Computer Science and Information Systems 21(2):453–472 https://doi.org/10.2298/CSIS220514051C

The Effects of Process Innovation and Partnership in SCM: Focusing on the Mediating Roles

Yoonkyo Cho[1] and Chunsu Lee[2,⋆]

[1] Dept. of K-Internet Business Management
Halla University, Wonju 26404, Korea
yoonkyo.cho@halla.ac.kr
[2] Dept. of International Trade,
Pukyong National University, Busan 48513, Korea
leecs@pknu.ac.kr

Abstract. In this study, we examined the impact of supply chain management factors on firm performance, and we focused on the mediating role of process innovation and partnerships. For the analysis, we surveyed 193 workers working in smartphone manufacturing companies. We found that information systems, support of top management, and performance management have positive impacts on a company's process innovation. The factors that affect partnership are the support of top management and performance management. Process innovation and partnership also positively affect a firm's financial and nonfinancial performance. Nonfinancial performance also shows effectiveness. Thus, to improve a firm's supply chain management (SCM) performance, companies should focus on enhancing process innovation and partnerships that positively affect firm performance. Furthermore, this research can serve as a stepping stone for the development of SCM in line with the technological innovation of Industry 4.0.

Keywords: process innovation, partnership, SCM factors, industry 4.0.

1. Introduction

The industrial environment is changing rapidly. In this environment, efficient supply chain management (SCM) is essential for companies to achieve high performance. Especially in the smartphone market, the life cycle of products—smartphones and their components—is shortening. Short life cycles increase the risk of product loss. This leads to intense global competition in the industry.

The smartphone manufacturing industry is a system of producing finished products in cooperation with each other, from raw material companies to parts manufacturers and finished goods-producing companies. This means that organic activities between companies on the supply chain (SC) line are critical to securing corporate competitiveness. Therefore, research on partnerships between companies is needed to ensure competitiveness in a complex business environment.

In addition, process innovation is perceived as an essential factor of the company's management strategy and performance. Process innovation is studied by many researchers to achieve and maintain an edge in competition over competitors [1,2,50]. Therefore, this

⋆ Corresponding author

study's results will demonstrate the relationships between SCM's key elements and firm performance.

To have a competitive advantage, firms need to solve the various difficulties in management. SCM performance is economically inefficient in the smartphone industry, as shown in Figure 1. Consumers' lack of awareness and understanding was the highest at 29%. Conditions that make it difficult to hire experts came in second with 18.1%. Other reasons include insufficient initial investment, lack of awareness by executives, and current systems' incompatibilities.

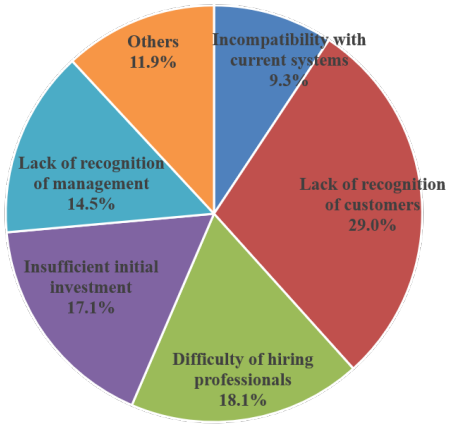

Fig. 1. The reasons for ineffective SCM performance

There are three contributions made in this study. First, we focus on intermediate companies (suppliers) in the smartphone industry. Prior research focused on companies dealing with complete products. However, it is essential for companies dealing with intermediate goods to link SCM with raw material companies located in the front of the SC and for SCM cooperation to work with final product companies in the rear. Thus, dealing with intermediate parts companies can demonstrate the importance of process innovation and intercompany partnerships to a firm's performance in its SCM operations.

Second, we suggest that both internal and external factors are important for a firm's performance. Because of the nature of smartphone parts companies with short product life cycles, it is necessary to reduce time and cost to survive and be competitive. Process innovation is what makes this possible. Thus, companies can improve their performance through process innovation internally. In contrast, collaboration between forward and backward companies is an essential factor because of the nature of intermediate parts companies. Therefore, improving and developing these matters can lead to high management performance. Therefore, to have superior performance regarding SCM, both process innovation (an internal factor) and partnership (an external factor) are important.

Third, we take a balanced approach to performance measurement. We examine the effects of SCM factors, process innovation, and partnership on both financial and non-financial performance. In most cases, management performance deals with nonmonetary performance or only monetary performance [8,31,44,45,65]. However, we have addressed both management performances and found that nonmonetary management performance positively affects monetary management performance. Therefore, both types of management performance can be crucial factors for the survival and growth of a company. This measurement can present a clear picture of organizational performance.

The order of the remainder of this paper is as follows. Section 2 introduces the theory and concept behind this research. Section 3 presents the data and methodology used. Section 4 presents the main results of the study. Section 5 concludes the study.

2. Theoretical Background and Hypotheses

2.1. Supply Chain Management

Ellram and Cooper [14] stated that reducing inventory investment, increasing customer service, and gaining a competitive advantage on the supply chain are the core of SCM. Lambert et al. [35] stated that SCM is a strategy that creates added value across the supply chain—such as products, services, and information—by integrating and operating processes from the initial supplier to the end user to the related businesses and customers.

Before the mid-1990s, when SCM was introduced in earnest, the concept of logistics was widely used [56]. This concept included the integration of other functions as part of an effort to achieve an entity's overall performance [46]. At this time, production-oriented planning and management, procurement of parts and raw materials, and sales and distribution processes were operated separately. Thus, manufacturers had to comply with delivery times on their own in the operation of manufacturing lines, increasing productivity and reducing inventory.

Entering the mid-1990s, SCM evolved into a concept that could create value through the coordination of functions outside the enterprise and various business functions within the organization. Currently, many companies have adopted SCMs to integrate logistics, information, and financial-related businesses and to build improved systems that have been limited within the firm-specific optimization. This has led to competition as a supply chain for several companies beyond a single enterprise. In addition, by improving the efficiency of business processes through information sharing between different businesses and organizations in the supply chain, inventory is reduced, and unnecessary logistics costs are minimized. Moreover, this increases customer satisfaction by improving management speed [25].

Most researchers' definition of SCM is subtly different, but in most studies, researchers define the core of SCM as a management technique that can increase customer satisfaction by connecting and managing all processes from the production stage of the product to the delivery to the consumer.

