Supply chain innovation and organizational performance in the healthcare industry

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Abstract

Purpose – The purpose of this paper is to examine supply chain (SC) innovation for improving organisational performance in the healthcare industry.

Design/methodology/approach – A research model is proposed which describes the impact of SC innovation, supplier cooperation, SC efficiency, and quality management (QM) practices on organisational performance. The proposed research model and hypotheses were tested using structural equation modeling based on data collected from 243 hospitals.

Findings – The results of the study support that organisational performance is positively associated with constructs of each SC innovation factor. Innovative design of SC has a significant impact on selection of and cooperation with excellent suppliers, improved SC efficiency, and encouragement of QM practices.

Research limitations/implications – The data used in this study were collected from relatively large hospitals with more than 100 beds in South Korea. The generalization of the study results may be limited by the size of sample hospitals.

Originality/value – This study provides useful planning information in the healthcare industry. The results suggest successful implementation of SC management is attained through continuous SC innovation with supplier cooperation, which in turn improves organisational performance.

Keywords South Korea, Hospitals, Supply chain management, Organizational performance, Health care, SC innovation, SC efficiency, Supplier cooperation, Quality management practice, Structural equation modeling

Paper type Research paper

Introduction

In recent years, health care has become a critical issue in the world, along with the increased concerns for medical errors, patient safety, and spiraling up medical costs (McFadden *et al.*, 2006a, b; Olden and McCaughrin, 2007; Stock *et al.*, 2007; Gowen *et al.*, 2008). Also, in today's intensively competitive global market, effective supply chain management (SCM) plays a critical role in improving organisational performance and competitive advantage (Schneller and Smeltzer, 2006; White and Mohdzain, 2009). The competitive environment requires organisations to provide high quality products and services, deliver rapid service response, and develop dynamic capabilities that are congruent with the rapidly changing business environment (Fawcett and Magnan, 2001; Lin *et al.*, 2005; Teece, 2009). Accordingly, organisations strive for efficient operations, such as value-added process improvement, reduction of delivery cost, and improved quality of products and services, while maintaining close cooperation with their suppliers.

Many researchers have stressed the importance of effective SCM in the healthcare industry (Fawcett and Magnan, 2001; Chan *et al.*, 2008; Kumar *et al.*, 2008; Mustaffa and Potter, 2009; Shin *et al.*, 2009; White and Mohdzain, 2009). Healthcare services

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involve comprehensive and complex systems that treat and prevent diseases, including medical consumables, laundry and cleaning, medical exercise equipment, home-care products, information systems, wheelchairs, vehicle fleet management, and general materials (Gattorna, 1998). One of the biggest challenges for SCM in the healthcare industry is managing costs while meeting customer demands (Hook, 2009). According to the Healthcare Financial Management Association (2008) SC survey, the healthcare industry is expected to invest as much as 55 percent of total hospital expenses on the implementation of SCM by 2011. For effective SCM, organisations need to first innovate their business processes, while considering their suppliers' processes.

Innovation is an imperative tool for organisations to gain their competitive advantage and improve organisational performance (Porter, 1990). SC innovation refers to a complex process which deals with uncertainty in the environment, so as to provide solutions for customer needs and find new ways to better organisational processes using new technologies (Porter, 1990; Herzlinger, 2006). SC innovation helps organisations achieve SC efficiency for more effective customer value creation (efficient data management, speedy processing of patient care, medical error reduction, etc.), which is expected to result in a positive impact on organisational performance. Innovative applications of information technology (IT) lead to value creation for customers, increased efficiency and accuracy of care service delivery, and improved quality care (Anderson, 2002; André *et al.*, 2008; Shih *et al.*, 2009).

This study proposes a research model to ascertain how SC innovation will improve organisational performance through SC efficiency, better cooperation with suppliers, and effective quality management (QM) practices. Data are collected from managers of SC or logistics departments in hospitals. Specifically, this research attempts to address the following questions:

- Does SC innovation have an impact on SC process improvement?
- Does SC process impact organisational performance?

The rest of this paper is organized as follows: the second section presents a review of relevant previous studies; the third section proposes a research model and develops hypotheses; the fourth section provides the research methodology; the fifth section reports the results of data analysis; the sixth section presents discussion of the results; and the seventh section provides the conclusion and limitations of the study.

Review of relevant literature

SCM in the healthcare industry

The SC is an integral part of providing quality care to the patient in the healthcare system. SC refers to "a set of organisations directly linked by one or more of the upstream and downstream flows of products, services, finances, and information from a source to a customer" (Mentzer *et al.*, 2001). There are many definitions of SCM. More commonly accepted definition by the Council of SCM Professionals is:

> [...] the planning and management of all activities involved in sourcing, procurement, conversion, and logistics management. It also includes the crucial components of coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers.

In recent years, SCM has drawn significant attention in the healthcare industry since SCM shows a significant impact on hospital performance in terms of reducing waste, preventing medical errors, improving quality of care and service, and increasing operational efficiencies (Byrnes, 2004; Schneller and Smeltzer, 2006; Kowalski, 2009; Shih *et al.*, 2009).

SCM in hospitals include the internal chain (e.g. patient care unit, hospital storage, patient, etc.) and the external chain (e.g. vendors, manufacturers, distributors, etc.) (Rivard-Royer *et al.*, 2002; Schneller and Smeltzer, 2006). A hospital receives products and services from suppliers, and then stores and distributes to each care unit based on the hospital's operation processes. Therefore, SCM includes business activities (e.g. purchasing, distribution, management of suppliers) and operations that integrate a continuous, seamless flow of materials and services for healthcare delivery (Rivard-Royer *et al.*, 2002; Shih *et al.*, 2009).

According to Singh *et al.* (2006), healthcare SCM processes have three types of flows: "physical product flow, information flow, and financial flow." The physical product flow manages customized products and services for the treatment of patients and their needs. Information and financial flows are related to SC design decisions for effective product flow and improved organisational performance (Singh *et al.*, 2006; Kowalski, 2009).

SC innovation

Innovation is essential for organisational sustainability (Drucker, 1985), and thus organisations in the fast evolving knowledge-intensive service industries must pay close attention to innovation (Howells and Tether, 2004; Miles, 2004). Chapman *et al.* (2003) suggest that the service industry needs to focus on SC innovation for effective delivery of services. While Drucker (1985) defined innovation as a specific tool for entrepreneurs, Tidd *et al.* (1997) defined innovation as:

> [. . .] a process of turning opportunity into new ideas and putting these into widely used practice. Innovation facilitates create new technical skills and knowledge that can help develop new products and/or services for customers (Afuah, 1998).

Three types of innovation are important in healthcare systems: "customer-focused, technology based, and integrator" (Herzlinger, 2006). Customer-focused innovation focuses on reducing patient waiting time as well as expenses and medical cost. The technology-based innovation is for improving the delivery system that depends on SC so that improved processes can provide high quality care, new types of treatment, prevention of diseases, the reduced delivery time of products and services, improved quality of delivered products and IT applications. The integrator innovation is for improved efficiency of healthcare services, group purchasing, and the integrated network, IT, and SC. IT applications can provide support to all three types of innovation.

SC innovation has been regarded as a critical success factor for organisational performance in the healthcare industry (Byrnes, 2004; Herzlinger, 2006; Schneller and Smeltzer, 2006; Singh *et al.*, 2006). SC innovation refers to tools that can improve organisational processes needed for effective SCM through seamless interactions with suppliers, manufacturers, distributors and customers (Lin, 2008). Thus, SC innovation allows reduction in cost and lead time, creation of new operational strategies, provision of consistent quality, and development of flexibility for dealing with rapid changes in the business environment (Stundza, 2009). Effective SC innovation contributes to quality healthcare services by ensuring continuous improvement and reducing medical errors (Singh *et al.*, 2006). Therefore, SC innovation will help ensure efficient supply of products and services to patents and hospitals in the rapidly changing environment.

