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Competitive Advantage of a Firm through Supply Chain Responsiveness and SCM Practices

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Ashish A. Thatte

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the Doctor of Philosophy Degree in
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Co-Chair: Dr. S. Subba Rao

Co-Chair: Dr. T.S. Ragu-Nathan

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ProQuest Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346

Committee Members,

Signature   Date of Signature

Dr. Anthony C. Koh
Associate Professor of Marketing
and International Business
College of Business Administration
The University of Toledo

Dr. Robert A. Bennett
Professor of Mechanical,
Industrial and Manufacturing Engineering
The University of Toledo

An Abstract of

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Today's business environment is more global and competitive than it has been in the past. The modern business is characterized with shorter product life cycles, rapid new product introductions, increasingly knowledgeable, well informed, and sophisticated customers. This forces supply chains to be more responsive. The modern supply chains are thus expected to respond rapidly, effectively, and efficiently to changes in the marketplace so as to sustain, and furthermore create competitive advantage. Most studies so far have focused on the organizational level manufacturing flexibility or agility. It is therefore of interest to study the responsiveness of supply chains.

This research studies the impact of various supply chain management (SCM) practices - external to the organization - and modularity based manufacturing practices - within the organization - on supply chain responsiveness. The study, further investigates the dimensions of supply chain responsiveness through an extensive literature review. It develops a reliable and valid instrument for the supply chain responsiveness construct, which will be beneficial for both practitioners and academicians. The study also assesses the impact of supply chain responsiveness on the outcome variable - competitive advantage - of the firm.

The large scale web-based survey yielded 294 responses from industry professionals in the manufacturing and supply chain area. The data collected was put through rigorous statistical analysis to test for content, construct, and criterion-related validity, as well as reliability analyses. Further a structural equation model was developed to test the relationships between SCM practices, modularity based manufacturing practices, supply chain responsiveness, and competitive advantage. In addition, rigorous regression analyses and MANOVA were performed to analyze the effects of various relationships at the sub-construct level as well as item level.

The research findings supported the hypotheses that SCM practices positively impact supply chain responsiveness, modularity based manufacturing practices are positively associated with supply chain responsiveness, supply chain responsiveness positively impacts competitive advantage of a firm, and SCM practices are positively associated with competitive advantage of a firm.

The research also found that ‘dynamic teaming’ and ‘process modularity’ practices were most influential in increasing operations system responsiveness, supplier network responsiveness, and the overall supply chain responsiveness. Further, effective relationships with customers and suppliers were found to positively influence a firm’s ability to be operationally responsive. In addition, effective relations with suppliers, and information sharing with trading partners in a supply chain were found to directly and positively lead to increased supplier network responsiveness. Furthermore, customer relationship and strategic supplier partnership practices, and operations system responsiveness and supplier network responsiveness were most influential in increasing the overall competitive advantage of a firm. The study found that higher level of operations system responsiveness creates higher level of competitive advantage for a firm, collectively based on low price, high delivery dependability, high product innovation, and low time to market, as well as individually on each of the said dimensions. Also, it was uncovered that higher level of supplier network responsiveness creates higher level of competitive advantage for a firm, collectively based low price and high delivery dependability as well as individually on each of the said dimensions.

The research also uncovered the critical and specific practices (at the item level) that increase supply chain responsiveness. Furthermore, the study uncovered the specific SCM practices and supply chain responsiveness criteria that increase competitive advantage of a firm.

This research has some important implications for practitioners. This research provides suitable recommendations on the scope for improvement based on current levels of various specific SCM and modularity based manufacturing practices that directly impact supply chain responsiveness and its dimensions. Also the study provides suitable recommendations on the scope for improvement based on current levels of various predominant SCM practices and supply chain responsiveness criteria that directly impact competitive advantage of a firm, so as to make the organizations more competitive.

