INFORMATION SYSTEM UTILIZATION STRATEGY FOR SUPPLY CHAIN INTEGRATION

by

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The introduction of information technology by a firm for integrated supply chain management could lead to better efficiency and effectiveness, compared to existing logistics systems (Goldhar and Lei 1991; Sullivan 1985). For example, under current warehouse management, it might be necessary to secure sufficient space to keep a large enough inventory for timely delivery. Integrated supply chain management utilizing information systems and a shared supply chain database can enable the company to identify optimal inventory levels, reduce warehouse space, and increase inventory turnover (Kaeli 1990; Kaplan 1986; Shull 1987). The new integrated supply chain management systems, if utilized properly, can lead to higher quality products, enhanced productivity, efficient machine utilization, reduced space, and ultimately increase logistics efficiency and flexibility (Gross 1984; Kaltwasser 1990). Furthermore, past research has shown that companies can achieve economies of scale by establishing a long-term strategic alliance or network relationship with suppliers for stable and continuous procurement (Coleman, Bhattacharya, and Brace 1995; Goldhar and Lei 1991; Tilanus 1997). Consequently, the introduction and utilization of integrated information systems for managing the supply chain would not only enhance quality as well as reduce delivery times and costs, but also eventually enhance the company's competitiveness and position it for further growth (Goldhar and Lei 1991; Huggins and Schmitt 1995; Kaeli 1990; Kaltwasser 1990; La Londe and Masters 1990).

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. This makes it difficult, if not impossible, to connect each functional system. It also lowers the effectiveness and efficiency of these systems. 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, Raghunathan, and Bagchi 1994).

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 these information systems' characteristics and supply chain management performance, and develops a set of guidelines for strategic utilization of information systems.

This paper is organized as follows. First, previous research on the role of information systems for supply chain management is discussed. Next, the characteristics of information systems utilized for supply chain management are identified, based on factor analysis of sample data from 244 of Korea's large manufacturing firms. Third, a conceptual model and hypotheses relating to utilization of information system and supply chain management (SCM) performance are developed and tested using LISREL analysis. A set of strategies for information system (IS) utilization in supply chain management is explicated based on SEM results. The implications of the results are discussed in the concluding section.

LITERATURE REVIEW

Supply chain management deals with the control of material and information flows, the structural and infrastructural processes relating to the transformation of the materials into value added products, and the delivery of the finished products through appropriate channels to customers and markets so as to maximize customer value and satisfaction. It seeks to enhance competitive performance by closely integrating the internal functions within a company (e.g., marketing, product design and development, manufacturing) and effectively linking them with the external operations of suppliers, customers, and other channel members. As John Gossman (1997), vice-president of materials management at AlliedSignal, recently noted: "competition is no longer company to company, but supply chain to supply chain." His statement emphasizes the strategic importance of supply chain management (Vickery, Calantone, and Dröge 1999). The benefit of such supply chain management can be attained through electronic linkage among various supply chain activities utilizing information technology and the construction of integrated supply chain information systems (Bowersox and Daugherty 1995; Currie 1993).

The introduction of information systems in supply chain management originally was limited to the automation of clerical functions (Williams et al. 1997). Information systems were viewed as providing infrastructural support to the value chain and having an indirect impact on the competitiveness of a product. Companies were able to reduce costs through information systems, but the benefits were not typically apparent to customers. With intensification of competition, firms started to utilize information systems to directly influence the processes comprising the value chain (Rushton and Oxley 1994; Williams et al. 1997). Through the utilization of information systems, companies have been able to integrate similar functions spread over different areas as well as curtail unnecessary activities, thus enhancing their capability to cope with sophisticated needs of customers and meet product quality standards (Bardi, Raghunathan, and Bagchi 1994).

Earl (1989) classified the scope of information technology into the following categories according to whether information technology is widely used in the value chain or selectively used for only information processing and whether it is applied for value creation or applied for the connection of value-adding activities: (1) Information technology that automates or improves the physical aspect of every activity; (2) Information technology used for physically connecting each value activity or controlling those activities at the connecting point; (3) Information systems that facilitate the implementation, support, and management of value activities; and (4) Information systems that optimize or adjust the connection of each value activity. Earl's classification is not only applicable to the internal value chain of a firm, but can also be extended to the company's supply chain, linking suppliers and customers.