According to previous studies (Lundvall, 1985; Sivadas and Robert, 2000; Roy *et al.*, 2004; Schneller and Smeltzer, 2006), interaction between buyers and sellers influence innovation, which involves changes or developments in products, services or processes to reduce cost and/or improve efficiency. Parnaby and Towill (2008) suggested that new SC innovation is imperative in the healthcare system. In this study, we developed measurement items of SC innovation, based on studies by Parnaby and Towill (2008).

Supplier cooperation

Supplier cooperation has become one of the most important strategies for long-term growth of the organisation (Chan *et al.*, 2008). As healthcare costs sky rocket, hospital managers and the government strive to find ways to contain medical costs through more effective purchasing. Purchasing functions often include inaccurate orders or incorrect shipping from suppliers. Lambert *et al.* (1997) also stressed the importance of supplier cooperation in the healthcare industry.

To select the best suppliers, organisations have examined dimensions of supplier cooperation based on four attributes of suppliers: quality of product, service, price, and delivery (Lambert *et al.*, 1997). According to respondents' perception in the Lambert *et al.* (1997) study, the healthcare industry has prioritized quality of products and services over cost reduction, even though most governments emphasize the other way around.

Lambert *et al.* (1997) examined feedback from 299 respondents from a survey of 1,005 hospitals. In the study, the top 20 of the 79 attributes of supplier cooperation are classified in the following five categories of consistency: the supplier's delivered product, supplier actions, healthcare professionals' service, competence of sales representatives, and delivery and service-related criteria. The significant result of the study showed that primary suppliers received the largest amount of orders (Lambert *et al.*, 1997). This means that a hospital chooses suppliers depending on the hospital's own supplier cooperation criteria. Therefore, an effective process of supplier cooperation will help hospitals achieve their objectives in SCM. This study adapted measurement items of supplier cooperation suggested by Lambert *et al.* (1997).

SC efficiency

In a dynamic competitive industry, organisations and suppliers must maintain a competitive advantage and position, and improve performance through efficient SC operations (Chen, 1997; Heikkilä, 2002). SC efficiency, which refers to profitability, flexibility, reliability, and waste elimination, can be unique to each individual organisation that supports better operational processes and improves speed of delivery or response to customer requests using information systems (Chen, 1997; Li and O'Brien, 1999; Heikkilä, 2002).

Fisher (1997) proposed efficient SC to reduce cost and improve quality through effective supplier selection. Cigolini *et al.* (2004) suggested that efficient SC reduces cost and improves service and quality. Chen (1997) stresses flows of cost and information to achieve SC efficiency in the acquisition process. SC creates and adds value to products and services for customers and cost components (e.g. cost of production, transportation, and internal material handling, etc.) play a role as operational processes (Chen, 1997). Cost can incur by an incorrect order-to-delivery cycle, complexity of the transportation process, and storage of products. Information networks help develop a positive relationship between customers and suppliers (Heikkilä, 2002).

There are some obvious benefits derived from SC efficiency: speed in response, waste elimination, and information networks within/between suppliers and customers (Fisher, 1997; Pin, 2001; Heikkilä, 2002; Cigolini *et al.*, 2004). Speed in response increases delivery lead time, captures customer consumption, and reduces operational response (Pin, 2001; Treville *et al.*, 2004). The waste elimination process includes reduced steps of supply which result in transportation cost reduction, and streamlined processes for waste reduction (Pin, 2001; Heikkilä, 2002). When companies develop or use more efficient information networks, they can improve processes for continuous replenishment and shipping based on ordering notices.

Companies can also explore other information technologies such as radio-frequency identification (RFID) for transportation tracking and shared databases, and electronic data interchange (EDI) for order placement and invoicing. The internet can also improve communication with customers. In this study, we use modified measurement items of SC efficiency, based on Heikkilä (2002) and Hsieh *et al.* (2007).

QM practice

The growing emphasis on organisational innovation necessitates the use of advanced information and communication technologies (ICTs) for SCM, QM, business process reengineering, enterprise resource planning (ERP), and customer relationship management to improve competitiveness (Lin *et al.*, 2005; Flynn and Flynn, 2005; Flint *et al.*, 2008). To achieve competitive advantage, organisations need innovation for better quality care/services, SC efficiency, and customer satisfaction based on care competencies.

QM is a key factor in a value-added process to provide high quality products and services. QM practice reduces process variance, shipping damage, and delivery cycle time on SC (Flynn and Flynn, 2005; Lin *et al.*, 2005). In reducing process variance, QM allows for improvement of delivery time and efficient operation, reduction of cycle stock and waste, and close relationships with customers and suppliers.

Lin *et al.* (2005) developed nine measurements of QM practice: "top management leadership, training, product/service design, supplier QM, process management, quality data reporting, employee relations, customer relations, and benchmarking learning." These measurements are included to assess QM practice in the Malcolm Baldrige Award criteria (Flynn and Flynn, 2005). This study modified the measurement items of QM practice, based on Flynn and Flynn (2005), Lin *et al.* (2005) and the National Institute of Standards and Technology (2009), which administers the Malcolm Baldrige National Quality Award.

Organisational performance

Many empirical studies have examined the causal relationship between SCM measurement items and organisational performance, as summarized in Table I.

To evaluate the impact of SC orientation on supplier/buyer performance, Shin *et al.* (2000) identifies two main performance factors; the supplier performance is measured by cost, lead time, quality, delivery reliability, and on time delivery; and buyer performance

Table I.
SCM measurements and organisational performance

Authors	Factors	Type	Approach	Main purpose of the paper
Shin *et al.* (2000)	Supplier performance – cost, lead time, quality, delivery reliability, and on time delivery Buyer performance – performance, reliability, conformance, features, and durability of product	Empirical	Causal	To evaluate the impact of SC orientation on supplier/buyer performance
Tan (2002)	On time delivery, single source items, acceptable incoming materials, number of suppliers, supplier certification, and total cost of purchased parts	Empirical	Causal	To investigate practices, concerns, and performance on SCM
Lin *et al.* (2005)	Product quality, competitive position, and customer service	Empirical	Causal	To identify the relationship between SC QM and organisational performance
Sanders (2007)	Cost improvement, product quality improvement, new product introduction time, delivery speed improvement	Empirical	Causal	To extend relationships between e-business technologies, collaboration, and performance
Chow *et al.* (2008)	Product quality, competitive position, and customer service	Empirical	Causal	To evaluate SCM effects on organisational performance
Flint *et al.* (2008)	Retaining customers and nurturing customer relationships	Empirical	Causal	To investigate customer value, SC learning and innovation management on performance perception

is measured by reliability, conformance, features, and durability of the product. Lin *et al.* (2005) suggested that product quality, the competitive position, and customer help indicate the relationship between SC QM and organisational performance. This study modified measurement items of organisational performance suggested by Lin *et al.* (2005).

