the values of general indices are significantly low, failing to meet all the standards of GOF of the model. Consequently, the model 2 can not be supported by the sample data of this research, meaning that the causal relation path has not been properly established between variables, or observed variables can not properly explain latent variables. The SMC for all of observed variables and COD in the measurement model of the model 1 and the model 2 are more than 0.3, and the SMC for all of endogenous variables and COD in the structural model of the model 1 and the model 2 are not too high or too low, suggesting no problem for the validity of observed variables and latent variables. Consequently, the problem lies in improper establishment of the relation path between variables. The analysis result of normalized residuals and modification indices show that the coefficients of paths, fixed under the assumption of little relationship, are very high. Accordingly, in order to enhance the GOF of the model, the above paths need to be free with the overall improvement of the model. Although not stated in the table 4, T-value of the maximum likelihood coefficient determining the significance level of relation paths also show that the values of β_{31}(creation function → support function), β_{32}(connection function → support function) and β_{43}(support function → SCM performance) of the model 2 represent 0.522, 0.408, and 0.969, respectively, not meeting the significance level of α = 0.05. Considering all the goodness of fit analysis, the model 1 where supporting function IS plays a indirect role in SCM performance can be interpreted as the more appropriate model.

Although not indicated here, the T-values of γ_{21}, γ_{12}, γ_{32} in the model 1 did not meet the significance level of α = 0.05. This means that those relation paths are not statistically significant, and consequently, by fixing the relation path at "0", an overidentified model can be constructed without any influence on

Table 5. The Validity Test of Measurement Model

Measurement Model of Dependent Variables						
	1. Maximum Likelihood	2. Standard Errors	1 + 2	1 - 2	T-Value	
LY_{11}	1.000		1.000	1.000		Reference Variable
LY_{21}	1.024	.141	1.165	.883	7.259	**
LY_{31}	1.047	.142	1.189	.905	7.375	**
LY_{41}	1.036	.142	1.178	.894	7.322	**
LY_{52}	1.000		1.000	1.000		Reference Variable
LY_{62}	1.021	.144	1.165	.877	7.102	**
LY_{72}	0.954	.141	1.095	.813	6.769	**
LY_{82}	0.983	.142	1.125	.841	6.915	**
LY_{92}	0.973	.142	1.115	.831	6.866	**
$LY_{10\ 3}$	1.000		1.000	1.000		Reference Variable
$LY_{11\ 3}$	1.068	.236	1.304	.832	4.523	**
Measurement Model of Independent Variables						
	1. Maximum Likelihood	2. Standard Errors	1 + 2	1 - 2	T-Value	
LX_{11}	1.000		1.000	1.000		Reference Variable
LX_{21}	1.093	.184	1.277	.909	5.940	**
LX_{31}	1.136	.189	1.325	.947	6.025	**

** Statistically Significant at $p \leq 0.05$

Table 6. The Validity Test of Structural Model

Structural Model between Independent Variable and Dependent Variable								
	Total Effect	Indirect Effect	ML	SE	ML+SE	ML-SE	T-value	*Test Result*
γ_{11}	.748		.748	.142	.890	.606	5.250	H1: S
γ_{21}	.631	.631						H2: R
γ_{31}	.505	.505						H7: R
Structural Model between Dependent Variables								
	Total Effect	Indirect Effect	ML	SE	ML+SE	ML-SE	T-value	*Test Result*
β_{21}	.844		.844	.129	.973	.715	6.529	H5: S
β_{31}	.675		.675	.130	.805	.545	5.208	H8: S
β_{12}	.	.						H6: R
β_{32}	.	.						H9: R

- ** Statistically Significant at $p \leq 0.05$
- ML: Maximum Likelihood, SE: Standard Errors
- S: Supported, R: Rejected
- H3 and H4 are not supported because T-value of the maximum likelihood coefficient of β_{31}(creation function → support function) and β_{32}(connection function → support function) of the model 2 represent 0.522 and 0.408 respectively, not meeting the significance level of $\alpha = .05$.

the overall GOF of the model. Like this, fixing unknown parameter is possible when the GOF of the model is sufficiently good. Since the GOF of the model 1 is quite satisfactory as proved in the preceding analysis, the overidentification of the model is available. Accordingly, model modification has been made by fixing the three paths at “0” one at a time. The overall GOF of the final model derived from the model modification is as follows, and the final model will be explained later.

