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Critical Success Factors of Web-based Supply Chain Management Systems: An Exploratory Study

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Abstract

This paper reports the results of a survey on the critical success factors (CSFs) of Web-based supply chain management systems (WSCMS). An empirical study was conducted and an exploratory factor analysis of the survey data revealed five major dimensions of the CSFs for WSCMS implementation, namely (1) communication, (2) top management commitment, (3) data security, (4) training and education, and (5) hardware and software reliability. The findings of the results provide insights for companies using or planning to use WSCMS.

Keywords: Web-based Supply Chain Management Systems, Critical Success Factors, Exploratory Factor Analysis.

1. Introduction

With an increasing number of competitors, both local and worldwide, businesses not only have to restructure their organizations to produce higher-quality products and services, reduce cost and be able to react quickly to the market, but also to manage their supply chain networks effectively.

Supply chain management (SCM) is the integration of all activities associated with the flow and transformation of goods from the raw materials stage through to the end-user, as well as the associated information flows (Handfield and Nichols 1999). Materials and information flow both up and down the supply chain. In this study a Web-based supply chain management system (WSCMS) is defined as an Internet-enabled SCM system that integrates networks of suppliers, factories, warehouses, distribution centres and retailers, through which the whole chain of logistic processes is managed so that faster and more flexible coordination can be achieved between a company and its customers and suppliers along the supply chain.

The role of information technology (IT) in SCM has changed dramatically in recent years, transforming business operations (Ghiassi and Spera 2003, Shore 2001) from electronic data interchange (EDI) systems and enterprise resource planning (ERP) systems to Internet/Intranet for supporting SCM (Pant *et al.* 2003, Shore 2001). Due to the popularity and functionality of the Internet/Intranet, many researchers have realized that benefits can be derived from applying Internet technology to communications and systems management in supply chains (Ghiassi and Spera 2003, García-Dastugue and Lambert 2003, Kalakota and Whinston 1997, Lancioni *et al.* 2003, Lancioni *et al.* 2000, Pant *et al.* 2003). Although the Internet/Intranet in SCM can add value in a number of ways such as saving costs, improving quality, delivery and support, and offering greater competitive advantages (Lancioni *et al.* 2000,

Kalakota and Whinston 1996), implementing a WSCMS is much more complex than implementing an EDI or ERP system (Pant *et al.* 2003). Therefore, it is crucial that the critical success factors for the successful implementation of WSCMS be identified.

This paper is organized as follows. In Section 2, we present a review of the literature. Section 3 describes the research method. In Section 4, we discuss conducting an exploratory factor analysis (EFA) on the collected data to investigate the underlying structure of the identified critical success factors (CSFs) for WSCMS implementation. A discussion of the findings of the study is presented in Section 5, and the final section concludes the paper.

2. Literature Review

2.1. Web-based Supply Chain Management Systems

With the rapid growth of IT, many companies are taking advantage of Internet technology to better manage their supply chains. The Web-based SCM system has provided an alternative means of managing an ever-increasing number of suppliers and customers and creating the necessary links among data, information and effective communication. White (1996) pointed out that the combined use of the Internet with SCM allows customers and suppliers to share mission-critical information on a timely basis to enable effective, real-time decision-making. Kalakota and Whinston (1996) viewed Web-based SCM applications as mission-critical business applications that are used by companies to run their businesses, such as taking customer orders and order management; planning the distribution of inventory and forecasting demand; accounting; and managing the flow of materials. Lancioni *et al.* (2003) conducted and compared two surveys about trends of Internet applications in SCM in US supply chain networks in 1999 and 2001, respectively. The results indicated that there had

been a large increase in Internet usage in various supply chain applications, such as purchasing/procurement and transportation. García-Dastugue and Lambert (2003) identified seven Internet-enabled coordination mechanisms to improve business practices in supply chains. However, Pant *et al.* (2003) highlighted the internal and external challenges to implementing a highly integrated e-supply chain system. They proposed a framework for implementing an e-supply chain system based on the complexity of an organization's operation and its ability to integrate partners in the supply chain.

2.2. Critical Success Factors

What are the CSFs of a WSCMS? Bullen and Rockart (1986) defined CSFs as 'the limited number of areas in which satisfactory results will ensure successful competitive performance for the individual, department, or organization. CSFs are the few key areas where 'things must go right' for the business to flourish and for the manager's goals to be attained'. A number of studies have attempted to identify the CSFs of SCM, EDI, and ERP systems. Bauer (2000) suggested that there are four CSFs in e-business for the automotive industry. The first CSF is understanding and working with diverse social and business cultures around the globe. The second CSF is ensuring that there is a physical Internet infrastructure available for use. The third is understanding the state of the physical infrastructure of the suppliers, and the fourth is changing internal management processes and points of view. Power *et al.* (2001) examined the critical factors that influence the agility of organizations in managing their supply chains. In their studies, they determined seven CSFs in agile SCM using factor analysis. Umble *et al.* (2003) identified the CSFs for the implementation of ERP systems. Angeles *et al.* (2000) reported 13 EDI implementation success factors that are considered relevant in implementing an inter-organizational system.