Research model and hypotheses

Figure 1 shows the proposed research model describing how SC innovation would affect supplier cooperation, SC efficiency and QM practice, which in turn affect

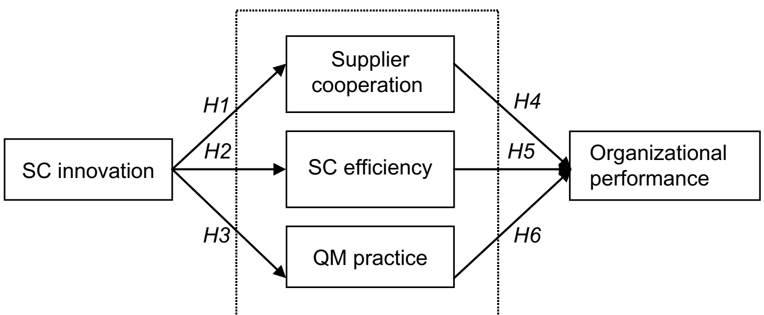


Figure 1.
The proposed research model

organisational performance. SC innovation plays a key role in developing products and services that fulfill customers' needs and values (Kahn, 2000; Flint *et al.*, 2005, 2008). On one hand, if an organisation focuses on value creation for customers, it can do so through customer acquisition, satisfaction, and loyalty (Kahn, 2000). On the other hand, if an organisation provides its products and services by a delivery system, it must improve its SC processes through innovation to continuously search for customers' needs and values (Flint *et al.*, 2005, 2008).

SC innovation and supplier cooperation

The organisation needs seamless cooperation and collaboration with suppliers to realize its strategic innovation (Chan *et al.*, 2008; Teichert and Bouncken, 2008). For example, a shared distribution center (warehouse) for retailers or suppliers is common, and data collection is usually accomplished at this location (Franks, 2000). If an organisation develops innovative new products and/or services, competent partner distributors can deliver them to the market and end-users with speed. On the other hand, Roy *et al.* (2004) mention that supplier alliances are a quick route to generate innovation in SC. However, medicinal products (e.g. medications, medical devices, etc.), which are produced by manufacturers, need approval from a government agency or the World Health Organisation to be used in hospitals. This necessitates a close cooperative relationship between hospitals and suppliers for their SC to be successful.

Customers often provide new ideas about the existing products and services to suppliers who, in turn, can communicate with the vendor to provide more value-added products, thus enabling innovation throughout the SC (Franks, 2000; Chan *et al.*, 2008). Suppliers can be involved at the early stage of innovation such as product development and organisational processes for packaging, storage, and transportation (Flint *et al.*, 2008). Thus, SC innovation can improve organisational processes for developing new ideas through cooperation with suppliers (Chan *et al.*, 2008; Lin, 2008). Consequently, SC innovation will have a positive relationship with supplier cooperation. Therefore, the following hypothesis is proposed:

H1. SC innovation will positively affect supplier cooperation.

SC innovation and SC efficiency

The competitive global environment is forcing organisations to become lean and effective. As a result, a growing number of firms are seeking innovation to bring efficiencies in all areas of their operation to remain competitive (Fisher, 1997; Roy *et al.*, 2004; Flint *et al.*, 2008; White and Mohdzain, 2009). SC efficiency streamlines the process for suppliers (Franks, 2000). For packaging, storage, and transportation, suppliers are usually involved at the very early stage of innovation for SC efficiency (Flint *et al.*, 2008). SC efficiency also allows a high-speed process using IT, such as RFID and EDI, enabling fast communication across organisations and eliminating waste (Li and O'Brien, 1999; Franks, 2000; Schneller and Smeltzer, 2006). SC efficiency plays a vital role in improving speed and performance, eliminating waste, and developing efficient information networks; all supported by SC innovation. SC innovation brings about SC efficiency including reduced lead time, new operation strategies, and consistent quality (Stundza, 2009). Thus, we propose the following hypothesis:

H2. SC innovation will positively affect SC efficiency.

SC innovation and QM practice

SC innovation includes QM practice to increase quality of products and services, which in turn affects customer satisfaction. Organisations strive to develop new and more efficient processes through collaborative innovation with their partners to improve customer satisfaction and performance. As SC innovation supports consistent quality of products and services, it can influence QM practice to reduce process variance and prevent rework and errors (Flynn and Flynn, 2005; Lin *et al.*, 2005; Singh *et al.*, 2006; Lin, 2008; Stundza, 2009). Thus, the following hypothesis is proposed:

H3. SC innovation will positively affect QM practice.

Impact on organisational performance

Suppliers can meet or exceed customer expectations with high quality products and services. Thus, good supplier cooperation is critical for improving performance and maintaining competitive advantage (Lambert *et al.*, 1997; Lin *et al.*, 2005; Flint *et al.*, 2008). Fisher (1997) suggested the physically efficient process and the market responsive process as reliable criteria for selecting the best supplier for organisational performance. If a company focuses on the physically efficient process, it may select suppliers based on cost and quality. On the other hand, if the market responsive process is a priority, the firm should choose suppliers primarily for speed, flexibility and quality.

In SCM, long-term relationships between the supplier and customers and/or an organisation are necessary to increase organisational performance and competitiveness (Lin *et al.*, 2005). Thus, if an organisation selects a good supplier as a partner in SCM, the customer base can be expanded in the competitive environment.

SC efficiency reduces waste and the speed of process flow, and increases performance through efficient operations, thus helping maintain competitive advantage (Chen, 1997; Fisher, 1997; Pin, 2001; Heikkilä, 2002; Cigolini *et al.*, 2004). Thompson *et al.* (2007) proposed that improvement of SC efficiency and effectiveness are important elements to improve organisational performance.

As discussed earlier, the role of QM practice is to improve quality of products and service and to improve organisational performance. Lin *et al.* (2005) suggest that QM practice can integrate collaborative efforts with suppliers and positively affect organisational performance. Thus, supplier cooperation, SC efficiency, and QM practice will have a positive relationship with organisational performance. The following hypotheses are proposed:

H4. Supplier cooperation will positively affect organisational performance.

H5. SC efficiency will positively affect organisational performance.

H6. QM practice will positively affect organisational performance.

Research methodology

Data collection

Data for this research were collected from 243 hospitals in South Korea. The reasons why Korean hospitals were chosen for data collection are as follows:

- South Korea has become a world leader in ICTs (Lee, 2003). Based on its superb ICT infrastructure, efficient and high-quality healthcare information systems have been developed and used in most hospitals (e.g. one-stop service).

Korean hospitals offer high-tech medical services by combining advanced IT and biotech, and continue to make significant advances in the field. According to The Korean Hospital News (2007), one of the hospitals implementing SCM systems exports its system to advanced countries, which was designed without using warehouses to decrease inventory and logistics cost.

- South Korea is one of the major medical tourism countries in the world. Recently, many medical specialists from other countries have visited Korea to learn and/or benchmark hospital SCM systems. A survey of international patients, who visited Korea for medical tourism in 2008, showed that 48.4 percent cited "the quality of medical service and technology" as the reason for choosing Korea (Korea Tourism Organisation, 2009).
- Korea has two types of medical care systems: Western and oriental medical treatment service. Hospitals can provide either Western or oriental medical service, or a combination of both, based on the approval the hospital received from the Ministry of Health and Welfare. Since SCM in two different types of hospitals differ from each another, the SCM system for the combined service needs more functions and features to facilitate two different systems.

A pilot study was conducted in 30 participating hospitals. Participation in this survey was totally voluntary. After the pilot survey, one of the measurement items of supplier cooperation (supplier action) was removed as it was suggested by logistics managers that the item was too ambiguous to measure. Also, some measurement items of the constructs were dropped from the preliminary instrument to increase reliability of constructs.

There are more than 2,300 hospitals (military and veterans hospitals excluded) in South Korea as of April 2009. According to the National Health Insurance in Korea, medical service facilities are categorized based on the number of beds and degree of specialization: first tier (0-30 beds), second tier (31- 700 beds), and third tier (more than 700 beds) (Choi *et al.*, 1998).