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CHAPTER 1: INTRODUCTION

In the new global era successful firms are those that accurately anticipate market trends and quickly respond to changing customer needs (Stalk et al., 1992). According to Towill and Christopher (2002), the end customer in the marketplace determines the success or failure of supply chains. They further state that "getting the right product, at the right price, at the right time to the consumer is not only the linchpin to competitive success but also the key to survival" (p. 299). Chase et al. (2000) contend that in the new global era companies are forced to find flexible ways to meet customer demand. The companies these days focus on optimizing their core activities so as to maximize the speed of response to customer demand. With increasingly sophisticated customer demand (product variety and customization) (Yang and Burns, 2003), and recent events of supply disruptions (Lee, 2004; Christopher and Peck, 2004; Gosain et al., 2004), supply chains have to be responsive to constantly changing market and business environment. It is thus incumbent on managers and researchers to strive for a better understanding of the responsiveness construct.

Today's highly competitive environment in which the manufacturing firms operate is characterized by growing world competition and increasingly demanding customers (Rich and Hines, 1997). Sparks and Fernie (1998) and Jones (2002) state that these dynamics are especially observed in the fashion and clothing retail industry (as cited in Storey et al., 2005, p. 242). Further, as the new competitive environment changes to more global, technologically oriented and customer driven, as product life cycles shrink and new products get introduced rapidly, as customers continually demand higher quality, faster response, and greater reliability of products and services (D' Souza, 2002), the new world market demands a more customer responsive behavior by companies. Womack and Jones (1996) argue that these pressures have fueled a continuous change process within organizations, impacting all the areas of a business, from rapid technological changes, to a much shortened product life cycle. They further state that since the late 1990s change and uncertainty surrounding manufacturing organizations and their supply chains grew. Firms have responded with innovative products and improved manufacturing processes to manufacture products. Sabath (1998) argues that supply chains need to be managed in a way that enables quick response, so as to cope with volatile demand. The underlying factor is the need to focus on time, flexibility, and speed of response of the supply chain to succeed in this increasingly global marketplace thereby creating competitive advantage for the firm (Stalk and Hout, 1990; Vokurka and O'Leary-Kelly, 2000; D' Souza and Williams, 2000; Suarez et al., 1995; Duclos et al., 2003; Gattorna, 1998; Pine, 1993; Goldman et al., 1995; Christopher, 1998). Vokurka and Fliedner (1998) suggest that this new environment calls for organizations to be more responsive to customer needs. Supply chain flexibility refers to the ability of the supply chain to adapt to internal or external influences, whereas supply chain responsiveness is the ability of the supply chain to rapidly address (speed combined with flexibility) changes and requests in the marketplace. Thus modern supply chains are expected to respond rapidly, effectively, and efficiently to customer demand (Towill, 1996; Duclos et al., 2003) so as to create competitive advantage in terms of increased quality, lower costs, reduced time to market, and product innovation (Henke et al., 1993; Aquilano et al., 1995). Narasimhan and Das (1999) concur by proposing that in the late 20th century, firms in the pursuit of competitive differentiation consider cost and quality as market entry qualifiers, whereas responsiveness and lean manufacturing are considered as order winners.

Most studies so far have focused on the organizational level manufacturing flexibility or agility. It is widely argued that competition is no longer between individual organizations but between supply chains (Christopher, 1992; Li et al., 2005; Vastag et al., 1994; Christopher and Peck, 2004; Academic Alliance Forum, 1999; Pelton et al., 1997). Lummus and Vokurka (1999) state that successful companies are those that manage across all nodes of the supply chain from their supplier's supplier to their customer's customer. It is therefore of interest to study the responsiveness of a group of organizations working together or widely called as supply chain.

