A Framework for Analyzing e-Supply Chains

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Abstract

The advent of the Internet has made it possible for companies to change the way they conduct their businesses. E-procurement, e-tailing, e-marketplaces are but a few examples of internet abled business applications that have revolutionized certain processes in supply chains and have given rise to e-supply chains. To ensure success, it is contended that a proper needs analysis is necessary before a company should embark on the e-business journey. The primary goal of this paper is to uncover the various factors that affect the implementation and performance of e-supply chains and subsequently to propose a framework that will exhibit the nature of the relationship between the said factors. This research employs a theoretical conceptual approach making use of existing literature and also a case study. Several groups of variables related to the success or failure of e-supply chains are uncovered. The relationships between these variables and the performance of e-supply chains are captured in the proposed contingency based framework. This paper also highlights that the framework can be used to explain existing e-supply chain dynamics and to generate new research questions that will aid in analyzing e-supply chains.

Keywords: E-supply Chains, E-supply Chain Management, Supply Chain Performance, Contingency Framework.
1. Introduction

A supply chain is a network of facilities and activities involved in delivering a product from raw materials through to the end customer. Supply chain management is a new way of managing the supply chain that links all partners in the chain including external partners such as suppliers, carriers, third party companies and information system providers so as to make the whole supply chain competitive (Lummus and Vokurka, 1999). One of the most important technological enabler that will provide supply chains with the much-needed advantage over their competitors is information and communication technology (ICT). The availability of highly flexible and inexpensive ICT such as the Internet presents new possibilities in restructuring the supply chains for better performance (Christiaanse and Kumar, 2000). Easy and cheap access to the Internet in particular has opened up a multitude of possibilities for individual firms and their supply chains. It has made it possible for companies to redesign their business processes and participate in e-business applications such as e-procurement, e-sell, e-auctions, e-marketplace and infomediaries, to name a few (Chakravarty, 2005). This has given birth to the so-called e-supply chains (van Hoek, 2001) and hence e-supply chain management. In this paper we are using the more common concept of e-supply chains to mean the adoption of e-business practices in supply chains or web based supply chains (Pant et al, 2003). E-business refers to the use of Internet based computing and communications to conduct and support business processes. Categories of e-business applications or practices includes e-marketplaces where buying and selling of good and services takes place; inter-organizational systems that facilitates inter and intra-organization flow of good, services, information, communication and collaboration; Customer service which includes sales and customer service and support (Chopra and van Mieghem, 2000; Cagliano et al, 2005). E-business application via inter-organizational information systems has also stimulated and enhanced the advantages promised by using supply chain strategies such as vendor managed inventory (VMI), collaborative planning, forecasting and replenishment (CPFR) and efficient consumer response (ECR).

Although the advantages are numerous, indiscriminate use of improper e-business applications may prove detrimental. This is highlighted by Phan (2002) via a case study at Intel who discovered that only through a proper needs analysis can e-business applications be used to leverage a company’s business. This idea of appropriateness between e-business application and the supply chain is also echoed by Chopra and Van Mieghem (2000). Problems that arose in the Amazon supply chain (van Hoek, 2001) also highlights the importance of finding an approach that will enable firms to properly design and managed their e-supply chains. This calls for research into the understanding of supply chain dynamics in the presence of e-business. Research into this area is important so that firms contemplating on e-business adoption will have a clearer picture of the impact of such a venture not only on their own firm but also on the supply chain as a whole.

The questions that arise now, are, how to determine the characteristics of the e-business application that is suited to the overall supply chain and how does this affect the performance of the e-supply chain. The primary goal of this paper is, via a review of existing works on e-business and supply chain management, to propose a framework that will exhibit the nature of the relationship between the said factors.