2.2. SCM and Industry 4.0

Industry 4.0 technology is developing rapidly around the world. The fourth industrial revolution predicts that artificial intelligence (AI) in the supply chain will gradually increase

the use of AI automation [41]. Because of the benefit of new technology, transportation and communication charges will be reduced, logistics and global supply chains will be operated more efficiently, and transaction costs will be reduced. All of this is expected to open new markets and trigger economic growth. This shows that the impact of the fourh industrial revolution will play a big role in supply chain management as well. The characteristics of the fourth industrial revolution affecting supply chain management are as follows.

First, robotics affects the supply chain process [13]. Many production processes already use pick-and-place robots that pick up objects and place them in designated locations. Daniela Rus, director of MIT's Computer Science–Artificial Intelligence Lab, predicts customized robots automating tasks in a wide range of areas. AI custom robots differ from conventional robots and reduce the time needed to equip automation in industries that rely on custom orders and short product life cycles. The robots know where to store data and how to assemble products, thereby increasing the efficiency of SCM.

The second is the use of big data. Big data refers to large-scale data with a shorter generation period and includes text and image data as well as numerical data. In the supply chain process, big data can be used to identify transportation information that identifies real-time transportation locations and problems based on past and present data. In addition, big data can predict traffic congestion or risk and identify expected arrival and delay times, weather events, and natural disasters. The use of such big data can greatly contribute to the efficiency of the supply chain by providing an optimal environment for logistics operations [61].

Third is the application of the Internet of Things (IoT). The IoT refers to intelligent technologies and services connecting all things based on the Internet to communicate information between people and things and between things and things. In other words, things establish a relationship with humans based on interconnected technology. The IoT is most widely used in remote monitoring technology. In the case of the transportation industry, companies can attach sensors to all boxes, trucks, and containers to obtain location information whenever they move. Consumers can also check when and where the goods they have purchased arrive in real time. With the development of the IoT, collecting various data generated in the logistics process is possible, and information that was difficult to grasp in the past supply chain management system can be grasped [32].

Fourth is the advent of unmanned transportation. Recently, drones have been in the spotlight as unmanned autonomous vehicles (UAVs), and more and more companies are using them. With the development of UAV technology, drones, boats, and aircraft have emerged as unmanned transportation means. UAVs in particular are developing quickly. UAVs will dramatically replace the role of existing transportation means. The use of suitable unmanned transportation means enables companies to increase supply chain management's performance (i.e., efficiency and effectiveness [48]).

2.3. SCM Factors, Process Innovation, and Partnership

Information System The introduction and utilization of an integrated information system for supply chain management not only increases quality, shortens delivery time, and reduces costs but also ultimately enhances the competitiveness of supply chain management for the continuous growth of firms [20,27,34]. Active use of information technology

and the standardization of products and data are required to increase the introduction effect of this system and enhance the competitiveness of firms. It is necessary to establish information systems such as point of sales, electronic data interchange, and electronic ordering systems for smooth information exchange between business organizations in the supply chain. The information system constructed in this way is premised on the accuracy of information sharing and information delivery between members and aims to standardize information systems and information linkage among organizational members. The maturity level of an organization's information system depends on how well it can be used for business applications or strategic purposes after the organization's information system is built [28]. Therefore, the higher the maturity of an information system, the easier it will be to use the system without difficulty, and the spread of this information system will have a greater impact on firm performance after SCM implementation. Companies with high information technology (IT) capabilities can be more active in information sharing between business processes. When business processes between companies are integrated along the value chain through information sharing, firm performance can be maximized. IT solutions are critical in realizing the abundant benefits of supply chain management implementation [39]. To exchange and share information flawlessly both inside and outside of the company, building a sound information system infrastructure and utilizing information technology are necessary. Therefore, the company's advanced information system will play a positive role in corporate performance by integrating internal and external SC processes of the company.

Hypothesis 1a *Information system has a positive effect on process innovation.*

Hypothesis 1b *Information system has a positive effect on partnership.*

Support from Top Management The will of the CEO plays a vital role in shaping the direction and values of the organization [33], is essential for cooperation between companies [47], and has a significant impact on the performance of the company [12]. The CEO's will, leadership, and commitment to change are major antecedents influencing successful SCM implementation [35]. For the same reason, the lack of the will of the CEO is a significant obstacle to the implementation of SCM [38]. The will of the CEO has a significant impact on the adoption and utilization of strategic systems such as interorganizational information systems and is also important for overcoming barriers and resistance to change and innovation [57].

As an innovation leader within the organization, the top management should properly recognize the characteristics and factors of SCM. If a new SCM is introduced in the existing organizational work process, it may face opposition from organizational members because it will bring about innovative changes. Because it is necessary to establish a new SCM through continuous support from the CEO, the CEO plays an essential role in the introduction and diffusion of information systems [9]. In particular, the introduction of the intercompany information system in SCM is a large-scale project that requires innovation of intercompany relationships and complex supply chains, so continuous investment is necessary for a certain period of time. In this process, the top management's support is most important to minimize the opposition of organizational members and to induce the participation of members in the innovation process. In addition, the CEO's support

is necessary to successfully establish a cooperative relationship that maintains a lasting relationship among several business partners outside the company.

Hypothesis 2a *Support from top management has a positive effect on process innovation.*

Hypothesis 2b *Support from top management has a positive effect on partnership.*

Planning For effective supply chain management, the accuracy and appropriateness of demand planning that leads the entire supply chain are essential [42,60]. Recent advances in IT are rapidly shortening the planning cycle for the supply chain. For example, the current trend is for SC plans to be implemented on a weekly, daily, and even shift basis. Rapid response to demand fluctuations through optimization can generate plans closer to market conditions by reflecting the constraints of the entire supply chain in real time. This plan is optimized to meet the supply chain demand, considering the limitations of equipment and materials for each base.

The results of a company's effective planning are no longer dependent on individual company profits or growth but rather on how well its members collaborate throughout the supply chain. Therefore, it is necessary to strengthen competitiveness based on collaboration among members of the supply chain [62]. As the need for such a collaboration to implement efficient planning systems increases, the supply chain has been developing by gradually expanding the exchange of information. Moreover, the development of IT and the emergence of e-business allow members to cooperate by forming a supply chain on the Web [36].

To establish a supply chain management system for a rapid market response, planning should play a role in improving the accuracy of demand planning and extending the range of collaboration, leading to a positive effect on the company's performance.