Porter and Millar (1985) asserted that the utilization of information technology has a significant influence on the relationships among value chain activities as well as on the physical aspects of individual value chain activities. Information technology helps to create and maintain the competitiveness of a company. Based on the concept of value chain, the following propositions can be made: (1) Competitiveness comes from creating value for customers; (2) Value creating activities of a company including procurement, manufacturing, and sales are not mutually exclusive, but interdependent in the form of value chain; (3) Firms can optimize or integrate their value chains through information technology to improve their competitiveness; and (4) Accommodation of information technology creates a new value chain. Porter and Millar concluded that the proper use of information technology minimizes costs while maximizing value, optimizing value activities, and guaranteeing competitive advantages.

The works of Earl, and Porter and Millar, on the strategic utilization of information technology have two major points in common. 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 utilization of technology to change an existing value chain and create a new value chain. Second, in its application to the value chain, information technology should not only automate and improve the physical aspect of value activities, but also create and optimize the structural connection among supply chain activities. These two points have significant implications for IS utilization strategy for supply chain integration (SCI). To better understand these implications for IS utilization strategy, the following fundamental research question needs to be considered. How should different roles be established for IS application-infrastructural support through information processing, value creation management for improving the physical aspect of value activities, and logistical operations that optimize connection of value activities? In other words, what set of criteria should be used to decide this priority?

On this question, Porter and Millar believe that management of information systems can no longer be the sole province of the electronic data processing (EDP) function, such as accounting and record keeping, focusing on cost reduction. The use of advanced information systems in value chain activities allows companies to enhance competitive differentiation as well as cost leadership and sustainable competitive advantage. The ability to pursue cost reduction and differentiation simultaneously should be a criterion for IS utilization. Earl supports the assertion of Porter and Millar. He contends that IS must have the potential to be a strategic weapon in at least one of the following four ways: (1) to gain competitive advantage; (2) to improve productivity and performance; (3) to enable new ways of managing and organizing; and (4) to develop new businesses. These arguments suggest that the utilization of IS in strategic and managerial activities is more important than in operational contexts. A similar view is expressed by McFarlan and McKenney (1984), through the presentation of an IT strategic grid. The grid illustrates that the role of IS should change from operational supporter to strategic enabler for competitive success. Closs (1994) stresses that IS application for supply chain management must be extensively reviewed or reengineered to shift from a functional to a process focus. In his view, newer applications must focus on the reengineering of processes to create competitive advantage. Existing applications should be a starting point for the reengineering process. Daugherty (1994) supports the theory of Porter and Millar by indirectly emphasizing the limitation of electronic data interchange (EDI) capabilities, a representative IS utilization for information processing. She argues that EDI provides the basis for establishing strategic linkages, but its technical aspects alone are not sufficient to achieve strategic linkage along the value chain. Accordingly, IS application beyond basic EDI is necessary to achieve strategic linkages and ultimately create differential competitive advantages.

Bowersox (1989) proposes that the process of supply chain integration should progress from the integration of internal logistics processes to external integration with suppliers and customers. Internal and external integration can be accomplished by the continuous automation and standardization of each internal logistics function, and by efficient information sharing and strategic linkage with suppliers and customers. This implies that the integration stage of supply chain may be another criterion in deriving the priorities for IS utilization in supply chain integration. Byrne and Markham (1991), Hewitt (1994), and Stevens (1989) also emphasize that the improvement of each internal function should precede the external connection with suppliers and customers in the external integration stage.

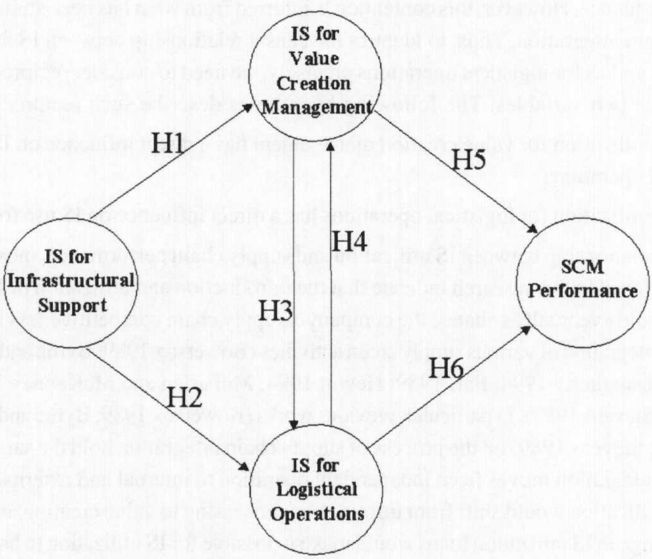
In summary, IS utilization for internal creation and external connection of value chain activities beyond existing information processing is required to reengineer the value chain and gain differential competitive advantage. The ability to pursue cost leadership and differentiation simultaneously, as well as supply chain integration, may be the criteria for prioritizing the three different roles of IS application in supply chains-value creation management, logistical operations, and infrastructural support.