χ^2 = 78.44 (P = .340), df = 74, GFI = .960, AGFI = .943, NNFI = 0.99, NFI = 0.93, RMSR = 0.080

The figures, when compared to the overall goodness of fit for the model 1 in table 4, show no difference. Actually, the result of χ^2 difference test shows that when χ^2 value is 2.02 (78.44 of the final model - 76.42 of the model 1) and degree of freedom is 3 (74 of the final model - 71 of the model 1), p-value is 0.42632, failing to meet the significant level of both α = 0.01 and α = 0.05. Accordingly, a null hypothesis that the difference in goodness of fit between the final model and the model 1 is 0 is accepted, suggesting that the final model can be an over-identified model not influencing on the overall goodness of fit of the model 1.

The Interpretation of Analysis Result. Table 5 shows the validity test result of measurement model of the final model and table 6 is the result of hypothesis testing on structural relationship between latent variables.

The results of the structural relationship between latent variables of the final model can be summarized in diagram as shown in figure 3.

The interpretation of the analysis results is divided into three aspects.

First is about the role of the support function IS. As shown in the figure, IS utilization of support functions does not have direct impact on SCM performance. However, indirect effect is significant (the indirect effect of γ_{31} = 0.505). Indirect effects here mean the level of impact on SCM performance by support function IS through creation function IS. This emphasizes that,

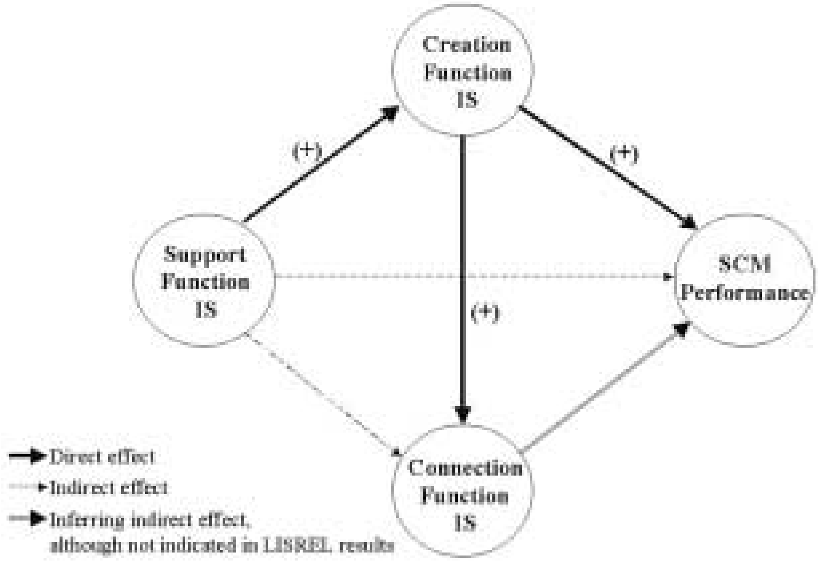


Figure 3. Causal Relationship between Latent Variables

in order to enhance SCM performance, the support function IS may play an indirect role through the utilization of creation function IS.

Second is about the structural relationship between functional information systems. When connecting the paths indicated to have direct effects between the three functions of information systems, the structural relationship of (support functions → creation functions → connection functions) can be derived. This means that the proper utilization of support function IS enhances the utilization level of creation function IS which, in turn, brings about an active utilization of connection function IS.

Third is the relationship between the utilization of connection function IS and SCM performance. To derive a conclusion that the above mentioned structural relationship between functional information systems (support functions → creation functions → connection functions) is desirable, it must be a precondition that the utilization of connection function IS, the final destination of the above relationship, have a significant impact on SCM performance. However, there indicates no direct relationship between the two as shown in the figure 3. For this contradiction, following interpretation is available. That is, it may be inferred that, even though the utilization of connecting function IS does not play a direct role in SCM performance, it influences on SCM performance indirectly through the external utilization mechanism of the information system, such as strategic capability, organization type, logistics initiatives, enabling the connection of the two variables. Accordingly, further analysis is required for confirming this.