Supply chain responsiveness literature is highly normative and conceptual with research studies primarily being based on case studies (Holweg, 2005; Storey et al., 2005), with little empirical research in the field of supply chain responsiveness. With this said the empirical study of supply chain responsiveness is very much called for. Since the significance of supply chain responsiveness in today's business world is presented, it is now of interest to understand what kinds of practices are called for within and between organizations in order to achieve supply chain responsiveness. Numerous studies emphasize the importance of integrating suppliers, manufacturers and customers (Frohlich and Westbrook, 2001; Clinton and Closs, 1997) (i.e. supply chain management) so as to attain flexibility and speed. It is expected that the current research, by addressing

SCM practices that contribute towards responsiveness, will help researchers better understand the scope and activities associated with SCM that create enhanced levels of supply chain responsiveness in today’s competitive marketplace, and which has not been empirically tested in past studies. Further, as uncertainty in markets and technology intensifies, more companies are adopting modular product and process architectures (i.e. modularity based manufacturing practices) to cope with increasing demand uncertainty (Tu et al., 2004). Modularity based manufacturing practices is defined as the application of unit standardization or substitution principles to product design, production process design and organizational design (Tu et al., 2004; Ulrich, 1995; Tu, 1999). Many empirical questions regarding the managerial and organization implications of modularity-based manufacturing are left unanswered (Ulrich, 1995). Thus it is of interest to explore the influence of modularity-based manufacturing practices on a supply chain’s ability to be responsive. Again, this has not been empirically tested before and would be interesting to study.

This study thus aims at studying the effect of various supply chain management (SCM) practices - external to the organization - and modularity based manufacturing practices - within the organization – on supply chain responsiveness. This study therefore aims at filling the gap in the literature on supply chain responsiveness by empirically testing the effect of various practices between and within organizations, on the supply chain responsiveness.

As it is of interest to study various factors on an outcome variable that is of practical importance to businesses, competitive advantage is the one that is of prime importance to survive and thrive in today’s high paced business environment. The study thus also assesses the impact of supply chain responsiveness on the outcome variable - competitive advantage - of the firm. The purpose of this study is therefore to empirically test a framework identifying the relationships among SCM practices, modularity based manufacturing practices, supply chain responsiveness, and competitive advantage.

This study builds the construct supply chain responsiveness based on prior literature in: manufacturing and supply chain flexibility, manufacturing and supply chain agility, and customer responsiveness. As in any empirical study, it will not be possible to test a relationship without valid and reliable measurement instruments for the constructs involved in the relationships. Therefore a contribution of the current research is the development of a valid and reliable instrument for the supply chain responsiveness construct. The measurement instruments for the SCM practices (Li et al., 2005, Li et al., 2006), modularity based manufacturing practices (Tu et al., 2004), and competitive advantage (Koufteros et al., 1997; Koufteros, 1995) in the proposed model are adopted with modifications from earlier studies. The newly developed instruments are then tested empirically, using data collected from respondents to a survey questionnaire. Structural equation modeling is used to test the hypothesized relationships.

Further, by offering a validated instrument to measure supply chain responsiveness, and by providing empirical evidence of the impact of SCM and modularity based manufacturing practices on supply chain responsiveness and competitive advantage, it is expected that this research will offer a useful guideline for measuring and improving supply chain responsiveness and competitive advantage, thus facilitating further research in this area.

The study is driven by the following research questions:

1. How do the SCM practices of a firm influence supply chain responsiveness?
2. How do modularity based manufacturing practices of a firm impact supply chain responsiveness? and
3. How does supply chain responsiveness affect competitive advantage of a firm?

The structure of this study is as follows: Chapter 2 is the literature review on the theoretical foundation and various constructs of the study. The overall framework that depicts the relationships between the constructs and the development of hypotheses are presented in Chapter 3. The research methodology for generating items for measurement instruments appears in Chapter 4. This methodology includes pre-testing with practitioners and academicians, a pilot study using the Q sort method. Large-scale survey, reliability, and validity results are reported in Chapter 5. In Chapter 6, the results of hypotheses testing are shown, using structural equation modeling methodology. Chapter 7 includes detailed dimension level analyses (at sub-construct and item levels) to gain ample insight into relationships between various practices, supply chain responsiveness, and competitive advantage components. Finally, Chapter 8 concludes with the summary of research findings and major contributions, implications for managers and researchers, limitations of the research, and recommendations for future research.