Hypothesis 3a *Planning has a positive effect on process innovation.*

Hypothesis 3b *Planning has a positive effect on partnership.*

Performance Management Even if a company uses an appropriate SCM, it cannot operate effectively if the performance achieved is not properly monitored and measured. An effective SCM performance measurement system improves the understanding of SCM, influences the behavior of organizational members, and provides information about the system's performance. Ultimately, measuring supply chain performance improves overall performance [52, 53]. Through the performance measurement system, it is important to set or improve the company's target by comparing it with the performance measurement of other companies in the same business category. And it is a necessary element for the growth of a company to establish an improvement direction and strategy to overcome the inferior performance on the part of the company through comparison with promising companies in the same industry.

Performance management can also be implemented through performance sharing between partners. Performance sharing reduces potential risks in the supply chain and increases profits through goal-oriented relationship building by forming common goals [49, 51]. If a shared performance goal is set and personnel inside or outside the company can perform joint production and research and development activities to achieve the goal, more open innovation can be achieved, positively affecting the company's performance.

Hypothesis 4a *Performance management has a positive effect on process innovation.*

Hypothesis 4b *Performance management has a positive effect on partnership.*

2.4. Process Innovation, Partnership, and Performance

Process Innovation Process innovation is a change to establish an efficient and effective organizational system, enabling a company to quickly respond to customer needs and flexibly respond to distribution channels and new environments. When the added value is generated transparently in the process from the purchase stage of a product to the final consumer, the efficiency of corporate management can be increased, and competitiveness can be achieved [59]. For this, innovation in the entire SC line should be organically developed and should prompt the processing of customer orders. For process innovation to be successful, it is necessary to coordinate and manage an efficient system through information sharing using information technology in its internal organization and the connected chain outside the company.

Today's process innovation reduces time and cost from the input of goods to the final output [66], achieves customer satisfaction by improving product quality, and eliminates various obstacles in inventory management through rapid transportation. Accuracy of demand forecasting due to process innovation can reduce delays by confirming actual sales based on manufacturers' point-of-sale information. As a result, reasonable inventory adequacy can be maintained. A company's efficient inventory management reduces excessive inventory levels by improving production technology [6]. In particular, prompt provision of sales information allows manufacturers to effectively maintain proper inventory and dramatically reduce the lead time required to produce items.

Rapid response due to SCM process innovation also affects efficiency increase. To respond quickly to customer orders, supply chain integration between the company's internal and external organizational structures is performed to increase customer satisfaction, thereby affecting the company's performance [18, 37]. Companies that have incorporated process innovation into their supply chain can secure a competitive advantage over their competitors and increase the efficiency of corporate management [29].

Process innovation enables changes in the entire process, from designing or introducing a new idea to practical use of skills and technologies by organization members. Through the propagation of new technology by the adoption of potential innovation, an organization advances over time. In addition, process simplification, standardization, and integration develop high-quality strategic systems and improve the quality of information support services for users, which will positively affect corporate performance.

Hypothesis 5a *Process innovation has a positive effect on a firm's financial performance.*

Hypothesis 5b *Process innovation has a positive effect on a firm's nonfinancial performance.*

Partnership One of the topics highlighted in recent supply chain management research is a collaboration among members of the supply chain [40]. This is because instead of maximizing its own profits, it is possible for a company to seek opportunities for greater business performance by forming cooperative relationships with partners.

Companies' efforts to form collaborative relationships and maintain close relationships with key partners can usually be discussed from three perspectives. The first is the point of view of transaction costs theory. The theory suggests that a company that increases investment in the specificity of transactions between companies can improve the performance of the supply chain by reducing the coordination cost and motivation cost associated with the transaction compared to a company that does not [64]. The second perspective is information processing theory. With this theory, a company seeks to overcome market uncertainty and improve corporate performance by sharing or integrating information or resources among companies. The third perspective is a sociopolitical approach. This is when a company seeks to increase the supply chain's performance by establishing intercompany relationships such as intercompany partnerships or strategic alliances [3, 30].

When the concept of collaboration is expressed from a sociopolitical approach, it is understood that collaboration is from the perspective of behaviors that appear according to the relationship between companies and the establishment of partnerships or strategic alliances between companies, joint coordination efforts on an equal footing, and flexibility according to the occurrence of situations. Collaborative behavior can be divided into two main aspects according to the integrated form of decision-making. The first is to jointly deal with problems that may arise in business-to-business transactions, such as joint task-solving actions. These actions appear throughout SCM, including production planning and operations, procurement, order processing, engineering design, and business integration. In particular, the more buyers and suppliers participate at the beginning of the planning process, the higher the opportunity to innovate a product or service.

The second aspect is the flexibility of collaboration between the parties to the transaction. In general, flexibility refers to the ability to cope with changes in an uncertain environment [24]. The uncertainty associated with the transaction between the buyer and the supplier is considerable. For example, unforeseen circumstances may result in a change in order quantity, additional costs, a request for service that exceeds the contractual terms, a request for replacement of new material, or delivery to a particular specification. In this case, if new contract terms can be concluded between companies or if the two companies can solve such problems jointly, the performance of the supply chain can be significantly improved compared to the case where it is not possible.

Partnerships between companies are important to design; they integrate the management of supply chain activities and enhance efficiency in supply chain operations. When partnerships between companies are formed, companies participating in the supply chain expand the scope of collaboration, such as information sharing, synchronization of plans, integration of business processes, and the creation of new business models, and increase the utilization of business processes between companies. Considering that this collaboration takes place within the supply chain, the performance of the supply chain will appear through the performance of the partnership.

Hypothesis 6a *Partnership has a positive effect on a firm's financial performance.*

Hypothesis 6b *Partnership has a positive effect on a firm's nonfinancial performance.*

2.5. Nonfinancial Performance and Financial Performance

Nonfinancial performance plays an important role in SCM as well as a company's financial performance. Reputation can be considered part of the nonfinancial performance of a company. It is the cumulative result of the perceived image of an organization's management-related attitudes and activities over a long period of time [15]. Reputation is a comprehensive evaluation according to the perception of stakeholders outside the organization. Also, as a thorough evaluation of the organization's consistent reliability and integrity, it is a term that includes expectations for future activities and evaluations of past activities of the organization.

When a company seeks to establish a business relationship with a new company, it pursues minimizing risks associated with the transaction. Adverse selection and moral hazard caused by a transaction have negative results for a company, so reputation can be used in a sufficient monitoring process before a transaction. For example, a company may refer to the evaluations or rumors circulated about the new counterparty by a third party who has done business with the company. Therefore, organizations strive to have a favorable reputation among their members. They also try to establish relationships and networks with companies with favorable reputations, exclude organizations with unfavorable reputations, or cut off business relationships [4]. A good reputation can be a valuable asset, and a considerable amount of time and money is invested in an individual company to have a favorable reputation. Reputation plays a role in limiting opportunistic behaviors in business relationships and affects trust. When the level of reputation of the trading company is good or excellent, the level of credit toward the trading company is also improved [19]. Transactions with partners that have good reputations lead to minimized transaction costs, including the financing cost. Therefore, good nonfinancial performance will positively affect a company's financial performance.

