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Use of IT for supply chain integration and performance: a literature review

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ABSTRACT

The use of Information Technology (IT) for supply chain management (SCM) is becoming more and more important in the context of an increasingly globalized and competitive economy. Companies are attempting to find ways to improve their flexibility and responsiveness and in turn competitiveness by changing their operation strategy, methods and Technologies that include the implementation of information technology. IT, by providing timely, accurate, and reliable information, has greatly improved supply chain performance. In this paper, the literature available on IT in supply chain management have been classified using suitable criteria and the critically reviewed to develop a framework for studying the use of IT in supply chain management .Based on this review and analysis, recommendations have been made regarding the use of IT in supply chain management and some future research directions are indicated

Keywords: *Information Technology; supply chain management; Literature review; Performance; Integration.*

1. Introduction:

Nowadays, companies are in the race for improving their organizational competitiveness in order to compete in the global market. This market is electronically connected and dynamic in nature. Therefore, companies are trying to improve their agility level with the objective of being flexible and responsive to meet the changing market requirements. In an effort to achieve this, many companies have decentralized their value-adding activities by outsourcing and developing virtual enterprise (VE). All these highlight the importance of information technology (IT) in integrating suppliers/partnering firms in virtual enterprise and supply chain. SCM is defined as the integration of key business processes from end user through original suppliers that provides products, services, and formation and hence adds value for customers and other stakeholders (Lambert et al., 1998). According to Simchi-Levi et al. (2000), SCM is a set of approaches utilized to effectively integrate suppliers,

manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system wide cost while satisfying service level requirements. It is impossible to achieve an effective supply chain without IT. Since suppliers are located all over the world, it is essential to integrate the activities both inside and outside of an organization. This requires an integrated information system (IS) for sharing information on various value-adding activities along the supply chain. IT is like a nerve system for SCM. Considering the importance of IT in achieving effective SCM, an attempt has been made in this paper to review the literature on IT in SCM based on suitable criteria. The main objective here is to identify the major issues surrounding the application of IT in SCM, using suitable classification scheme and develop a framework for IT applications in SCM. The organization of the paper follows as Section 2 discusses the role of IT in SCM. The research methodology is presented in Section 3. Section 4 presents the classification scheme and a brief review of the literature. In Section 5, a framework has been developed for the application of IT in SCM. Finally, conclusions are presented in Section 6.

2. Role of Information technology in supply chain management:

Supply chain management emphasizes the overall and long-term benefit of all parties on the chain through co-operation and information sharing. This signifies the importance of communication and the application of IT in SCM. This is largely caused by variability of ordering (Yu et al., 2001).Recently the concepts of supply chain design and management have become a popular operations paradigm. This has intensified with the development of information and communication technologies (ICT) that include electronic data interchange (EDI), the Internet and World Wide Web (WWW) to overcome the ever-increasing complexity of the systems driving buyer–supplier relationships. The complexity of SCM has also forced companies to go for online communication systems. Information sharing between members of a supply chain using EDI technology should be increased to reduce uncertainty and enhance shipment performance of suppliers and greatly improve the performance of the supply chain system (Srinivasan et al., 1994). Companies need to invest large amount of money for designing internal organizational and technical processes, changing traditional and fundamental product distribution channels and customer service procedure and training staff to achieve IT-enabled supply chain (Motwani et al., 2000).

3. Research methodology:

The research methodology employed for developing the framework for the successful application of IT in SCM is the literature survey. We have collected literature primary through journals that are in the areas of operations management, supply chain, operations research, and information systems. The list of journals and the number of articles from each of those journals are presented in Table 1. In addition to the classification of the literature on IT in SCM, the tools used to model and analyze various IT-enabled SCM environments also presented. These include access to the journals published by a numerous publishers in particular Elsevier, Emerald, and Taylor & Francis. The literature search was aimed at implementing a successful IT system for achieving an effective SCM.