CHAPTER 2: LITERATURE REVIEW

2.1 Supply Chain Management

The Council of Supply Chain Management Professionals (CSCMP) (2004), (formerly The Council of Logistics Management (CLM)), a leading professional organization promoting SCM practice, education, and development, defines SCM as: "SCM encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities, including coordination and collaboration with suppliers, intermediaries, third-party service providers, and customers" (Thus the supply chain encompasses all activities involved in the production and delivery of a final product or service, from the supplier's supplier to the customer's customer). In essence, supply chain management integrates supply and demand management within and across companies (www.cscmp.org). CSCMP emphasizes that SCM encompasses the management of supply and demand, sourcing of raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, and distribution and delivery to the customer. Cooper et al. (1997) define SCM as the management and integration of the entire set of business processes that provides products, services and information that add value for customers.

Several authors have defined supply chain management. Christopher (1998), New and Payne (1995), and Simchi-Levi et al. (2000) define supply chain management as “the integration of key business processes among a network of interdependent suppliers, manufacturers, distribution centers, and retailers in order to improve the flow of goods, services, and information from original suppliers to final customers, with the objectives of reducing system-wide costs while maintaining required service levels” (as cited in Stapleton et al., 2006, p. 108). The Global Supply Chain Forum (GSCF) defines supply chain management as “the integration of key business processes from end user through original suppliers, that provides products, services, and information that adds value for customers and other stakeholders” (as cited in Lambert et al., 1998, p. 1). The APICS dictionary (1995) describes SCM as – “the processes from initial raw materials to the ultimate consumption of the finished product, linking across supplier-user companies”.

A supply chain is a network of organizations performing various processes and activities to produce value in the form of products and services for the end customer (Christopher, 1992). SCM concerns the integrated and process-oriented approach to the design, management and control of the supply chain, with the aim of producing value for the end customer, by both improving customer service and lowering cost (Bowersox and Closs, 1996; Giannoccaro and Pontrandolfo, 2002).

Lummus and Vokurka (1999) summarize SCM as “all the activities involved in delivering a product from raw material through to the customer, including sourcing raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels, delivery to the customer, and the information systems necessary to monitor all of these activities” (p. 11).

According to Li et al. (2006) the dual purpose of SCM is to improve the performance of an individual organization as well as that of the entire supply chain. CLM definitions clearly establish that SCM is more broadly conceived than merely "logistics outside the firm" (Lambert, 2004; Lambert et al., 1998, p. 2). Recent research supports this conception, portraying SCM as a strategic level concept (Stank et al., 2005). Mentzer et al. (2001) consider SCM as a systemic, strategic coordination of business functions within an organization and between organizations within the supply chain, for improving the long-term performance of individual companies and the supply chain as a whole. The emphasis of each of these definitions is on the objective of SCM to create a distinctive advantage by maximizing the total value of products and services (Stank et al., 2005).

SCM is a discipline in the early stages of evolution (Gibson et al., 2005). SCM gives a concrete form to the so called “business ecosystem idea” and provides a framework of processes for firms to engage in co-existence rather than competition (Bechtel and Jayaram, 1997). Consultants proposed the term and educators proposed the structure and theory for executing SCM. The term "supply chain management" first appeared in 1982. Around 1990, academics first described SCM from a theoretical point of view to clarify the difference from more traditional approaches and names (such as logistics), to managing material flow and the associated information flow (Cooper et al., 1997). Cooper et al. (1997) provide a valuable review of 13 early SCM definitions: a solid argument that SCM and logistics are not identical. The term supply chain management has grown in popularity over the past two decades, with much research being done on the topic. SCM is widely being talked about in various journals and magazines related to manufacturing, distribution, marketing, customer management, or transportation (Ross, 1998).

Furthermore, Lummus and Vokurka (1999) add that SCM links all the departments within an organization as well as all its trading partners (viz: suppliers, customers, 3PL providers, and information systems providers). There is mutual collaboration and companies work together to make the whole supply chain competitive. Information technology is widely used to share information and generate demand forecasts. The underlying idea in SCM is that the entire process must be viewed as a single system. The core competencies of individual organizations are determined and are cashed on, to create enhanced competitive advantage for the supply chain.

