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SUPPLY CHAIN FLEXIBILITY: SOME PERCEPTIONS

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ABSTRACT

Supply chain flexibility has gained important in recent years because of competitive factors in the enterprises. There are multiple definitions of flexibility within the research community and supply chain practitioners. This paper explores the concept of supply chain flexibility along five perspectives. The first perception considers supply chain flexibility as an extension of manufacturing flexibility while the second perception considers flexibility in relation to product complexity within the supply chain. The third notion of supply chain flexibility considers it as an extension of flexibility of individual nodes in the supply chain. The fourth perception of flexibility views the flexibility within supply chain in terms of the flexibility of choosing and managing the structural relationships. Finally, the fifth perception of supply chain flexibility considers it as a performance metric in the supply chain. The literature related to these perceptions of flexibility is collated to highlight the need of development of an integrated framework to exploit the supply chain flexibility for improving the supply chain performance.

Introduction

Supply chain flexibility is a relatively new area with a growing number of publications appearing during recent times. Literature indicates the existence of several definitions and perceptions on flexibility in the domain of manufacturing systems as well as supply chain systems. Wadhwa and Rao (2000) define flexibility as the ability to deal with change by judiciously providing and exploiting controllable options dynamically. The developments in manufacturing flexibility stimulated efforts on flexibility at the level of systems and enterprises as well. For example, Sushil (2000) defines flexibility as the exercise of free will or freedom of choice on the continuum to synthesize the dynamic interplay of thesis and antithesis in an interactive and innovative manner, capturing the ambiguity in systems and expanding the continuum with minimum time and efforts. Wadhwa and Rao (2003) examined the concept of flexibility in relation to the concept of agility, highlighted certain commonalities and differences and suggested a possible vision for future evolution of these two important concepts. Wadhwa and Browne (1989) defines the different action points in a flexible system.

Researchers as well as practitioners agree that, to be competitive in a dynamic business environment, supply chains must be sufficiently flexible. Hence, there is considerable interest to enrich this domain. However, there have been multiple perceptions of flexibility within the research community (see Figure 1). While some authors view supply chain flexibility in terms of manufacturing flexibility, several other authors view supply chain flexibility as an extension of

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the flexibility concept from individual entities to the entire supply chain. Many authors view flexibility as an important performance parameter of a supply chain, just like the time, cost, and quality. In addition, several authors view supply chain flexibility in terms of the product customization. A number of other authors view supply chain flexibility in terms of supply chain structural relationships. Supply chain flexibility is also being discussed in relation with product complexity that arises in the case of short life cycle products. For such products, IT is needed for quickly identifying the customer requirements, making suitable product designs and manufacturing the customized products. A firm in the downstream market can choose between irreversibly committing to an early order and postponing ordering until after better demand information is available. In our view, such growth in complexity in supply chain structures highlights the research and industry motivation to focus on supply chain flexibility. As complexity increases, a variety of outcomes become possible and a more detailed modeling would be required with a greater number of contingencies to deal with the added dimensions. This paper explores different perceptions of supply chain flexibility (shown in Figure 1).

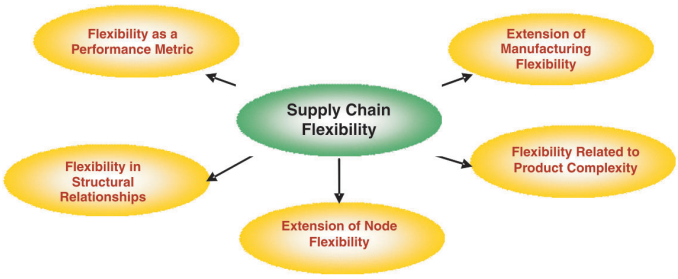

Figure 1: Some Perceptions of Supply Chain Flexibility

SCF as an Extension of Manufacturing Flexibility

Many of the publications on flexibility focus on the manufacturing flexibility dimension (Wadhwa and Rao 2003a). One of the most accepted frameworks for manufacturing flexibility is the framework proposed by Browne et al (1984). This framework identifies and defines eight types of manufacturing flexibilities: machine, routing, product, process, operation, volume, expansion and production flexibilities. The interrelationships among these flexibility types have also been identified in this framework. The flexibility in manufacturing environments, particularly computer integrated manufacturing systems (CIMS), can be intelligently exploited by judicious use of IT (Wadhwa and Rao 2000). In his research, Wadhwa (1988) suggested a focus on interaction delays caused by processes involving the control on flow of multiple entities. He also proposed three types of decision points linking the decision (direction of status change) and information (system status) to exploit available flexibility in flexible manufacturing systems. In a later work, Wadhwa and Aggarwal (1993) suggested flexibility, integration and automation as three key dimensions of computer-integrated systems based on this framework.