RESEARCH MODEL AND HYPOTHESES

Figure 1 presents the research model of this study. The research model is comprised of two parts. The first part relates to the relationship among the three different functions of IS utilized in a supply chain. The second part pertains to the relationship between IS utilization and supply chain performance under different developmental stages of supply chain integration.

FIGURE 1

RESEARCH MODEL



This model is derived from prior studies discussed in the literature review section (Closs 1994; Daugherty 1994; Earl 1989; McFarlan and McKenney 1984; Porter and Millar 1985). These studies indicate that IS for information processing including EDI, provides the basis for establishing strategic linkages. When integrated into the value chain, IS utilization makes it possible to achieve strategic competitive advantage. This means that IS for information processing plays a role as an infrastructural support for direct IS utilization in supply chain functions. Thus, the following hypotheses can be suggested.

H1: IS utilization for infrastructural support has a direct influence on IS use for value creation management.

H2: IS utilization for infrastructural support has a direct influence on IS use for logistical operations.

Prior research on the process of supply chain integration emphasizes that the systematization of each function within a firm in the internal integration stage should precede external connection with suppliers and customers in the external integration stage (Bowersox 1989; Byrne and Markham 1991; Hewitt 1994; Stevens 1989). It is reasonable to argue that IS utilization strategy should also follow this sequence. However, this contention is inferred from what has been studied in the context of supply chain integration. Thus, to identify the causal relationship between IS for value creation management and IS for logistical operations precisely, we need to consider reciprocal relationships between these two variables. The following hypotheses describe such reciprocal relationships.

H3: IS utilization for value creation management has a direct influence on IS use for logistical operations.

H4: IS utilization for logistical operations has a direct influence on IS use for value creation.

On the relationship between IS utilization and supply chain performance, most of the previous studies introduced in this research indicate that the introduction and utilization of IS in value chain processes would eventually enhance the company's supply chain competitiveness through efficient linkage and integration of various supply chain activities (Bowersox 1989; Byrne and Markham 1991; Closs 1994; Daugherty 1994; Earl 1989; Hewitt 1994; McFarlan and McKenney 1984; Porter and Millar 1985; Stevens 1989). In particular, previous works (Bowersox 1989; Byrne and Markham 1991; Hewitt 1994; Stevens 1989) on the process of supply chain integration 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 value connection. The change in IS utilization focus would make it possible for IS utilization to have a direct effect on supply chain competitiveness. The following hypotheses represent such view.

H5: IS utilization for value creation management has a direct influence on supply chain performance.

H6: IS utilization for logistical operations has a direct influence on supply chain performance.

RESEARCH METHODOLOGY

A brief overview of the research methodology is provided next.

Sampling

Consistent with the purpose of this study, target corporations to be sampled were large manufacturing corporations carrying out all the value chain activities in a supply chain. The data were collected through questionnaires sent to supply chain managers in 590 large manufacturing corporations from Korea's listed and registered corporations. The questionnaires were transmitted by fax and mail. Follow-up phone calls were made to answer questions and remind the participants to complete and return the questionnaires. Also, two repeat mailings were done to increase response rate. The respondents were, in the main, supply chain managers. In cases where exclusive organization for supply chain management did not exist, response was requested from a top-level executive of the sales, production, planning, or information system department responsible for or well acquainted with supply chain policies and IS utilization strategies of the firm. In order to raise the reliability of measurement, respondents were requested to consult with others in the SCM department or functional executives as appropriate when answering questions. The reliability of responses on objective measures was confirmed through comparison with data collected from annual reports of the companies. Of 590 firms, 265 replied (142 from first mailing, 77 from second mailing, and 46 from third mailing). Of 265 responses, 21 incomplete responses were discarded. Accordingly, the analysis that follows and all reported statistics were based on a sample of 244 manufacturing organizations. Respondent and non-respondent companies were compared for industry and size to test for response/non-response bias. There were no differences between respondents and non-respondents for industry (χ^2 = 4.75, p>.05), and for size measured as sales (t = 1.02, p>.05) and as assets (t = .96, p>.05). Also, a comparison of first with second and third wave respondents revealed no differences in mean responses for industry (χ^2 = 6.84, p>.05), for sales (F = .95, p>.05), and for assets (F = .87, p>.05).