In order to confirm more precisely the relationship between the utilization of connection function IS and SCM performance, and to identify whether the utilization mechanism exists between the two, correlation analysis has been conducted between IS utilization degrees of the three functions and SCM performance under the developmental stage of supply chain management. Table 7 exhibits the results of correlations, where indicate that the utilization of support function IS has the highest correlation with SCM performance in the independent operation stage, while the utilization of creation function IS in the functional and internal integration stages and the utilization of connection function IS in the external integration stage have the highest correlations,

Table 7. Correlation Analysis

	Independent Operation		*Functional Integration*		*Internal Integration*		*External Integration*	
	Cost	Differ	Cost	Differ	Cost	Differ	Cost	Differ
Primary LIS	.282*	.138	.427***	.305**	.285**	.408***	.295*	.307**
Connection LIS	.017	.115	.014	.139	.226*	.307**	.406***	.520***
Support LIS	.372**	.348***	.235*	.209	.185	.180	.170	.217

*p ≤ 0.1, **p ≤ 0.05, ***p ≤ 0.01

Cost: The Level of Cost Reduction, Differ: The Level of Differentiation

respectively. This is as expected in the hypotheses of this research, thereby supporting all of H7a, H8a, and H9a.

The above result confirms that the structural relationship of (support functions → creation functions → connecting functions) derived from LISREL analysis is to be recommended for improving SCM performance. In particular, the fact that the utilization of connection function IS has the highest significant correlation with SCM performance in the external integration stage, the final stage of supply chain integration, even though no direct causal relationship between the two was indicated from LISREL analysis can be interpreted as reconfirming the validity of the previous proposition that connection function IS indirectly influences SCM performance through the external utilization mechanism.

The Utilization Strategy of IS for Supply Chain Integration. Combining all the previous analyses, IS utilization strategy for the efficient integration of supply chain can be broadly divided into an internal aspect and an external aspect. The strategy in the internal perspective focuses on the priority of functional information systems utilized for supply chain integration. According to the priority derived from the preceding empirical results, following three stepwise strategies can be suggested.

First stage is to establish the operational foundation for the direct IS application to supply chain activities by the utilization of support function IS. The key point of IS utilization in this stage is how efficiently and precisely it can plan and control various kinds of supply chain activities operated totally independently. The utilization of advanced network communication system and the establishments of accounting information system (AIS) and office information system (OIS) on the basis of sophisticated network communication system make the accomplishment of the above key point possible. The role of OIS for supply chain management is to computerize all of clerical works related to supply chain activities as a type of database (O'Brien 1991), while AIS contributes to the improvement of supply chain process by the feedback of the systemical evaluation results on supply chain performance to each supply chain function (Lambert and Stock. 1993). The effects of OIS and AIS is doubled up by the utilization of network communication system such as Electronic Data Interchange (EDI) or several kinds of expert systems for network planning/ design (Allen and Helferich 1990). Such network communication system not only expands the scope covering multiple supply chain functional areas but also provides the opportunity to interface real time with other functional systems in a supply chain through full monitoring and controlling assistance for overall supply chains (Permin and Wichers 1989).

Second stage is to automate or improve the physical aspect of each supply chain function and to realize the efficient linkage between related functions by the utilization of Creation function IS. More advanced computer integrated system (CIM) makes it possible not only to maximize the efficiency of production function itself through the control of all of processes by computer communication (Allen and Helferich 1990), but also to link with inventory and warehousing system through the sharing of information generated from production process (Gustin 1994). Such linkage is also applied to sales function. The effect of point of sales (POS) system, the most representative type of sales management system (Cohen 1990), is maximized through the linkage with customer information system. Such linkage makes it possible not only to establish an efficient marketing strategy through the realtime utilization of sales and customer information, but also to enhance the accuracy of transportation, inventory management, and production plan. The physical improvement of each supply chain function in this stage plays a role as a prerequisite for the above functional linkage or integration.

Third stage is to accomplish the internal integration of all the supply chain functions within a company and the external integration with suppliers and consumers by the utilization of connection function IS, and, in this stage, internal integration is ahead of the external integration. The role of forecasting system in the internal integration is very important. That is, forecasting system predicts future demand by analyzing data on the present state of sales obtained from sales management system and, on the basis of this prediction, provides the required planning of products and materials to production and procurement systems, thus leading to the linkage or integration between production and sales systems. Also, the real-time linkage of forecasting system with procurement system based on JIT concept enhances the efficiency of overall production logistics systems from materials planning and master production scheduling to finished goods inventory management (Allen and Helferich 1990), and makes it possible to establish the on-line real time system with suppliers. The roles of automatic ordering system and transportation system in this stage also cannot be ignored. These systems are at the head of substantial transactions or relationships with suppliers or customers, and consequently play a role of practical bridge between internal and external players (Kay 1991). Accordingly, these systems are connected with every functional IS abovementioned directly or indirectly. The utilization of plant & warehouse location selection system is the closing point of supply chain integration, but on the other hand it is also the starting point. That is, this system decides the optimal location by detailed analysis on informations obtained from other information systems, but at the same time, this decision has an indirect effect reversely on the operations of other information systems by transmitting the evaluations on the level of cost, quality, and differentiation to network communication system. Accordingly, the feedback process among functional information systems is reiterated.