Hypothesis 7 *Nonfinancial performance has a positive effect on financial performance.*

3. Methodology

3.1. Research Model

In this study, we analyzed the effect of SCM factors on a company's performance, focusing on the mediating effect of process innovation and partnership. The research model of this study based on the hypotheses is shown in Figure 2.

3.2. Data

The subjects of this study were smartphone parts manufacturing companies operating SCM. We directly visited the companies located in Busan. We explained the purpose of the questionnaire to the other parts manufacturing companies through email and distributed 230 copies of the questionnaires. We collected a total of 206 questionnaires. Of these, we used 193 as the data for this study, excluding the questionnaires containing missing responses. We measured all study variables on a 5-point Likert scale. The characteristics of the 193 smartphone component manufacturers surveyed are shown in Figures 3–5.

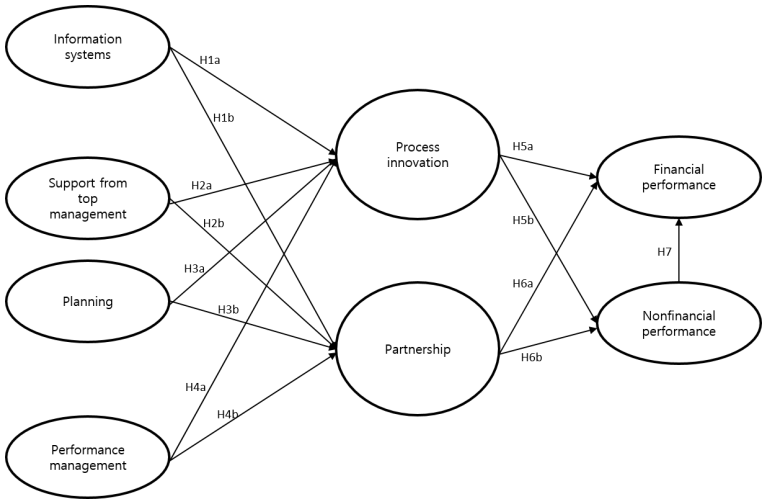

Fig. 2. Research model

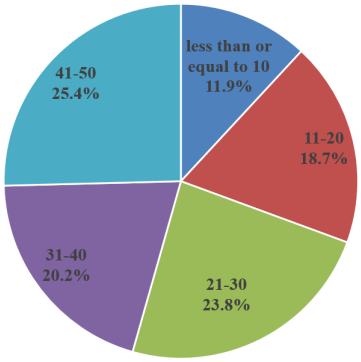

Fig. 3. Firm age (Year)

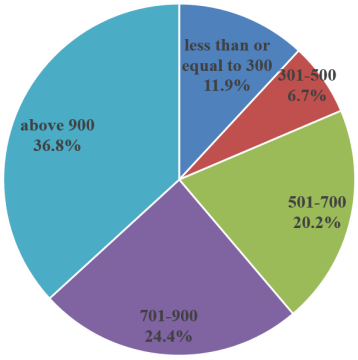

Fig. 4. Firm size (Number of employees)

First, 25.4% of companies were 41–50 years old, followed by 23.8% for 21–30 years, 20.2% for 31–40 years, and 18.7% for 11–20 years, and 11.9% for less than 10 years. The following companies were in the order of 11.9%. The number of employees with more than 900 employees was the highest at 36.8%, followed by 24.4% with between 700 and 900 employees, 20.2% with between 500 and 700 employees, 11.9% with fewer than 300 employees, and 6.7% with between 300 and 500 employees. In the case of sales in the previous year, results showed that sales amounted to 31.6% of the companies with more than 100 billion won, followed by 25.4% of companies with more than 70 billion won, 22.8% of companies with more than 50 billion won, 11.4% of companies with more than 10 billion won, and 8.8% of companies with less than 10 billion won.

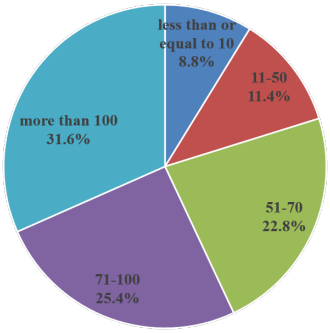

Fig. 5. Sales (Billion won)

3.3. PLS Structural Equation Research Model

In this study, we applied the partial least square structural equation model (PLS-SEM) to analyze the effect of SCM factors on company management performance. The structural equation model is a more powerful analytical method than traditional multivariate analysis. It can indirectly measure nonobservable potential variables through observable measurement variables and explain the measurement error of observed variables. It is widely used in the field of social science research. Because PLS-SEM estimates the path coefficients to maximize the explanatory power (R^2) by minimizing the error term of endogenous latent variables, it focuses on the explanation and prediction of intrinsic latent variables corresponding to dependent variables rather than the structural characteristics of the model. Therefore, it is more suitable for theory development and exploratory research. PLS-SEM shares all assumptions in multiple regression analysis and creates a predictive model when there are a large number of factors or very high multicollinearity. The PLS-SEM can be effectively applied to small sample sizes and complex models with virtually no assumptions regarding the distribution of the data to be analyzed and can easily include formative measurement models and reflective measurement models. Single-item potential variables can also be applied without model identification problems [23].

4. Results

4.1. Validity and Reliability

Validity refers to how accurately a measurement instrument measures the concept or property that it is trying to measure. The purpose of this study was to examine the validity of SCM factors of smartphone component makers as independent variables, process innovation and intercompany partnerships of smartphone component manufacturers as mediators, and nonmonetary and monetary management performance measures as dependent variables. To verify the validity, the research factors were composed of a measurement model and the confirmatory factor analysis of the research factors. Table 1 represents the measurement of each variable.