Wadhwa and Rao (2003) also highlight the importance of supply chain flexibility while proposeing an multiple entity flow perspective to understand and exploit different types of flexibilities within the supply chain. They view supply chain in terms of five entity flows: *information flow*, *decision flow*, *material flow*, *resource flow,* and *money flow*. In the this framework, shown in **Error! Reference source not found.**, information flow and decision flow were viewed as constituting the control system, which controls the material flow and resource flow. The information and decision flows meet at discrete points called the decision points, and the material and resource flows meet at discrete points called the action points. The decision points and the

action points interact with each other to ensure smooth functioning of the system.

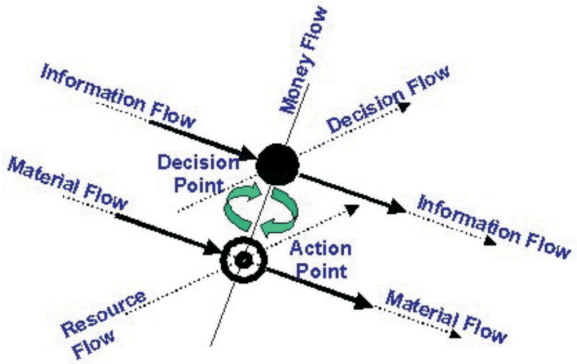

Figure 2 Multiple Entity Flow Perspective (Wadhwa and Rao 2003)

A number of authors consider supply chain flexibility as an extension of manufacturing flexibility. For instance, Koste and Malhotra (1999) feel that the presence or absence of manufacturing flexibility in supply chains and its relationship with performance should be explored and the effect of supply chain integration on the development of manufacturing flexibility in supply chains should be examined. Similarly, Duclos *et al.* (2001) argue that supply chain flexibility, which includes manufacturing flexibility, should further improve the performance of supply chain. In a recent work, Ozbayrak *et al.* (2006) highlight that flexible systems like MTO are required for meeting diverse and customized orders in a supply chain. These examples clearly highlight that the idea of the flexibility can be extended from the manufacturing domain into the supply chain domain, since the underlying concepts of manufacturing and supply chain flexibility are very similar.

SCF in Relation with Product Complexity

Supply chain flexibility is also being discussed in relation with product complexity that arises in the case of short life cycle products. In their survey, De Meyer *et al.* (1989) identified that product range flexibility is viewed as a core competence for competitive success by managers. Similarly, while reviewing the evolving business environment, Beamon and Ware (1998) observe that today's changing industry dynamics have influenced the design, operation and objectives of supply chain systems by increasing emphasis on flexibility of product customization to meet customer needs. However, this added flexibility may come at an additional investment costs and higher logistics cost, as identified by Randall and Ulrich (2001) while investigating a bicycle industry supply chain. Alshawi (2001) observes that flexibility to offer business partners the ability to make changes in their operations or products is more important than providing visibility over materials, information, and money. He mentions an example where the members of the potato-crisp supply chain might decide to produce potato sticks as an alternative snack food. Viswanath and Gilbert (2002) examine the trade-off between strategic commitment and operational flexibility as it arises in a supply chain when a supplier offers competing buyers opportunities to make early purchase commitments for a product with a short life cycle. In their model, a firm in the downstream market has two options: irreversibly committing to an early order and postponing the ordering until better demand information is available. Suppliers are able to manipulate the tradeoff between flexibility and strategic commitment by offering early purchasing opportunities.

In a recent work, Chandra *et al.* (2005) modeled a major automotive company in terms of

capacity planning, flexibility, and part commonality. Their experimental results showed that increasing level of flexibility and part commonality yielded improvements in production profitability. Similarly, Wu *et al.* (2007) assert that manufacturers and suppliers need to be flexible in the product range they offer and in the volumes they supply in order to adapt to uncertain and unpredictable changes from customers. This discussion brings out an important perception of flexibility as an option available to a customer.