The preceding empirical results also recommend that, in order for system's internal dimension strategies to be effective, the additional strategies from the viewpoint of system's external dimension be supported. The strategies from an external dimension include the establishment of priorities between IS utilization and corporate characteristics or external variables such as corporate strategies, organization structure, supply chain initiatives. Inferring from the analysis results of this research, it is advisable that, in the functional integration stage or the beginning stage of internal integration where the utilization of creation function IS having a direct causal relationship with SCM performance has the highest correlation with SCM performance, the construction and operation of IS be the focus of supply chain management, but, in the latter stage of internal integration or external integration stage where the utilization of connection function IS having no direct causal relationship with SCM performance has the highest correlation with SCM performance, IS utilization be performed in such a way to play an indirect role transforming corporate characteristics into a shape suitable for integrated supply chain management and thus improving the overall structure of supply chain.

CONCLUSION

Bowersox and Daugherty (1995) assert that a company must resolve trade-off relationship between cost leadership and differentiation to achieve competitive advantage, and emphasize the balancing of pursuit toward cost or differentiation. The analysis result of mean values for the research variables of this paper disclosed that supply chain integration can make it possible to pursue cost leadership and differentiation simultaneously, and the successful utilization of information systems can make great contributions to that end. This means that the integration level of supply chain can play a role as a guide for the suggestion of an advisable IS strategy.

This research, in the perspective of supply chain integration, suggested an utilization strategy of functional information systems on the basis of the priority (support functions → creation functions → connection functions) among the three major functions of information systems derived through the relationship analysis with SCM performance. The following two facts verified empirically in this research shapes the general framework of the above strategy.

First, the utilization of support function IS has an indirect influence on the performance and competitiveness of supply chain management by providing the foundation for the direct IS utilization to supply chain functions. The validity of this is reconfirmed by the existing studies mentioned in literature review, which assert that support function IS provides the basis for establishing strategic linkages, and, based on support function IS, the direct IS application to value chain activities may make it possible to pursue cost leadership and differentiation simultaneously and consequently gain competitive advantage.

Second, the utilization of creation function IS plays a role as a prerequisite for the utilization of connection function IS in the perspective of supply chain integration. In other words, this means that the utilization of creation function IS should reach a certain level for the proper utilization of connection function IS. This is in the same context with the previous researches mentioned in literature review, which emphasizes that the improvement of each internal function in internal integration stage should be ahead of the external connection with suppliers and customers in external integration stage, and the above integration process also should set IS utilization strategy.

However, most of the above previous researches represent the relationship among information systems indirectly based on theoretical interpretation rather than empirical verification. Accordingly, the result of this research can be interpreted as having a significant meaning in that theoretically ambiguous priority among three functional information systems has been actually testified.

This research also disclosed that, in order for the above IS strategy to be implemented successfully, the establishment of proper relationship with external utilization mechanism of the system is strongly required. The analysis result of this research implies that as supply chain integration stage moves from the functional integration to external integration, the role of information systems also shifts from a direct determinant factor for the competitiveness of supply chain management to a supporter indirectly influencing on SCM performance by assisting the improvement of supply chain structure, such as strategy, organization, supply chain initiatives, in order to create a corporate environment appropriate for integrated supply chain management. This means that, in the stage of external integration requiring a high level of integration technology, the optimization of a partial technology alone such as the utilization of information systems cannot result in effective integration. Earl

(1989), Gustin (1994), and Closs (1994) have the same opinion in that as the application level of IS moves from operational and tactical to strategic, the efficient linkage of IS strategy with the external environments of the system is strongly required. When considering IS utilization for external integration with suppliers or consumers as a decision making in the strategic dimension, the above analysis has considerable persuasive power. Like this, demonstrating the necessity of strategy in the system's external dimension is one of contributions made by this research.

