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Critical Success Factors in the Adoption of Ubiquitous SCM Systems: Strategic Implications

Changsu Kim*, Sung Won Kim** and Gyanendra Prasad Joshi ***

** School of Business, Yeungnam University, 214-1 Dae-dong, Gyeongsan-si, Gyeongsangbuk-do 712-749, Korea*

*** Department of Information and Communication Engineering, College of Engineering, Yeungnam University, 214-1 Dae-dong, Gyeongsan-si, Gyeongsangbuk-do 712-749, Korea*

**** Department of Information and Communication Engineering, College of Engineering, Yeungnam University, 214-1 Dae-dong, Gyeongsan-si, Gyeongsangbuk-do 712-749, Korea*
E-mail: joshi@ynu.ac.kr

Abstract

The purpose of this study is to identify the critical success factors in the adoption of ubiquitous supply chain management systems and to examine their relationships with organizational performance. Based on a literature review and interviews with managers from Korean firms, the study compiles a list of 12 critical success factors consisting of 63 items. The results of a survey administered to managers from various organizations in Korea indicate that the critical success factors from management and technical aspects explain organizational performance at various levels.

Key Words: Supply Chain Management; Critical Success Factors; Organizational Performance

1. Introduction

More firms are making use of supply chain management (SCM) and ubiquitous computing tools to improve their performance. Ubiquitous computing refers to a new computing paradigm in which computers completely pervade the user's life [1] and the way of doing business [2]. Xerox PARC's Mark Weiser, the originator of the term "ubiquitous computing," highlighted pervasive, context–aware computing or a computing environment in which individuals can use computers whenever and wherever with whomever by installing invisible computing and embedded computer networks into objects, locations, and people [3][4]. In addition, this technology can integrate physical and electronic virtual worlds [5–7].

There are several types of ubiquitous computing technologies, including automatic identification systems, sensors, wireless communications systems, and embedded computing [2][8–10][63]. However, these technical characteristics alone may not provide a clear understanding of the diverse range of business models enabled by ubiquitous computing [2][8]. The most successful application of ubiquitous computing has been in SCM [2][5][11]. Therefore, this study uses the term "ubiquitous supply chain management" (USCM), which is a type of SCM using a new technology for effective SCM. USCM provides organizations with forecasting tools, web-based interfaces for collaboration, and report systems for sales and operations, and metrics for more accurately forecasting and profiling consumer demand. Accurate demand predictions for SCM can directly facilitate the organization's competitive advantage, inventory management, business productivity, and cost effectiveness. Global markets such as Korea and the U.S., which have a free trade agreement, face massive pressure to reduce costs while increasing innovation and improving customer service and responsiveness. USCM adoption enables firms to more accurately forecast demand, empowering them to adapt their supply chain process to an ever-changing competitive environment.

However, despite the increasing adoption of USCM, very little is known about the success factors associated to USCM. Particularly lacking is a theory for explaining the phenomenon of USCM adoption on a priori basis. In this regard, the present study focuses on examining the critical success factors of USCM adoption, which in turn affects organizational performance.

The purpose of this study is to determine the critical factors influencing the success of USCM adoption and their effects on firm performance. Through the literature review and interviews, the study compiles a list of 12 critical success factors consisting of 63 items and provides a survey of managers in charge of SCM at several Korean firms in various industries (around 18% response rate). The study presents a model of USCM adoption that integrates factors from both management and technological aspects to explain organizational performance. In particular, the model provides a more elaborate and strategic approach to USCM adoption. The model is expected to be useful for managers and executive planning to adopt USCM.

The rest of this paper is organized as follows: Section 2 provides a review of previous research on USCM. Section 3 explains the operational measures and data collection processes. Section 4 presents the results, and Section 5 concludes with a discussion on important implications.

2. Literature review

2.1. Overview of USCM

In general, a supply chain refers to a process from the purchase of raw materials to the production of finished products that reach consumers, that is, the whole process from the supplier to the consumer [3][12][13]. The goal of SCM is to minimize the cost of the supply chain, increase its value, and remove wasteful business activities [12][14–16]. Recently, SCM has been described as a digitally enabled inter-enterprise activity that focuses on improving and innovating the end-to-end process between enterprises and their customers and suppliers [17][18]. Because SCM involves complex systems of interorganizational activities and processes relevant to the flow of products, services, and information, effective SCM is influenced by information technology (IT) [5][14] [16–21].

Recently, ubiquitous computing technologies have offered new SCM opportunities within and across firms, integrating a number of organizational, functional, and technological issues [2][3][7][9][22][23]. With ubiquitous computing becoming more mobile and pervasive, USCM has emerged as a key issue for organizations wishing to process supply chain transactions more accurately, quickly, and efficiently. The present study defines USCM as the planning, control, and management of the supply chain based on ubiquitous computing technologies such as radio frequency identification (RFID) system, sensors, mobile devices, and personal data assistants (PDAs). USCM encompasses a range of activities, including purchasing, material handling, production planning and control, warehousing, logistics, inventory management, distribution, delivery, and vendor management [2][5][9][16]. Therefore, it is not surprising that an increasing number of firms are adopting USCM.