Table 1 summarizes the sample characteristics according to industry type and size. As can be seen in Table 1, the sample firms in this study encompass a diversity of industry types and sizes. The diversity of the sample should strengthen the external validity of the study results.

TABLE 1

SAMPLE CHARACTERISTICS

		Type of Industry					
		Consumer Industry[a]		Basic Industrial Material Industry[b]		Electronic and Machinery Industry[c]	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	500-1,000	Above 1,000	Total
No. of Firms	Sales	18	50	52	70	30	24	244
	Assets	14	34	60	64	38	34	244

[a]Consumer industry: food processing, sweetmeats, pharmaceuticals, footwear, clothes, wood, furniture
[b]Basic industrial material industry: textile, organic chemical, inorganic chemical, petrochemical, cement, paper, tire, fertilizer, fabric, pulp, metal
[c]Electronics and machinery industry: computer, home appliances, communication equipment, electronic parts, automobile, automobile parts, machinery

Measurements

Functional information systems

Based on prior research (see Table 2), which classify logistics activities in integrated supply chain management and functional information systems for logistics management, nine traditional uses for information systems in supply chain management were identified: *plant and warehouse location selection, order processing, resource management, production plan and process control, inventory and warehouse management, distribution and transportation management, sales and price management, consumer service and customer management, and forecasting.* By adding three more sub-functional information systems *(network planning and design system, office information system, and accounting information system)*, a total of 12 functions were identified. IS utilization level in each of these 12 functions was measured for two different time frames—three years ago and current time period—by seven-point Likert scales. Growth in the utilization level of information systems was derived by comparing data for these two time frames.

TABLE 2

PRIOR RESEARCH

The Classification of Logistics Activities

Ballou (1985)	Core Activities 1. Transportation 2. Inventory 3. Customer Service 4 . Order Execution 5. Information Flow Supporting Activities 1.Warehouse Management 2. Resource Management 3. Packaging 4. Product Planning 5. Facility Locations
Bowersox (1989)	Production Logistics Function 1. Manufacturing 2. Scheduling 3. Quality Control 4. Process Control 5. Inventory Management 6. Warehouse Management Connection Logistics Function 1. Facility Location 2. Resource Management 3. Order Processing 4. Packaging 5. Transportation 6. Forecasting Sales Logistics Function 1. Market Research 2. Sales Promotion 3. Price Decision 4. Product Mix 5. Sales Information Management 6. Customer service
Cooper & Ellram (1993)	Physical Activities 1. Production 2. Transportation 3. Inventory Transaction Activities 1. Order Cycle Management 2. Transportation/Distribution

The Classification of Functional Information Systems for Logistics Management

Ballou (1985)	1. Facility Location 2. Inventory Control 3. Order Entry 4. Vehicle Scheduling 5. Warehousing Layout Planning 6. Freight Rate Retrieval 7. Product/Shipment Tracing
Gustin (1994)	1. Forecasting 2. Planning 3. Budgeting 4. Inventory Management 5. Production Planning/Control 6. Procurement 7. Order Processing/Invoicing 8. Customer Service 9. Transportation Management 10. Facility Management
Mentzer, Schuster, & Roberts (1990)	1. Facility Location 2. Terminal Analysis 3. Carrier Routing/Scheduling 4. Logistics System Design
Robeson & House (1985)	1. Facility Location 2. Inventory Control 3. Transportation Scheduling 4. Production Scheduling 5. Total Physical Distribution
Stenger (1986)	1. Transaction System 2. Short-term Scheduling & Inventory Replenish System 3. Flow Planning System 4. Network Planning/Design

SCM performance

In this research, multi-dimensional indices ranging from financial factors reflecting the level of cost reduction to nonfinancial factors reflecting the level of differentiation were used to capture supply chain management performance comprehensively. This approach to measuring SCM performance by dividing it into financial and nonfinancial measures has been used by previous researchers (Bowersox 1989; Germain 1989; Mentzer and Konrad 1991; Shapiro 1984; Sterling and Lambert 1984). This study used *purchasing cost, operation cost, inventory cost, warehouse cost, sales cost, and distribution/transportation cost* as financial indices related to supply chain management. Non-financial measures (Birou, Fawcett, and Magnan 1998; Lummus, Vokurka, and Alber 1998; Tan, Kannan, and Handfield 1998; Zaheer, McEvily, and Perrone 1998) 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 performance on cost reduction was derived by comparing the costs three years ago to the current level, according to each company's annual financial data. Non-financial performance dimensions of each sample firm were measured by a subjective rating relative to its major industry competitors on a seven-point scale with endpoints labeled "Worst in Industry" and "Best in Industry."