Table 1. Measurement items for study constructs

Constructs	Measurement	Literature
Information systems	IS01 IT is implemented in various services and functions. IS02 Information is shared across functions. IS03 Expense of operating IT technology is reasonable.	[39]
Support from top management	TS01 CEO highly pays attention to SCM initiatives. TS02 CEO actively invests in SCM adoption and utilization.	[26, 43]
Planning	PN01 Implementable plans are established for production/sales at the supply chain level. PN02 Plans for SCM are set periodically. PN03 Expectations for SCM are clearly stated, understood, and agreed to up front.	[16, 58]
Performance management	PM01 Measures are established systematically for performance. PM02 Activities of employees are reported for performance management. PM03 Roles and responsibilities and incentives are specified clearly.	[21, 52]
Process innovation	PI01 SCM improves and manages processes in an enterprise. PI02 Top management is actively involved in the exploration of challenges for process innovation. PI03 The company possesses a mechanism by which process innovation can be applied to other functions. PI04 The company possesses systems to maintain and manage changes in processes.	[5, 63]
Partnership	PS01 There is on-time delivery to partner firms. PS02 Our partner initiates contracts. PS03 We share information with partner firms in timely manner.	[7, 54]
Financial performance	FP01 Revenue is increased. FP02 Marginal profit is increased. FP03 Inventory costs is reduced.	[21]
Nonfinancial performance	NF01 Flexibility is improved in SCM. NF02 Rate of damage-free in the production is increased. NF03 Reputation is improved.	[22]

Through the confirmatory factor analysis, items that lowered the factor load or impaired the fit of the measurement model were removed, and the factors of SCM consisted of three items of information system, two items of support from top management, three items of planning, and three items of performance management. The final metrics consisted of four items for process innovation and three items for partnership among companies. In addition, three questions each consisted of nonmonetary and monetary outcomes as dependent variables. Because all the extracted values show more than 0.6, there seems to be no problem with the validity of the variables. Table 2 shows the results of the factor analysis conducted with the validation.

We also performed reliability verification. Table 3 shows the results of the reliability analysis. As a result of reviewing the reliability of the final metric, Cronbach's α coefficient was 0.637 for the information management factor, 0.771 for the activation support factor, 0.727 for the planning and collaboration factor, and 0.744 for the process innovation factor. The partnership factor between companies was 0.642, the nonmonetary performance was 0.664, and the monetary performance factor was 0.715. Every coefficient of Cronbach's α is above 0.6, and the constructive reliability is acceptable [11, 55].

Next, the concept reliability and average variance extraction (AVE) were reviewed to examine the concentration validity of latent factors.

Table 2. The value of cross-loading

		Info	Support	Plan	Perform	Innov	Partner	Fin	Nonfin
Info	IS01	**0.823**	0.273	0.326	0.431	0.352	0.297	0.338	0.196
	IS02	**0.777**	0.225	0.214	0.352	0.265	0.198	0.257	0.093
	IS03	**0.667**	0.204	0.313	0.350	0.200	0.227	0.213	0.137
Support	TS01	0.294	**0.920**	0.315	0.362	0.317	0.315	0.320	0.232
	TS02	0.268	**0.883**	0.271	0.292	0.237	0.289	0.318	0.180
Plan	PN01	0.362	0.274	**0.869**	0.451	0.272	0.323	0.355	0.140
	PN02	0.299	0.316	**0.839**	0.382	0.245	0.224	0.210	0.125
	PN03	0.226	0.189	**0.692**	0.287	0.198	0.182	0.244	0.122
Perform	PM01	0.428	0.333	0.388	**0.837**	0.332	0.376	0.422	0.208
	PM02	0.335	0.266	0.389	**0.792**	0.230	0.310	0.259	0.222
	PM03	0.451	0.286	0.381	**0.808**	0.346	0.281	0.331	0.240
Innov	PI01	0.284	0.200	0.156	0.267	**0.692**	0.211	0.209	0.189
	PI02	0.227	0.166	0.230	0.137	**0.747**	0.255	0.230	0.178
	PI03	0.283	0.201	0.270	0.305	**0.681**	0.298	0.227	0.129
	PI04	0.257	0.290	0.202	0.331	**0.725**	0.293	0.299	0.292
Partner	PS01	0.276	0.177	0.272	0.315	0.311	**0.756**	0.339	0.199
	PS02	0.259	0.353	0.229	0.341	0.238	**0.801**	0.384	0.136
	PS03	0.203	0.227	0.215	0.255	0.319	**0.731**	0.315	0.226
Financial	FP01	0.367	0.359	0.340	0.409	0.328	0.400	**0.861**	0.320
	FP02	0.311	0.308	0.276	0.349	0.286	0.397	**0.880**	0.327
	FP03	0.168	0.150	0.190	0.238	0.202	0.285	**0.642**	0.293
Nonfinancial	NF01	0.182	0.235	0.073	0.219	0.271	0.159	0.344	**0.779**
	NF02	0.082	0.092	0.112	0.198	0.218	0.207	0.238	**0.802**
	NF03	0.192	0.213	0.203	0.221	0.166	0.199	0.323	**0.735**

First, concentration validity represents the degree of correlation between two or more measurement items for a potential factor. If the concept reliability is 0.7 or more [10] and the AVE index is 0.5 or more, the concentration validity is acceptable. The concept reliability is more than 0.7 in all variables, and the AVE value is more than 0.5, which proves the validity of potential factors.

4.2. Validation of Research Hypotheses

Correlation Analysis The correlations among potential factors, such as SCM factors, process innovation, partnerships between companies, and management performance of smartphone parts manufacturing companies, are shown in Table 4. Numbers in bold type with diagonal lines represent the squared root of AVE. Because this number is larger than the other nondiagonal numbers, the component has a reasonable level of discriminant validity [17].

Table 3. Reliability

	Item	Mean	SD	Weight	Cronbach's α	Composite Reliability	AVE
InfoSys	IS01	3.83	0.93	0.823	0.637	0.802	0.576
	IS02	3.89	0.82	0.777			
	IS03	3.86	0.82	0.667			
TmtSupport	TS01	3.77	0.86	0.920	0.771	0.897	0.813
	TS02	3.63	0.89	0.883			
Plan	PN01	4.01	0.97	0.869	0.727	0.844	0.646
	PN02	3.89	0.83	0.839			
	PN03	3.84	0.89	0.692			
PerfMgt	PM01	4.03	0.88	0.837	0.744	0.853	0.660
	PM02	3.80	0.92	0.792			
	PM03	3.82	0.87	0.808			
ProcessInnov	PI01	3.67	0.88	0.692	0.679	0.804	0.507
	PI02	3.50	0.93	0.747			
	PI03	3.58	0.93	0.681			
	PI04	3.68	0.87	0.725			
Partner	PS01	3.85	0.92	0.756	0.642	0.807	0.583
	PS02	3.95	0.89	0.801			
	PS03	3.89	0.85	0.731			
Nonfinancial	NF01	3.77	1.01	0.779	0.664	0.816	0.596
	NF02	3.78	0.96	0.802			
	NF03	3.90	1.03	0.735			
Financial	FP01	3.62	0.88	0.861	0.715	0.842	0.643
	FP02	3.70	0.77	0.880			
	FP03	3.95	0.84	0.642			