However, the above contribution also serves as a guide on the limitation of this research and the future research direction. This research has focused on verifying the structural relationship between functional information systems and SCM performance, and made an inference on the necessity of strategy in the system's external perspective according to the result in the system's internal dimension. Accordingly, in order to confirm the necessity of strategic linkage with the system's external utilization mechanism, additional analysis on the structural relationship among information systems, corporate characteristics and SCM performance should be followed. Also, the direction for the utilization of information systems suggested by this research has been derived from the process of specification search for an optimal LISREL model. This kind of process is not a confirmatory test, but a exploratory procedure. Therefore, for the generalization of the model suggested in this research, the cross-validation process applying the model to new data and evaluating its goodness of fit has to be performed. These issues will undoubtedly be addressed in future research.

REFERENCES

Allen, M. K. and O. K. Helferich (1990), "Putting Expert Systems to Work in Logistics," paper presented at the Council of Logistics Management, Oak Brook, IL.

Arlbjorn, J. S., C. Y. Wong and S. Seerup (2007). "Achieving Competitiveness through Supply Chain Integration," *International Journal of Integrated Supply Management*, 3(1), 4-24.

Bagozzi, R. P. (1991), "Evaluating Structural Equation Models with Unobservable Variables and Measurement Error: A Comment," *Journal of Marketing Research*, 18(August), 375-381.

Ballou, R. A. (1985), *Business Logistics Management*, Englewood Cliffs NJ: Prentice-Hall.

Bardi, E. J., T. S. Raghunathan and P. K. Bagchi (1994), "Logistics Information Systems: The Strategic Role of Top Management," *Journal of Business Logistics*, 15(1), 71-85.

Boomsma, A. (1982), "The Robustness of LISREL against Small Sample Size in Factor Analysis Models," in *Systems Under Indirect Observation: Causality, Structure, Prediction*, K. G. Joreskog and H. Wold, eds. Amsterdam: North Holland.

Bowersox, D. J. (1989), "Logistics in the Integrated Enterprise," paper presented at The Annual Conference of the Council of Logistics Management, St. Louis, MO.

______ and P.J. Daugherty (1995), "Logistics Paradigm: The Impact of Information Technology," *Journal of Business Logistics*, 16(1), 65-80.

______ M. B. Cooper, C. L. Droge, D. S. Rogers and D. L. Wardlow (1989), "Leading Edge Logistics Competitive Positioning for the 1990s," paper presented at the Council of Logistics Management, Oak Brook, IL.

Byrne, P. M. and W. J. Markham (1991), "Improving Quality and Productivity in the Logistics Processes: Achieving Customer Satisfaction Breakthroughs," paper presented at the Council of Logistics Management, Oak Brook, IL.

Chen, H., D. D. Mattioda and Daugherty P. J. (2007), "Firm-wide Integration and Firm Performance," *The International Journal of Logistics Management*, 18(1), 5-21

Closs, D. J. (1994), "Positioning Information in Logistics," *The Logistics Handbook*, The Free Press, 699-713.

Cohen M. A. (1990), "Out of Touch with Customer Needs? Spare Parts and After Sales Service," *Sloan Management Review*, 31(2), 55-56.

Coleman, J. L., A. K. Bhattacharya and G. Brace (1995), "Supply Chain Reengineering: A Supplier's Perspective," *The International Journal of Logistics Management*, 6(1), 85-92.

Cooper, M. C. and L. M. Ellram (1993), "Characteristics of Supply Chain Management and the Implications for Purchasing and Logistics Strategy," *The International Journal of Logistics Management*, 4(2), 13-22.

Currie, K. W. (1993), "An Empirical Study of Logistics Organization, Electronic Linkage, and Performance," Working Paper, Texas A&M University.

Daugherty, P. J. (1994), "Strategic Information Linkage," in *The Logistics Handbook*, J. F. Robenson and W. C. Capacino, eds. New York, NY: The Free Press, 757-769.

Devaraj, S., L. Krajewski and J. C. Wei (2007), "Impact of E-Business Technologies on Operational Performance: The Role of Production Information in the Supply Chain," *Journal of Operations Management*, 25, 1199-1216.

Earl, M. J. (1989), *Management Strategies for Information Technology*, Englewood Cliffs NJ: Prentice Hall.

Ellram, L. M. (1992), "Partners in International Alliances," *Journal of Business Logistics*, 13(1), 1-25.

Frohlich, M. T. and R. Westbrook (2002), "Demand Chain Management in Manufacturing and Services: Web-based Integration, Drivers and Performance," *Journal of Operations Management*, 20(6), 729-45.

Germain, R. (1989), "The Effect of Output Standardization on Logistical Structure, Strategy, and Performance," *International Journal of Physical Distribution and Materials Management*, 19(1), 20-29.