Developmental stage of supply chain integration

The prevailing views of integrated supply chain management were employed in this study to define supply chain integration developmental stages. Some of the existing research on supply chain management emphasize that supply chain integration should be accomplished sequentially from internal integration to external integration (Byrne and Markham 1991; Ellram 1992; Heskett 1989; Hewitt 1994; Narasimhan 1997; Stevens 1989). In particular, Stevens presents the integration process of supply chain management comprehensively starting with the integration of related functions to internal integration and on to external integration.

TABLE 3

FOUR INTEGRATION STAGES OF SUPPLY CHAIN MANAGEMENT

Stage	Definitions
Stage 1: Independent Operation of each function	• Business functions such as sales, manufacturing, planning, material control, and purchasing are operated on an almost separate basis. • This stage is characterized by organizational boundaries, whereby purchasing might control the incoming material flow of raw material stocks, manufacturing and production control then cover raw material through the processes which convert it into finished goods, and further along the chain, sales and distribution divide the responsibility for outbound supply chain and inventories.
Stage 2: Functional Integration	• Limited integration between functions such as shipping and inventory or purchasing and raw material management is accomplished. • This stage is characterized by emphasis on cost reduction rather than performance improvement; discrete business functions, each of which is buffered by inventory; elements of internal trade-off between, for example, purchase discount and the level of inventory investment; high plant-utilization and batch sizing; and reactive customer service.
Stage 3: Internal Integration	• All internal functions from raw material management through production, shipping, and sales are connected and integrated realtime. • This stage is characterized by full systems-visibility from distribution through to purchasing medium-term planning; a focus on tactical rather than strategic issues; an emphasis on efficiency rather than effectiveness; and reaction to customer demand rather than managing the customer.
Stage 4: External Integration	• Full supply chain integration extending the scope of integration outside the company encompassing suppliers and customers is accomplished. • This stage is characterized by the supply of high quality products shipped direct to the line on time; completely shared information on products, processes and specification changes; technology exchange and design support; a focus on strategic rather than tactical issues; and above all long-term commitment, which usually means the elimination of multiple-sourcing.

Source: Graham C. Stevens (1989), "Integrating the Supply Chain," *International Journal of Physical Distribution and Materials Management,* Vol.19, No. 8, pp. 3-8.

In this research, respondents were asked to indicate the stage of supply chain integration their firms were at based on the conceptual definition of four integration stages of supply chain management discussed by Stevens (1989). Table 3 describes the definitions of each of four supply chain integration stages.

RESULTS

The Classification of the Characteristics of IS Utilized for Supply Chain Management

Factor analysis by Varimax rotation was used to assess the constructs of the 12 measured degrees of functional IS utilization. Table 4 shows the results of factor analysis after Varimax rotation of factors.

TABLE 4

FACTOR ANALYSIS

Measurement Item	Factor	IS for Logistical Operations (α=0.8356)[a]	IS for Value Creation Management (α=0.9050)	IS for Infrastructural Support (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 and 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

[a]α : the result of Cronbach α test

As shown in Table 4, the 12 functions identified can be divided into three major utilization areas. The first is the IS utilization for *logistical operations* that focuses on the connection among value chain activities within and outside of a corporation *(plant/warehouse location selection, resource management, order processing, distribution/transportation management, and forecasting)*. The second is the IS utilization for *value creation* management that focuses on 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 third is the IS utilization for *infrastructural support* which provides infrastructural foundation for the effective operation of value chain activities *(network planning/design system, office information system, and accounting information system).*

The above classification into three clusters of utilization areas has validity in light of the previous studies on the classification of logistics activities and functional information systems for logistics management (Ballou 1985; Bowersox 1989; Cooper and Ellram 1993; Gustin 1994; Lambert and Stocks 1993; Mentzer, Schuster, and Roberts 1990; Robeson and House 1985; Stenger 1986). The functional information systems comprising the same factor have high level factor loadings on the factor, thus reflecting a high construct validity.