USCM has been regarded as one of various functional systems in organizations because it plays a vital role in the relationship between organizations and their suppliers in terms of the global supply chain and supports new types of ubiquitous businesses related to the supply chain [2][3][5][24]. Although USCM plays a critical role in managing global supply chain activities, few studies have provided theoretical and empirical analyses. The following section reviews previous research on USCM.

2.2. Previous research on USCM

As discussed earlier, although some studies have examined ubiquitous computing and SCM, few have focused on USCM, which integrates ubiquitous computing with SCM. Previous SCM research has considered various issues such as inventory management [25][26], material management [27], interorganizational capability [28], frameworks [29][30], strategies [31], effects [12][21][32], development [1][33], IT applications in SCM [17][18][20][21], and SCM planning [34].

The following review of previous studies provides a useful theoretical basis for this study. From a management perspective, Fish and Forrest [9] reported seven factors underling successful RFID adoption and the reasons for RFID implementation. The seven success factors include 1) developing a clear strategy with top management support, 2) facilitating RFID implementation as a project, 3) managing a gradual rollout, 4) continuously improving procedures, 5) working on negotiations and building trust between flexible partners, 6) using cross-functional teams, and 7) developing robust technologies throughout the whole supply chain. Although these factors have yet to be verified through empirical data, they provide a theoretical basis for further research on the selection of appropriate variables for successful USCM adoption.

Kourouthanassis and Roussos [35] addressed the design of pervasive retail experiences brought about by the emergence of ubiquitous computing and argued that the most important issues derived from the development of ubiquitous retail applications are trust and privacy. Their research contributes by showing the practical application of pervasive retail businesses within ubiquitous computing. Recently, Narayanaswami et al. [2] reviewed pervasive retail businesses dealing with ubiquitous computing technologies such as smartphones, sensors, and wireless technologies and provided a better understanding of the application of ubiquitous computing in the retail sector.

From a technological perspective, Roussos [7] addressed the SCM standards for ubiquitous commerce and reviewed the history of unique identifier and product classification systems, providing an overview of the European Article Number (EAN) UCC system, including its recent specifications for the wireless auto-identification of products. In addition, he reviewed global cataloguing schemes and standards for ubiquitous commerce. His work focuses on reviewing SCM standards and thus contributes to research on emerging USCM standards. Hackenbroich et al. [22] described enterprise software packages for SCM, focusing on SAP's SCM and Auto-ID technology and discussing two Auto-ID pilot cases. Because both RFID and Auto-ID technologies play major roles in USCM adoption, their work provides a better understanding the relationship between ubiquitous-computing technologies and business applications. Thiesse et al. [24] described the design and adoption of a real-time identification and localization system using RFID and ultrasound sensor technologies to improve tracking visibility for inbound logistics. Their work extends existing knowledge of RFID and ubiquitous technology applications. Singh et al. [23] focused on issues related to IT-enabled supply chains and their impact on organizational processes and argued that the choice of adopting the right technology depends on the compatibility of the technology with appropriate organizational practices and policies. Lin and Ho [36] argued that logistics firms' willingness to adopt the RFID technology depends considerably on the explicitness and accumulation of the technology, organizational support for innovation, the quality of human resources, and government support. Recently, Giner et al. [6] proposed a technique for designing pervasive workflow and applying them to the development of several mobile workflow applications such as smart libraries and home notification systems and found that the automatic identification capability of ubiquitous computing can improve implicit interactions to connect the physical world to the digital supply chain process.

Previous studies of USCM are generally recent and tend to take exploratory approaches. In addition, such studies have been conducted from two distinct perspectives: management and technology. Studies from the technological perspective are generally narrow in their focus and rarely consider factors such as interorganizational system, suppliers, and supply chains, all of which are closely related to USCM adoption. On the other hand, those from the management perspective tend to be much wider in their focus but are limited in terms of their explanatory power because they lack a technological perspective. Based on this review, there is a need for a better understanding of USCM through an in-depth empirical analysis of both management and technological issues because the two perspectives together may better explain the phenomenon of USCM adoption.

2.3. Previous research on IT adoption

IT is recognized as a major enabler for organizations to increase their efficiency and effectiveness and gain a competitive advantage (e.g., [37–42]). IT adoption takes place in many organizations, societies, and countries. In this regard, there is growing interest in IT adoption (e.g., [38–44]).

Because the present study focuses on USCM adoption, it is useful to consider innovation theory as a theoretical foundation. Innovation diffusion theory has been used to explain the adoption of various IT applications, including open systems [45], groupware [46], software packages [47], web technologies [48], the Internet [49], websites [50], telemedicine [51], the broadband Internet [39], IT platforms [52], customer relationship management [37], mobile Internet services [44], enterprise application integration [38], online banking [42], data warehouses [40], mobile shopping [43], and mobile data services [41].