4. Classification of the literature and review of previous research on IT in SCM:

Table 4.1 Summary of references under classification scheme of the literature on IT in SCM

Classification	Need of classification	Sub-classification	References
Strategic planning for IT in SCM	The strategic planning is a critical task especially for IT-enabled SCM. It has long-term implications on the performance of IT in SCM systems.	Marketing reasons of IT in SCM Economic reasons Organizational Technological	Rock hart and Scott Morton (1984), Webster (1995), Ho (1996), King(1978) Porter and Millar (1985), Williams (1997), Talluri (2000) Gallupe et al. (1992), Henderson and Venkataraman (1993), Rogerson and Fidler (1994), Maloni and Benton (1997), Christiaanse and Kumar (2000), van Hooft and Stegwee (2001)
Virtual enterprise and SCM	Companies integrate various links of the supply chain and their supporting information systems that are driven by the need to streamline operations. The relationships of VE and the Internet have brought SCM to the attention of top management.	Partnership Virtual reality and supply chain Virtual enterprise and IT	Webster (1995), Skyrme (1996), Voss (1996), Lewis and alalayevsky(1997), Zimmerman (2000) Benjamin and Wigand (1995), Clarke (1998), Bal and Gundry (1999), Webster (1995), Clements (1997), Naylor et al. (1999), Black and Edwards (2000), van Hoek (2001), Turowski (2002)
E-commerce and SCM	With the development of Internet based technologies, integration of e-commerce with SCM systems is becoming a necessity. B2B ecommerce has tremendous influence on integrating partners in an organization to achieve an effective SCM.	Purchasing B2B e-commerce and supply chain Logistics	Emmelhainz (1990), Murray (1996), Carbone (1995), Min and Galle(1999), Elliman and Orange (2000), Emiliani (2000), McIvor et al. (2000), Hackney et al. (2000), Kaplan and Sawhney (2000), Marshall and McKay (2000), Salcedo and Grackin (2000), Overby and Min Clarke (1998), Ranchhod and Gurau (1999), Emiliani (2000), van Hoek and Chong (2001), Damen (2001).
Infrastructure for IT in SCM	The infrastructure includes the hardware and software and the nature and type of systems required for IT system in a supply chain environment	Organizational Technological	Klouwenberg et al. (1995), Mukherji and Mukherji (1998), Watson et al. (1998), Zsidism et al. (2000), Attaran (2001), Cheng et al. (2001), (2000), Lau and Lee (2000), Perry and Sohal (2000) Au and Ho (2002), Sharma and Gupta (2002), Yamaya et al. (2002).

Knowledge and IT management in SCM	Knowledge and IT management requires a systemic approach or framework for educating and training workers in teamwork and be innovative. Management of technology requires planning, developing and implementation decisions based on the characteristics of business processes and organizational objectives.	Technology management Education and training	Dos Santos (1991), Angeles and Nath (2000), Motwani et al. (2000), Talluri (2000), Walsh et al. (2000), Boubekri (2001), Nah et al. (2001), Warkentin et al. (2001), Jutla et al. (2002), Spekman et al. (2002) McCampbell et al. (1999), Tracey and Smith-Doerflein (2001).
Implementation of IT in SCM	Top management support is essential in order to provide moral support as well as the financial and technical support for the implementation of IT for achieving SCM.	Organizational Methodological Human resource	Ho (1996), McIvor et al. (2000) Cooper and Zmud (1990), Scott (1996), Calza and Passaro 997), Hicks (1997), Mullin (1997), Williams et al. (1998), Al-Mashari and Zairi (2000), ngeles and Nath (2000), Lauer (2000), Pawar and Driva (2000) Calza and Passaro (1997), Williford and Chang (1999) A. Gunasekaran, E.W.T. Ngai / European Journal of Operational Research 159 (2004) 269–295 275

The literature available on IT in SCM has been reviewed for its application and development based on the classification scheme discussed above.

4.1. Strategic planning for IT in SCM

Companies are now focusing on the strategic planning with the objective of developing long-term plans and changes to their organization and in turn to improve their competitiveness. A. Gunasekaran, E.W.T. Ngai / European Journal of Operational Research 159 (2004) 269–295 273 For example, IT will facilitate quick partnership formation by making available the right information and hence developing a virtual enterprise. Organizational restructuring may be required if a company decides to go for an enterprise resource planning (ERP) systems such as SAP, Oracle, People soft, and BAAN with the objective establishing an effective supply chain.

4.1.1. Marketing reasons of IT in SCM

To compete in a new market, organizations need to be capable of reconfiguring its resources to meet the changing requirements. This requires organizations to have an effective supply chain or physically distributed enterprises. Ho (1996) highlights three major roles of IT as administrative, operational and competitive (King, 1978; Rockhart and Scott Morton, 1984).