Table 4. Correlations of constructs

	Info	Support	Plan	Perform	Inno	Partner	Nonfin	Fin
Info	**0.759**							
Support	0.312	**0.902**						
Plan	0.376	0.326	**0.804**					
Perform	0.502	0.366	0.474	**0.812**				
Inno	0.370	0.311	0.300	0.377	**0.712**			
Partner	0.323	0.336	0.312	0.400	0.375	**0.763**		
Nonfin	0.194	0.231	0.160	0.274	0.287	0.242	**0.773**	
Fin	0.364	0.353	0.343	0.423	0.345	0.455	0.389	**0.802**

Note: Bold numbers show square root of AVE

Empirical Analysis In this study, the SCM factors of smartphone parts manufacturers were designed as independent variables, and the dependencies were designed to verify the causality of the SCM factors and management factors. An SEM analysis was conducted to look at the causal relationship between SCM factors, process innovation, intercompany partnerships, and management performance factors. Figure 6 shows the results.

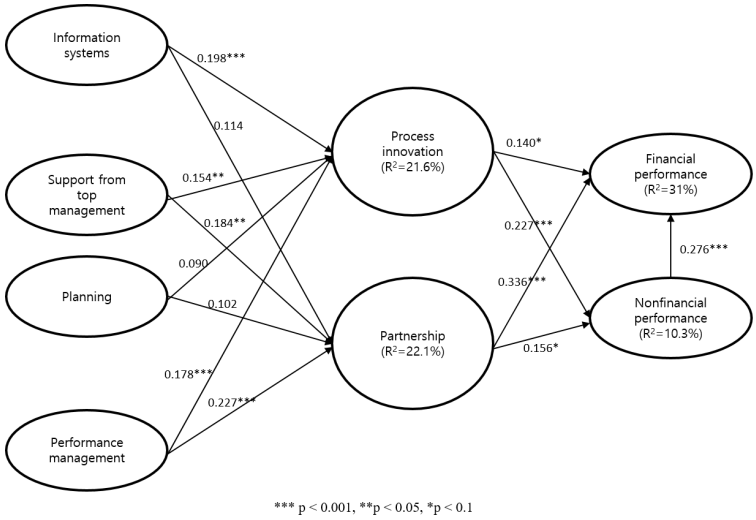

Fig. 6. Results

First, the information system had a significant effect on process innovation ($\beta = 0.198, p < 0.001$). Therefore, Hypothesis 1a was supported. The effect on partnership showed a positive signal but did not show a significant effect. Second, support from top management was found to have a significant effect on process innovation and partnership, respectively ($\beta = 0.154, p < 0.05; \beta = 0.184, p < 0.05$). Therefore, both Hypotheses 2a and 2b were supported. Here, we once again discover that the role of top management is important for improving SCM performance. Third, it was found that planning had no effect on process innovation and partnership. Fourth, performance management was found to have a significant effect on process innovation and partnership ($\beta = 0.178, p < 0.001; \beta = 0.227, p < 0.001$). Therefore, Hypotheses 4a and 4b were supported. Process innovation was found to have a positive effect on both the financial and nonfinancial performance of a company ($\beta = 0.140, p < 0.1; \beta = 0.227, p < 0.001$), and Hypotheses 5a and 5b were supported. Partnership was also found to have a positive effect on both financial and nonfinancial performance of a company ($\beta = 0.336, p < 0.001; \beta = 0.156, p < 0.1$), and Hypotheses 6a and 6b were supported. Finally, nonfinancial performance was found to have a positive effect on financial performance ($\beta = 0.276, p < 0.001$), and Hypothesis 7 was supported. The results for each hypothesis are summarized in Table 5.

Table 5. Summary of results

Hypothesis	Relationship	Beta	Std. Error	T Statistics	Support
1a	InfoSys → ProcessInnov	0.198	0.030	6.514	O
1b	InfoSys → Partner	0.114	0.037	3.034	x
2a	TmtSupport → ProcessInnov	0.154	0.033	4.699	O
2b	TmtSupport → Partner	0.184	0.031	5.983	O
3a	Plan → ProcessInnov	0.090	0.033	2.737	x
3b	Plan → Partner	0.102	0.036	2.862	x
4a	PerfMgt → ProcessInnov	0.178	0.029	6.110	O
4b	PerfMgt → Partner	0.227	0.036	6.243	O
5a	ProcessInnov → Financial	0.140	0.034	4.097	O
5b	ProcessInnov → Nonfinancial	0.227	0.032	7.205	O
6a	Partner → Financial	0.336	0.028	12.193	O
6b	Partner → Nonfinancial	0.156	0.036	4.357	O
7	Nonfinancial → Financial	0.276	0.028	9.777	O

5. Conclusions

To improve corporate performance, we examined how SCM factors affect corporate performance using two intermediates: process innovation and partnership. The results are as follows. First, top management support and performance management have positive significant effects on both process innovation and partnership. Second, an information system has a positive significant effect on process innovation. Third, both process innovation and partnership have a positively significant effect on financial and nonfinancial performance. Forth, nonfinancial performance has a positive effect on financial performance. Fifth, information systems have an insignificant effect on partnerships. Information sharing can have a positive effect on partnerships; however, if general staff answered the survey, it may be difficult to gain a detailed understanding of whether information sharing has a positive effect on the partnership. Lastly, planning has an insignificant effect on both process innovation and partnership. First, we conjecture that planning is related to maintenance and may not have much to do with process innovation and partnership. Second, if general staff answered the survey, the results would be insignificant because general staff members do not have much knowledge about the planning process.

Companies that produce fast-changing high-end products or components have different characteristics than those in other industries. In particular, high-tech goods companies change their cycles quickly because of the short life of the products they produce. As new technology development speeds up throughout the industry, these companies will likely survive if they can follow the faster cycle through internal process innovation. In addition, parts companies take raw materials, make intermediate parts, and deliver them to finished product companies. If there is a problem with the company supplying the raw material or if there is a problem with the company that produces the finished product, the company will interfere with the production schedule. Therefore, partnership with other companies is also crucial for companies producing intermediate goods.

From the result of this study, we provided important implications for managers. To have a good performance through SCM, companies need to focus more on the support of top management and performance management. Also, process innovation and partnership are critical factors that affect firms' performances. Although prior research does not equally weigh the importance of internal and external factors, there are of the same importance. Therefore, firms need to invest in process innovation and make appropriate relationships with their partners.