A growing number of studies have noted that IT plays a vital role in enhancing the competitive advantage of organizations and industries [37][38][40–42][52]. Given the characteristics of USCM-based technological innovation, the present study makes theoretical contributions by providing a better understanding of USCM adoption because, although many studies have examined a wide range of IT adaptation, few have investigated the factors influencing USCM adoption. In addition, the use of ubiquitous computing in SCM represents a special case of technology adoption [23][34][53].

3. Research model and procedures

Various factors influence USCM adoption. Among these, IT plays a significant role in facilitating supply chain transactions, information sharing, and collaboration with suppliers and business partners [6][18][20][21][23][34][41]. In particular, ubiquitous computing has been applied most successfully to supply chain areas for improving the competitiveness of firms [2][7][9][22][23]. spite the increasing application of ubiquitous computing to SCM, few studies have examined the factors influencing the successful adoption of USCM in terms of management aspects such as management planning, management support, and relationship/process/risk management as well as technological aspects such as the system infrastructure, applications, network foundations, enacted technology acceptance, and technology planning (e.g., [2][23] [35][36]). In this regard, the present study classifies these factors into two groups: management and technological factors. Therefore, this study proposes a research model considering these two types of factors in the context of USCM adoption (Fig. 1). Given that no study has thoroughly elucidated management and technological perspectives in this context, this study employs both expert interviews and surveys in Korea.

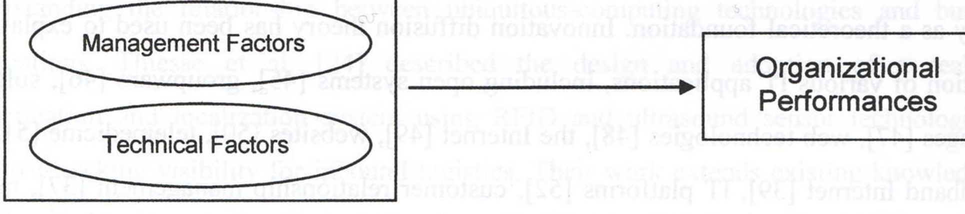

Fig. 1. Research model.

The research procedure was as follows: First, to discern the critical success factors in USCM adoption, we conducted a literature review and interviews. Before the interviews, we e-mailed the participants documents that explained the major objectives of the study and the key factors influencing the successful adoption of USCM. In the interviews, we discussed the issues in an informal, "brainstorming" manner, using a tape recorder to record the sessions, each of which lasted for about one to two hours. Then we analyzed the data collected from the interviews and summarized the content of each meeting. Based on the interviews, we identified 33 management factors (Table 2), 31 technological factors (Table 3), and 27 organizational performance factors (Table 4). Second, we developed a questionnaire based on the key success factors and the perceived performance of USCM adoption (Tables 2, 3, and 4). We measured most of the items based on a five-point Likert-type scale and conducted a pretest to determine whether the instructions and questions were clear and whether answers to the questions could be provided. The pretest process allowed for the identification of any ambiguity in instrument items and for appropriate revisions. Third, with respect to cost, time, and logistical considerations, we collected empirical data through a survey in Korea, a country known for having the fastest broadband connections in the world [54]. Korea is an emerging and rapidly changing market. On April 2, 2007, Korea and the U.S. agreed to a free trade agreement, and this has resulted in major changes in the market in terms of more effective SCM. Because this new market reality requires better SCM between the two parties through the adoption of ubiquitous computing technologies, data from Korea can be considered practical and appropriate. Fourth, we conducted an in-depth analysis of the relationships between the critical success factors and USCM adoption performance. Finally, based on the results, we considered important conclusions and implications.

4. Analysis and results

4.1. Respondents

We conducted a survey of senior managers from firms who were in charge of USCM adoption. These firms represented a wide range of industries from manufacturing to financial services and varied widely in terms of their size (fewer than 50 employees to more than 3,000). We sent the questionnaire by both e-mail and mail to SCM managers at more than 750 Korean firms selected from the company directory of the Korea Chamber of Commerce and Industry [62] over a three-month period.

Table 1. Respondent characteristics (N = 141)

Division		Frequency	%	Division		Frequency	%
Industry	Logistics & delivery	26	18.4%	Function	Logistics	34	17.0%
	Manufacturing	38	27.0%		Manufacturing	20	10.0%
	Electricity, gas, and water	3	2.1%		Marketing/sales	23	11.5%
	Construction	5	3.5%		Customer service	15	7.5%
	Wholesale and retail	16	11.3%		IT/IS	38	19.0%
	Hotels and restaurants	2	1.4%		General management	36	18.0%
	IT & telecommunications	31	22.0%		Procurement	21	10.5%
	Transport	6	4.3%		HRM	12	6.0%
	Banking and finance	2	1.4%		Other	1	0.5%
	Public administration	6	4.3%	USCM technology adoption area	Inbound logistics	33	17.7%
	Education	7	4.7%		Production (operations)	21	11.3%
	Health and social services	5	3.5%		Outbound logistics	30	16.1%
Number of employees	50 or fewer	40	28.4%		Sales and marketing	15	8.1%
	51-500	40	28.3%		Customer service	22	11.8%
	501 ~ 3,000	27	19.1%		Administrative Infrastructure	16	8.6%
	3,001 or more	34	24.2%		Human resource management	7	3.8%
Annual turnover	Less than $250 thousand	16	11.3%		Technology development	13	7.0%
	$250 thousand~ $2.5 million	36	25.5%		Procurement	10	5.4%
	$2.5 million ~ $80 million	48	34.1%		Information systems	19	10.2%
	More than $80 million	41	29.1%				

