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Diffusion of Web Technologies in the Supply Chain Management Function: Examining the Role of Environmental and Organizational Factors

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Abstract

The last decade has seen a rapid increase in the organizational adoption of supply chain management (SCM) concepts in business. A key reason for this has been that web-technologies and their enhanced capabilities have made integrated supply chain management viable as a managerial and strategic option. Building on prior MIS literature on technology diffusion and SCM research, this study seeks to understand the nuances in using web-technologies for SCM function in organizations. Based on a large-scale, questionnaire survey of North American organizations, it specifically investigates organizational and environmental factors that influence the internal and external diffusion of web-technologies in the supply chain management function. The paper also investigates the performance impacts of web-technology diffusion, in relation to customer service, cost reduction, inventory management, cycle time reduction, supplier relationship management and competitive advantage. Results suggest that both internal and external diffusion of web-technologies for SCM has a significant impact on benefits realized. Supplier inter-dependence and IT intensity were found to be the significant environmental factors impacting the diffusion of web-technologies in SCM. Further, organizational factors such as centralization and formalization in the IT unit structure and high levels of managerial IT knowledge were found to be significant antecedents of web-technology diffusion in the SCM function.

Diffusion of Web Technologies in the Supply Chain Management Function: Examining the Role of Environmental and Organizational Factors

1.0 Introduction

After only a few years of commercial usage, the Internet has revolutionized the way in which organizations have been conducting their businesses. The emergence of the Internet and web technologies has provided an opportunity for many firms to move towards an extended enterprise business model - one that enhances value across the total supply chain (Kim and Umanath, 1999; Reves et al., 2002). Several companies such as Dell, General Electric, Cisco and Ford have claimed significant benefits through use of web applications in their supply chain management (SCM) function (Anderson & Lee, 2002; Lee & Whang, 1999).

SCM encompasses a range of activities such as purchasing, materials handling, production planning and control, warehousing, logistics, inventory management, distribution, delivery and vendor management. The primary objectives of SCM function include cost reduction, service improvement, improved communication and interaction among the firms, and increased flexibility in terms of delivery and response times. Internet and web technologies have presented firms with significant opportunities in the form of efficient and timely order fulfillment, reduced cycle times, electronic payments, e-procurement etc., for improving their supply chain performance. Hence, it is not surprising that there is an increase in the number of firms deploying web-based business-to-business (B2B) SCM systems, particularly in the areas of e-procurement and e-sourcing (Gebauer & Segev, 2001). Firms are taking a variety of initiatives such as building their own web-based supply chain systems, developing private market places (eg., Walmart's RetailLink and GE's Global Exchange), joining industry-oriented B2B exchanges (eg., Transora.com) or joining the B2B hubs of other third parties (e.g., VerticalNet). Such B2B e-commerce initiatives resulted in a market worth of $433 billion in 2000, and that is forecasted by the Gartner Group to grow to $6 trillion by 2004 (McGuire, 2001). According to Jupiter Communications, $6.3 trillion worth of inter-firm trade will happen over the web by 2005.

Though the potential benefits of web-technologies[1] in the SCM function are well acknowledged, firms tend to face several challenges in implementing web-technologies and systems. Successful deployment of web applications requires smooth integration of a number of organizational, functional and technological factors (Chattterjee et al., 2002). In the SCM context, the success of a web-based system is largely contingent upon the extent to which the system gets diffused internally and among networks of suppliers. Given these challenges in deploying web-based SCM systems, several questions remain unanswered. For instance, is the use of web-based SCM systems an improvement over traditional EDI systems for inter-organizational coordination? How can organizations effectively diffuse and assimilate web technologies in their SCM function? What are the managerial mechanisms required for successful deployment of web-systems in the SCM function?

The overarching theme of this research is to gain an understanding of the use of web technologies in the SCM function of organizations. Our objective is to develop an empirical understanding of the factors affecting the deployment and diffusion of web technologies and applications in the SCM function. The specific research questions addressed in this study are:

1. *Do web-technologies and applications create any significant value in the SCM function?*
2. *What are the key environmental and organizational factors that affect the diffusion of web technologies in the SCM function?*

Though there has been considerable research on issues pertaining to traditional systems like inter-organizational systems (IOS) and EDI, there is little empirical research on web-based systems. Web-based systems are fundamentally different from the traditional EDI systems that were primarily based on locking-in customers and suppliers due to higher switching costs. However, web-technologies and systems are relatively inexpensive, highly flexible and have greatly reduced the switching costs of suppliers and customers (Porter, 2001). Hence, it becomes important to examine if our knowledge on inter-organizational and EDI systems extends to the context of web-systems. Further, given the increased usage of web-based SCM systems, it also becomes compelling to ascertain the true impact of these systems, and to identify the pertinent factors that facilitate their diffusion.