Hospitals with more than 100 beds were randomly selected according to the suggestion of Goldstein and Schweikhart (2002) that "small hospitals often do not share the complexity issues of large hospitals and may not have developed extensive QM systems." Tan (2002) proposed that directors or managers are more objective and knowledgeable with respect to their organisations' operations. We collected data from a single respondent (a senior manager of logistics) in each hospital to minimize respondent variance (Tan, 2002).

Questionnaires were sent to the director, vice president, or manager of logistics departments of 700 hospitals. No military, veterans, or specialty hospitals were included in the study due to the differences in the markets to which they provide care and service. Subsequently, we received useable questionnaires from 243 hospitals (a response rate of 34.7 percent).

The characteristics of hospitals and demographic information of respondents are summarized in Table II. The types of surveyed hospitals are teaching (6.2 percent), foundation (49.4 percent), public (11.9 percent), and private hospitals (32.5 percent). The categorized hospital type includes second (86.4 percent) and third tier (13.6 percent). The ranges of the number of beds were from more than 100 to more than 1,000. The two types of the respondents' positions in the logistics department were: manager (94.7 percent) and director (5.3 percent).

Table II. Hospital and respondents' characteristics

	Frequency	Percent
Hospitals' characteristics		
Hospital type		
Teaching	15	6.2
Foundation	120	49.4
Public	29	11.9
Private	79	32.5
Categorized hospital type		
Third tier	33	13.6
Second tier	210	86.4
Number of beds		
More than 1,000	8	3.3
More than 700-1,000	25	34.6
More than 200-700	93	38.3
More than 100-200	58	23.8
Respondents' characteristics		
Department		
Logistics	243	100.0
Position		
Manager	230	94.7
Director	13	5.3
Total respondents = 243		

Various types of information and SCM systems are used by participating hospitals, and some outsource their entire SCM operations, as shown in Table III. EDI (100.0 percent) is used by all hospitals surveyed, and the second most widely used was hospital management information system (HMIS) (66.3 percent). ERP systems are used by 2.9 percent and RFID systems 1.2 percent of the surveyed hospitals. Among the respondents, 81.5 percent had the knowledge about HMIS, and 35.8 percent about ERP and RFID systems.

There is an amazing range in the number of suppliers for medicine, material of medical examinations, and other material used in the hospital; from more than 100 (73.7 percent) to more than 300 (9.9 percent). Also, about 23 percent of hospitals use the outsourcing method for some of SCM operations and 13.8 percent have plans to use outsourcing.

Model variables, reliability, and validity

The questionnaire utilized five-point Likert scales to measure the constructs. Scales to measure each of the constructs were developed based on prior studies as much as possible. Some measures were modified to adapt to this research. Table IV provides means and standard deviations of measurement items for SC innovation, supplier cooperation, SC efficiency, QM practice constructs, and organisational performance.

The supplier cooperation is measured by three variables: consistency of the supplier's delivered product-related criteria (SC), healthcare professional-related criteria (SP), and delivery and service-related criteria (SD). SC efficiency is measured by three individual measurement items: waste elimination in processes (EW), convenience of information access (EN), and on time delivery, service speed (ES1). QM practice is measured by four individual measurement items: emphasis on QM (QM1), consistency of order fill (QM2),

Table III. Various information and SCM systems used by sample hospitals

Systems in use		*Degree of using in the participated hospitals*		*Degree of perception by the respondents*		
		Yes	*No*	*Yes*	*No*	
Hospital management information system (HMIS)		161 (66.3)	82 (33.7)	161 (81.5)	45 (18.5)	
Electronic medical record (EMR)		112 (46.1)	131 (53.9)	218 (89.7)	25 (10.3)	
Electronic data interchange (EDI)		243 (100.0)		243 (100.0)		
Order communication system (OCS)		160 (65.8)	83 (34.2)	243 (100.0)		
Enterprise resource planning (ERP)		7 (2.9)	236 (97.1)	110 (45.3)	133 (54.7)	
Bar code		15 (6.2)	228 (93.8)	162 (66.7)	81 (33.3)	
Radio frequency identification tags (RFID)		3 (1.2)	240 (98.8)	87 (35.8)	142 (58.4)	
					Frequency	
Number of suppliers in the sample hospital	More than 100-200				179 (73.7)	
	More than 200-300				38 (15.6)	
	More than 300				24 (9.9)	
	Missing				2 (0.8)	
	Total				243 (100.0)	
		Implemented		*Planning in the future*		
		Yes	*No*	*Yes*	*No*	*Missing*
Outsourcing parts of SC		55 (22.6)	188 (77.4)	26 (13.8)	15 (8.0)	147 (78.2)
					Frequency	
Experience of using outsourcing	More than 1-3 years				36 (65.5)	
	More than 3-5 years				13 (23.6)	
	More than 5 years				4 (7.3)	
	Missing				2 (3.6)	
	Total				55 (100.0)	

Note: Values in parenthesis are in percentage

resolution of problems and complaints (QM3), and joint approach to solve problem (QM4). Also, to measure organisational performance three, individual measurement items used: overall, our care quality is better (OP1); overall, our competitive position is superior (OP2); and overall, our service level is higher (OP3).

Reliability and validity tests were performed for the four latent-independent variables and their constructs (Lin *et al.*, 2005). Reliability represents the variance of measurement values resulting from a repeat measurement of the same concept. It is related to non-systematic error that can be expressed as stability, consistency, predictability, and accuracy. Reliability was tested based on Cronbach's α-value (Table V). All of the coefficients of reliability measures for the constructs exceeded the threshold value of 0.70 for exploratory constructs in basic research (Nunnally, 1978). In the reliability test, the Cronbach's α-value for organisational performance was the highest, 0.878, and SC innovation was the lowest, 0.811. All of the study constructs have Cronbach's α larger than 0.8, which reveals high reliability at the 0.05 level.

Validity refers to the accuracy of a measure. The purpose of the principal component analysis (PCA) is to identify the most meaningful basis and to express similarities

Table IV.
Mean and SD of measurement items

Constructs	Sub constructs	Items of measurement	M	SD
SC innovation		Pursue continuous innovation in core processes (IN1)	3.64	0.731
		Pursue new technological innovation (IN2)	3.79	0.878
		Focus on process innovation (IN3)	4.03	0.785
Supplier cooperation	Consistency of the supplier's delivered product-related criteria (SC)	Emphasize product reliability (SC1)	4.04	0.926
	Healthcare professional-related criteria (SP)	Emphasize consistency of delivered products (SC2)	3.84	1.05
	Delivery and service-related criteria (SD)	Emphasize accuracy in supply and orders (SC3)	3.74	1.06
		Technical services: problem solving (SP1)	3.39	0.668
		Technical service: product knowledge (SP2)	3.46	0.756
		Technical service: responsiveness (SP3)	3.75	0.792
		Stability of controls (SD1)	4.07	0.787
		Supplier expedites emergency orders (SD2)	4.12	0.913
		Lead time for emergency orders (SD3)	4.02	0.904
SC efficiency		Waste elimination in processes (EW)	4.07	0.815
		Convenience of information access (EN)	3.85	0.805
		On time delivery, service speed (ES1)	3.50	0.658
Quality management (QM) practice		Emphasis on quality management (QM1)	4.15	0.864
		Consistency of order fill (QM2)	3.99	0.968
		Resolution of problems and complaints (QM3)	4.12	0.845
		Joint approach to solve problem (QM4)	3.93	0.925
Organisational performance (OP)		When we compare our hospital to those in the similar size	4.12	1.044
		Overall, our care quality is better (OP1)	4.34	1.069
		Overall, our competitive position is superior (OP2)	4.20	0.980
		Overall, our service level is higher (OP3)		