By the 1990s, firms recognized the necessity of collaboration with suppliers and customers in order to create superior customer value. This movement titled supply chain management or value chain management shifted a company’s focus from within an enterprise to managing across firm boundaries.

Boddy et al. (1998) found that more than half of the respondents to their survey considered that their organizations had not been successful in implementing supply chain partnering; Spekman et al. (1998), noted that 60% of supply chain alliances tended to fail. Deloitte Consulting survey reported that only 2% of North American manufacturers ranked their supply chains as world class although 91% of them ranked SCM as important to their firm’s success (Thomas, 1999). Thus, while it is clear that SCM is important to organizations, effective management of the supply chain does not appear to have been realized.

Bowersox and Closs (1996) argued that to be fully effective in today's competitive environment, firms must expand their integrated behavior to incorporate customers and suppliers. This extension of integrated behaviors, through external integration, is referred to by Bowersox and Closs (1996) as supply chain management. In this context, the philosophy of SCM turns into the implementation of supply chain management: a set of activities that carries out the philosophy. This set of activities is a coordinated effort called SCM between the supply chain partners, such as suppliers, carriers, and manufacturers, to dynamically respond to the needs of the end customer (Greene, 1991).

Thus SCM integrates both information flow and the flow of goods seamlessly between trading partners as an effective competitive weapon (Childhouse and Towill, 2003; Feldmann and Muller, 2003). SCM has been receiving increased attention from all fronts, namely academicians, consultants, and business managers (Tan et al., 2002; Croom et al., 2000; Van Hoek, 1998) since the early 1990s. Organizations have recognized that SCM is the key to building sustainable competitive edge (Jones, 1998) in the 21st century. SCM has been widely talked about in prior literature from various viewpoints (Croom et al., 2000) such as purchasing, logistics/distribution/transportation, operations and manufacturing management, organizational behavior, and management information systems. Industrial organization and transaction cost analysis (Ellram, 1990; Williamson, 1975), resource-based and resource-dependency theory (Rungtusanatham et al., 2003), competitive strategy (Porter, 1985), and social–political perspective (Stern and Reve, 1980) are some of the aspects of SCM that have been discussed in past literature. However, in spite of the increased attention paid to SCM, the literature has not made a significant contribution to aid the practice of SCM (Cigolini et al., 2004) and to respond to environmental uncertainty on supply and demand sides of the supply chain. Due to its interdisciplinary origin and evolutionary nature, there is no generally accepted definition of SCM in literature (Feldmann and Muller, 2003).

The concept of SCM has been studied from two perspectives, namely purchasing (supply management), and logistics (transportation, distribution, warehousing, and inventory management) (Tan et al., 1998). According to the purchasing perspective, SCM is synonymous with supplier integration and has evolved from traditional purchasing and materials functions (Banfield, 1999; Lamming, 1993). From the logistics management perspective, SCM is synonymous with distribution, logistics, inventory management, and customer relationships (Alvarado and Kotzab, 2001; Bechtel and Jayaram, 1997; Romano and Vinelli, 2001; Rudberg and Olhager, 2003; Van Hoek, 1998). In due course, these two perspectives evolved into one single philosophy of SCM with integrated systems, processes, and practices between trading partners.

To better understand the influence of SCM practices and modularity based manufacturing practices on supply chain responsiveness, and the effect of supply chain responsiveness on competitive advantage, four constructs have been identified through a comprehensive literature review. A research framework is then developed that depicts the various causal relationships between these constructs.

The four proposed constructs in the model include: 1) *SCM Practices:* “A set of activities undertaken by an organization to promote effective management of its supply chain” (Li et al., 2006, p. 108); 2) *Modularity Based Manufacturing Practices:* The application of unit standardization or substitution principles to product design, production process design and organizational design (Tu et al., 2004); 3) *Supply Chain Responsiveness:* The capability of promptness and the extent to which the supply chain addresses changes in customer demand; 4) *Competitive Advantage:* "The extent to which an organization is able to create a defensible position over its competitors" (Li et al., 2006, p. 111). Table 2.1.1 summarizes these constructs and their literature basis.