4.1.2. Economic reasons

The economic reasons here is the cost reason. Though flexibility and responsiveness are important in order to compete in a global and networked market, the cost still plays an important role in being competitive. Obviously, flexibility and responsiveness are interconnected with cost. Many companies choose cost reduction

as a competitive performance objective. In order to reduce the cost of production, companies have implemented the concept of SCM with a view to eliminate non value-adding activities. IT helps to improve the accurate information flow and in turn accurate decisions to support the business process in an effort to meet the changing market requirements.

4.1.3. Organizational

Strategic planning of IT in SCM includes organizational issues such as organizational structure, awareness of top management, business processes, strategic alliances, and information technology that influence the overall performance of IT-enabled SCM.. Henderson and Venkataraman (1993) proposed a comprehensive framework of IS strategic alignment incorporating four fundamental domain of strategic choice: business strategy, IT strategy, organizational infrastructure and processes, and IT infrastructure and processes.

4.1.4. Technological

IT helps to improve collaborative- supported work using different automation that includes computer-aided design/ computer aided manufacturing (CAD/CAM) and CIM. For example, IT-enabled SCM facilitate effective technology transfer between partners in a network of firms. The widespread availability of highly flexible, functional, and inexpensive information and communication technologies provides us with opportunities for a radical redesign of supply chains. Redesign of supply chain should include a rethinking of the governance structures, a choice of the supply chain actors, redesign of the supply chain structure (sequence of activities in the chain), and redesign of information communication and co-ordination structures.

4.2. Virtual enterprise in SCM

The business partners are integrated using information and ommunication technology. Virtual Corporation is the industrial strategy for structuring and revitalizing the corporation for the 21st century (Davidow and Malone, 1992). Lean production and agile manufacturing mainly focus on intra-enterprise performance, while also recognizing the necessity and importance of partnerships with supplies and customers (Mariotti, 1996). The extended enterprise and the virtual enterprise can be seen in the context of enterprise partnerships, designed to facilitate co-operation and integration across the value chain (Browne and Zhang, 1999). Some of the key factors in virtual enterprise development are IT-enabled SCM, partnership, virtual enterprise and supply chain, and virtual enterprise and IT.

4.2.1. Partnership

The virtual products and services are produced, delivered, and sold through electronic networks. Lewis and Talalayevsky (1997) argue that the managerial and cultural aspects of strategic partnerships in logistics involving such issues as ‘‘openness to innovation’’ and ‘‘trust’’ are just as critical as IT.

4.2.2. Virtual teams and supply chain

The design, manufacture, and delivery of a product require ever-higher levels of knowledge and expertise within the supply chain. Virtual teaming is the most appropriate mechanism to examine the relationship between all parties along the value chain, created across a distributed supply chain, with members separated geographically.

4.2.3. Virtual enterprise and IT

The partners may be dispersed geographically either nationally or internationally. It becomes more complicated to integrate partners with different objectives and platforms to function. This could be achieved by suitable enterprise resource planning systems including e-commerce and IT for a co-operative supported work in such a virtual enterprise environment. Without IT, one could hardly imagine a virtual enterprise development.

4.3. E-commerce and SCM

To support the inter-organizational sharing of resources and competencies in network structure, communication and co-ordination need to be maintained. IT has a pivotal role to play in improving communication and co-ordination by acting as an enabler (Love, 1996). E-business is the establishment of a computer network to search and retrieve information in support of business decision making and inter-organizational cooperation (Kalakota and Whinston, 1996). The Internet helps to manage supply chain activities by offering information about what kind of product is demanded, what is available in the warehouse, what is in the manufacturing process, and what is entering and exiting the physical facilities and customer sites (Lancioni et al., 2000).Webster (1995) highlights the power of EDI in supporting collaboration and resolving conflict in a supply chain.

4.3.1. Purchasing

The increased popularity of e-commerce is due to a multitude of operational benefits it can bring to purchasing practices. EC purchasing has serious problems to the successful implementation of a cyber-purchasing system include a host of security, legal, and financial problems (Min and Galle, 1999). The Internet has the scope to transfer complex information accurately and to reduce the delays as information passes up and down the supply chain (Elliman and Orange, 2000; Emiliani, 2000).

4.3.2. Operations

The adoption of more integrated Internet commerce (I-commerce) models should strengthen the relationship between a network orientation and global supply chain management. Not only the Internet make foreign markets more accessible, it now makes it much easier to integrate foreign customers, suppliers, and intermediaries into closely managed supply chain relationships, boosting savings and speeding innovation (Overby and Min, 2001). The emergence of e-commerce will only accentuates this move towards collaboration as technology creates the ability to forge relationships more effectively and efficiently (Fontanella, 2000).