Constructs	Model statistics	goodness-of-fit	Variables	Standardized loading	*t*-value	*p*-value	Eigen value	Percent of variance explained	Cronbach's α
Supplier cooperation			SC1	0.527	–		3.113	34.594	
			SC2	0.859	8.137	0.000			
			SC3	0.528	6.321	0.000			
			SP1	0.682	–		2.292	25.464	0.876
			SP2	0.628	8.407	0.000			
			SP3	0.833	9.407	0.000			
			SD1	0.969	–		1.573	17.474	
			SD2	0.863	23.993	0.000			
	χ^2	2.8	SD3	0.867	23.321	0.000			
QM practice	χ^2/df.	1.4							
	CFI	0.998	QM1	0.662	–				
	GFI	0.994	QM2	0.702	9.662	0.000	2.877	71.933	0.868
	RMSEA	0.041	QM3	0.887	11.596	0.000			
	RMR	0.011	QM4	0.905	11.690	0.000			
SC innovation	GFI	1	IN1	0.741	–				
			IN2	0.746	10.075	0.000	2.186	72.856	0.811
			IN3	0.826	10.199	0.000			
SC efficiency	GFI	1	EW	0.877	–				
			EN	0.748	12.183	0.000	2.323	77.431	0.853
			WE	0.817	13.011	0.000			
			OP1	0.904	–				
OP		GFI 1	OP2	0.738	13.403	0.000	2.418	80.601	0.878
			OP3	0.888	16.331	0.000			

Notes: Comparative fit index (CFI); goodness-of-fit index (GFI); root mean square error of approximation (RMSEA); root mean square residual (RMR)

Table V.
Results of reliability, CFA, and PCA

and differences on the data. Also, confirmatory factor analysis (CFA) is a way of testing how well-measured variables represent the constructs. The results of CFA can provide evidence of the convergent and discriminant validity of theoretical constructs (Brown, 2006).

This model consists of five major components: SC innovation, supplier cooperation, SC efficiency, QM practice, and organisational performance. Supplier cooperation is a multidimensional construct with second-order latent variables in three dimensions: consistency of the supplier's delivered product-related criteria (SC), healthcare professional-related criteria (SP), and delivery and service-related criteria (SD). On the other hand, SC innovation, SC efficiency, QM practice, and organisational performance were assessed by measurement items. Statistics of CFA are shown in Table V. A just-identified model, which has an equal number of knowns and unknowns, should have the GFI value of 1 and χ^2-value of 0 (zero) (Brown, 2006). As shown in Table V, there are three just-identified models: SC innovation, SC efficiency, and organisational performance.

To use a second-order factor, Beltrán-Martín *et al.* (2008) suggested the following:

> [. . .] (a) each observed variable will have a nonzero loading on the factor, (b) error terms associated with each observed variable will be uncorrelated, (c) the first-order factors will be correlated, and (d) covariation among the first-order factors and the observable variable will be explained fully by their regression onto the second-order factor.

In this model, supplier cooperation involves intercorrelated latent variables that are measured by the second-order factor method using structural equation modeling (SEM). To measure a second-order factor, the first-order factors operate as dependent variables. This means that their variances and covariances are no longer estimated parameters in the model (Beltrán-Martín *et al.*, 2008). Statistics of CFA for second-order factors are shown in Figure 2.

The supplier cooperation model indicated the fit indices and CFAs of second order in Figure 2. These results provide evidence of an internal fit among the supplier cooperation dimensions. As shown in Figure 2, single-headed arrows leading from the second-order factor of supplier cooperation to each of its first-order factors (SC, SP, and SD) indicate the prediction of these dimensions from the higher order supplier cooperation factor. Consequently, fit statistics related with this model confirm the proposed structure of supplier cooperation (Figure 2). The suggestions of Beltrán-Martín *et al.* (2008) for using the second-order factor for supplier cooperation were satisfied (Figure 2).

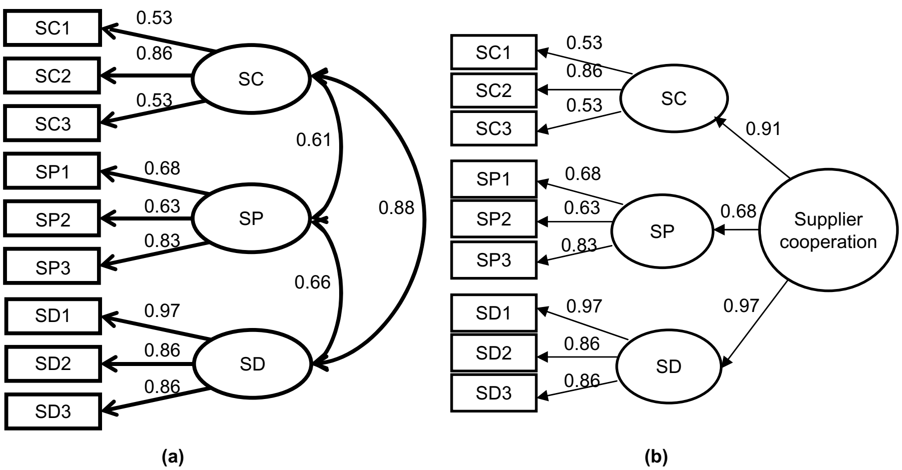
The percentages of variance explained were 60 or higher for each of the constructs on statistics of PCA in Table V: SC innovation (72.856), supplier cooperation (77.532), SC efficiency (77.431), QM practice (71.933), and organisational performance (80.601). The standardized factor loadings and *t*-values for measurement variables, results of SEM analysis using the AMOS program, were presented in Table V and Figure 2. The values of standardized regression weight of SC innovation, supplier cooperation, SC efficiency, QM practice, and organisational performance were all greater than 0.5 and all variables proposed by the study were statistically significant at the 0.05 level.

Results

SEM was used to test the hypotheses. AMOS 5.0 was chosen for this study by virtue of its powerful graphic representations and easy-to-use interfaces. This section presents the results of hypotheses tests, including the standardized coefficient of each path in the research model. The results of goodness-of-fit test for the model are summarized in Table VI. As a result of the goodness-of-fit test, the value of χ^2 was 485.2, χ^2/d.f. 2.54, GFI 0.899, CFI 0.917, RMR 0.052, RMSEA 0.067, and the *p*-value of 0.000. Compared to the recommended values for the goodness-of-fit tests, in this model the values of CFI (0.917), RMSEA (0.067), χ^2 (485.2), and the *p*-value (0.000) were satisfactory, but GFI (0.899) and RMR (0.052) were not.

The results of significance tests for paths of the model are shown in Table VII and Figure 3. Lines in Figure 3 indicate the significant paths among the latent variables. For *H1*, the standardized path coefficient between SC innovation and supplier cooperation was 0.415 and statistically significant at the 0.001 level. Thus, *H1* was supported. When SC innovation is focused on improving value for the customer, supplier cooperation is an important idea to create innovation for providing better value to customers through the reduced cost and improved quality of products and services (Flint *et al.*, 2008).

For *H2*, the standardized path coefficients between SC innovation and SC efficiency was 0.170 and statistically significant at the 0.05 level. *H2* was supported. SC innovation affects SC efficiency focused to provide efficient operation through SC processes.