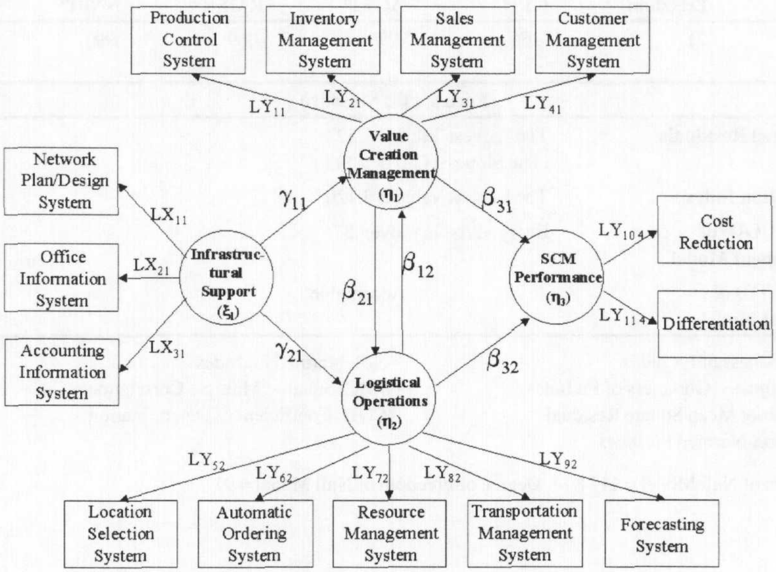
Structural Equation Model

Structural equation modeling technique was used to model the interrelationships among the latent variables.

The hypothesized interrelationships are shown in Figure 2.

FIGURE 2

STRUCTURAL EQUATION MODEL



This model has been constructed on the assumption that IS utilization for infrastructural support can bring about a change in the level of IS utilization for value creation management or logistical operations. This assumption is based on the fact that IS for infrastructural support is foundational and as such plays a role in IS utilization in the supply chain. This assumption also implies that IS utilization for infrastructural support may have an indirect impact on SCM performance by aiding IS utilization for value creation management or logistical operations.

We used the maximum likelihood method for the estimation of unknown parameters since it is generally recognized as being superior (Bagozzi and Yi 1989; Boomsma 1982), and also employed the matrix of covariance among measurement variables as input data for LISREL analysis.

Goodness of Fit (GOF) of the Models

Table 5 shows the results of Goodness of Fit for the established structural equation model.

TABLE 5

THE GOODNESS OF FIT OF THE STRUCTURAL EQUATION MODEL

Overall Fit Measure						
χ^2 Value	Degree of Freedom	GFI[a]	AGFI[b]	RMSR[c]	NNFI[d]	NFI[e]
76.42 (P=.457)	71	.966	.950	.069	.99	.93
Focused Fit Measure						
Normalized Residuals		The Largest Value is 1.523 (The Slope of Q-plot ≥ 1)				
Modification Index		The Largest Value is 3.120				
SMC[f] or COD[g] of Measurement Model		Every Variable is over .3				
SMC or COD of Structural Model			Acceptable			

[a]GFI: Goodness of Fit Index
[b]AGFI: Adjusted Goodness of Fit Index
[c]RMSR: Root Mean Square Residual
[d]NNFI: Non-Normed Fit Index
[e]NFI: Normed Fit Index
[f]SMC: Squared Multiple Correlations
[g]COD: Coefficient of Determination

[d, e]χ^2 Value of Null Model = 1174.74, Degree of Freedom of Null Model = 91

As shown in Table 5, most indices except Root Mean Square Residual (RMSR) satisfy the standards of Goodness of Fit, indicating that the data fit the model well. Also, the model leaves nothing to be desired as judged by the modification indices. It can be noted that the RMSR value of 0.069 does not meet the generally accepted standard (0.05). However, RMSR cannot be the decisive factor in judging the Goodness of Fit of the model because the matrix of covariance was employed as input data for LISREL analysis. Considering all the Goodness of Fit indicators, the proposed structural equation model can be judged to fit the data very well.

The results showed that the T-values of γ_{21}, β_{12}, β_{32} in the model did not meet the 5% significance level. Consequently these paths are not statistically significant. By fixing the path coefficients at a value of zero, an overidentified model can be constructed when the Goodness of Fit of the established model is satisfactory as established in the preceding analysis. Accordingly, the model was modified by fixing the three path coefficients at "0" one at a time. The overall Goodness of Fit measures of the final, modified model was:

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

These measures, when compared to the overall Goodness of Fit measures for the initial model in Table 5, show little or no difference. The result of a χ^2 difference test fails to reject the null hypothesis that the difference in Goodness of Fit between the final model and the initial model is not different from zero, suggesting that the over-identified model does not decline the overall Goodness of Fit of the initial model.

The Interpretation of Results

Table 6 shows the results of the validity test of the measurement model and Table 7 shows the results of hypothesis testing of the structural relationships among latent variables.