From the above review of the literature, we have found no studies on identifying the CSFs that would lead to successful WSCMS. It is desirable to explore the CSFs for successful WSCMS implementation. Possible items related to these factors were identified from an expert panel discussion. The expert interviews helped ensure content validity of the items in the research questionnaire.

3. Research Methodology

This investigation is a theory-building exploratory study to identify the critical success factors for the implementation of WSCMS. This study was based on empirical data collected through a survey of a multinational chemical company, ABC Company (the company name has been disguised to conceal its identity), which is listed in the Dow Jones Industrial Index. The company has a global supply chain network encompassing sales offices, service centres, warehouses, distribution centres and production plants that are widely dispersed around the world. It is considered a leading company in terms of the scale of its supply chain operations in the chemical industry in the USA.

The study was carried out in several phases. The first phase consisted of a discussion with some experts in the ABC Company. Following this, a preliminary questionnaire was developed. In the second phase, we conducted a pilot study with eight logistics professionals. The questionnaire was refined a number of times based on the feedback from the pilot test, and a final questionnaire was developed to measure the CSFs of WSCMS. In the third phase, we gathered information on CSFs by sending out the survey questionnaires to a randomly selected sample of subjects associated with the ABC Company. A statistical analysis of the survey results was then carried out, and an EFA was performed to identify the underlying structure of the

CSFs for the implementation of WSCMS. The EFA approach was employed because little was known about the number of underlying dimensions of the CSFs associated with the implementation of WSCMS.

3.1. Data Collection

The selected population in this study involved people in the fields of logistics, customer services, sales and marketing, purchasing, plant and warehousing, transportation, management, accounting and financing, external customers and suppliers of the ABC Company. According to the staff of the company and based on an internal estimation, there were about 1,200 people directly related to the daily operations of the company's SCMS. Three hundred and fifty subjects were randomly selected from this population.

The questionnaire and a letter were emailed to the sampled subjects. The respondents were asked to respond via email or fax within two weeks. Precautions were taken to minimize non-response bias. A reminder email was sent to the non-respondents two weeks after the questionnaires were emailed. Measures were also taken to avoid duplication in the selection of supply chain practitioners. A total of 112 questionnaires were returned, but 3 were not useable because of incompleteness of the questionnaires concerned. The remaining 109 responses yielded a response rate of 31 per cent. The non-response bias was examined. A series of chi-square tests were performed between the two samples obtained from the two waves of mailing: 70 respondents were from the first wave and 39 from the second wave. The results showed that there were no significant differences in the responses between the two samples. We can confirm that there was no significant non-response bias. An analysis of the returned questionnaires was conducted using an SPSS computer package.

3.2. Measurement Instruments

Based on a detailed analysis of past literature on EDI, ERP, SCM and management information systems (MIS), together with preliminary interviews with several logistics professionals in the ABC Company, we compiled a set of 47 items representing a collection of the CSFs for the implementation of WSCMS. These 47 items were incorporated into a survey questionnaire that asked the respondents to indicate the degree they considered each item a CFS by using a five-point Likert-type scale, with 1 being 'strongly disagree' and 5 being 'strongly agree'.

3.3. Reliability of the Instrument

Reliability refers to the extent to which the constructs are free from error and therefore yield consistent results. Cronbach's alpha was used to measure the internal consistency of the multi-item scales used in this study. If any scale below the normal acceptable level (Cronbach's α=0.6) (Nunnally, 1978), it would be deleted. Furthermore, items were deleted if they led to a significant increase in the alpha value. Consequently, the scales provided a reliable and consistent measure of the intended dimensions.

3.4. Instrument Validity

Validity is defined as the extent to which any measuring instrument measures what it is intended to measure (Carmines and Zeller 1979). In this study, we examined the instrument for content and construct validity only. Content validity implies that all aspects of the attribute being measured are considered by the instrument. According to Nunnally (1978), evaluating content validity is basically a question of judgement. To ensure content validity, a thorough examination was made of the relevant literature, and consultation with logistics practitioners was carried out during the development of the questionnaire. Questions were reworded to improve their readability. The

questionnaire was also tested through a pilot study, the results of which suggested that the instructions and questions were clear enough. Thus, the content validity of the measures has been accounted for in this study.