Model	χ^2	χ^2/d	*p*-value	CFI	GFI	RMSEA	RMR
First order CFA	47.15	1.0	0.003	0.87	0.94	0.030	0.044
Second order CFs	47.153	1.96	0.003	0.87	0.914	0.030	0.044

Notes: (a) Supplier cooperation first-order CFA; (b) supplier cooperation second-order CFA

Figure 2. The second-order CFA of supplier cooperation

Model	χ^2	χ^2/df	*p*	CFI	GFI	RMR	RMSEA
Model	485.2	2.54	0.000	0.917	0.899	0.052	0.067
Recommended value		≤3.0		≥0.9	≥0.9	≤0.05	≤0.08

Table VI. Results of goodness-of-fit test

It means that SC innovation for SC efficiency helps improve operation and management, reduce waste, and effectively use networks with hospitals and suppliers. As Chen (1997) proposed concerning the effect of SC efficiency on SCM, *H2* in the study showed a positive relationship between SC innovation and SC efficiency.

For *H3*, the standardized path coefficients between SC innovation and QM practice was 0.966 and statistically significant at the 0.001 level. *H3* was supported. QM is an important factor in the value-added process and delivery of products in SCM (Sila *et al.*, 2006). SC innovation provides a reliable supply of consistent quality products, reduces lead time during the delivery to customers, and serves the guarantee of safety and environmental protection by delivered products (Stundza, 2009).

For *H4-H6*, the standardized path coefficients among the supplier cooperation, SC efficiency, and QM practice and organisational performance were 0.161, 0.311, and 0.693, respectively, all statistically significant at the 0.01 level. *H4-H6* were supported. The study has a similar result to previous studies on relationships between supplier cooperation and organisational performance (*H4*), SC efficiency and organisational performance (*H5*) (Chen, 1997; Li and O'Brien, 1999), as well as QM practice

Table VII.
Results of significance test for paths of the model

Path	Path coefficient	SE	*t*-value	*p*-value
SC innovation → Supplier cooperation (*H1*)	0.415	0.050	4.825	0.000***
SC innovation → SC efficiency (*H2*)	0.170	0.117	2.361	0.018*
SC innovation → QM practice (*H3*)	0.966	0.081	9.845	0.000***
Supplier cooperation → organisational performance (*H4*)	0.161	0.100	3.050	0.002**
SC efficiency → organisational performance (*H5*)	0.311	0.033	6.463	0.000***
QM practice → organisational performance (*H6*)	0.693	0.098	9.333	0.000***

Note: $^{*}p < 0.05$, $^{**}p < 0.01$, and $^{***}p < 0.001$

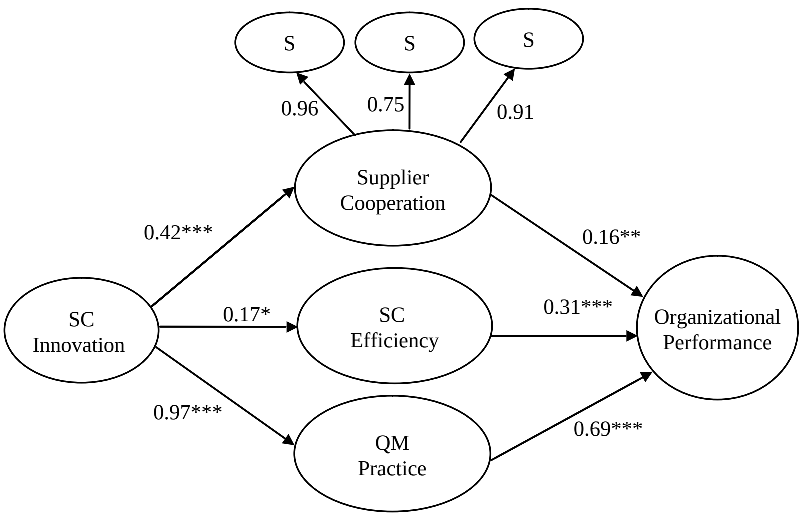


Figure 3.
Significant path coefficients in the model

and organisational performance (*H6*) (Lin *et al.*, 2005). One of the SC efficiency factors, an efficient information network, can provide real-time information within the organisation as well as in the network with suppliers, improve customer response time, and reduce delivery time from ordering.

Discussion

The results of the study provide important insights on how to improve organisational performance through supplier cooperation, SC efficiency, and QM practice. Innovative design of a SC has a significant impact on the selection of and cooperation with best suppliers, increase of SC efficiency, and enhancement of QM practice, which subsequently will improve organisational performance. The results imply that prior to implementing SCM, organisation leaders need to implement innovative ideas that can streamline their operational processes including those of suppliers. The healthcare system should focus on innovating and developing the overall business strategy (e.g. investigate the applicability of new technologies and resources in SCM) to enhance competitive advantage. The 2nd Annual Leadership Summit on Healthcare Supply Chain Management (2008) reported the importance of innovative SCM for eliminating unnecessary cost, accelerating financial returns, implementing IT, and streamlining SC processes in the healthcare industry.

The study showed that organisational performance is associated with QM practice (0.693), SC efficiency (0.311), and supplier cooperation (0.161). The results also show that deliveries of materials and products are important to support critical activities and strategies of hospitals along with supplier cooperation (Lambert *et al.*, 1997; Kannan and Haq, 2007; Chan *et al.*, 2008) and QM practices (Flynn and Flynn, 2005; Lin *et al.*, 2005; Sila *et al.*, 2006). As suggested by Flynn and Flynn (2005), QM should drive cost reduction and improve organisational performance in SCM if both the organisation and suppliers try to have a positive relationship and devise approaches to collaboratively solve problems for improving quality. As a result, the collaborative strategy will provide competitive advantage to both organisations. To improve quality of care by SCM in hospitals, each organisation (e.g. hospital and supplier) should consider itself a partner to the other and develop tools or methods that can be used by both organisations.

In addition, hospitals should categorize the SC activities to standardize needed materials to ensure a lean SC which can provide the highest quality of care at the lowest possible cost. It is important to ensure that medical staff participate in the material standardization efforts. Hospitals also need to analyze whether or not they are actually paying the contracted prices for materials, equipment and related care items because some hospitals have experienced overpaying their suppliers about 2-7 percent (Anderson, 2001).

Conclusions and limitations

SCM is designed to include best practices of the industry to streamline entire processes from the ordering to supply through delivery processes. These processes encompass efficient management and distribution for the flow of products/services for on time delivery of high-quality medical care.

To identify factors that will improve organisational performance through SCM, this study proposed a research model involving the relationships among SC innovation, supplier cooperation, SC efficiency, and QM practice. Data were collected from logistics managers of 243 hospitals in South Korea to test six hypotheses in the model.

This study contributes useful information to organisational leaders and managers in the healthcare industry, as the results suggest successful implementation of SCM is attained through continuous SC innovation with supplier cooperation, which in turn improves organisational performance. To achieve SC innovation, organisation leaders must nurture an excellent work environment, which includes providing right resources to support efficient operational processes for high quality of care and reduced medical errors at the lowest cost or highest level of efficiency (Byrnes, 2004; Herzlinger, 2006; Schneller and Smeltzer, 2006; Singh *et al.*, 2006; Shih *et al.*, 2009). Consequently, these goals would benefit the society at large through improved medical care for better quality of life.

The healthcare organisation would benefit from understanding the importance of continuous quality improvement and SC efficiency, which need to be incorporated into SCM strategies. For example, healthcare providers that use limited technology in their work stations (administration, nursing, laboratory, surgery, etc.) will typically rely on standardized manual systems for ordering supplies. The manual process can result in data entry errors and inaccurate information for ordering. These problems create inefficiency and poor performance in SCM.