In process innovation, it is necessary to consider the following points. Depending on the degree of establishment and development of a company's production process, the extent to which process innovation is affected by SCM factors will be different. Also, different level of company's production process development may have different effects on the company's business performance. In this study, we verified the effect of process innovation on business performance, but we did not make a detailed classification of process innovation itself, which is a limitation. Therefore, future research is needed to systematically classify differences in the process establishment and development level of smartphone parts manufacturing companies and to investigate their performance.

Many fields of industry are facing changes due to the fourth industrial revolution—in particular, the advanced technologies of the 4th Industrial Revolution. Robotics, the IoT, big data, and unmanned transportation are expected to have a major impact on the overall SCM. For a company to achieve sustainable growth with a competitive advantage by utilizing this phenomenon, it is necessary to understand the existing SCM's characteristics and performance and to use that data to implement a new strategy.

In this study, we examined the performance of SCM for companies that currently produce high-tech products. Findings from this research can further serve as an important foundation for future research that measures the performance of other high-tech products or processes applied by Industry 4.0, such as artificial intelligence, the IoT, robotics, and big data within the SCM model.

References

1. Al-Sa'di, A.F., Abdallah, A.B., Dahiyat, S.E.: The mediating role of product and process innovations on the relationship between knowledge management and operational performance in manufacturing companies in jordan. Business Process Management Journal (2017)
2. Arshad Ali, A., Mahmood, A., Ikram, A., Ahmad, A.: Configuring the drivers and carriers of process innovation in manufacturing organizations. Journal of Open Innovation: Technology, Market, and Complexity 6(4), 154 (2020)
3. Bensaou, M.: Portfolios of buyer-supplier relationships. MIT Sloan Management Review 40(4), 35 (1999)
4. Berg, A., Gottschalg, O.F.: Understanding value generation in buyouts. Journal of Restructuring Finance 2(01), 9–37 (2005)
5. Blakeslee Jr, J.A.: Implementing the six sigma solution. Quality progress 32(7), 77 (1999)
6. Cachon, G.P., Fisher, M.: Supply chain inventory management and the value of shared information. Management science 46(8), 1032–1048 (2000)
7. Cadilhon, J.J., Fearne, A.P., Moustier, P., Poole, N.D.: Modelling vegetable marketing systems in south east asia: phenomenological insights from vietnam. Supply Chain Management: an international journal (2003)
8. Cao, M., Zhang, Q.: Supply chain collaboration: Impact on collaborative advantage and firm performance. Journal of operations management 29(3), 163–180 (2011)

9. Chandren, S., Qaderi, S.A., Ghaleb, B.A.A.: The influence of the chairman and ceo effectiveness on operating performance: Evidence from malaysia. Cogent Business & Management 8(1), 1935189 (2021)
10. Chin, W.W.: Commentary: Issues and opinion on structural equation modeling (1998)
11. Cossío-Silva, F.J., Revilla-Camacho, M.Á., Vega-Vázquez, M., Palacios-Florencio, B.: Value co-creation and customer loyalty. Journal of Business Research 69(5), 1621–1625 (2016)
12. Day, D.V., Lord, R.G.: Executive leadership and organizational performance: Suggestions for a new theory and methodology. Journal of management 14(3), 453–464 (1988)
13. Demir, S., Paksoy, T.: Ai, robotics and autonomous systems in scm. Logistics 4.0: Digital Transformation of Supply Chain Management p. 156 (2020)
14. Ellram, L.M., Cooper, M.C.: Supply chain management, partnership, and the shipper-third party relationship. The international journal of logistics management 1(2), 1–10 (1990)
15. Eltantawy, R.A., Fox, G.L., Giunipero, L.: Supply management ethical responsibility: reputation and performance impacts. Supply Chain Management: An International Journal (2009)
16. Fisher, M.L.: What is the right supply chain for your product? Harvard business review 75, 105–117 (1997)
17. Fornell, C., Larcker, D.F.: Evaluating structural equation models with unobservable variables and measurement error. Journal of marketing research 18(1), 39–50 (1981)
18. Frohlich, M.T., Westbrook, R.: Arcs of integration: an international study of supply chain strategies. Journal of operations management 19(2), 185–200 (2001)
19. Ganesan, S.: Determinants of long-term orientation in buyer-seller relationships. Journal of marketing 58(2), 1–19 (1994)
20. Goldhar, J.D., Lei, D.: The shape of twenty-first century global manufacturing. The Journal of Business Strategy 12(2), 37 (1991)
21. Gunasekaran, A., Kobu, B.: Performance measures and metrics in logistics and supply chain management: a review of recent literature (1995–2004) for research and applications. International journal of production research 45(12), 2819–2840 (2007)
22. Gunasekaran, A., Patel, C., Tirtiroglu, E.: Performance measures and metrics in a supply chain environment. International journal of operations & production Management (2001)
23. Hair Jr, J.F., Sarstedt, M., Hopkins, L., Kuppelwieser, V.G.: Partial least squares structural equation modeling (pls-sem): An emerging tool in business research. European business review (2014)
24. Heide, J.B., Miner, A.S.: The shadow of the future: Effects of anticipated interaction and frequency of contact on buyer-seller cooperation. Academy of management journal 35(2), 265–291 (1992)
25. Heikkilä, J.: From supply to demand chain management: efficiency and customer satisfaction. Journal of operations management 20(6), 747–767 (2002)
26. Higginson, J.K., Alam, A.: Supply chain management techniques in medium-to-small manufacturing firms. The International Journal of Logistics Management 8(2), 19–32 (1997)
27. Huggins, J.W., Schmitt, R.G.: Electronic data interchange as a cornerstone to supply chain management. In: Annual Conference Proceedings of the 1995 Council of Logistics Management (1995)
28. Imache, R., Izza, S., Ahmed-Nacer, M.: An enterprise information system agility assessment model. Computer science and information systems 9(1), 107–133 (2012)
29. Jeon, S.S., Lee, R.: Impact of scm system operation strategy on scm performance and mediating effect of process innovation. Journal of Theoretical and Applied Information Technology 100(5) (2022)
30. Ke, W., Wei, K.K.: Factors affecting trading partners' knowledge sharing: Using the lens of transaction cost economics and socio-political theories. Electronic Commerce Research and Applications 6(3), 297–308 (2007)