Table 1 shows the characteristics of the respondents, including industries, the number of employees, annual turnover, functional areas, and USCM adoption areas. As shown in the table, a majority of the respondents were general IT managers and above (72%). This distribution met the objective of obtaining responses from managers who were most likely to have an in-depth understanding of USCM and ensuring data quality.

4.2. Validity and reliability

We evaluated the validity and reliability of the data to assess their quality for further analysis. A powerful method for testing construct validity is factor analysis [55], which can identify the main underlying dimensions of a set of variables. In general, the individual factor analysis is used to verify the factor structure of scales, and the joint factor analysis, to explore the structure of factors [56]. We conducted a joint factor analysis, not an individual factor analysis, for each variable because the object of this study is to explore the underlying structure of the variables. Table 2 shows the results of the joint factor analysis with respect to management aspects. The results indicate that the critical success factors for management aspects showed higher construct validity. More specifically, all the factor loadings exceeded 0.4, and the percentage of the variance explained exceeded 68%.

Based on the factor analysis, we identified six factors with respect to management aspects and classified them into USCM planning, management support, relationship management, new USCM models, process management, and risk management. The six factors have two to nine measurement items. We removed the seventh factor because it has a single measurement item.

In the same manner, we identified the relevant factors for technological aspects. Each construct had six factors, and Table 3 shows the results. These six factors showed sufficient construct validity. That is, all the factor loadings exceeded 0.4, and the explanatory power of the factors exceeded 66%.

Table 2. Analysis of key success factors: Management aspects

Factor	Measurement Item	Component						
		1	2	3	4	5	6	7
USCM planning	Planning for long-term supply chain improvements	0.712	0.324	0.383	0.097	0.076	0.060	0.014
	End-to-end process management	0.709	0.197	0.162	0.117	0.223	0.095	0.113
	Trust building among business partners	0.686	0.183	0.330	0.003	0.110	0.068	0.050
	Cultural change management	0.679	0.068	0.101	0.220	0.114	0.132	0.270
	Cross-functional USCM planning	0.653	0.347	-0.110	-0.077	0.170	0.355	0.156
	High level of trust with suppliers and customers	0.631	0.339	0.343	0.241	-0.049	0.157	0.126
	Offer of good supply chain services	0.622	0.275	0.072	0.165	0.223	0.311	0.022
	Cross-functional project teams	0.494	0.079	0.084	0.155	0.008	0.451	0.456
	Development of USCM strategy planning	0.423	0.351	0.214	0.345	0.261	0.170	0.375
Management support	Business and process standardization	0.241	0.765	-0.145	0.072	0.204	0.267	0.073
	Right USCM view of top management	0.236	0.628	0.329	0.198	0.070	0.085	0.256
	Top management's strong support	0.273	0.611	0.279	0.192	0.017	0.011	0.101
	Continuous investment in new IT applications	0.209	0.592	0.185	0.354	0.175	0.089	0.265
	Firm's USCM environment awareness	0.185	0.581	0.287	-0.045	0.384	0.136	0.010
	The CEO's cooperative relationship with the CIO	0.149	0.578	0.246	0.384	-0.080	0.153	0.301
	Supplier performance management	0.306	0.563	0.331	0.168	0.244	0.079	0.029
	Providing suppliers with valuable information	0.272	0.479	0.319	0.284	0.148	0.174	0.128
Relationship management	Long-term relationships with suppliers	0.431	0.133	0.684	0.140	0.147	0.136	0.006
	Strategic alignment between supply chain participants	0.163	0.280	0.683	0.227	0.147	0.056	0.160
	Work experience of project participants	0.229	0.112	0.672	0.098	0.032	0.157	0.442
	Level of ubiquitous-technology adoption	0.063	0.262	0.647	0.208	0.412	0.128	0.136
	Strong USCM cooperation with suppliers	0.121	0.183	0.608	0.056	0.037	0.368	0.260
New USCM model	Creation of new sources of profits	0.005	0.149	0.228	0.757	0.104	0.267	0.067
	Development of new USCM models	0.073	0.276	0.124	0.745	0.166	0.037	0.174
	Innovative ideas of the management board	0.379	0.069	0.167	0.624	0.136	0.159	0.106
	Firm's progressive image change	0.521	0.146	0.005	0.564	0.310	0.026	0.054
Process management	Entrepreneur spirit to enter new business areas	0.112	0.043	0.032	0.258	0.728	0.313	0.074
	Process design for portability	0.216	0.231	0.203	0.147	0.689	0.058	0.291
	User-oriented USCM adoption	0.378	0.413	0.119	0.004	0.644	0.059	0.057
	Adoption of convenient payment models	0.116	0.027	0.431	0.298	0.548	0.122	0.039
Risk management	Level of the organization's USCM knowledge	0.179	0.466	0.200	0.040	0.115	0.603	0.145
	Risk management for USCM	0.183	0.231	0.443	0.175	0.170	0.598	0.059