4.3.3. Logistics

With virtual logistics, the physical and information aspects of logistics operations are treated independently from each other. In such operations, ownership and control of resources is affected through the Internet (or the Intranet) applications rather than direct physical control, Many researchers explained the close links between information systems and the management of logistics (Christopher, 1997; Cooper, 1994; Feraud, 1998). Chiu (1995) presented an integrated framework for distribution firms to establish and so improve their distribution systems.

4.4. Infrastructure for IT in SCM

Infrastructure for IT in SCM consists of Internet connectivity, hardware and software including application systems integration. Nevertheless, training and education cell for IT is important to fully utilize the IT available for SCM. There are different IT platforms and systems available to enable the application of IT in SCM (Haeckel, 1999). In evaluating the formation of customer–supplier relationships, Sarkis and Sundararaj (2002) focus on two major dimensions that will influence the formation process. The first is the type of organizational structure and relationships, and the second major dimension is the electronic commerce environment.

4.4.1. Organizational

The organizational infrastructure requirements include top management involvement, strategic fitness of IT, major players in the organization (power brokers), IT skills available, etc. An organization should be a learning unit so that the IT can be absorbed for the benefit of SCM. The information systems for supply chain management should be accessibility, compatibility, user-friendly, stability and reliability, minimal training and strong after-sales service.

4.4.2. Technological

The ERP systems represent an optimum technology infrastructure that when integrated properly with a process-oriented business design can support the supply chain management systems effectively (Hicks, 1997; Mullin, 1997). Lau and Lee (2000) propose an infrastructure of a supply chain information system, focusing on the component module necessary for the building up of such a system with a description of the creation of these modules.

4.5 Knowledge and IT management in SCM

Knowledge and IT management requires a systemic approach or framework for educating and training workers in teamwork and be innovative. Management of technology requires planning, developing, and implementation decisions based on the characteristics of business processes and organizational objectives.

4.5.1. Technology management

In the emerging e-procurement marketplaces, firms establish efficient web-based electronic relationships that allow for closer integration between buyer–supplier. The reliance on application service providers for high-value e-procurement and other business purchases makes the reliability of knowledge transfer paramount. There are several researchers (Angeles and Nath, 2000; Nah et al., 2001) whom deal with the information technology management in a supply chain perspectives.

4.5.2. Education and training

Education and training are the most important component of any change process in an organization. In order to be successful, it is important that we have the full co-operation of employees at all levels; otherwise, technologies alone will not help to improve the organizational competitiveness.

4.6. Implementation of IT in SCM

People and processes in an organization must undergo significant change, learning, adaptation, and growth in response to the introduction of IT.

4.6.1. Organizational

Successful implementation of IT as an enabler of SCM depends upon the support of top management and overall organizational structure. The nature of skills available within an organization influences the success of IT in supply chain. Ho (1996) discussed in detail IT implementation strategies for manufacturing organizations. Decisions of a structural nature contain three dimensions: system competencies, (ii) technology scope, and (iii) IT alliance.

4.6.2. Methodological

There are different tools that could be used for the implementation of IT in SCM and some of them include (i) quality function deployment (QFD), (ii) concurrent engineering, and (iii) life cycle approach (Scott, 1996). Lauer (2000) describes the role played by a very active industry interest group that has served as a supporter and advocate for the adoption of EDI within the automotive supply chain.

4.6.3. Human resource

Human factors such as the behavioral attitude towards the implementation of IT in SCM, level of education, knowledge in computers, international exposure, training and education, reward and employee empowerment and incentive scheme impact the successful implementation of IT in SCM.