One powerful and indispensable method of construct validation is factor analysis (Kerlinger 1986). An exploratory factor analysis (EFA) with a varimax rotation was conducted on the 47 statements. We adopted the convention advocated by Nunnally (1978), which states that factors are generally named based on loadings greater than or equal to 0.4. Using this criterion, only items with factor loadings of at least 0.4 were retained. Detailed discussions of the results are given in the next section.

4. Results and Analysis

4.1. Descriptive Statistics

A summary of the demographic characteristics of the sample is presented in Table 1. Of the 109 responses received, about half of the companies had fewer than 1,000 employees. Four major industries, namely (i) Manufacturing, (ii) Wholesale, Retail and Import/Export Trades, (iii) Financial and Banking Service, and (iv) Transport, Storage and Communications, constituted 79% of the respondents. This indicates that these industries are aggressively pursuing the implementation of WSCMS in their organizations. About 69% of them had implemented WSCMS to support daily operations in supply chain management.

About 86% of the respondents had a post-secondary level of education. Approximately 80% had more than fives years of working experience. This highlights the importance of education and working experience in the implementation of supply chain management systems.

[Insert Table 1 about here]

4.2. Exploratory Factor Analysis

EFA was used to summarize the identified CSFs of WSCMS into a new, smaller set of uncorrelated dimensions with a minimum loss of information. In this study, EFA was first applied to determine the underlying structure of the CSFs for WSCMS implementation. The main objectives of using EFA in this study were to identify the new, meaningful underlying structure of the CSFs for WSCMS implementation and to reduce the dimensionality of the CSFs set as a prelude to further analysis of the data.

Before conducting EFA, two tests were performed to check the possible presence of multicollinearity or correlation among the CSFs: the Kasier-Meyer-Olkin (KMO) measure for measuring sampling adequacy, and the Bartlett Test of Sphericity for testing the presence of correlation. The KMO was 0.63, which was greater than the minimum acceptance value of 0.5. The Bartlett Test of Sphericity was found to be 5400.848, with significance beyond the 0.000 level. This means the correlation matrix was not an identity matrix. The results of both tests supported the use of EFA for the 47 CSFs.

EFA using varimax rotation was used to identify the underlying factors (dimensions) of the CSFs for WSCMS implementation and to reduce the data. In the first EFA, the initial solution contained 10 factors with eigenvalues of above 1.0, and the proportion of the variance explained by the 10 factors was 77.5 per cent. However, eight of the initial 47 items were either cross-loaded or had a factor loading of less than 0.4. When interpreting the rotated factor pattern, an item is said to load on a factor if the factor loading is 0.4 or greater (Nunnally 1978). Using this criterion, the rotated pattern matrix was examined for items that did not load on a factor with other

items from the same scale. Items that cross-loaded on multiple factors were also examined and were deleted. In addition, eigenvalues were examined to determine the number of factors to extract. Therefore, these items were removed for further analysis. Correspondingly, after five additional analyses, the final EFA showed that the factor patterns remained constant and five factors explained 72.6% of the total variance among the remaining 28 variables (see the Appendix). Table 2 summarizes the results of the factor analysis.

In order to ensure that the variables comprising each proposed research construct were internally consistent, a reliability assessment was performed using Cronbach's alpha. The values of Cronbach's alpha for all of the five dimensions of the CSFs for the implementation of WSCMS were above the recommended value of 0.60 for exploratory results (Nunnally 1978). Table 2 shows that the alpha coefficients ranged from 0.8064 to 0.9687, which indicates that this instrument can be considered highly reliable and internally consistent.

[Insert Table 2 about here]

After five factors (dimensions) were extracted from conducting the EFA procedure, we interpreted the results by assigning labels to the factors. The underlying factors were labelled as follows:

- Factor 1- Communication: This encompasses seven items that explained 21.8% of the variance. The items are all related to the communicative power of WSCMS throughout the customer and supply chain network.

- Factor 2- Top management commitment: This includes eight items that accounted for 16.3% of the variance. These items deal with the importance of top management support in the implementation of WSCMS.
- Factor 3- Training and education: This consists of five items that relate to various training programmes on WSCMS provided to end-users, which are important to the success of the implementation of WSCMS. This factor explained 14.5% of the variance.
- Factor 4- Data security: This is comprised of five items that deal with the importance of data security in maintaining WSCMS, which accounted for 11.3% of the variance.
- Factor 5- Reliability of hardware and software: This includes three items that relate to the reliability of the hardware and software in WSCMS. This factor explains 8.8% of the variance.