TABLE 6

VALIDITY TEST OF MEASUREMENT MODEL

	Maximum Likelihood	T-Value	
Measurement Model of Dependent Variables			
LY_{11}	1.000		Reference Variable
LY_{21}	1.024	7.259	**
LY_{31}	1.047	7.375	**
LY_{41}	1.036	7.322	**
LY_{52}	1.000		Reference Variable
LY_{62}	1.021	7.102	**
LY_{72}	0.954	6.769	**
LY_{82}	0.983	6.915	**
LY_{92}	0.973	6.866	**
$LY_{10\,3}$	1.000		Reference Variable
$LY_{11\,3}$	1.068	4.523	**
Measurement Model of Independent Variables			
	Maximum Likelihood	**T-Value**	
LX_{11}	1.000		Reference Variable
LX_{21}	1.093	5.940	**
LX_{31}	1.136	6.025	**

** Statistically Significant at $p \leq 0.05$

TABLE 7

VALIDITY TEST OF STRUCTURAL MODEL

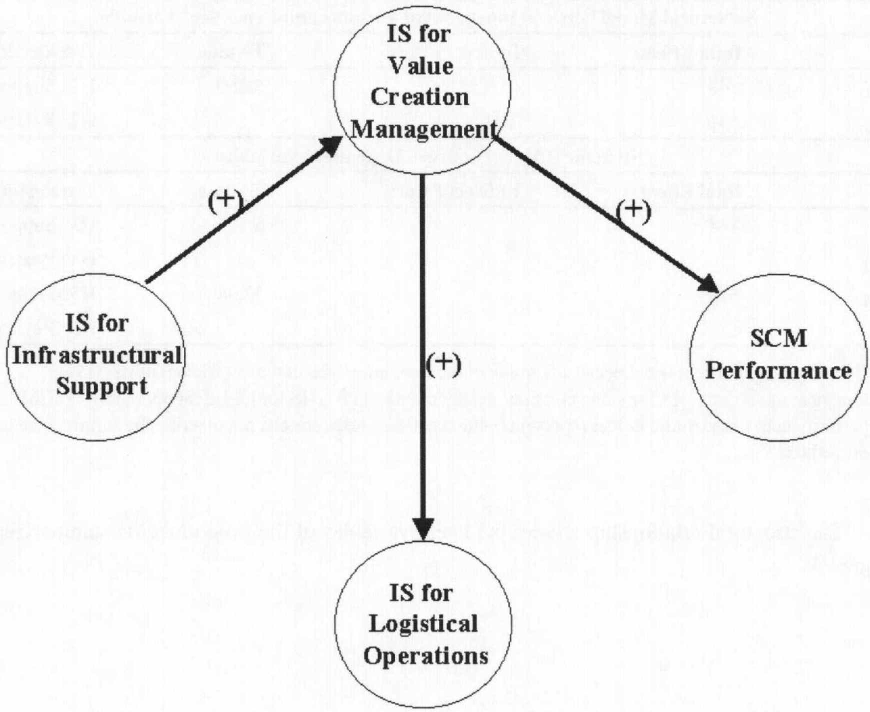
Structural Model between Independent Variable and Dependent Variable				
	Total Effect	**Indirect Effect**	**T-value**	***Test Result***
γ_{11}	.748		5.250	H1 : Supported
γ_{21}	.631	.631		H2 : Rejected
Structural Model between Dependent Variables				
	Total Effect	**Indirect Effect**	**T-value**	***Test Result***
β_{21}	.844		6.529	H3 : Supported
β_{12}				H4 : Rejected[a]
β_{31}	.675		5.208	H5 : Supported
β_{32}				H6 : Rejected[b]

[a, b] H4 and H6 are not supported because T-value of the maximum likelihood coefficient of β_{12} (IS for logistical operations→IS for value creation management) and β_{32} (IS for logistical operations→SCM performance) of the initial model represent 0.408 and 0.922 respectively, not meeting the significance level of α=0.05.

The structural relationship among the latent variables of the final model is summarized in Figure 3.

FIGURE 3

CAUSAL RELATIONSHIP BETWEEN LATENT VARIABLES



As can be seen in Table 7, the results from the structural model confirm H1, H3, and H5, but do not lend support for H2, H4, and H6.

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

First, IS for infrastructural support, as shown in Figure 3, does not have a direct impact on SCM performance. However, IS utilization for infrastructural support has a direct effect on IS utilization for value creation management, and IS utilization for value creation management has a direct effect on SCM performance. This means that IS utilization for infrastructural support may play an indirect role in enhancing SCM performance through IS utilization for value creation management.