This paper discusses the issues relating to e-business and supply chains in an effort to lay the groundwork for the proposed framework. An account of contingency theory in supply chain management is given and its suitability as the guiding methodology for the proposed framework is highlighted. Subsequently, the contingency framework for analyzing e-supply chains is posited and the implications and limitations of the framework are discussed. The paper concludes with some discussion on further work in the area.
2. E-business and supply chains

Supply chain management advocates close collaboration between partners via information sharing and information visibility. Advances in information and communication technologies provided the tools needed to achieve such collaboration. Indeed it has given rise to the various e-initiatives that are seen today. In fact new models of e-business are continuously being developed. The presence of various e-business applications or practices presents problems to companies in deciding on the suitable choice of e-business application. Stockdale and Standing (2002) for instance reported on the difficulty faced by organizations in developing strategies, policies and procedures in relation to the e-marketplace selection process. Joo and Kim (2004) iterated that the selection of e-marketplaces is at best industry specific. Although substantial benefits are enjoyed by companies that adopt e-business, through efficiency improvements, better asset utilization, enhanced customer service and ultimately higher shareholder value (Johnson and Whang, 2002), there are also cases where several problems are encountered as described by van Hoek (2001) and Grieger (2003). Among the contributing factor to these unsuccessful stories is the fact that the supply chain dimension has been ignored by firms adopting the e-business model and vice versa, that is the e-business models or practices developed did not totally embrace the concepts of supply chain management (Smart, 2008; Chopra and Van Mieghem, 2000; Grieger, 2003).

In the following subsections, using existing literature and a local case study, we will highlight and discuss the relationship between e-business practices and several supply chain concepts thus laying the groundwork for the proposed framework.

2.1. E-business practices and supply chain processes

ICT with all its purported benefits to the supply chain should impact on all supply chain processes. However, research has indicated that this is not the case. Van Hoek (2001), for instance uncovers the fact that the current usage of information harvested via ICT are more operational in nature rather than strategic and the supply chain scope of e-business is more likely fragmented and partial in nature rather than integral. Eng (2004) reported similar results in a study based on a survey involving food service companies, retailers, and wholesalers in the UK. It is shown that the e-marketplace supply chain applications enable the majority of companies to automate transaction-based activities and procurement-related processes rather than strategic supply chain activities. Among the reasons given for this occurrence are technological incompatibility and issues of trust.

Focusing on levels of Internet adoption in the supply chain processes, Cigliano et al (2005) research results in the identification of four clusters of companies. These four clusters are named the traditional, e-sellers, e-purchasers and e-integrators depending on the scope and function affected by the use of the e-business such as procurement and retailing. Results of the study indicated that adoption of e-business are dependent upon factors such as type of industry, company size, existence of an e-business strategy and the position of the companies in the supply chain. Their findings also suggest an evolutionary path towards e-integration by companies in the e-sellers and e-purchasers clusters. In other words, given time, all of the companies will be in a state where total integration of supply chain processes is achieved. Differentiating along two dimensions, that is, the ability to partner and the complexity of supply chain processes, Pant et al (2003) comes up with five approaches to e-supply chain implementation. The type of e-business practice adopted by organizations will depend on the two dimensions mentioned. The importance of strategy and type of industry in determining the best e-business practices for optimum supply chain performance is also held by Chopra and Van Mieghem (2000) and Joo and Kim (2004). The competitive strategy of a company will determine a company’s strategic position in its market. This also affects the type of e-business to be adopted. It is important that the e-business system deployed will strengthened this position rather than erode it (Webster, 1995; Phan, 2002).
From the above, it can be seen that there are varying levels and types of e-business practices in the supply chains. The factors that impacted upon the type of e-business practice are the type of industry, company size, existing IT infrastructure, e-business strategy, competitive strategy etc.