5. Discussions

This study has identified the CSFs for the adoption of WSCMS. These CSFs are classified into the following five dimensions: communication, top management commitment, data security, training and education, and reliability of hardware and software. Each dimension is described as follows:

5.1. Communication

The growing trend of globalization has imposed higher standards for communication networks in SCM. Thus, many organizations have been using the Internet for SCM (Lancioni *et al.* 2000) in order to achieve effective communication, internally and externally. According to Badiru (1988), communication is a pre-requisite for the cooperation of employees in the successful implementation of any

project. The Internet can reduce the problem of internal coordination by allowing both internal and remote employees to access current information when it is released. The Internet can be considered an effective communication tool in SCM (McIvor *et al.* 2003, Strader *et al.* 1998). With the successful implementation of WSCMS, information and material flows across multiple organizations will be integrated to create a supply chain that improves communication between customers and suppliers. Parties in the supply chain will then enjoy a greater degree of information sharing.

5.2. Top Management Commitment

The commitment of top management has been recognized as one of the most important elements in the successful implementation of EDI (Angeles *et al.* 2001, Emmelhainz 1988, Scala and McGrath 1993), IS (Bruwer 1984) and ERP systems (Umble *et al.* 2003). Since the primary responsibility of top management is to provide sufficient financial support and adequate resources for building a successful system, the support of management will ensure that the WSCMS project has a high priority within the organization and that it will receive the required resources and attention. The lack of financial support and adequate resources will inevitably lead to failure. Apart from this primary support, psychological or behavioural support is also important to the smooth implementation of the project, especially if there is significant resistance from the staff involved.

5.3. Data Security

With the greater use of the Internet in SCM, organizations are able to gather more data than before, allowing managers to make timely and effective decisions on such matters as production runs, costs and so forth. Such data could be extremely valuable to help sharpen the competitive edge of an organization. Warren and Hutchinson (2000) have warned that there are several security risks associated with

WSCMS; therefore, some level of data security is required for the successful implementation of SCMS.

5.4. Training and Education

Training and education are important for the successful implementation of any new system (Sprague and McNurlin 1993). Previous researchers have included the training and education of end-users as an important issue for the successful implementation of EDI (Angeles *et al.* 1998, Cater *et al.* 1987), IS (Nath 1989) and ERP systems (Umble *et al*. 2003). Hills (1997) also pointed out the importance of training and education in ensuring the success of an Intranet. Adequate training of the employees in an organization is important in allowing the benefits and advantages of using the Internet in SCM to be fully realized.

5.5. Reliability of Hardware and Software

A high-quality technical system is absolutely essential in ensuring the success of a computer-based system (Bruwer 1984). In order to encourage the use of the Internet in SCM, a reliable system must be made available. The reliability of the SCMS hardware and software is very important in that it affects the performance of the system. Reliability here is considered to consist of the accuracy of the data, adequate maintenance of the system, and the capability of the hardware.

6. Conclusions

In order to remain competitive in the global markets of the future, manufacturers and businesses must face up to the challenge of sustaining superior performance in three important aspects of operational capability, namely flexibility, speed, and ability to serve the customer. In this paper, we have emphasized that industry practitioners need to be aware of the application of state-of-the-art Web-based SCM systems to

strengthen their ability to compete in global markets and remain as competitive as ever internationally. The successful implementation of WSCMS often requires a substantial amount of investment and intensive research. The need for such research to support a supply chain has not been fully recognized by industry practitioners. This may be due to a lack of awareness of the technologies and their benefits, and of the kind of support that WSCMS can provide.

In this study, the results of an EFA revealed five major dimensions of the CSFs for implementing WSCMS: communication, top management commitment, data security, training and education, and hardware and software reliability. These results will be beneficial to i) industry practitioners because it is essential for them to consider the factors that are critical to the success of implementing WSCMS; ii) future research, as it forms the basis of a more detailed investigation of the subjects related to the adoption of Internet-based SCM systems.

6.1 Implications of the Research Findings

This study is valuable to SCM researchers and practitioners because it identifies the key areas that companies need to address while implementing WSCMS. The EFA provides very interesting results by identifying the factors that actually have an impact on the successful implementation of WSCMS. Although the results of this study should be further validated through replication and further studies on the subject, the findings identify items of importance that should help practitioners in their effort to implement WSCMS.

This study provides a basis for different avenues for further research. Because of the limitations of this study, namely a relatively small sample size and a small supply chain, the study should be replicated with different supply chains to ensure that the findings can be generalized. Another future study could consist of longitudinal case

studies to investigate the implementation of WSCMS from start to finish in different companies. Such a study can help to identify the barriers and the issues involved in WSCMS implementation, and offer a longitudinal perspective that companies practicing SCM should appreciate when implementing WSCMS.