[1] In this manuscript, we use the term web-technologies and web-systems interchangeably to represent the application of e-commerce in the SCM function.

While the operations management literature is replete with studies pertaining to the strategic and managerial aspects on SCM, there remains a significant gap in relation to the application of web-technologies in SCM. This paper addresses this gap, examining the factors affecting the diffusion of web technologies in supply chains. It is organized in the following manner. First, the literature review is presented. Second, the research model and hypotheses are formulated. Third, data analyses results using the Partial Least Squares (PLS) approach are reported. The paper concludes with a discussion of the results and the implications for research and practice.

2.0 Literature Review

The background for this study is derived mainly from literature on the adoption and diffusion of innovations with particular emphasis on IOS and EDI. In addition, the literature pertaining to operations and supply chain management are also examined.

IT diffusion in organizations has received considerable attention from IS researchers. Most studies have emphasized a three-stage model of IT diffusion that consists of initiation, adoption and diffusion. However, this model has been refined to provide a broader conceptualization of the diffusion process, with sub-stages of adaptation, acceptance, routinization and infusion (Cooper & Zmud, 1990). *Diffusion* is defined as the extent to which the use of a technology permeates across business processes and activities in an organization. Several IOS and EDI researchers have distinguished between internal and external diffusion. In our study, we operationally define *internal diffusion* as the extent to which web technologies and applications are being used in key organizational activities in the SCM function. *External diffusion* refers to the extent to which the firm has integrated with its supply chain partners and transactions with them using web technologies and systems. Our definitions are consistent with similar conceptualizations in the literature (Premkumar and Ramamurthy, 1995; Iacovou et al., 1995).

The implementation and diffusion of IT within and across organizations has been the focus of a considerable number of researchers, especially in relation to IOS and EDI systems. Electronic B2B linkages among firms and suppliers have traditionally been carried out using EDI via a value-added network. These EDI systems are proprietary and costly in nature. As a result, there is a tendency for smaller firms not to use EDI since the cost is prohibitive. The

advent of user-friendly web browsers in the early 1990s gave rise to Internet-enabled EDI and B2B systems whose costs are more affordable even for smaller firms. Benefits of EDI includes quick response time, lower manpower costs, reduced purchase lead time, greater accuracy and improved customer service (Premkumar et al.,1994). In addition to these benefits, web-enabled SCM also offers several other advantages such as ease of implementation, platform independence, new marketing and sales channel, demand management capabilities, supplier support capabilities and ease of use.