2.2. E-business practices and supply chain structure

Supply chain structure usually refers its physical configuration. This definition is found limiting and is expanded to include the physical layout, geographical positioning and also the buyer-supplier relationship that exist between players in the supply chain (Mukhtar et al, 2001). Utilising this expanded view of supply chain structure, it can be seen via a critical examination of the literature, that there exist certain dynamics between the supply chain structure and e-business practices. This is supported by Moon (2004) who reported that ICT and e-business implementation affects the supply chain structure, in this case the physical layout. Chae et al (2005) posits that the interplay between IT and existing relationship between partners in a supply chain affects interorganizational collaboration, hence the supply chain structure. This view is also held by Marchewka and Towell (2000) who studied the network relationship of companies that adopted e-commerce. Evidence that the physical layout of supply chains is affected by e-business adoption can be seen in Disney et al (2004) who describes five e-business scenarios or structures in their simulation analysis of supply chains. In their study it was shown that the adoption of certain e-business practices reduces the number of echelons in the supply chain thus changing the supply chain physical structure. Chopra and Van Mieghem (2000) also indicated that companies adopting e-business, in the form of e-tailing will ultimately have to accommodate returns thus also affecting its supply chain physical structure. Skjøtt-Larsen et al (2003) discovered that different buyer-supplier relationships require different e-marketplaces. The impact of the electronic supply chain on buyer-supplier relationship is also discussed by Williams et al (2002) and Greiger (2003).

2.3. E-business practices and supply chain performance

Real time access to data and the global reaches afforded by the Internet has greatly revolutionized the procurement and retailing function in a supply chain. It is now possible, for instance via e-marketplaces, to participate in e-auctions to procure supplies at the cheapest possible price. Much more than that the Internet enables firms to undertake e-collaboration. E-collaboration is defined as business-to-business interactions facilitated by the Internet. These interactions go beyond simple buy/sell transactions and may be better described as relationships. These include such activities as information sharing and integration, decision sharing, process sharing, and resource sharing (Johnson and Whang, 2002). Of these four activities, the impact of information sharing on supply chain performance is the most investigated (Li et al., 2005). Using various methodologies ranging from mathematical models (Li et al, 2005), simulation analysis (Disney et al, 2004) up to the novel application of the balance scorecard method (Chopra and Van Mieghem, 2000), it has been shown that sharing information on inventory, product demand, production schedule and order status help reduces the bullwhip effect, helps improve supply chain coordination, reduce transaction costs, and allows a much faster time to market. E-business practices such as e-tailing, also reduces the number of tiers in a supply chain thus resulting in increased supply chain performance.

2.4. E-business practices in small medium enterprises (SMEs)

SMEs are considered to be the backbone of many countries. In this era of globalization SME’s are urged by most governments to leverage the Internet to conduct their business. However the uptake of e-business practices amongst SMEs have been slow and riddled with problems. Studies by Ren et al (2006) in Europe listed several factors that led to this state of events.

In Malaysia various government initiatives have been carried out to encourage and assist local SMEs to be a part of the digital economy. Whilst participation is encouraging it is still far from
satisfactory. Ramayah et al (2004) in a survey conducted on e-readiness in SMEs located in the Northern Malaysia states found out that the companies are ready to participate in e-business but factors such as commitment from top level management and investment in ICT can be factors that might hinder success. A recently conducted preliminary case study (Mukhtar et al, 2007) on six companies in the wood and wood products industry in Malaysia revealed several contingent factors that led to the state of a virtually non-existent presence of e-business practices especially those that support strategic decision-making. Using a case studies approach, it was discovered that the use of ICT is mainly to support operations and management while the use of the Internet is mainly for promotion of goods and as a vehicle to expedite the searching of potential suppliers. Among the reasons cited for this state of events are the lack of an e-business strategy, the existing competitive strategy does not warrant the application of e-business, the position of the company in the supply chain and the state of ICT infrastructure and expertise.

