



Multi Dimensional Flexibility in Supply Chains: A Survey

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Abstract

Flexibility is a measure of competitiveness in today's fierce marketplace. A lot of literature pertaining to flexibilities from the manufacturing viewpoint is available. However there have been limited studies addressing supply chain flexibility as a whole. This paper tries to provide an insight into supply chain flexibility at different levels of hierarchy and echelons. Supply chain flexibility is viewed from different perspectives: functional aspects (flexibility in operations, marketing, and logistics), hierarchical aspects (flexibility at basic, system or aggregate level), and strategic aspects (centered on the strategic relevance of flexibility), time horizon aspects (long-term vs. short-term flexibility), echelon specific (upstream, downstream) and measurement aspects (range, response)

Key words: *Supply Chain Flexibility, Flexibility Dimensions, Multi echelon Flexibility*

1. Introduction

Flexibility is the capacity to adapt across four dimensions: temporal, range, intention, and focus (Ilyas et al., 2008). Being flexible can improve the company's competitiveness, particularly for the decision-making process of implementing technologies. Today's managers find that flexibility exists not only at the detailed level such as in machine flexibility, but also at the system level. In this broader context, flexibility in supply chain is the ability of the supply chain to adapt to changing situations. Supply chain flexibility incorporates those flexibility dimensions that directly impact a firm's customers and are the shared responsibility of two or more functions along the supply chain, whether internal (marketing, manufacturing) or external (suppliers, channel members) to the firm (Sanchez and Perez, 2005). This paper examines the role of flexibility at various levels of the supply chain.

2. Literature Review

When one considers flexibility from the functional perspective, researchers find that flexibility should be considered at every function related to supply chain. For example, in their study of manufacturing flexibility, Koste and Malhotra(1999) presented ten dimensions of flexibility: machine, labor, material handling, routing, operations, expansion, volume, mix, new product and modification. These dimensions cover most of the flexibilities internal to a manufacturing system. Similarly, Chang et al. [2001] proposed six dimensions of manufacturing flexibility: product, product mix, product modification, volume, delivery and service.

For the supply chain function, Sanchez and Perez, (2005) consider two main aspects of flexibility: process flexibility concerning the number of product types that can be manufactured in each production site (supplier or assembler); and logistics flexibility, related to the different logistics strategies which can be adopted either to release a product to a market or to procure a component from a supplier.

For the logistics function, Zhang et al. (2005) provide an excellent survey of literature on logistics flexibility and the impact of flexibility on customer satisfaction. For the sake of completeness, some of these are discussed below. Flexibility in logistics is the ability of a firm to respond efficiently to the needs of delivery, support, and services and includes movements within and between organizations (Ilyas et al, 2008; Van Hoek, 2001; Daugherty and Pittman, 1995). Coordination among various functions such as sourcing, making, and distribution enhances the company's ability to respond to market changes by eliminating redundant activities and reducing response time. This facilitates the seamless flow of demand information, supply materials, and finished goods (Fung and Wong, 1998; Juga, 1996; Krajewski and Wei, 2001).

Day (1994) distinguishes between two categories of flexibility in logistics: competencies and capabilities. According to him, flexibilities that directly affect the customer are capabilities whereas flexibilities that are not visible to the customer are competencies. He identifies physical supply flexibility and purchasing flexibility as competencies and physical distribution flexibility and demand management flexibility as capabilities. Physical supply flexibility involves flexibility in various logistic processes that take place before or during the production process such as inbound transportation, material warehousing, and inventory control (Ernst and Whinney, 1987; Langley and Holcomb, 1992; Zhang et al., 2002). Purchasing ability refers to the ability of a firm to buy materials and supplies quickly and effectively by building cooperative relationships with suppliers. Manufacturers are aware of supplier's capabilities, and they seek cooperative relationships with suppliers based on a high level of coordination, participation, and close communication (Day, 1994; Krajewski and Wei, 2001; Zhang et al., 2002). Physical distribution flexibility deals with inventory, packaging, warehousing, and transportation of physical products to meet customer needs, quickly and effectively (Zhang et al., 2002). Porter (1985) calls it outbound logistics flexibility. Strategic responses are based on physical distribution flexibility as it directly affects the customers. Demand management flexibility is the ability of a firm to effectively respond to customer needs for service, deliver time, and price. Such data mining is an information-intensive and market-sensing activity that must meet demands quickly by creating and managing close customer relationships (Day, 1994; Zhang et al., 2002; Lee, 2001). To achieve this, firms foster direct customer contact, collect information about customer needs, and use customer-supplied information to design and deliver products and services (Schneider and Bowen, 1995). As customer sophistication and knowledge increase, their

attention to detail and ability to articulate gaps between expectations and experiences improves (Lengnick-Hall, 1996).