Table 2.1.1 Construct Definitions and Literature Support

Constructs	Definitions	Literature
SCM Practices	"A set of activities undertaken by an organization to promote effective management of its supply chain" (Li et al., 2006, p. 109)	Li et al., 2005; Tan 2001; Monczka et al., 1998; Balsmeier and Voisin, 1996; Noble, 1997; Sheridan, 1998; Zielke and Pohl, 1996; Walton, 1996; Donlon, 1996; Tan et al., 1998; Alvarado and Kotzab, 2001
Modularity Based Manufacturing Practices	The application of unit standardization or substitution principles to product design, production process design and organizational design	Tu et al., 2004; Ulrich, 1995; Tu, 1999
Supply Chain Responsiveness	The capability of promptness and the degree to which the supply chain can address changes in customer demand	Holweg, 2005; Prater et al. 2001; Lummus et al., 2003; Duclos et al., 2003
Competitive Advantage	"The capability of an organization to create a defensible position over its competitors" (Li et al., 2006, p. 111)	Porter, 1985; McGinnis & Vallopra, 1999; Tracey et al., 1999; White, 1996; Skinner, 1985; Roth and Miller, 1990; Koufteros et al., 1997; Cleveland et al., 1989; Safizadeh et al., 1996; Vickery et al.,1997; Solis-Galvan, 1998; Rondeau et al., 2000

All the constructs are higher-level constructs and are represented by several sub-constructs. SCM practices includes three sub-constructs (strategic supplier partnership, customer relationship, and information sharing; modularity based manufacturing practices contains three sub-constructs (product modularity, process modularity, and dynamic teaming); supply chain responsiveness comprises of (operations system responsiveness, logistics process responsiveness, and supplier network responsiveness); competitive advantage is represented by five sub-constructs (price, quality, delivery dependability, time-to-market, and product innovation). For descriptive purpose, all of them, including high-level constructs and sub constructs, are called constructs in later discussion.

We first define and discuss these constructs. The following section will present a detailed review of existing literature concerning each of the four constructs proposed above. In the next chapter, five research hypotheses are then developed based on this review.

2.2 SCM Practices

'SCM practices' is defined as "the set of activities undertaken by an organization to promote effective management of its supply chain" (Li et al., 2006, p. 109).

Li et al. (2005, 2006) proposed 'SCM practices' as a multi-dimensional construct that includes both upstream and downstream sides of the supply chain. Donlon (1996) considered outsourcing, supplier partnership, information sharing, cycle time compression, and continuous process flow, as SCM practices. Tan et al. (1998) used quality, purchasing, and customer relations to represent SCM practices, in their empirical study. Alvarado and Kotzab (2001) focused on inter-organizational system use, core competencies, and elimination of excess inventory through postponement, as SCM practices. Using factor analysis, Tan et al. (2002) identified: supply chain integration, information sharing, customer service management, geographic proximity, and JIT capability, as the key aspects of SCM practice. Lee (2004) in his case study based research identified five practices at the supply chain level that are a key to creating supply chain responsiveness. They are: outsourcing, strategic supplier partnerships, customer relationships, information sharing, and product modularity. Chen and Paulraj (2004) used long-term relationship, cross-functional teams, supplier base reduction, and supplier involvement. Min and Mentzer (2004) identified long-term relationship, information sharing, vision and goals, risk and award sharing, cooperation, process integration, and supply chain leadership underlying the concept of SCM. Li et al. (2005, 2006) identified strategic supplier partnership, customer relationship, and information sharing as key SCM practices. This study adopts the same practices (viz: strategic supplier partnership, customer relationship, and information sharing) as sub-constructs for the SCM practices construct. Li et al. (2005) developed a valid and reliable instrument to measure SCM practices. The same instrument has been adopted in this study. Thus the literature depicts SCM practices from different perspectives with a common goal of improving organizational performance. In reviewing and consolidating the literature, three distinct dimensions of SCM practice that are perceived to lead to supply chain responsiveness, have been identified. These are strategic supplier partnership, customer relationship, and information sharing.