The healthcare industry has been slow to modify and innovate its business models and adapt to the rapidly changing business environment when compared to other industries, especially ICT. The total investment in IT for all work processes, including SCM, in the healthcare industry amounted to 3.9 percent of revenue in 2003 (Warner, 2004). Healthcare organisations should investigate the potential benefits that can come from IT-enabled SCM, such as barcode technology, ERP and RFID that could improve SC efficiency by supporting supply replenishment and reduced operating cost.

There are some limitations of the study. First, data were collected from relatively large hospitals with more than 100 beds. Considering that SCM is also important for hospitals with less than 100 beds and that SCM has been implemented in those hospitals and other settings such as outpatient clinics, which also utilize supplies and maintain relationships with suppliers. Generalisation of the results of this study may be limited. Second, even though South Korea is a world leader in ICT, and SCM has been deployed in many hospitals there, data collected from Korea might be a constraint when we consider the level of linkages and cooperation between upstream and downstream of SCM in the healthcare industry.

Future research should consider, in addition to the limitations mentioned above, cross-cultural and longitudinal studies of organisational performance. Also, an analysis of the data will be used on some classification, such as the type of information systems for SCM, the type of hospitals, and the number of beds. Recently, many hospitals outsource some of their operations. Those that outsource their operations might differ from those that do not in terms of strategies and management involving the factors identified in our research: SC innovation, SC efficiency, supplier cooperation, and QM practice. Future research should also explore the differences and similarities of those factors between the two groups of hospitals.

References

Afuah, A. (1998), *Innovation Management: Strategies, Implementation, and Profits*, Oxford University Press, New York, NY.

Anderson, J. (2001), "The value of e-commerce in the healthcare supply chain: industry study report", June.

Anderson, J. (2002), "Evaluation in health informatics: social network analysis", *Computers in Biology and Medicine*, Vol. 32, pp. 179-93.

André, B., Ringdal, G., Loge, J.H., Rannestad, T., Laerum, H. and Kaasa, S. (2008), "Experiences with the implementation of computerized tools in health care units: a review article", *International Journal of Human-Computer Interaction*, Vol. 24 No. 8, pp. 753-75.

Beltrán-Martín, I., Roca-Puig, V., Escrig-Tena, A. and Bou-Llusar, J. (2008), "Human resource flexibility as a mediating variable between high performance work systems and performance", *Journal of Management*, Vol. 34 No. 5, pp. 1009-44.

Brown, T. (2006), *Confirmatory Factor Analysis for Applied Research*, The Guilford Press, New York, NY, pp. 5-71.

Byrnes, J. (2004), "Fixing the healthcare supply chain", *Harvard Business School Working Knowledge*, available at: http://hbswk.hbs.edu/archive/4036.html (accessed 10 November 2009).

Chan, F., Chan, H., Lau, H. and Ip, R. (2008), "Critical success factors in managing global supply chains", *International Journal Manufacturing Technology and Management*, Vol. 15 No. 1, pp. 28-44.

Chapman, R., Soosay, C. and Kandampully, J. (2003), "Innovation in logistic services and the new business model: a conceptual framework", *International Journal of Physical Distribution & Logistics Management*, Vol. 33 No. 7, pp. 630-50.

Chen, J. (1997), "Achieving maximum supply chain efficiency", *Lie Solutions*, Vol. 29, pp. 30-5.

Choi, E., Kim, J. and Lee, W. (1998), *Health Care Systems in Korea*, Korea Institute for Health and Social Affairs, Seoul.

Chow, W., Madub, C., Kueib, C., Luc, M., Lind, C. and Tsengd, H. (2008), "Supply chain management in the US and Taiwan: an empirical study", *OMEGA*, Vol. 36, pp. 665-79.

Cigolini, R., Cozzi, M. and Perona, M. (2004), "A new framework for supply chain management: conceptual model and empirical test", *International Journal of Operations & Production Management*, Vol. 24 No. 1, pp. 7-41.

Drucker, P.F. (1985), *Innovation and Entrepreneurship*, Harvard Business School, Cambridge, MA.

Fawcett, S. and Magnan, G. (2001), *Achieving World-class Supply Chain Alignment: Benefits, Barriers, and Bridges*, Center for Advanced Purchasing Studies, Arizona State University Research Park, Tempe, AZ.

Fisher, M. (1997), "What is the right supply chain for your product?", *Harvard Business Review*, March/April, pp. 103-16.

Flint, D., Larsson, E. and Gammelgaard, B. (2005), "Logistics innovation: a customer value-oriented social process", *Journal of Business Logistics*, Vol. 26 No. 1, pp. 113-47.

Flint, D., Larsson, E. and Gammelgaard, B. (2008), "Exploring processes for customer value insights, supply chain learning and innovation: an international study", *Journal of Business Logistics*, Vol. 29 No. 1, pp. 257-81.

Flynn, B. and Flynn, E. (2005), "Synergies between supply chain management and quality management: emerging implications", *International Journal of Production Research*, Vol. 43 No. 16, pp. 3421-36.

Franks, J. (2000), "Supply chain innovation", *Work Study*, Vol. 49 No. 4, pp. 152-5.

Gattorna, J. (1998), *Strategic Supply Chain Alignment: Best Practice in Supply Chain Management*, Gower Publishing, Aldershot.

Goldstein, S. and Schweikhart, S. (2002), "Empirical support for the Baldrige award framework in US hospitals", *Health Care Management Review*, Vol. 27 No. 1, pp. 62-75.

Gowen, C. III, Stock, G. and McFadden, K. (2008), "Simultaneous implementation of Six Sigma and knowledge management in hospitals", *International Journal of Production Research*, Vol. 46 No. 23, pp. 6781-95.

Healthcare Financial Management Association (2008), *Opportunities for Supply Chain Improvement: Highlights and Expert Insights Regarding HFMA's 2008 Supply Chain Survey*, HFMA Educational Report, Healthcare Financial Management Association, Westchester, IL, pp. 1-8.

Heikkilä, J. (2002), "From supply to demand chain management: efficiency and customer satisfaction", *Journal of Operations Management*, Vol. 20 No. 6, pp. 747-67.

Herzlinger, R. (2006), *Innovating in Health Care-framework*, Harvard Business School Publishing, Boston, MA, HBS No. 9-306-042.

Hook, B. (2009), "The healthcare industry dilemma", *World Trade 100*, September, pp. 44-5.

Howells, J. and Tether, B. (2004), "Innovation in services: issues at stake and trends", A Report for DG Enterprise of the European Commission, Under Contract INNO Studies 2001: Lot 3 (ENTR-C/2001), European Commission, Brussels.

Hsieh, Y., Lin, C. and Chen, J. (2007), "Customer satisfaction measurement with neural network", *Human Systems Management*, Vol. 26 No. 1, pp. 47-52.

Kahn, K. (2000), *Product Planning Essentials*, Sage, Thousand Oaks, CA.

Kannan, G. and Haq, N. (2007), "Analysis of interactions of criteria and sub-criteria for the selection of supplier in the built-in-order supply chain environment", *International Journal of Production Research*, Vol. 45 No. 17, pp. 3831-52.

Korea Tourism Organisation (2009), available at: http://english.visitkorea.or.kr/enu/index.kto (accessed 10 November 2009).

Kowalski, J. (2009), "Need: a strategic approach to supply chain management", *Healthcare Financial Management*, pp. 90-8.