Factor	Measurement Item	Component						
		1	2	3	4	5	6	7
Removed	Engaging in business process reengineering	0.086	0.366	0.062	0.043	0.232	0.019	0.746
	% of the variance	15.227	13.672	11.602	8.918	8.267	5.510	5.359
	Cumulative %	15.227	28.900	40.502	49.420	57.688	63.197	68.557

We tested construct validity for the dependent variable (organizational performance) for all the measurement items. All the items showed evidence of sufficient construct validity, with factor loadings exceeding 0.4 and the percentage of the variance explained exceeding 67%. Table 4 provides a more detailed explanation of the six categorized factors.

Table 3. Analysis of key success factors: Technological aspects

Factor	Measurement Items	Component					
		1	2	3	4	5	6
USCM system infrastructure	Adoption of user-friendly USCM systems	0.744	0.215	-0.004	0.030	0.205	0.037
	Adoption of USCM in a stable system infrastructure	0.715	-0.039	0.362	0.032	0.246	0.135
	Successful connections to existing systems	0.710	0.295	0.018	0.118	0.203	0.069
	Successful replacement of existing systems through USCM adoption	0.682	0.358	-0.110	0.174	-0.019	0.069
	Pursuit of technological stability	0.662	0.007	0.456	0.142	0.281	0.301
	Accumulated system development ability	0.650	0.071	0.304	0.270	0.053	0.239
	Convenient user interface	0.607	0.338	0.387	0.174	-0.034	0.202
	Good network infrastructure	0.547	0.142	0.283	0.354	0.276	0.052
	Prices of ubiquitous technologies such as RFID tags, sensors, mobile devices, and PDAs etc.	0.526	0.400	0.012	0.297	0.157	0.230
	Design of USCM systems with a long-term view	0.410	0.391	0.409	0.197	0.169	-0.203
USCM Technology Application	The CIO as a business innovator, not just a technology manager	0.068	0.650	-0.054	-0.006	0.144	0.107
	Selection of the best outsourcing provider for USCM system development	0.366	0.638	0.236	0.246	0.035	-0.053
	Wide use of RFID technologies	0.162	0.612	0.383	0.133	0.103	-0.144
	Adoption of suitable RFID technologies	0.324	0.569	0.399	0.179	0.184	-0.121
	Optimal USCM network design	0.486	0.542	0.381	0.109	0.237	0.168
	Adoption of standardized ubiquitous technologies	0.018	0.522	0.461	0.430	-0.202	0.128
	Security management of USCM systems	0.288	0.518	0.300	0.167	0.042	0.238
	Project participant's broad skills across multiple dimensions of USCM	0.371	0.514	0.175	0.318	0.223	0.010
	Periodical evaluation of supply chain networks	0.310	0.499	0.336	0.203	0.356	-0.105
	Continuous improvements in USCM systems	0.039	0.456	0.283	0.374	0.378	0.237
Efficient USCM use	Adoption of standard client server methods	-0.007	0.210	0.792	0.267	0.154	0.122
	Improvements in system use efficiency	0.29	0.262	0.741	-0.014	0.218	0.080
USCM network foundation	Industry-level databases on supplier performance	0.183	0.105	0.073	0.827	0.135	0.120
	Interconnected supply chain network of firms	0.290	0.193	0.091	0.706	0.343	-0.143
	Standardization for USCM	0.194	0.310	0.391	0.560	0.236	-0.029
	Consideration of customer information as the most important element	0.181	0.382	0.276	0.422	-0.152	0.374
Enacted technology acceptance	Inventory visibility	0.347	-0.014	0.090	0.179	0.717	0.005
	Enacted view of technology adoption	0.262	0.344	0.222	0.090	0.644	0.198
	Full technology development throughout the whole supply chain	0.092	0.452	0.185	0.166	0.633	0.209
USCM development plan	Adoption of USCM as a project	0.310	0.103	0.069	-0.071	0.120	0.748
	Gradual development of USCM	0.131	0.059	0.053	0.250	0.523	0.610
	% of the variance	17.464	14.607	10.951	9.425	8.852	5.625
	Cumulative %	17.464	32.070	43.021	52.447	61.298	66.923