3. Research questions
The above review of literature is by no means exhaustive. However, it is deemed sufficient to highlight several issues. It can be seen that there are many factors involved in the adoption of e-business practices. It can also be seen that these practices can lead to changes in the supply chain structure and also changes in supply chain performance. A local case study revealed low use of e-business because of several factors. All of these issues lead to the following questions:

a) What are the factors that need to be considered in order to explain the different levels and type of e-business practices?

b) What is the nature of the relationship between these factors in the context of evaluating the performance of a supply chain?

c) Could these factors and their interrelationships be incorporated in one comprehensive framework?

Since there are a myriad of factors or variables that seems to be contributing to the success of e-business applications, a major problem now is to establish causality. In this respect we refer to contingency theory (Lawrence and Lorsch, 1969), which is an approach to the study of organizational behavior, which is explained in the next section.

4. Contingency in supply chains
Contingency theory provides an interesting way in viewing activities in a supply chain. It is an approach to the study of organizational behaviour in which explanations are given as to how contingent factors such as technology, the external environment and culture influence the design and functioning of organizations. The term contingency theory was coined by Lawrence and Lorsch (1969). They argued that the amount of uncertainty and rate of change in an environment impacts the development of internal features in organizations.

Intertwined with the concept of contingency theory, is that of organization structure. Organizational structure has been defined and classified in a number of ways in the literature. A simple way of describing organizational structure differentiates between organizations on the dimension of centralization or decentralization (Stock et al, 1998). However among the most often used categorization is due to Mintzberg (1979). In his seminal work he identified five different types of organizational structure namely the simple structure, machine bureaucracy, divisionalised form, professional bureaucracy and adhocracy. Each structure can be described according to eleven attributes that include coordinating mechanism, formalization of behaviour and decentralization.

There are a number of approaches in contingency theory. There are studies that investigate the interactive effect of contextual variables such as size and organizational structure variables such as centralization on particular areas of organization performance (Kraft et al, 1995). On the other hand there are also studies that investigate the effects of contingent variable such as technology on structure
variables without investigating the effect on performance (Vickery et al., 1999). Jordan and Tricker (1995) for instance, found out that the operations of different organization structures are supported by different information systems. It is purported by Kraft et al. (1995) that the original idea in contingency theory is that different structural contingencies produce different types of performance. In their work they remarked that there might be some structural contingencies that are more important for social performance (measured in terms of absenteeism or strikes) while others are more important for economic performance (measured in terms of returns on investment, etc.). Likewise, they stipulated that a particular structural contingency is unlikely to provide best performance for both categories of performance.

Contingency effects in the analysis of supply chains, although not specifically described as such, had been noted by several researchers. Of particular relevance is the work by Harland (1997), Fisher (1997), Lamming (2000), Childerhouse and Towill (2000) and Ernst and Kamrad (2000). All of them had generally worked with the idea of how certain strategies are only appropriate for certain supply chains or how certain products are only appropriate for certain supply chains. Then there is the work of Bensaou (1999) that discussed the concept of how certain product and market conditions has a direct consequence on the type of buyer–supplier relationship which will in the end influence the performance of the supply chain. Product process assignment too has an effect on the effect of the physical layout of the supply chain and hence in its performance as investigated by Davis (1993), Garg (1999) and Ernst and Kamrad (2000).

From the above deliberations it can be concluded that contingency theory can be used as a general methodology for the analysis of supply chains. Its ability to deal with various factors and complex issues in the analysis of organizational performance lends itself as a natural tool for the analysis of supply chains.

5. Positing the framework

In the last section it was shown how contingency effects are present in supply chains and that contingency theory is relevant in as much that it can be used to establish causality between the various factors that affect supply chain performance (Mukhtar et al., 2002) and in explaining the theoretical underpinnings of supply chain management (Stonebraker and Afifi, 2004). In organization theory, the variables related to organization structure are well known. However, the case is not particularly that straightforward for e-supply chains. Following the tenets of contingency theory, it is necessary to identify and group the variables into practice variables, contingency variables, supply chain structure variables and supply chain performance variables as follows.