Flexibility can also be considered from the view point of hierarchy. Sanchez and Perez(2005) propose a conceptual model in which three dimensions of flexibility are viewed hierarchically: flexibility at shop, plant and company level. Further detailing of flexibility at different levels has been done by several researchers. Product flexibility is the ability to handle difficult, non-standard orders, to meet special customer specifications, and to produce products characterized by numerous features, options, sizes, and colours Vickery et al. (1997). Volume flexibility is the ability to effectively increase or decrease aggregate production in response to customer demand (Cleveland et al., 1989). Volume flexibility directly impacts supply chain's performance by preventing out-of-stock conditions for products that are suddenly in high demand or by preventing high inventory levels. Routing flexibility is the capability of processing a part through varying routes by using alternative machines, flexible material handling, and flexible transporting network; this flexibility reduces the negative impact of environmental uncertainty and unforeseen inefficiencies in the production process (Gupta and Buzacott, 1989). Delivery flexibility help to adapt lead times according to the customer requirements; an example of high delivery flexibility is JIT, where suppliers deliver the products to the customer at the right quantity, place and time. Transshipment flexibility involves movement of stock between locations at the same echelon level where physical distances between the demand locations and the supply locations are small (Barad and Sapir, 2003). Postponement flexibility is the ability to keep products in their generic form as long as possible, in order to incorporate the customer's product requirements in later stages (Barad and Sapir, 2003). Sourcing flexibility is the company's ability to find suppliers for each specific component or raw material. This would reduce the risk of dependency on one particular supplier. Response flexibility captures the overall ability of the firm to respond to the needs of its customers (McDonald, 1993). Launch flexibility is the ability to rapidly introduce new products and varieties is a strategic decision that requires the integration of numerous value activities across the entire supply chain. Access flexibility is the ability to provide widespread or intensive distribution coverage for customer satisfaction. Close coordination of internal or external downstream activities in the supply chain is needed.

Duclos et al.(2003) find that flexibility in the supply chain has six components. These are as follows:

(a) Operations system flexibility is the ability to react efficiently to changing customer needs of product, volume, and mix by configuring operations accordingly. (b) Market flexibility is the ability to customize, modify, design products according to customer needs. (c) Logistics flexibility is the ability to receive supplies from vendors and deliver product to customers in a cost effective way in a dynamic environment when the suppliers and customers keep changing. (d) Supply flexibility is the ability to match customer demand by adjusting the supplies of product. It involves building relationships with suppliers and channel members. (e) Organizational flexibility is the ability to meet customer requirements by managing human resources, labor force. (f) Information systems flexibility is the ability to configure information systems with the changing technology, information needs of the organization.

Though substantial work has been done on deterministic aspects (such as production and distribution systems) of a supply chain, and also the stochastic aspects (such as inventory safety

stock decisions) not much work appears to have been done on the importance of flexibility at different echelons of the supply chain and its advantages in competitive positioning.

Ilyas et al. (2008), suggest that upstream flexibility in the supply chain is the capability of the supply chain to fill distribution centers from plants. Thus, if all plants can supply all distribution centers all the items in the product portfolio, the supply chain has complete upstream flexibility. Similarly, downstream flexibility is defined as the capability of the supply chain to ship products from the distribution center to the market (regional warehouses or the retailer).

Hyun and Ahn (1992) define strategic flexibility as the ability of firms to reposition themselves in a market, change their game plans, or dismantle their current strategies when the customers they serve are no longer as attractive. Conventionally, the decisions at strategic level drive the decisions at operational level. But some decisions may be dependent and may drive each other. Kumar et al. (2008) suggest that flexibility enablers at the strategic level include: rerouting flexibility, warehousing and distribution flexibility, flexibility to delay product differentiation, flexibility in demand variation, and flexibility in currency value.

Flexibility can also be viewed along a time dimension. While short term flexibility is the capability to deviate from a standard way of working, long term flexibility implies changing the standard way of working. If a system can change in short period of time to adapt to the environment, it has short term flexibility. When a system is built so as to adapt to long time frame changes it is said to have long term flexibility. For example, adapting to machine failure is short term flexibility whereas adapting to changes in market, regulations and technology can be put under long term flexibility. An important long-term flexibility is the product mix flexibility, which is the ability to provide a variety of products/ services with the same system architecture.

The two most agreed upon dimensions for measuring flexibility of any type are range and response (Gerwin, 1993; Upton, 1994). Range is a measure of the number of available alternatives for a system to operate. It is measured by counting the number of options available or by a normalized index. The response dimension measures the easiness with which the system adapts to the changes and is measured in terms of the reaction time (or cost) needed to respond to the change that occurred.

Slack (1990) addressed flexibility in a production context and examined how it can be measured. Slack argued that flexibility has three dimensions (quoted by Ilyas et al., 2008): (1) range of states the system can adopt; (2) cost of moving from one state to another; and (3) time required to move from one state to another. Slack also argues that perhaps there is no single measure of flexibility because it is ultimately a measure of the systems potential to perform rather than its actual performance.

Ramasesh and Jayakumar (1991) propose an approach in which flexibility is measured by the ability of a manufacturing system to generate revenues consistently across all states. Their measure of flexibility is the ratio of the mean to the standard deviation of revenues.

3. Discussions

A study of available literature indicates that though a lot of work has been done on manufacturing flexibility, limited literature is available on supply chain flexibility. Researchers offer different perspectives on flexibility, and suggest different dimensions of flexibility at various echelons, and hierarchy levels. Thus, there appears to be no consensus on the appropriate metrics of flexibility that can exist in the supply chain. There are related issues, for example, determining the “right” amount of flexibility, cost (and payoffs) of designing flexibility into the system, deciding upon some measure of aggregate system flexibility, and monitoring of the usage of flexibility in implementation.

4. Conclusions

This paper tries to provide an insight into supply chain flexibility at different levels and stages. Supply chain flexibility is viewed at the following levels: functional aspects, hierarchical and echelon aspects, strategic aspects, time horizon aspects, and measurement aspects. The views of several authors have been captured and an attempt has been made to find a coherent view of flexibility in supply chain. The flexibility concepts that are presented in this paper are generic in nature and do not pertain to any particular sector or industry.

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