5. A framework for identification and application of IT in SCM:

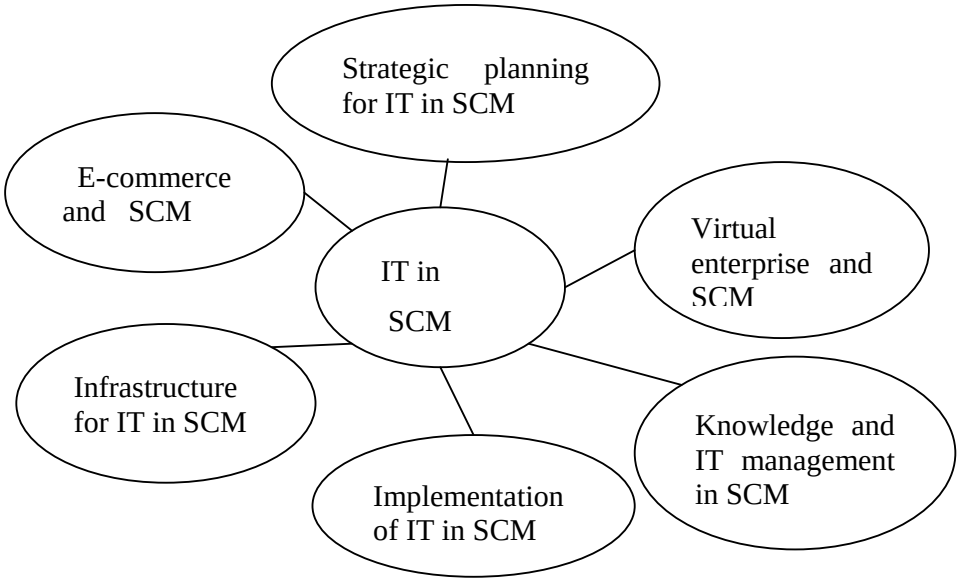

Fig 5.1 a framework for the development of IT for effective SCM.

In this section, a framework has been presented for identifying the implications and applications of IT in SCM. This framework is based on the review of literature on IT in SCM. Critically reviewing the literature helped to identify the major strategies, enabling technologies and critical success factors for the application of IT in SCM.

Table 5.1 a framework for the development of IT for effective SCM.

Criteria's	Issues
Strategic Planning of IT	Top management participation, Long-term business plan, Global market and competitiveness, Virtual Enterprise, Agility and cost, Global outsourcing, E-business, Strategic partnerships, Mergers, Acquisitions, New products/services, New market creation, Reputation, Integrated systems
Virtual Enterprise	Partnership based on core competencies, Collaborative network of firms, Virtual teaming, Virtual manufacturing, Virtual logistics, Enterprise resource planning systems, E-Commerce including B2B, B2C and B2A, Training and Education in IT
Implementation of IT	Top management support, Cross functional project team with IT skills, Business process reengineering, Quality function deployment, Concurrent engineering, Life cycle approach, Project management, Performance measures and metrics
E-Commerce	Global market and competition, Digital firms, Access to alternative markets, Opportunities for Networking, Technological advances, Enhanced strategic alliances with partners, Reduction in cost and increase in agility, Open communication, Enhanced teamwork, Customer relationship management
Infrastructure	Fitness for the Business process, Internet connectivity, IT investment, Enterprise resource planning, Software and hardware availability, Autonomous agents, EDI, E-commerce platform, XML, LAN, MAN, WAN, Intranet, Extranet, IT skills, Training and Education in IT, IT evaluation
Knowledge and IT Management	IT training and education, Core competency training, Investment in knowledge capital, E-learning, Entraining, Groupware, Multimedia, Workflow technologies, Cross functional training, Job rotation, Reward and incentive schemes, Empowerment, and team work, Contribution to knowledge capital

5.1. Implementation issues of IT in SCM

A well-documented implementation plan is required for IT in developing an effective supply chain. Moreover, the top management support and involvement are essential for the successful implementation of IT in SCM. Implementation may require making necessary changes to organizational business processes with the objective of absorbing the IT system such as SAP and CAD/CAM. Before implementing IT, there is a need to look at the business model and then identify suitable IT systems required to support the objective of achieving agility in a supply chain. There are several tools and methods available for effectively managing the implementation of IT for responsive supply chain and some them can include QFD, CE and life cycle approach. Suitable performance measures and metrics should be developed to monitor the implementation of IT over a time period. This will also include planning phase, pilot phase and go live. Implementation of IT for achieving an effective supply chain warrants suitable framework that is based on theoretical analysis and past experiences.

6. Concluding remarks

As a result of the literature review, we can see that IT has a tremendous influence on achieving an effective SCM. There are many research articles on IT in SCM, but there is a lack of critical review of the literature with the objective of brings out the pertinent factors that would influence the successful application of IT in SCM.

The literature available on IT in SCM has been reviewed based on the major components of IT enabled SCM. As a result of the literature survey, the major components of IT-enabled SCM comprises of six major areas: (i) strategic planning, (ii) virtual enterprise, (iii) e-commerce, (iv) infrastructure, (v) knowledge and IT management and (vi) implementation. Following are comments that derived from the literature survey on IT in SCM:

• The strategic information systems should include the strategic objectives of SCM
• Performance measures and metrics need to be established for measuring the performance and suitability of IT in SCM.

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