SCF as an Extension of the Flexibility of Each Entity

Several authors view supply chain flexibility as an extension of the flexibility within individual supply chain nodes to the entire supply chain. For example, Taylor (2000) highlights the need for developing systems capable of coordinating the supply chains, while emphasizing flexible response in a supply chain. Chandra and Kumar (2000) feel that the agility realized through flexible organization is an important attribute for any enterprise. They feel that a flexible organization of a firm supports plant and distribution networks by achieving operational efficiency through quick line changeovers as well as savings realized by avoiding back hauling and enhanced product realization. Similarly, Simatupang et al (2002) observe that a firm needs to develop effective coordination within and beyond its boundaries in order to maximize the potential for converting competitive advantage into profitability. Along similar lines, Garavelli (2003) argues that networked enterprises like supply chains need coordination among many plants, which produce and deliver goods to customers located in different places, and suppliers, who provide each plant with the required components. The idea that the supply chain as a whole should work in a coordinated manner indicates an important direction of research.

SCF in Terms of Structural Relationships

A number of authors view supply chain flexibility in terms of supply chain structural relationships. For example, Jordan and Graves (1995) introduced the concept of 'chaining' as an effective flexibility strategy. They define a 'chain' as a group of products or plants, which are all connected, directly or indirectly, by product assignment decisions. Literature indicates that such complex supply chain structures may be a common feature in future. For example, Ritchie and Brindley (2000) predict that the extant linear supply chain relationship model that dominates most sectors will rapidly be replaced by a more amorphous supply chain relationship model. The amorphous relationship reflects that the structures may be difficult to map and they may be subject to a process of continuous change and reformulation depending on the strategies of the individual partners, both present and prospective. They suggested the ability to build flexible alliances quickly as a critical management skill required for these emerging business models. Similarly, while discussing the importance of buyer supplier relationships, Hoyt and Huq (2000), observe that buyer-supplier relationships play an important role in an organization's ability to respond to dynamic and unpredictable change. If the relationship is too restrictive, flexibility will be difficult to achieve. Some authors view supply chain flexibility as an ability to restructure the supply chain. For example, Mello (2001) views supply chain flexibility as the ability to restructure the system quickly and inexpensively. Similarly, Marquez and Blanchar (2004) consider flexibility regarding supplier contract in their paper. They have defined, characterized and simulated three generic types of supplier contracts to accomplish varying degrees of security and flexibility.

SCF as a Performance Metric in Supply Chains

A number of authors view flexibility as an important performance parameter of a supply chain, just like time, cost, and quality. For example, while discussing the appropriateness of various performance measures for supply chains, Beamon (1999) identified flexibility, perceived as how well the system reacts to uncertainty, as a vital component to supply chain success. They

argue that a supply chain performance measurement system must place emphasis on flexibility measures such as volume flexibility, delivery flexibility, mix flexibility and new product flexibility. However, they caution that each type of flexibility may not be appropriate for every supply chain. The work by Bruniaux (2000) considers flexibility as one of the important parameters for event management in supply chains. Similarly, while reviewing the evolving business environment in the context of supply chain management, Barratt and Oliveira (2001) observe that the battle commands of today are flexibility, speed, and productivity. Gunasekaran *et al.* (2001) also argue that flexibility should be an important metric for measuring supply chain performance. They argue that the previous research established a strong correlation of supply chain response time and flexibility. Hence, by defining flexibility as a metric and by evaluating it, companies can achieve what was previously impossible: rapid response to meet individual customer requirements. Similarly, Chan (2003) considered flexibility as one the seven performance metrics in their AHP based framework for supply chain performance measurement. Along the similar lines, Chan and Qi (2003), consider manufacturing flexibility, delivery flexibility, transport flexibility and order flexibility as some of the important constituents of supply chain performance measurement.

Some authors perceive supply chain flexibility as an essential requirement for functioning of supply chains in real life. For example, Lamming (1996) argues that for supply chain to function in a real situation, certain basic flexibility is necessary. This flexibility might take the form of 'time to think' or 'space to experiment'. He observes that a workforce which has no 'time to think' might not deliver innovation through suggestion schemes, and might dislike their jobs so much that their organization would derive no benefit from their motivation. While reviewing the role of supply chains in the economic development, Bateman (1998) emphasizes that dynamic, flexible and quality-conscious local supply chains are now considered a critically important feature in an industrial structure. He observes that, in Italy and Germany regional success largely came about because of the efficient operation of regionally based supply chains involving dynamic and highly flexible groups of small and medium-sized manufacturing enterprises. This clearly indicates that supply chains play an important role in economic development and they are of vital importance for developing countries.