The second aspect pertains to the structural relationship among the three IS latent variables characterizing IS utilization in a supply chain. The paths that are statistically significant indicate the structural relationship: infrastructural support→value creation management→logistical operations. This implies that utilization of IS for infrastructural support enhances the utilization level of IS for value creation management which, in turn, brings about utilization of IS for logistical operations.

The third aspect is the relationship between IS utilization for logistical operations and SCM performance. The result of LISREL analysis shows that the path coefficient associated with the link leading from IS utilization for logistical operations to SCM performance is not statistically significant. This suggests that the benefits of IS utilization for logistical operations on SCM performance are not supported in the study sample. Partial explanation for this result can be found in the items that were used in this study to capture SCM performance. An overwhelming majority of the items related to aspects of supply chain over which the logistics function does not exercise direct control. This linkage merits further examination in a future study. Another explanation could be that IS utilization for logistical operations and its influence could be related to the firm's stage of supply chain integration. For example, it can be speculated that IS utilization for logistics operations is more beneficial in firms that are pursuing external integration than in firms that are pursuing internal integration.

In order to verify this, a correlation analysis was conducted between IS utilization degrees in the three areas and SCM performance for each developmental stage of supply chain management. Table 8 shows the results of the correlation analysis, which indicate that IS utilization for infrastructural support has the highest correlation with SCM performance in the independent operation stage, while IS utilization for value creation management in functional and internal integration stages, and IS utilization for logistical operations in external integration stage, have the highest correlations respectively.

TABLE 8

CORRELATION RESULTS

	Independent Operation		Functional Integration		Internal Integration		External Integration	
	Cost[a]	Differ[b]	Cost	Differ	Cost	Differ	Cost	Differ
IS for Value Creation Management	.282*	.138	.427***	.305**	.285**	.408***	.295*	.307**
IS for Logistical Operations	.017	.115	.014	.139	.226*	.307**	.406***	.520***
IS for Infrastructural Support	.372**	.348***	.235*	.209	.185	.180	.170	.217

* p≤0.1 ** p≤0.05 *** p≤0.01

[a]Cost: The Level of Cost Reduction
[b]Differ: The Level of Differentiation

These results suggest that the structural relationship: infrastructural support (value creation management→logistical operations derived from SEM analysis is to be recommended for improving SCM performance. In particular, the fact that IS utilization for logistical operations has the highest, statistically significant correlation with SCM performance in the "external integration" stage should be noted.

CONCLUSION

This research, within the general conceptualization of supply chain integration, suggests an IS utilization strategy which calls for a sequential IS utilization approach starting with infrastructural support, followed by value creation management, and ending with logistical operations. The above strategy is based on the empirical test of several hypotheses.

First, it was noted that IS utilization for infrastructural support has an indirect influence on SCM performance by providing the foundation for IS utilization in supply chain functions. The validity of this is confirmed by existing studies, which assert that IS utilization for infrastructural support provides the basis for establishing strategic linkages, and that the direct IS application to value chain activities may make it possible to pursue cost leadership and differentiation simultaneously and consequently gain competitive advantage (Closs 1994; Daugherty 1994; Earl 1989; McFarlan and McKenney 1984; Porter and Millar 1985).

Second, the results show that IS utilization for value creation management is a precondition for the utilization of IS for logistical operations. In other words, IS utilization for value creation management should be well established in order to utilize IS for logistical operations properly. This coincides with the previous studies, which emphasize that the improvement of each internal function in the internal integration stage should precede the external connection with suppliers and customers in the external integration stage, and IS utilization strategy also should follow the above sequence in the integration process (Bowersox 1989; Byrne and Markham 1991; Hewitt 1994; Stevens 1989).

This research also suggests that, in order for the recommended IS strategy to be implemented successfully, it must be coordinated with the requirements of "external integration" as the firm moves through various stages as it pursues supply chain integration. This means that as supply chain integration moves to external integration requiring a high level of integration technology, the utilization of information systems alone cannot maximize the effect of supply chain integration. Closs, Earl, and Gustin have expressed 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 system's external environments is required. This research provides empirical support to their assertion.

This paper suggests that the functional relationship between the stage of supply chain integration and IS utilization may be a reason for the lack of a statistically significant relationship between IS utilization for logistical operations and SCM performance. The validity of such a contention can be confirmed through the test of the proposed model, by supply chain integration stage of sample firms. This line of inquiry is worthwhile pursuing in a future study. Also, the proposed model can be generalized by the cross-validation process of applying the model to new data and evaluating its "Goodness of Fit" by analyzing the structural relationships among 12 functional information systems constituting three IS utilization areas. The effect of intervening variables on the relationship between IS utilization and SCM performance also deserves further investigation.

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