Table 4. Factor analysis of organizational performance

Factor	Measurement Items	Component					
		1	2	3	4	5	6
Competitive advantage	Increase collaboration with business partners	0.797	0.107	0.071	0.180	0.010	-0.012
	Enable competitiveness or strategic advantage	0.756	0.147	0.243	0.158	0.040	0.052
	Enable easier access to information on suppliers	0.712	0.146	0.287	-0.010	0.145	0.117
	Link the ubiquitous technology to the back-office legacy system	0.663	0.197	0.119	-0.082	0.218	-0.129
	Enable more reliable demand forecasts	0.610	0.195	-0.029	0.313	0.341	0.307
	Enable better responses to partners in the supply chain	0.531	0.385	-0.033	0.157	0.436	0.064
	Improve supply chain visibility	0.510	0.504	0.363	0.114	-0.108	0.036
	Enable your organization to catch up with competitors	0.505	-0.112	0.475	0.315	0.188	-0.317
	Establish real-time supply chain intelligence	0.403	0.399	0.342	0.120	0.377	0.006
Inventory management	Eliminate packing and shipping errors	0.038	0.849	0.106	0.102	0.195	-0.020
	Provide accurate inventory levels and locations	0.201	0.772	0.156	0.257	0.203	0.123
	Enable track and trace authentication	0.508	0.614	0.135	0.079	-0.048	-0.073
	Enable protection against business counterfeiting or theft	-0.080	0.612	0.287	0.101	0.442	-0.095
	Eliminate excess inventory by drawing on the latest data	0.329	0.593	0.064	0.466	0.041	0.241
	Enhance customer responsiveness and satisfaction	0.194	0.584	0.286	0.124	0.073	0.033
	Improve data collection accuracy	0.406	0.540	0.374	0.001	-0.080	0.184
	Improve supplier relationships	0.435	0.521	0.047	0.001	0.049	0.286
	Enhance logistics and transportation management	0.188	0.463	0.452	0.292	0.115	-0.091
Increased business productivity	Enhance employee productivity or business efficiency	0.128	0.328	0.734	0.246	-0.018	0.009
	Improve the way the organization conducts business	0.177	0.341	0.646	0.142	-0.074	0.062
	Minimize manual interventions	0.310	0.169	0.594	0.011	0.221	0.326
Reduced logistics cost	Reduce logistics costs	0.119	0.251	0.175	0.838	-0.073	-0.005
	Reduce procurement costs	0.090	0.186	0.170	0.809	0.179	0.016
Cost savings	Save money by avoiding the need to increase the workforce	0.019	-0.103	0.454	0.322	0.469	-0.084
	Cost savings in lost, stolen, or wasted products	0.346	0.276	-0.014	0.053	0.785	0.051
New market opportunity	Enable the organization to create new market opportunities	0.398	0.257	0.139	0.307	-0.221	0.654
	Reduce stockouts	0.228	0.235	0.237	0.181	-0.110	0.644
	% of the variance	17.868	17.777	10.574	9.297	6.735	5.216
	Cumulative %	17.868	35.645	46.219	55.516	62.251	67.467

In sum, based on the results indicating sufficient construct validity, we used all the items for reliability tests. We tested the reliability of the six measures of management factors influencing the success of USCM adoption, the six measures of technical factors influencing the success of USCM adoption, and the six measures of organizational performance.

Table 5. Reliability analysis results

Division		Factors	No of items	Cronbach-α
Critical success factors	Management aspects	USCM planning	9	0.904
		Management support	8	0.894
		Relationship management	5	0.846
		New USCM model	4	0.749
		Process management	4	0.792
		Risk management	2	0.697
	Technological aspects	USCM system infrastructure	10	0.911
		USCM technology application	10	0.902
		Efficient USCM use	2	0.795
		USCM network foundation	4	0.770
		Enacted technology acceptance	3	0.774
		USCM development plan	2	0.672
Organizational performance		Competitive advantage	9	0.888
		Inventory management	7	0.893
		Increased business productivity	3	0.727
		Reduced logistics costs	2	0.825
		Cost savings	2	0.671
		New market opportunity	2	0.261

Table 6. Summary of correlation analysis results

Division	Factors	Organizational Performance				
		Competitive advantage	Inventory management	Increased business productivity	Reduced logistics costs	Cost savings
Management aspect	USCM planning	0.273**	0.396**	0.302**	0.243**	0.215**
	Management support	0.264**	0.264**	0.164*	0.161*	0.032
	Relationship management	0.274**	0.247**	0.121	0.066	0.265**
	New USCM model	0.189**	0.243**	0.119	0.210**	0.127
	Process management	0.247**	0.273**	0.101	0.105	0.170**
	Risk management	0.230**	0.189**	0.203**	0.190**	0.107
Technological aspect	USCM system infrastructure	0.186**	0.264**	0.244**	0.129*	0.085
	USCM technology application	0.224**	0.143*	0.113	0.095	0.211**
	Efficient USCM use	0.218**	0.092	0.199**	0.146*	0.075
	USCM network foundation	0.209**	0.121*	0.104	0.088	0.166*
	Enacted technology acceptance	0.261**	0.200**	0.066	0.095	0.067
	USCM development plan	0.148*	0.173**	0.180**	0.115	0.034