Gimenez, C. and E. Ventura (2003), "Supply Chain Management as a Competitive Advantage in the Spanish Grocery Sector," *The International Journal of Logistics Management*, 14(1), 77-88.

______ (2005), "Logistics-production, Logistics-marketing and External Integration: Their Impact on Performance," *International Journal of Operations & Production Management*, 25(1), 20-38.

Gunasekaran, A. and E. W. T. Nagi (2004), "Information Systems in Supply Chain Integration and Management," *European Journal of Operational Research*, 159, 269-296.

Gustin, C. M. (1994), *Distribution Information System: The Distribution Management Handbook*, New York: McGraw-Hill.

Heskett, J. L. (1989), "Leadership Through Integration: The Special Challenge of Logistics Management," paper presented at the *Council of Logistics Management Annual Conference Proceeding of the 1988*.

Hewitt, F. (1994), "Supply Chain Redesign," *The International Journal of Logistics Management*, 5(2), 1-8.

Huggins, J. W., and R. G. Schmitt (1995), "Electronic Data Interchange as a Cornerstone to Supply Chain Management," paper presented at the C*ouncil of Logistics Management Annual Conference Proceedings*.

Kalakota, R. and A. B. Whinston (1997), *Electronic Commerce: A Manager's Guide*, Massachusetts: Addison-Wesley Longman.

Kay, E. (1991), "Relief for Your Order-Entry Headaches," *Datamation*, July, 51-52.

Klein, R. (2007), "Customization and Real Time Information Access in Integrated E-Business Supply Chain Relationships," *Journal of Operations Management*, 25, 1366-1381.

Lambert, D. M. and J. R. Stock (1993), *Strategic Logistics Management*, Homewood, IL: Irwin.

Lee, H. L. and S. Whang (2000), "Information Sharing in a Supply Chain," *International Journal of Technology Management*, 20(3-4), 373-387.

Mentzer, J. T., C. P. Schuster and D. J. Roberts (1990), "Microcomputer versus Mainframe Usage in Logistics," *Logistics and Transportation Review*, 26(2), 115-132.

Nolan, R. L. (1982), "Managing Information Systems by Committee," *Harvard Business Review*, 60(4), 72-79.

O'Brien, J. A. (1991), *Introduction to Information Systems in Business Management*, Homewood, IL: Irwin.

O'Keeffe, M. (2001), "Building Intellectual Capital in the Supply Chain ? The Role of E-Commerce," *Supply Chain Management: An International Journal*, 6(4), 148-151.

Permin,J. L. and T. Wichers (1989), "Architectural & Functional Model for Business Communication Systems," *Electrical Communication*, 63(1), 4-16.

Porter, M. E. and V. E. Miller (1985), "How Information Gives You Competitive Advantage," *Harvard Business Review*, 63(4), 149-160.

Radstaak, B. G., and M. H. Ketelaar (1998), "Worldwide Logistics: The Future of Supply Chain Services," *Holland International Distribution Council*, Hague, Netherlands.

Rushton, A and J. Oxley (1994), *Handbook of Logistics and Distribution Management*, London, England: Kogan Page Ltd..

Stephens, G. (1989), "Integrating the Supply Chain," *International Journal of Physical Distribution and Materials Management*, 19(8), 3-8.

Thonemann, U. W. (2001), "Improving Supply Chain Performance by Sharing Advance Demand Information," *European Journal of Operational Research*, 142, 81-107.

Tilanus, B. (1997), *Information Systems in Logistics and Transportation*, Oxford, England: Elsevier Science Ltd..

Treville, S., R. Shapiro and A. P. Hameri (2004), "From Supply Chain to Demand Chain: The Role of Lead Time Reduction in Improving Demand Chain Performance," *Journal of Operations Management*, 21(6), 613-627.

Williams, L. R., A. Nibbs, D. Irby and T. Finley (1997), "Logistics Integration: The Effect of Information Technology, Team Composition, and Corporate Competitive Positioning," *Journal of Business Logistics*, 18(2), 31-41.

Williamson, E. A., D. K. Harrison and M. Jordan (2004), "Information System Development within Supply Chain Management," *International Journal of Information Management*, 24, 275-385.

Zhu K. and Kraemer K. L. (2005), "Post-adoption Variations in Usage and Value of E-business by Organizations: Cross-country Evidence from the Retail Industry," *Information Systems Research*, 16(1).