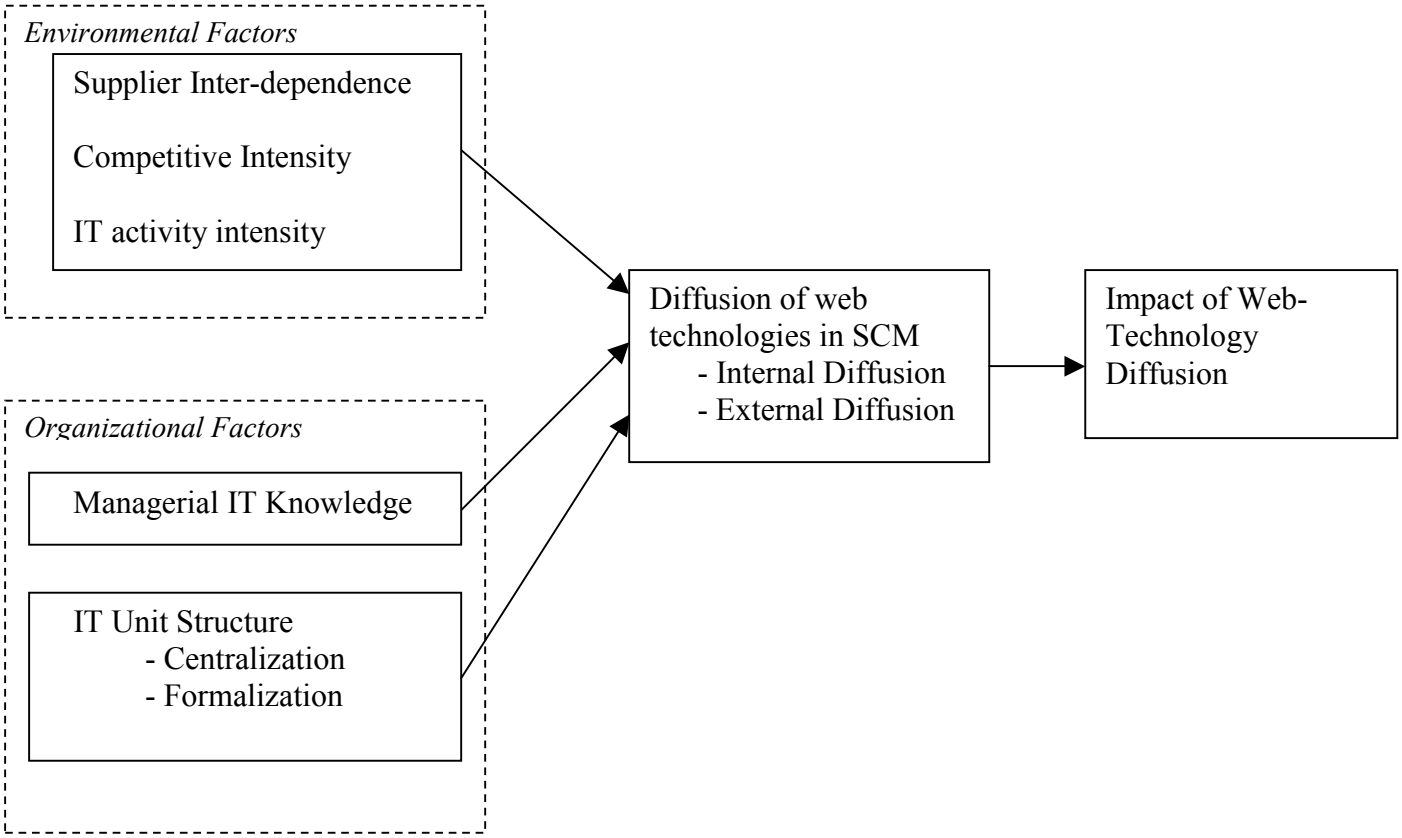
Previous research has examined EDI use in specific industries, EDI benefits and barriers as well as factors influencing EDI adoption and diffusion. Other researchers examined electronic linkages and inter-organizational systems in terms of trading partner relationships and balance of power, selection of suppliers, assessing value of investments (Gebauer & Buxmann, 2000), electronic markets, and Internet-enabled supply chain electronic commerce (Johnston and Mak, 2000).

In a study on consumer-based IOS, Grover (1993) found that a proactive technological orientation and an internal push for the system are key facilitators. In contrast, Premkumar et.al (1997) found that firm size, competitive pressure, customer support and top management support distinguishes adopters from non-adopters. Similarly, in another study, Premkumar and Ramamurthy (1995) found that competitive pressure, exercised power, internal need and top management support are important variables influencing EDI diffusion. Further, they found that compatibility, relative advantage, championing, scope for EDI use within the firm's task environments and being an early adopter determines the extent to which EDI gets internally diffused while technical compatibility, top management support and being an early adopter determines the extent to which EDI gets internally diffused. In a similar vein, Premkumar et.al.,(1994) found that relative advantage and duration of use are important predictors of internal diffusion while technical compatibility and duration of use are important determinants of external diffusion.

A key objective of SCM is the creation, maintenance and real-time optimization of an integrated and seamless supply chain for products and services across functional and inter-organizational boundaries through the integrated management and synchronization of physical, information and financial flows (Anderson & Lee, 2002). A central theme underlying SCM involves integration and collaboration in operational planning and

execution, both in relation to internal logistics functions such as inventory management, production planning, cycle time reduction and warehousing as well as external supply chain functions such as distribution network coordination, transportation planning, integrated purchasing portals, and inter-organizational or market-based coordination in reverse logistics, post-sales customer service and technical support (Reves et.al, 2002). The use of ERP systems for integrating internal manufacturing and logistics functions marked the first stage of the IT-based SCM in organizations . The advent of the Internet revitalized and accelerated this trend as it facilitated a second stage of web-based SCM in organizations. This stage focused on the external deployment of web-technology for SCM applications such as inventory synchronization, geographical positioning, creating B2B marketplaces, building aggregation portals, as well relationship building. Use of web technologies and applications in SCM provides an opportunity to realize certain efficiencies and cost-related benefits that improve internal information-sharing and processing tasks. As well, there are opportunities to improve business processes through synchronized information exchange between a firm and its supply chain partners (Johnston & Mak, 2000). For the web technologies to get diffused in a supply chain function, a number of factors from the external and internal organizational environment become critical. Based on the literature review, we identified a set of key environmental and organizational factors that are likely to affect the diffusion of web-technologies in SCM. Our intent is to identify and examine a set of critical factors, rather than prepare a comprehensive list of all potential predictors of web-technology diffusion in SCM. After a review of the literature on IT diffusion, IOS, EDI, operations management and SCM, we identified six factors namely – *supplier inter-dependence, competitive intensity, IT activity intensity, managerial IT knowledge, centralization and formalization of IT unit structure*. The overall conceptual model is presented in Figure1. Each of the factors, along with the expected relationships with web technology diffusion, are discussed in the following section.