31. Kim, D., Cavusgil, S.T., Calantone, R.J.: Information system innovations and supply chain management: channel relationships and firm performance. Journal of the academy of marketing science 34(1), 40–54 (2006)
32. Kothari, S.S., Jain, S.V., Venkteshwar, A.: The impact of iot in supply chain management. International Research Journal of Engineering and Technology 5(8), 257–259 (2018)
33. Kotter, J.: A force for change: How management differs from leadership. New York: FreePress (1990)
34. LaLonde, B.J., Masters, J.M.: Logistics: perspectives for the 1990s. The International Journal of Logistics Management (1990)
35. Lambert, D.M., Cooper, M.C., Pagh, J.D.: Supply chain management: implementation issues and research opportunities. The international journal of logistics management 9(2), 1–20 (1998)
36. Le Tan, T., Thi Dai Trang, D.: Issues of implementing electronic supply chain management (e-scm) in enterprise. European Business & Management 3(5), 86–94 (2017)
37. Lee, S.M., Lee, D., Schniederjans, M.J.: Supply chain innovation and organizational performance in the healthcare industry. International Journal of Operations & Production Management (2011)
38. Loforte, A.J.: The implications of multicultural relationships in a transnational supply chain. In: National association of purchasing management annual conference proceedings. pp. 69–77 (1991)
39. Marien, E.J.: The four supply chain enablers. SUPPLY CHAIN MANAGEMENT REVIEW, V. 2, NO. 3 (FALL 1998), P. 60-68: ILL (2000)
40. Mentzer, J.T., Min, S., Zacharia, Z.G.: The nature of interfirm partnering in supply chain management. Journal of retailing 76(4), 549–568 (2000)
41. Min, H.: Artificial intelligence in supply chain management: theory and applications. International Journal of Logistics: Research and Applications 13(1), 13–39 (2010)
42. Min, H., Yu, W.B.: Collaborative planning, forecasting and replenishment: demand planning in supply chain management. International Journal of Information Technology and Management 7(1), 4–20 (2008)
43. Premkumar, G., Ramamurthy, K.: The role of interorganizational and organizational factors on the decision mode for adoption of interorganizational systems. Decision sciences 26(3), 303–336 (1995)
44. Qrunfleh, S., Tarafdar, M.: Supply chain information systems strategy: Impacts on supply chain performance and firm performance. International journal of production economics 147, 340–350 (2014)
45. Quang, H.T., Sampaio, P., Carvalho, M.S., Fernandes, A.C., An, D.T.B., Vilhenac, E.: An extensive structural model of supply chain quality management and firm performance. International Journal of Quality & Reliability Management (2016)
46. Quinn, F.J.: What's the buzz. Logistics Management 36(2), 43–47 (1997)
47. Rai, A., Borah, S., Ramaprasad, A.: Critical success factors for strategic alliances in the information technology industry: an empirical study. Decision Sciences 27(1), 141–155 (1996)
48. Rejeb, A., Rejeb, K., Simske, S.J., Treiblmaier, H.: Drones for supply chain management and logistics: a review and research agenda. International Journal of Logistics Research and Applications pp. 1–24 (2021)
49. Ryals, L.J., Humphries, A.S.: Managing key business-to-business relationships: what marketing can learn from supply chain management. Journal of Service research 9(4), 312–326 (2007)
50. Salvador, F., Villena, V.H.: Supplier integration and npd outcomes: Conditional moderation effects of modular design competence. Journal of Supply Chain Management 49(1), 87–113 (2013)
51. Sarmah, S.P., Acharya, D., Goyal, S.: Coordination and profit sharing between a manufacturer and a buyer with target profit under credit option. European Journal of Operational Research 182(3), 1469–1478 (2007)

52. Shepherd, C., Günter, H.: Measuring supply chain performance: current research and future directions. Behavioral operations in planning and scheduling pp. 105–121 (2010)
53. Stefanović, N., Stefanović, D.: Supply chain performance measurement system based on scorecards and web portals. Computer Science and Information Systems 8(1), 167–192 (2011)
54. Su, Q., Song, Y.t., Li, Z., Dang, J.x.: The impact of supply chain relationship quality on cooperative strategy. Journal of Purchasing and Supply Management 14(4), 263–272 (2008)
55. Taber, K.S.: The use of cronbach's alpha when developing and reporting research instruments in science education. Research in science education 48(6), 1273–1296 (2018)
56. Tan, K.C.: A framework of supply chain management literature. European Journal of Purchasing & Supply Management 7(1), 39–48 (2001)
57. Teo, T.S., Tan, M., Buk, W.K.: A contingency model of internet adoption in singapore. International Journal of electronic commerce 2(2), 95–118 (1997)
58. Tyndal, G., Gopal, C., Partsch, W., Kamauff, J.: Making it happen: the value producing supply chain. Ernst & Young, available at: www. ey. com/global/gcr. nsf/US/Supercharging_Supply_Chains_-_Think_Tank_-_ Ernst_% 26_Young _LLP (accessed 10 January 2001) (2000)
59. Un, C.A., Asakawa, K.: Types of r&d collaborations and process innovation: The benefit of collaborating upstream in the knowledge chain. Journal of Product Innovation Management 32(1), 138–153 (2015)
60. Uzsoy, R., Fowler, J.W., Mönch, L.: A survey of semiconductor supply chain models part ii: demand planning, inventory management, and capacity planning. International Journal of Production Research 56(13), 4546–4564 (2018)
61. Waller, M.A., Fawcett, S.E.: Data science, predictive analytics, and big data: a revolution that will transform supply chain design and management (2013)
62. Wankmüller, C., Reiner, G.: Coordination, cooperation and collaboration in relief supply chain management. Journal of Business Economics 90(2), 239–276 (2020)
63. White, R.E., Hamermesh, R.C.: Toward a model of business unit performance: An integrative approach. Academy of Management Review 6(2), 213–223 (1981)
64. Williamson, O.E.: Assessing contract. Journal of Law, Economics, & Organization 1(1), 177–208 (1985)
65. Wisner, J.D.: A structural equation model of supply chain management strategies and firm performance. Journal of Business logistics 24(1), 1–26 (2003)
66. Yip, G., McKern, B.: China's many types of innovation. Forbes, Sept 19, 2014 (2014)

Yoonkyo Cho received the Doctorate (Ph.D.) in Management from The State University of New York at Buffalo, USA in 2017. She is currently working as an assistant professor at Halla University in Wonju, Korea. Her research interests are in the fields of strategic management, international business, and entrepreneurship.

Chunsu Lee received the Doctorate (Ph.D.) in International Business Management from the Korea University at Seoul, Korea in 2006. He is currently working as a professor at Pukyong National Unversity in Pusan, Korea. His research interests are in the fields of international business, international marketing and strategic management.

Received: May 14, 2022; Accepted: December 26, 2022.