** and * indicate significance at < 0.01 and < 0.05, respectively.

Reliability refers to the stability of measures over a variety of conditions [57]. The number of errors made by any measure can be determined using Cronach's alpha. Table 5 shows the results for the reliability of the measures for the critical success factors and organizational performance. There is no absolute standard for interpreting Cronbach's alpha, but it is generally known that the minimum acceptable threshold is 0.80 for analyses of attitudes or values. More generally, a satisfactory level for an exploratory analysis is greater than or equal to 0.70 [57]. The far-right column of Table 4 shows the results for Cronbach's alpha and indicate that most of the variables met this recommended threshold. Three variables were marginally acceptable: risk management ($\alpha = 0.697$), USCM development plans ($\alpha = 0.672$), and cost savings ($\alpha = 0.671$). We removed one variable (new market opportunities) from further analysis ($\alpha = 0.261$).

4.3. Results

We conducted a correlation analysis to examine the relationships between the critical success factors and organizational performance (Table 6).

Among the critical success factors for management aspects, the results indicate that USCM planning was significantly related to all organizational performance measures: competitive advantage ($r = 0.273$, $p < 0.01$), inventory management ($r = 0.396$, $p < 0.01$), increased business productivity ($r = 0.302$, $p < 0.01$), reduced logistics costs ($r = 0.243$, $p < 0.01$), and cost savings ($r = 0.215$, $p < 0.01$). Supportive management was significantly related to competitive advantage ($r = 0.264$, $p < 0.01$), inventory management ($r = 0.264$, $p < 0.01$), increased business productivity ($r = 0.164$, $p < 0.05$), and reduced logistics costs ($r = 0.161$, $p < 0.05$). Successful relationship management was significantly related to organizational performance in terms of competitive advantage ($r = 0.274$, $p < 0.01$), inventory management ($r = 0.247$, $p < 0.01$), and cost savings ($r = 0.265$, $p < 0.01$). Well-managed business processes were positively related to competitive advantage ($r = 0.247$, $p < 0.01$), inventory management ($r = 0.273$, $p < 0.01$), and cost savings ($r = 0.170$, $p < 0.01$). Risk management was a good indicator of organizational performance in terms of competitive advantage ($r = 0.230$, $p < 0.01$), inventory management ($r = 0.189$, $p < 0.01$), increased business productivity ($r = 0.203$, $p < 0.01$), and reduced logistics costs ($r = 0.190$, $p < 0.01$).

The technological factors influenced the success of USCM adoption, which in turn increased organizational performance. The results indicate that the USCM system infrastructure was a significant indicator of organizational performance in terms of competitive advantage ($r = 0.186$, $p < 0.01$), inventory management ($r = 0.264$, $p < 0.01$), increased business productivity ($r = 0.244$, $p < 0.01$), and reduced logistics costs ($r = 0.190$, $p < 0.01$). Carefully designed and selected USCM applications were positively related to three dependent variables: competitive advantage ($r = 0.224$, $p < 0.01$), inventory management ($r = 0.143$, $p < 0.05$), and cost savings ($r = 0.211$, $p < 0.01$). Efficient USCM use was a key success factor in terms of competitive advantage ($r = 0.218$, $p < 0.01$), increased business productivity ($r = 0.199$, $p < 0.01$), and reduced logistics costs ($r = 0.146$, $p < 0.05$). The USCM network foundation (e.g., databases or interconnected supply chain networks) had a significant effect on organizational performance: competitive advantage ($r = 0.209$, $p < 0.01$), inventory management ($r = 0.121$, $p < 0.05$), and cost savings ($r = 0.166$, $p < 0.05$). Enacted technology acceptance was a key success factor in terms of competitive advantage ($r = 0.261$, $p < 0.01$) and inventory management ($r = 0.200$, $p < 0.01$). USCM development plans were positively related to competitive advantage ($r = 0.148$, $p < 0.05$), inventory management ($r = 0.173$, $p < 0.01$), and increased business productivity ($r = 0.180$, $p < 0.01$).

Among the five variables for organizational performance, two were most frequently influenced by the 12 critical success factors. Competitive advantage was positively related to all 12 critical success factors (6 management factors and 6 technological factors), and inventory management was positively related to 11 factors (6 management factors and 5 technological factors). That is, competitive advantage and inventory management tend to be the most demanding reasons facilitated by successful USCM adoption in the Korean context.

5. Implications, conclusions, and future research

This study examines the critical success factors in USCM adoption and their impacts on organizational performance. The study compiles a list of 12 critical success factors consisting of 63 items through interviews and a literature review and proposes a model of USCM adoption. The model integrates management and technological factors to explain organizational performance. In particular, the model provides a more elaborate and strategic approach to USCM adoption and thus can be useful for managers and executives planning to adopt the USCM.