Figure.1 Conceptual Model



2.1 Supplier Interdependence

Firms tend to use their persuasive and coercive power to influence their suppliers to adopt EDI systems (Hart and Saunders, 1998). Firms have used persuasive tools like educating their partners about benefits of IOS/EDI, providing them with assistance in adopting, deploying and implementing systems etc. On the other hand, several firms have also used coercive techniques like forcing their partners to adopt a particular technology or system, or even threatening to drop suppliers unless they adopted a particular system. EDI and some of the earlier systems often required a proprietary standard for formatting and exchanging information. This largely limited the flexibility of suppliers to establish electronic linkages with other partners. However, with the emergence of open standards and flexible web technologies that are platform and technology independent, it has become easy to establish multiple partnerships or even switch across partnerships (Kumar and Christiaanse, 1999; Porter, 2001). In cases where firms and suppliers have a high degree of inter-dependence between each other, it is important that both agree and work jointly in establishing their

electronic linkages via the web. The inter-dependence between a firm and its suppliers has been found to have influenced the deployment of IOS and EDI (Premkumar et.al.,1997; Hart & Saunders, 1998)

H1 : The greater the interdependence between a firm and its suppliers, the greater will be the diffusion of web technologies in SCM function.

2.2 Competitive Intensity

Several researchers have identified competitive pressure to be an important variable influencing the deployment and diffusion of IOS in organizations (Grover, 1993; Iacovou et al., 1995). Firms who are first-movers in deploying IOS in industry tend to derive more advantages and in order to realize these gains, there is significant pressure for them to diffuse the systems quickly, both internally and externally. Peer pressure from industry and other competitors may also force firms to deploy web-based applications faster. The fact that the value of business-to-business supplier networks and marketplaces is a function of the critical mass of partners participating (Sawhney and Parikh, 2001), has also increased the pressure on firm in competitive settings to undertake rapid roll-out of their SCM applications before their competitors.

H2 : The greater the competitive intensity facing a firm, the greater will be the diffusion of web technologies in its SCM function.

2.3 IT Activity Intensity

IT activity intensity refers to the extent to which a firm's partners, suppliers, customers, and competitors adopt and deploy IT in their business processes and activities (Ranganathan & Sethi, 2000). IT activity intensity represents the level of IT use amongst a network of industry players. Several researchers have identified that the amount of IT use by customers and suppliers influences the IT activities and IT use in an organization (Boynton et.al, 1994). We anticipate that the same relationship holds in the case of web-technologies as well. The more that industry players deploy and use web-related technologies, the more will be the extent to which a firm will be able to diffuse web-technologies in its internal as well as in its external SCM activities.

H3 : The greater the IT activity intensity in the industry, the greater will be the diffusion of web technologies in SCM.

2.4 Managerial IT Knowledge

Managerial IT knowledge refers to the union of IT-related and business-related knowledge possessed and exchanged among IT executives, top managers and functional managers (Boynton et.al.,1994). It is a conjunction of (i) the tacit knowledge of top management regarding the strategic potential of IT, (ii) knowledge of functional managers regarding IT, and (iii) the business related knowledge possessed by IT executives and personnel. The necessity of top and functional management knowledge and appreciation of IT for ensuring the success of IT diffusion is well understood and documented. In order to achieve an effective alignment of IT and business objectives, it is imperative for the CIO and the senior IT executives to have a good knowledge of the business domains in which the firm operates (Armstrong & Sambamurthy, 2001).

Boynton et.al, (1994) suggest that only an amalgamation of IT and business knowledge could lead to effective technology diffusion. Armstrong and Sambamurthy (2001) found evidence of a positive impact of senior management's IT knowledge on the extent of IT assimilation. They also emphasize creating appropriate mechanisms and structures that would enhance development of overall managerial IT knowledge in organizations. Based on an empirical study of over 62 organizations, Chatterjee et.al (2002) found senior management leadership to be an important factor influencing the diffusion of web-technologies in organization. In another study, Purvis et.al (2001) found managerial IT knowledge to be an effective enabler of IT diffusion. For a firm to deploy and diffuse web-technologies in its SCM, it is important that the senior leadership, functional management responsible for SCM activities and IT management have a good understanding of both web-technologies as well as the potential strategic impact of web-technologies on the SCM function.

H4 : Higher levels of managerial IT knowledge will be positively associated with greater diffusion of web technologies in SCM.