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Appendix: Final questionnaire items (total = 28 items)

Variable	Item
V2	Accurate and timely communication in supply chains
V3	Transparency in WSCMS
V4	Easy communication between the customers and supply chains.
V7	Sharing information and insights
V8	High level of collaboration in the supply chain
V9	Stable availability of information in the supply chain
V10	Trusting relationship with partners in the supply chain
V12	Knowledge and good understanding of top management of WSCMS
V14	Commitment of top management to the implementation of a WSCMS
V15	Involvement of top management in the WSCMS
V16	Commitment of top management to the WSCMS throughout the supply chain
V17	Persuasion of employees by top management to participate in the development of a WSCMS.
V18	Establishment of a complete performance measurement system in WSCMS by top management
V19	The delegation of authority by top management in the implementation of the WSCMS.
V20	Managing the transition to the new WSCMS by top management
V23	Availability of the use of information in the WSCMS across the supply chain
V24	A cost-effective security system in the WSCMS
V25	Availability of secure modes in the WSCMS for transmitting information
V27	The greater effectiveness of WSCMS in handling sensitive information
V28	Security of transactions across over the WSCMS
V32	Training on WSCMS implementation
V33	Personnel qualified to execute the WSCMS through training
V34	Developing own in-house training on WSCMS
V36	All personnel understand the benefits of the WSCMS
V37	Training on use of the WSCMS
V42	Reliable hardware and software in WSCMS
V45	Technical team supports the software and hardware of WSCMS
V46	The performance of the Internet and response time of the server.

	Frequency	Percentage
Number of employees		
< 100	31	28.4
100-499	15	13.8
500-999	9	8.3
1000-3000	41	37.6
> 3000	13	11.9
Total	109	100.0%
Industry Type		
Manufacturing	16	14.7
Wholesale, Retail and Import/Export Trades	34	31.2
Financial and Banking Services	12	11.0
Transport, Storage and Communications	47	43.1
Total	109	100.0%
Internet/Intranet-based Supply Chain Management Systems		
Not adopted	34	31.2
Adopted	75	68.8
Total	109	100.0%
Education		
Post-graduate	45	41.3
Post-secondary	49	45.0
Secondary	15	13.8
Total	109	100.0%
Working experience		
< 5 years	21	19.3
5 – under 10 years	21	19.3
10 – under 15 years	32	29.4
15 years – under 20 years	17	15.6
20 years – under 25 years	14	12.8
> 25 years	4	3.7
Total	109	100.0%

Table 1: Profile of the respondents and their organizations

Variables	Factor 1 Communication	Factor 2 Top Management Commitment	Factor 3 Data Security	Factor 4 Training and Education	Factor 5 Reliability of Hardware and Software
V2	**.953**	.143	.064	.054	.152
V3	**.875**	.174	.040	.124	.150
V4	**.904**	.115	.088	.011	.113
V7	**.872**	.127	.130	.079	.121
V8	**.896**	.173	.057	.103	.109
V9	**.937**	.136	.077	.005	.101
V10	**.837**	.027	.068	-.003	.097
V12	.109	**.666**	-.100	-.194	.173
V14	.148	**.726**	-.213	-.120	.111
V15	.054	**.777**	.181	.089	-.230
V16	.025	**.746**	.180	.048	-.039
V17	.236	**.770**	.133	.179	-.240
V18	-.012	**.775**	-.093	.168	-.099
V19	.193	**.813**	-.116	-.227	.049
V20	.254	**.614**	-.064	-.111	.254
V23	.253	.197	**.649**	.196	.240
V24	.064	.003	**.933**	.038	.096
V25	.035	-.042	**.895**	-.113	.103
V27	.081	-.098	**.884**	-.062	.087
V28	.070	-.064	**.866**	.024	.069
V32	.036	-.023	-.130	**.835**	.044
V33	.061	-.089	-.091	**.707**	-.107
V34	-.058	-.004	-.030	**.863**	.088
V36	.071	.055	.138	**.781**	.304
V37	.146	-.019	.147	**.531**	-.069
V42	.279	.029	.329	.144	**.714**
V45	.204	-.062	.086	-.061	**.805**
V46	.226	-.017	.196	.122	**.866**
Eigenvalue	6.115	4.563	4.055	3.153	2.451
Cumulative variable explained	21.839	38.136	52.620	63.880	72.633
Cronbach's Alpha	.9687	.8779	.9178	.8064	.8477

Table 2: Results of exploratory factor analysis