As discussed in the previous section, the results indicate that organizations are more likely to adopt USCM to gain a competitive advantage and effectively cope with inventory management. In addition, it is observed that among the critical success factors, USCM planning from the management aspect is playing a crucial role in the successful adoption of USCM, which in turn had a positive effect on organizational performance. Before adopting USCM, managers should place great emphasis on planning in terms of changes, such as building trust between business partners, suppliers, and customers affected by the system, cultural changes, cross-functional system planning, project teams, and strategic planning.

On the other hand, with respect to technological success factors, the USCM system infrastructure was a major factor closely related to organizational performance. The system infrastructure included senior managers' positive attitudes toward innovation, carefully selected outsourcing partners, widely used RFID systems, and optimal networks. This result closely reflects the Korean environment. Korea ranks among the top in the world in terms of internet use and broadband dissemination. Broadband subscribers accounted for nearly 90% of all households in the country as of the end of 2006, and there is strong demand for the RFID technology in Korea, which in turn has facilitated government projects focusing on RFID technology development and commercialization. One such project is New Songdo, a ubiquitous city located on an artificial island of 1,500 acres about 40 miles from Seoul. In the city, all information systems share residential, medical, business, and government data, among others, and are built into houses, streets, and buildings. The $25 billion project, a free-enterprise zone, is expected to be completed in 2014 and is recorded as the largest private real estate development in the world, providing homes to 65,000 residents and work to 300,000 people [58]. RFID use in Korea is currently expanding, and mobile RFID systems are expected to make extensive contributions to broadband networks in terms of reading RFID tags and generating new information. In general, industry growth may sharply reduce the level of risk inherent in investing in technologies at their initial stages, which in turn can accelerate the maturation of technologies [59]. In this regard, the results of this study indicate that the USCM system infrastructure is closely related to competitive advantage, inventory management, business productivity, and reduced logistics costs, which are outcomes of USCM adoption.

There are several ways to extend this study. First, this study can be replicated by considering a larger sample of firms in other countries. That is, we limited the sample to Korean firms (N = 141), but future research should consider a larger, broader sample to better assess critical success factors and their relationships with organizational performance. Second, future research should comprehensively examine and empirically validate key success factors in terms of their accuracy, predictability, and parsimony. Here the challenge is to create a stable metric that can effectively accommodate rapidly evolving technologies and supply chain needs. Third, future research should focus on dependent variable of organizational performance. Here more objective measures such as return on assets (ROA) or Tobin's q should be devised and empirically tested. The Q-ratio is widely used in business, economics, and finance research to measure business performance [60] and in information system research to examine the relationship between IT and firm performance [61]. Organizations need to manage their supply chains more effectively than ever for their success, and therefore there is a need for a more refined set of measures and metrics for quantifying this success and determining the best practices. Despite some limitations, this study is expected to be useful for both scholars and practitioners because it provides an insightful framework for explaining the critical factors influencing the successful adoption of USCM.

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Authors' Biography

Changsu Kim is an Associate Professor at School of Business, Yeungnam University in Korea. He was a visiting scholar at the MIT Sloan School of Management. He received his PhD in Information Systems from London School of Economics (LSE) in the UK. His research interests include ubiquitous computing and digital business.

Sung Won Kim received his B.S. and M.S. degrees from the Department of Control and Instrumentation Engineering, Seoul National University, Korea, in 1990 and 1992, respectively, and his Ph.D. degree from the School of Electrical Engineering and Computer Sciences, Seoul National University, Korea, in August 2002. From January 1992 to August 2001, he was a Researcher at the Research and Development Center of LG Electronics, Korea. From August 2001 to August 2003, he was a Researcher at the Research and Development Center of AL Tech, Korea. From August 2003 to February 2005, he was a Postdoctoral Researcher in the Department of Electrical and Computer Engineering, University of Florida, Gainesville, USA. In March 2005, he joined the Department of Information and Communication Engineering, Yeungnam University, Gyeongsangbuk–do, Korea, where he is currently a Professor. His research interests include resource management, wireless networks, mobile networks, performance evaluation, and embedded systems.

Gyanendra Prasad Joshi is an assistant professor in Department of Information and Communication Engineering at Yeungnam University, Gyeongsang buk–do, South Korea. He received PhD degree in information and communication engineering from Yeungnam University. He worked in Minigate co. ltd., South Korea as an IT manager after his graduation from Ajou University. He has served on the review process of several international journals and conferences. His main research interests include MAC and routing protocols for next generation wireless networks, MANET, cognitive radio networks, RFID system, digital convergence business, and information system.

***Corresponding author: Gyanendra Prasad Joshi, Ph.D.

Department of Information and Communication Engineering

College of Engineering, Yeungnam University

214–1 Dae–dong, Gyeongsan–si, Gyeongsangbuk–do Korea 712–749

Email: joshi@ynu.ac.kr