2.5 IT Unit Structure

Centralization of IT unit structure refers to the extent to which the key decision responsibilities for IT activities reside primarily with the IT unit as opposed to the functional business units. IT and SCM activities that occur under centralized IT unit structures will tend to involve lesser participation of logistics and SCM managers, as well as external suppliers.

SCM executives are likely to possess greater knowledge about supply chain processes, and their co-operation and interaction is important for the web systems to become diffused within and outside the organization. Use of decentralized co-ordination mechanisms with responsibilities for e-business initiatives resting with cross-functional teams has often been suggested by several authors (eg., Earl & Khan, 2001). Recently, Chaterjee (2002) found a positive association between extent of co-ordination across IT and other business units, and the extent of web-technology diffusion. Hence,

H5 : Centralization of IT unit structure will be negatively associated with the diffusion of web technologies in SCM.

Formalization refers to the extent of reliance on formal rules, procedures and task committees for carrying out the activities in the organization. The use of formal mechanisms are especially important in the context of implementing a web-based SCM system as it spawns across organizational boundaries and involves active participation by suppliers as well. Several firms tend to rely on formal contractual agreements for implementing and diffusing EDI and web-based SCM systems.

H6 : Formalization of IT unit structure will be positively associated with the diffusion of web technologies in SCM.

2.6 Impact of the Diffusion of Web Technologies

One of our research questions related to assessing the value generated by using web technologies and applications in SCM. This refers to the benefits realized by utilizing web-technologies in SCM, as perceived by the firm. The internal and external diffusion of web technologies in SCM merely indicates the level of use of web-technologies in the supply chain activities of a firm. These may not necessarily indicate the actual value realized by the firm. There have been instances where firms have reported little or insignificant gains from the use of web-technologies despite installing, commissioning, and using web applications for a period of time (Porter, 2001). Hence it is critical to examine the association between web-technology diffusion and its impact.

Several IOS and EDI researchers have pointed to a strong association between systems diffusion and impact. Iacovou et al. (1995) found that impact was enhanced with increased usage of EDI. Similar results have been reported by Premkumar et al. (1994), Ramamurthy

& Premkumar (1995), and Lee et al., (1999). Researchers in operations management have also suggested a strong impact of web systems on the SCM function (Lancioni et.al, 2000). Hence we anticipate a positive relationship between web-technology diffusion in SCM and the realized benefits accruing from them.

H7 : The greater the diffusion of web technologies in SCM, the greater will be their impact.

3.0 Research Method and Findings

3.1 Measures

Diffusion of web-technologies in SCM was assessed using two constructs namely internal and external diffusion. Internal diffusion was assessed by asking our respondents about the extent to which they used web-technologies and applications in five SCM activities namely (i) supplier selection (getting quotes, bids etc), (ii) purchase order processing, (iii) procurement from suppliers – including distribution, warehousing, and logistics etc, (iv) invoicing and payment processing and (v) demand management and procurement analysis. This set of activities was derived from the literature on SCM and later refined during our pilot tests.

External diffusion was measured using three items that asked respondents to indicate the proportions of: total suppliers they interacted with using web-technologies, total supplier transactions that were done using web applications, and overall supplier interactions handled through web applications. These items, along with the measures for inter-dependence with suppliers (5 items) and competitive intensity (3 items) were adapted from Premkumar and Ramamurthy (1995) and Grover (1993). IT activity intensity was measured using four items that were obtained from Ranganathan and Sethi (2000). Items for measuring managerial IT knowledge were adapted from Boynton et al (1994) and Armstrong and Sambamurthy, (2001). The measures for centralization and formalization of IT unit structure were derived from Ranganathan & Sethi (2002). Based on the SCM literature we identified six areas to measure the impact of web-technology on SCM. Almost all the measures have been used in prior studies. All items were measured on a seven-point Likert-type scale. Table 1 presents the measures used in this study. The survey questionnaire was pre-tested with academics, supply chain and web-technology experts and then with a set of eight top IT executives, and refinements were made at each stage based on the feedback.