5.1. Practice variables

These variables refer to the type and level of e-business practice in supply chains and it follows closely the taxonomy proposed by van Hoek (2001). Type here refers to the use of information obtained via e-business practices, which is categorized as ranging from operational to strategic. Whilst level refers to the scope of e-business practices in supply chain processes which ranges from partial/fragmented to integral. This designation results in four possible combinations of e-business practice variables corresponding to each of the four quadrants in Figure 1. Obviously this taxonomy can be refined by respectively refining the type and level components of the variables.
Figure 1: Type and level of e-business practices (adapted from van Hoek (2001))

E-procurement and e-tailing that only involves automation of purchasing and selling transactions will fall in the bottom left hand quadrant. E-marketplaces that provide only e-auctions will also fall into this category, whilst e-marketplaces that provide strategic functions could fall into the two top quadrants depending on whether the level of use is partial or integral. E-collaboration in terms of sharing of resources and involves all functions in the supply chain will fall in the top right hand quadrant.

5.2. Contingency variables

Variables grouped under this category are those that have a certain amount of influence over the overall choice of e-business practice, which subsequently affect the performance of a supply chain. This means that supply chain performance is contingent on these factors, hence the name contingency variables.

A non-exhaustive list gathered from existent literature and conducted case study includes:

(i) Size of companies, the position of the business in the supply chain, type of industry (Cagliano et al., 2005; Mukhtar et al., 2007);
(ii) Products supplied which include complexity of product and complexity of supply chain processes (Marchewka and Towell, 2000; Pant et al., 2003) and product demand (local consumption or for export) (Mukhtar et al., 2007);
(iii) Existing relationship with supplier/customer (Chae et al., 2005);
(iv) Strategy of the company especially the existence of an e-business strategy (Phan, 2002; Chopra and Van Mieghem, 2000; Cagliano et al., 2005).

5.3. Supply chain structure variables

Supply chain structure is a subject not extensively studied but mentioned almost everywhere when researching about supply chains (Moon, 2004). Lambert et al. (1998) mentioned the importance of comparing supply chain structures. For this research, the definition for supply chain structure is expanded from the definition proposed by Mukhtar et al. (2002). This new definition is consistent with the definition of supply chains as comprising of both the physical flow of goods and/or services and also the flow of information. It incorporates the information driven supply chain structure as described by Lewis and Talalayevsky (2004). Briefly, the supply chain structure variables consisted of the following components:

(i) The physical variables: The configuration or layout of the supply chain; refers to the number of tiers and location of factories, warehouses, etc.
(ii) The relationship variables: Buyer supplier relationships between players in the supply chain. It ranges from arms length and collaboration. It also incorporates power in the supply chain. This variable determines the coordination mechanisms between supply chain members.

(iii) The ICT infrastructure variables: Refers to the extent and type of ICT infrastructure that is present in the supply chain; it includes (although not limited to) Internet access and also the availability of software to players in the supply chain; this variable will help describe information flow in the supply chain.

(iv) Spatial variables: Refers to the geographical location of players in the supply chain; this variable caters for the international or global supply chain and captures information pertaining to issues of logistics and hence the type of carriers used in transporting materials or goods.

5.4. Supply chain performance variables

The effectiveness of any supply chain management practice is manifested in improved supply chain performance. In general terms supply chain performance variables refer to the measures of supply chain performance, which are centred around increased customer satisfaction and reduced overall costs. Metrics used ranges from fill rates and response times to measures such as level of commitment of individual players in the chain and percentage of customisation achieved with respect to customer order (van Hoek, 1998). Measures related to supply chain flexibility and agility are also used (Beamon, 1999).

6. Resulting framework

6.1. The framework for e-supply chain analysis

Having categorized the various groups of variables, and following the approach of contingency theory, we now propose the following contingency- based framework for e-business adoption as depicted in Figure 2. Figure 2 illustrates the relationships between the groups of variables. E-business practices in a supply chain will affect the supply chain structure and in turn affects the supply chain performance (the bold arrows in the figure). How it does so is mediated by the variables identified as contingency variables, as symbolized by the dashed arrow in the figure.