Kumar, A., Ozdamar, L. and Zhang, N. (2008), "Supply chain redesign in the healthcare industry of Singapore", *Supply Chain Management: An International Journal*, Vol. 13 No. 2, pp. 95-103.

Lambert, D., Adams, R. and Emmelhainz, M. (1997), "Supplier selection criteria in the healthcare industry: a comparison of importance and performance", *International Journal of Purchasing and Materials*, Vol. 33 No. 1, pp. 16-22.

Lee, S. (2003), "Korea: from the land of morning calm to IT hot bed", *Academy of Management Executive*, Vol. 17 No. 2, pp. 7-18.

Li, D. and O'Brien, C. (1999), "Integrated decision modeling of supply chain efficiency", *International Journal of Production Economics*, Vol. 59 Nos 1-3, pp. 147-57.

Lin, C. (2008), "Determinants of the adoption of technological innovations by logistics service providers in China", *International Journal of Technology Management and Sustainable Development*, Vol. 7 No. 1, pp. 19-38.

Lin, C., Chow, W., Madu, C., Kuei, C. and Yu, P. (2005), "A structural equation model of supply chain quality management and organisational performance", *International Journal of Production Economics*, Vol. 96 No. 3, pp. 355-65.

Lundvall, B.-A. (1985), "Innovation as an inter-active process: from user-producer interaction to the national system of innovation", in Dosi, G., Freeman, C., Nelson, R., Silverberg, G. and Soete, L. (Eds), *Technical Change and Economic Theory*, Pinter, London, pp. 349-69.

McFadden, K., Stock, G. and Gowen, C. III (2006a), "Exploring strategies for reducing hospital errors", *Journal of Healthcare Management*, Vol. 51 No. 2, pp. 123-35.

McFadden, K., Stock, G. and Gowen, C. III (2006b), "Implementation of patient safety initiatives in US hospitals", *International Journal of Operations and Production Management*, Vol. 26 No. 3, pp. 326-47.

Mentzer, J., Keebler, J., Min, S., Nix, N., Smith, C. and Zacharia, Z. (2001), "Defining supply chain management", *International Journal of Business Logistics*, Vol. 22 No. 2, pp. 1-25.

Miles, I. (2004), "Innovation in services", in Fagerberg, J., Mowery, D. and Nelson, R. (Eds), *Understanding Innovation*, Oxford University Press, Oxford.

Mustaffa, N. and Potter, A. (2009), "Healthcare supply chain management in Malaysia: a case study", *Supply Chain Management: An International Journal*, Vol. 14 No. 3, pp. 234-43.

National Institute of Standards and Technology (2009), available at: http://nii.nist.gov (accessed 10 November 2009).

Nunnally, J. (1978), *Psychometric Theory*, 2nd ed., McGraw-Hill, New York, NY, pp. 244-5.

Olden, P. and McCaughrin, W. (2007), "Designing healthcare organisations to reduce medical errors and enhance patient safety", *Hospital Topic: Research and Perspectives on Healthcare*, Vol. 85 No. 4, pp. 4-9.

Parnaby, J. and Towill, D. (2008), "Enabling innovation in health-care delivery", *Health Services Management Research*, Vol. 21 No. 3, pp. 141-54.

Pin, T. (2001), *Improving Supply Chain Efficiency through E-business Collaboration*, Seagate Technology International, available at: http://unpan1.un.org/intradoc/groups/public/documents (accessed 10 November 2009).

Porter, M. (1990), *The Competitive Advantage of Nations*, Macmillan, London.

Rivard-Royer, H., Landry, S. and Beaulieu, M. (2002), "Hybrid stockless: a case study: lessons for health-care supply chain integration", *International Journal of Operations & Production Management*, Vol. 22 No. 4, pp. 412-24.

Roy, S., Sivakumar, K. and Wilkinson, L.F. (2004), "Innovation generation in supply chain relationships: a conceptual model and research propositions", *Journal of the Academy of Marketing Science*, Vol. 32 No. 1, pp. 61-79.

Sanders, N. (2007), "An empirical study of the impact of e-business technologies on organisational collaboration and performance", *Journal of Operations Management*, Vol. 25 No. 6, pp. 1332-47.

Schneller, E. and Smeltzer, L. (2006), *Strategic Management of the Health Care Supply Chain*, Jossey-Bass, San Francisco, CA.

Shih, S., Rivers, P. and Sonya Hsu, H. (2009), "Strategic information technology alliances for effective health-care supply chain management", *Health Care Management Research*, Vol. 22 No. 3, pp. 140-50.

Shin, H., Collier, D. and Wilson, D. (2000), "Supply management orientation and supplier/buyer performance", *Journal of Operations Management*, Vol. 18 No. 3, pp. 317-33.

Sila, I., Ebrahimpour, M. and Birkholz, C. (2006), "Quality in supply chains: an empirical analysis", *Supply Chain Management: An International Journal*, Vol. 11 No. 6, pp. 491-502.

Singh, M., Rice, J. and Riquier, D. (2006), *Transforming the Global Health Care Supply Chain*, MIT Center for Transportation and Logistics, Cambridge, MA.

Sivadas, E. and Robert, F. (2000), "An examination of organisational factors influencing new product success in internal and alliance-based processes", *Journal of Marketing*, Vol. 64, pp. 31-49.

Stock, G., McFadden, K. and Gowen, C. III (2007), "Organisational culture, critical success factors, and the reduction of hospital errors", *International Journal of Production Economics*, Vol. 106 No. 2, pp. 368-92.

Stundza, T. (2009), "Supply chain innovation is important", *Purchasing*, available at: www.purchasing.com/article/354518-Supply_chain_innovation_is_important.php (accessed 10 November' 2009).

Tan, K. (2002), "Supply chain management: practices, concerns, and performance issues", *Journal of Supply Chain Management*, Vol. 38 No. 1, pp. 42-53.

Teece, D. (2009), "Dynamic capabilities and strategic management: organizing for innovation and growth", Oxford University Press, Oxford.

Teichert, T. and Bouncken, R. (2008), "Strategic impulses for innovation in supply chains", *Academy of Management Annual Meeting 2008 Proceedings* (*Best Paper Proceedings*), *Anaheim, CA, USA*, pp. 1-6.

The Korean Hospital News (2007), *Hospital SCM System is to Export*, Korean Hospital Association, Seoul.

The 2nd Annual Leadership Summit on Healthcare Supply Chain Management (2008), available at: www.worldcongress.com/events/HL08006/?confCode=HL08006 (accessed September 15, 2010).

Thompson, R., Eisenstein, D. and Stratman, T. (2007), "Getting supply chain on the CEO's agenda", *Supply Chain Management Review*, July/August, pp. 26-33.

Tidd, J., Bessant, J. and Pavitt, K. (1997), *Managing Innovation: Integrating Technological, Market, and Organisational Change*, Wiley, New York, NY.

Treville, S., Shapiro, R. and Hameri, A. (2004), "From supply chain to demand chain: the role of lead time reduction in improving demand chain performance", *Journal of Operations Management*, Vol. 21 No. 6, pp. 613-27.

Warner, M. (2004), "Under the knife", *Business 2.0.*, January/February.

White, A. and Mohdzain, M. (2009), "An innovative model of supply chain management: a single case study in the electronic sector", *International Journal of Information Technology and Management*, Vol. 8 No. 1, pp. 69-84.

Further reading

Lambert, D., Lewis, M. and Stock, J. (1993), "How shippers select and evaluate general commodities LTL motor carriers", *Journal of Business Logistics*, Vol. 14 No. 1, pp. 131-43.

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