3.2 Research Method

A field survey method was adopted for our study. An initial sampling frame was assembled from the ACR directory of top computer executives in North America and from senior IT executives of organizations listed on the Toronto Stock Exchange's Listed Company Directory. We randomly chose 1200 organizations that had more than 500 employees and at least twenty IT personnel. After sending out the questionnaire and two reminders, we received 249 responses back. Of these, only 176 firms indicated that they had deployed web technologies in supplier-related activities. In line with our research goals, we considered only these responses in our final analysis. See Appendix-A for the demographic profile of our respondents. Our sample was representative of firms from both manufacturing and service industries, and had considerable amount of large firms (annual revenues in excess of 50 million dollars)

3.3 Data Analysis & Findings

We used structural equation modeling using the partial least squares (PLS) approach to test our research model. Given our small sample size, and our intent to assess and explain relationships among different constructs, PLS was considered appropriate for our purposes. PLS allows for simultaneous assessment of a structural model, as well as the measurement models of the various constructs. For assessing validity and reliability of our measures, we examined the unidimensionality, convergent reliability and discriminant validity (See Table1 for results). Unidimensionality was examined using factor loadings as indicated by the PLS measurement model. All loadings were above the prescribed level of 0.55. For assessing convergent reliability, we examined the average variance extracted (AVE) for each of the constructs. All of these were above 0.50, implying that our constructs captured more than 50% of the variance in the respective measurement items. Discriminant validity was examined by checking if the shared variance between any two constructs was less than the AVEs extracted by items measuring those constructs, and this too proved to be satisfactory.

Bootstrapping was used to produce estimates of parameters, standard errors and t-values. We generated 250 random samples of observations from the original data set by sampling through replacement where each sample size was similar to the number of cases in our

original data set. The resultant PLS structural model , along with path co-efficients and their significance values are shown in Figure 2.

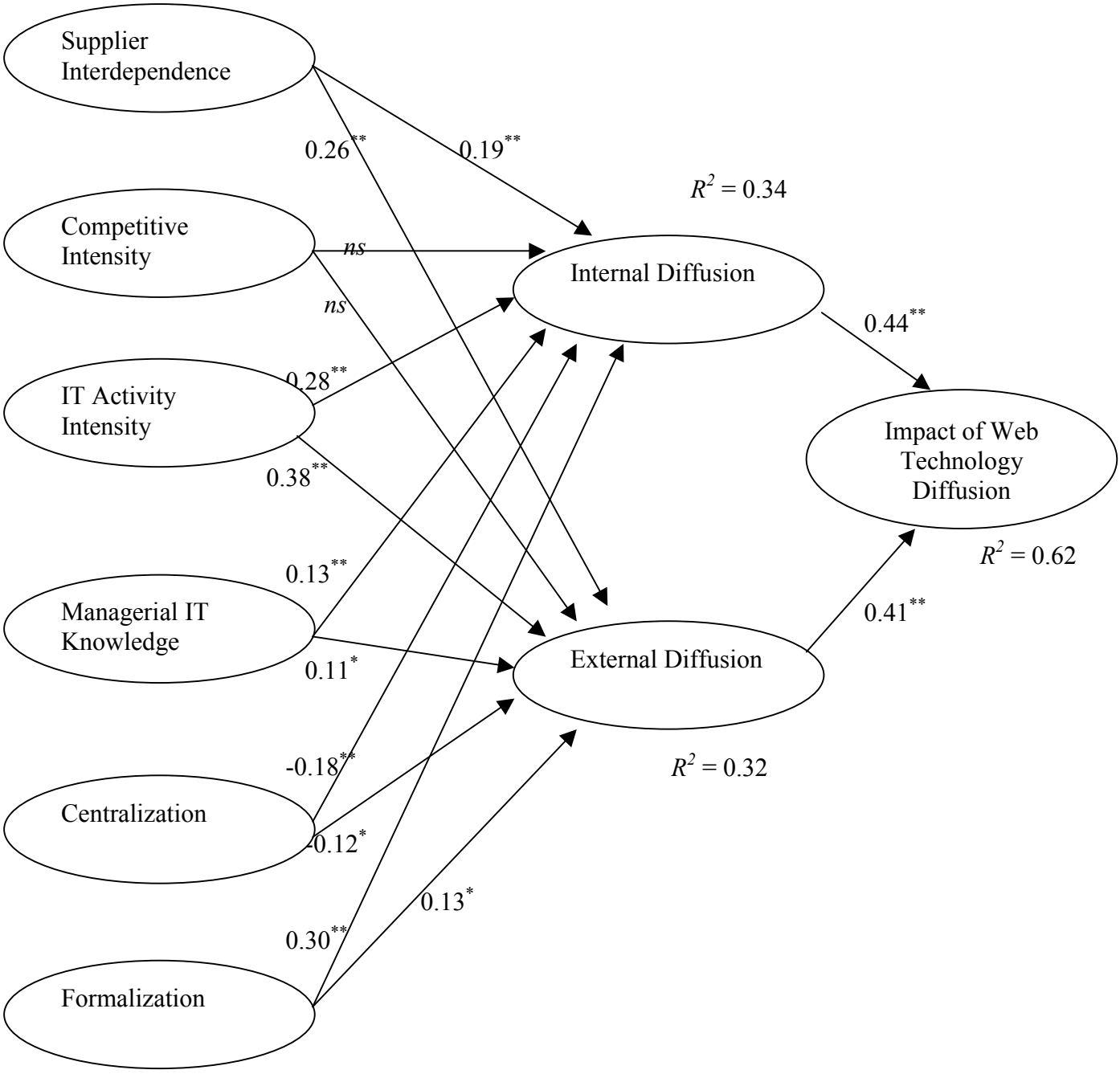
All the hypothesized paths, with the exception of those linking competitive intensity and the diffusion constructs, were found to be significant. The R^2 values of the structural model with internal diffusion as the dependant variable was 0.34,and 0.32 with external diffusion. With web-technology impact as the dependant variable, it was 0.62. These figures imply that our constructs and the predicted paths accounted for a significant portion of the variance in our dependant variables.