![Figure 2: Contingency based framework for e-business adoption in supply chains](image)

The driving logic of this framework is that one might identify interesting e-business practices, which deliver improve performance. However, having done that, it should be adapted to suit particular situations with particular contingencies. The interactions between the contingencies and the practices...
will determine the structure of the supply chain of which performance in terms of increase customer satisfaction and reduction in costs for the supply chain is the outcome.

6.2. Simulation based decision framework

In its present form, the contingency framework is of limited use to practitioners. However, if moulded into an e-supply chain analysis tool by incorporating simulation analysis, it will make it easier and more practical for firms to analyse their respective supply chains so that they can decide on how much, in what sequence and in which supply chain process they should invest in e-business.

The integration of the contingency framework and the simulation modelling can be moulded into an e-supply chain structures simulation framework. This framework, shown in Figure 3 provides a systematic way by which a supply chain can be analysed. It begins with the identification of the supply chain or its relevant parts. The next step involves the mapping of the supply chain in terms of its structural variables and contextual variables. The identification of the various strategic options comes next. This will lead to possible changes in the supply chain structure. All of these are then moulded into supply chain structure scenarios for simulation. The simulation results are analysed and further refinements are made as needed until the required performance levels are attained.
7. Implications of the framework

Research into the adoption and impact of e-business in supply chains are mostly case based and fragmented in nature. There has been a limited effort to categorize the various decision variables involved in any e-business implementation. There is an even more limited effort to quantitatively
evaluate the effect of e-business on supply chain performance as opposed to firm performance. This research highlights the need for this exercise by proposing four different categories of variables. The relationship between these variables culminates in the form of the contingency framework. Although the contingency framework might seem complex, however if properly utilised it forces a balanced and thorough decision making process on the part of the decision maker. Hence, the framework provides an avenue by which better and more thorough understandings of e-supply chain dynamics is possible. By using the framework, it is now possible to approach the subject of e-supply chains in a systematic and holistic manner thereby facilitating comparisons of research results.

In addition to this, the contingency framework can also be used to generate various research questions, for example:

(i) Given a particular product (contingency variable), what are the relevant e-marketplace functions (practice variable) and buyer-supplier relationship (e-supply chain structure variable) that will best support its supply chain processes for optimum supply chain performance?

(ii) Given a particular industry (contingency variable), how does the relationship between the type of e-marketplace (practice variable) and the existence of power between supply chain players (e-supply chain structure variable) affect supply chain performance?

(iii) Given a company’s competitive strategy (contingency variable), what is the type of e-marketplace (practice variable) and supply chain information system (e-supply chain structure variable) that will improve overall supply chain flexibility?

8. Conclusion

Accessibility to the Internet presents companies with various possibilities in developing and executing new ways of doing business. However, companies may often become overzealous in implementing e-business scenarios that might be too advanced for their needs or too resource intensive to implement and operate, thus resulting in an overstretching of resources and capabilities. This paper highlights the fact that any forays into e-business have to be context driven and should not be undertaken without a thorough understanding of the interplay of variables involved. En route to the development of the proposed framework, and taking insights from contingency theory, several categories of variables are formed. The interactions of these variables and their relationship with supply chain performance culminate in the form of the contingency based framework that can be used to analyze e-supply chains. To exhibit the applicability of the framework especially as an aid in decision making, an e-supply chain simulation framework is proposed. Besides its explanatory function, it was also demonstrated that the framework can also be used to generate research questions and/or research hypotheses. As such, it serves as a valuable tool that provides an avenue that will enable comparisons between different researches to take place. This will be beneficial for further research into the area of e-supply chain and supply chain performance. The framework is currently used to evaluate several e-supply chain simulation scenarios.
References