Many authors have considered flexibility as an important parameter for designing supply chains decision support tools. For instance, Sadeh *et al.* (2001) also focused on flexibility as an important constituent in their reconfigurable agent based planning tool called MASCOT. Similarly, Janssen (2005) considered flexibility as an important parameter for improving supply chain responsiveness, while presenting a multi-agent system for supply chain management. Mangina and Vlachos (2005) considered flexibility as an important dimension in their agent-based framework for supply chain management and demonstrated that agents can enhance the flexibility in the supply chain. Along similar lines, Ding *et al.* (2005) developed a discrete event simulation package to achieve modeling flexibility and simulation efficiency, based on generic modeling and simulation framework for supply chain design. In a recent paper, Liu *et al.* (2007) exploited flexibility for modeling events and event rules for supply chain event management.

A number of authors view supply chain flexibility as a way of dealing with this growing complexity. For example, Hobbs and Young (2000) observe that supply chain complexity leads to transaction complexity. As complexity increases, a variety of outcomes become possible and a more detailed contract would be required with a greater number of contingencies to deal with the added dimensions of the transaction. They visualise that a strategic alliance, which allows sufficient flexibility in the relationship to deal with the complexities, should be a possibility. In the context of steel stock supply chain, McAdam and Brown (2001) consider flexibility as the ability to meet one-off needs. Similarly, Wu *et al.* (2007) are of the view that manufacturing

industry is suffering from an increasing requirement for more flexibility and agility to deal with the variety and uncertainty in the markets it serves. A supply chain should have enough built-in flexibility in order to handle such changes without the need for interrupting activities or major re-structuring. A number of authors discussed supply chain flexibility in relation to the concept of agility. Wadhwa and Rao (2003) provide a detailed literature review on the interrelationships between these two important concepts.

Some authors feel that increasing flexibility is not sufficient to cope with the variety and uncertainty inherent in the supply chain. For instance, Upton (1995 and 1997) observed that 40% of flexibility-improvement projects were unsuccessful due to 'failure to identify precisely what kind of manufacturing flexibility was needed, how to measure it, or which factors affected it most. Jordan and Graves (1995) found that offering limited flexibility yielded most of the benefits to be had from being flexible. Similarly, Garavelli (2003) proposed the adoption of limited flexibility to improve supply chain performance. They considered partial flexibility as a particular configuration of product assignments to plants and components to suppliers, which can yield many benefits without dramatically increasing the flexibility costs. In a recent work, Wu *et al.* (2007) observed that although flexibility or agility is widely accepted as a core competence in coping with variety and uncertainty, being flexible is not, by itself, the whole answer to coping with the variety and uncertainty inherent in a supply chain. They further suggest that adaptability of the suppliers to demand changes and adaptability achieved by implementing appropriate planning and scheduling procedures is essential. Figure 3 summarizes the role of promoting innovation and knowledge management to in the supply chain. These ideas can be improved the performance of supply chain and implemented in the industrial contexts. (Wadhwa and Saxena, 2006). They have discussed the web based supply chain and also promote the role of knowledge management in web based supply chain.

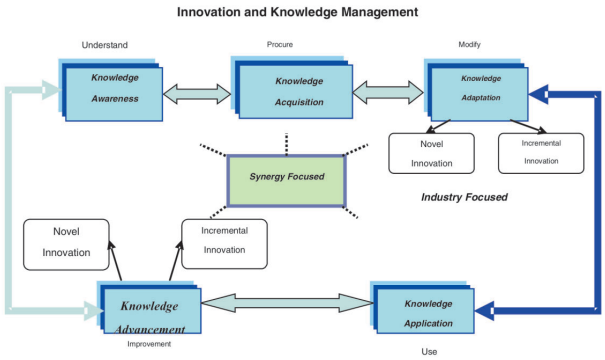

Figure 3: Vision for promoting innovation and KM in supply chain frameworks

Concluding Remarks

This paper discussed supply chain flexibility in terms of five different perceptions, as viewed by different researchers. Firstly, supply chain flexibility was viewed as an extension of manufacturing flexibility. Subsequent discussion focused on the flexibility in the supply chain, which is discussed as a method of dealing with product complexity. The view of supply chain flexibility as composed of the flexibilities within each entity within the supply chain was presented next. This was followed by a discussion on supply chain flexibility in terms of structural relationships within the supply chain. Finally, the role of flexibility as an essential component and as a performance metric of supply chain was presented. The paper clearly highlights the importance of flexibility in the supply chain framework. Hence, there is a need to model supply

chain framework with flexibility, which can give more profit, customer satisfaction etc. Simultaneously, the role of knowledge management is also very important and it will help to achieve the goals of the supply chain.

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