We found support for all our hypotheses except *H2*. Interdependence with suppliers, IT activity intensity, managerial IT knowledge, and formalization of IT unit structure were all found to positively influence both the internal as well as external diffusion of web technologies in SCM. As expected, centralized IT unit structure was negatively associated with diffusion. Further, the impact of web-technologies in SCM was found to have a strong positive association with both the internal and external diffusion constructs. This implies that the web-technologies are likely to have stronger, positive impacts on SCM if the technology gets both internally as well as externally diffused in the SCM function.

Table 1: Measurement Model Loadings

Constructs & Items	Loading
Supplier Interdependence (AVE = 0.57)	
Importance of having continued business relationship with suppliers	0.74
Significant proportion of total profits related to profits from sale/service to suppliers	0.81
Dependence of suppliers on firm for achieving their business goals	0.65
Bargaining power of suppliers/partners	0.80
Competitive Intensity (AVE = 0.84)	
Tracking new initiatives of competitors	0.92
Monitoring competitor moves	0.93
Competitor information considered important for firm's decisions	0.90
IT Activity Intensity (AVE = 0.69)	
IT activities and practices of competitors	0.88
Use of IT by key suppliers	0.81
Use of IT by key customers	0.75
Use of IT by key business partners and other agents.	0.87
Managerial IT Knowledge (AVE = 0.77)	
Top management knowledge on strategic potential of Web	0.88
Top management knowledge on productivity impacts of Web	0.91
Functional management knowledge on strategic potential of Web	0.93
Functional management knowledge on productivity impacts of Web	0.90
CIO's participation in business meetings	0.87
IT management knowledge on business operations	0.87
IT management knowledge on business strategies	0.84
	0.81
Centralization of IT Unit Structure (AVE = 0.57)	
Locus of decision-making responsibilities for:	
Application development and outsourcing	0.72
Procurement of hardware and software	0.82
IT operations and maintenance	0.66
Staffing IT positions	0.66
Capital budgeting decisions related to IT	0.71
Formalization of IT unit structure (AVE = 0.56)	
Documented job descriptions for IT personnel	0.82
Use of operating rules and procedures for IT activities	0.77
Use of task forces and committees for IT activities	0.65
Use of formal procedures and guidelines for evaluating new technologies and ideas	0.74
Internal Diffusion (AVE = 0.79)	
Extent to which web applications are used in :	
Supplier selection (getting quotes, bids etc)	0.87
Purchase order processing	0.91
Procurement from suppliers (distribution, warehouse, logistics etc)	0.92
Invoicing and payment processing.	0.91
Demand Management (procurement analysis).	0.84
External Diffusion (AVE = 0.91)	
Proportion of total suppliers with whom the firm interact through web.	0.94
Proportion of total supplier transactions done through web.	0.97
Proportion of overall interactions with suppliers through web.	0.94
Web-technology Impact (AVE = 0.83)	
Perceived, realized benefits from web-technology :	
Improved customer service	0.89
Better inventory control	0.92
Reduced operations costs	0.91
Reduced cycle time	0.93
Better relationship with suppliers	0.91
Generate competitive advantage	0.87

Figure.2. Results of the PLS Structural Model



** - 5% significance level; ** - 1% significance level, ns – not significant*

4.0 Discussion and Conclusion

Though firms have been increasingly adopting web-technologies and systems in their supply chain operations, there has been little empirical research on the diffusion of these systems as well as on the factors affecting the diffusion. Drawing upon several theoretical perspectives from IS and SCM research, we investigated key environmental and organizational factors that affect the diffusion of web-technologies in SCM, and the performance impact of this diffusion.

Of the environmental factors, we found evidence that IT activity intensity and supplier interdependence have a positive impact on the diffusion of web-systems in SCM. The greater the mutual dependence between a firm and its suppliers, the better is the likelihood that the firm will diffuse web-technologies in its internal as well as external SCM activities. The significant result for supplier interdependence has another interesting dimension as it relates to the argument that unlike EDI systems, web-technologies lower switching cost in B2B relationships with suppliers. Given that web-technology diffusion is enhanced when there is greater mutual dependence and this in turn can be expected to lower switching costs, this implies that over the longer term this will aid in the transformation of the currently static supply chains into dynamic supply chains as characterized by Kumar and Christiaanse (1999). They argue that dynamism in the choice of partners in the supply chain is a critical requirement for supply chain transformation.

The findings regarding the impact of IT activity intensity on the diffusion process is interesting. When key supply chain players start using web- technologies, firms seem to respond to the peer pressure to adopt the technologies, especially if their SCM operations are tied closely to those of outside parties. More than the internal needs for web-connectivity, the need for establishing external SCM connectivity and supplier interdependence seems to drive the diffusion of web-technologies. We did not find support that competitive intensity influences web-technology diffusion. It is likely that the IT activities of competitors and the extent of IT use by the industry have a stronger impact than the competitive pressure faced by firms.

Of the organizational variables, higher levels of managerial IT knowledge were found to positively impact the diffusion process. Our findings complement the results of Chatterjee

et.al. (2002) and Armstrong et al., (2001) who found collective IT knowledge in the organization to be a key predictor of technology assimilation and diffusion. Organizations with a higher understanding of the strategic potential of web-technologies in improving SCM seem to diffuse web-technologies more easily and pervasively than those firms who lack such knowledge and understanding among the senior business and IT executives. .

Our results also indicate a significant impact of IT unit structures on the diffusion of web technologies in SCM. Web-based supply chain projects need active participation from operations, logistics, warehousing and other functional managers, apart from IT executives. Only a collective effort can enhance the effective usage of web-technologies in SCM. Similarly, use of formal mechanisms like guidelines and rules, and the assignment of formal responsibilities to task forces or inter-disciplinary teams for executing the web-based SCM projects seem to augment the web diffusion.

The results pertaining to the impact of web-technology diffusion hold significant lessons for organizations contemplating investing in web-technologies for SCM purposes. Both the internal and external diffusion of web-technologies yield significant positive benefits in terms of measures such as reduced cycle time, better inventory management, reduced costs and improved supplier relationship management. This implies that it is just as prudent to invest in internal SCM web applications as in external SCM web applications.

4.1 Contributions and Future Research

This study makes significant contributions to both research and practice. Firstly, it adds to the scant empirical research on web-technology diffusion in organizations by building upon prior work in IOS and EDI. Our study throws light on the performance impacts of web-technology diffusion, as well as on the factors affecting web-technology diffusion. Secondly, most studies on SCM have largely adopted either an analytical modeling or practitioner case study approach. Empirical studies based on field data of web-based SCM initiatives are very few. Our study addressed this gap, and we have provided some insights into real-world web-SCM efforts. Thirdly, our findings help managers identify ways through which they can enhance their e-commerce efforts in relation to SCM. For example, through enhancement of overall IT knowledge and by devising appropriate structural mechanisms, they could not only

improve the web usage for SCM purposes, but also improve the overall benefits realized by using web-enabled SCM.

Our study has some important limitations as well. First, we used senior IT executives as our respondents. Our results are based on the perceptions of IT executives rather than SCM managers. Secondly, our measures are mostly subjective as they are based on the perceptions of the respondents. Future researchers could try and incorporate some objective measures, especially about the impact of web-technology usage for SCM. Thirdly, our study examined only a few key environmental and organizational variables that impact web diffusion. There are several other factors such as supply chain structure, complexity of processes, IT infrastructure etc. that could also influence web diffusion. This is another potential area for expanding this research in future.

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Appendix-A : Demographics of Responding Firms

Industry Type		Frequency	%
Manufacturing/Engineering related		32	18.2
Chemicals		3	1.7
Finance / Banking/Insurance-related		26	14.8
Computer/IT-related		14	8.0
Medical/Healthcare related		5	2.8
Oil/Gas/Energy		6	3.4
Business services		9	5.1
Real Estate/Property		7	4.0
Publishing/Information/news related		6	2.4
Transportation / logistics related		12	6.8
Retailing/Wholesale/trading related		24	13.6
Hotel/travel/tourism-related		6	3.4
Others		17	9.7
NA		10	5.7
	Total	176	100.0

Annual revenue level		Frequency	%
less than 1 million		1	0.60
1.1-5 million		4	2.3
5.1-10 million		13	7.4
10.1-50 million		39	22.3
50-100 million		56	31.8
> 100 million		62	35.2
NA		1	0.6
	Total	176	100.0