This study aims at studying the effect of supply chain responsiveness on competitive advantage of a firm by the implementation of a set of SCM practices - by an organization.

SCM has been supported as a strategic level concept in prior literature (Bowersox et al., 1999; Cooper et al., 1997; Mentzer, 2001), with a “multi-firm focus” on creating competitive advantage “by maximizing the total value delivered to end-customers” (Defee and Stank, 2005, p. 30). Supply chain responsiveness focuses on not just creating value but maintaining the value or customer service level by being responsive to any turbulence or uncertainty on both sides of the value chain (i.e. supply as well as demand). This study focuses only on the customer side turbulence.

Table 2.2.1 lists the three dimensions of SCM practices along with their definitions and supporting literature.

Table 2.2.1 List of Sub-Constructs for SCM Practices

Constructs	Definitions	Literature
Strategic Supplier Partnership	“The long-term relationship between the organization and its suppliers. It is designed to leverage the strategic and operational capabilities of individual participating organizations to help them achieve significant ongoing benefits” (Li et al., 2006, p. 109)	Li et al., 2005; Gunasekaran et al., 2001; Balsmeier and Voisin, 1996; Monczka et al., 1998; Noble, 1997; Stuart, 1997; Lamming, 1993; Sheridan, 1998; Tan et al., 2002
Customer Relationship	“The entire array of practices that are employed for the purpose of managing customer complaints, building long-term relationships with customers, and improving customer satisfaction” (Li et al., 2006, p. 109)	Li et al., 2005; Moberg et al., 2002; Aggarwal, 1997; Claycomb et al., 1999; Tan et al., 1998; Wines, 1996; Noble, 1997; Magretta, 1998, Day, 2000
Information Sharing	“The extent to which critical and proprietary information is communicated to one’s supply chain partner” (Li et al., 2006, p. 110)	Li et al., 2005; Monczka et al., 1998; Mentzer et al., 2000b, Stein and Sweat, 1998, Yu et al., 2001; Towill, 1997; Balsmeier and Voisin, 1996; Jones, 1998; Lalonde, 1998; Vokurka and Lummus, 2000; Lancioni et al., 2000; Ballou et al., 2000.

Strategic supplier partnership is defined as "the long term relationship between the organization and its suppliers. It is designed to leverage the strategic and operational capabilities of individual participating organizations to help them achieve significant ongoing benefits" (Li et al., 2006, p. 109). Gunasekaran et al. (2001) assert that a strategic partnership emphasizes long-term relationship between trading partners and "promotes mutual planning and problem solving efforts" (as cited in Li et al., 2006, p. 109). Strategic partnerships between organizations promote shared benefits and ongoing collaboration in key strategic areas like technology, products, and markets (Yoshino and Rangan, 1995). Strategic partnerships with suppliers facilitate organizations to work closely and effectively with a few suppliers rather than many suppliers that have been selected solely on the basis of cost. Some of the advantages of including suppliers early in the product-design process as mentioned by Tan et al. (2002) are that suppliers can offer cost effective design alternatives, assist in selecting better components and technologies, and aid in design assessment.

Porter (1980) suggested that co-operation can enable partners to achieve a stronger position together than they can alone.

Globalization (includes global sourcing) has forced companies to manage their supply, manufacturing, and logistics more effectively. Mentzer et al. (2001) suggests that the key to effective management in the global environment is to have closer relationships with suppliers. Cooperation among the supply chain members is required for effective SCM (Tyndall et al., 1998; Boddy et al., 2000; Ellram and Cooper, 1990).

The past two decades have seen an increasing trend in long term, collaborative relationships by organizations with a few trusted suppliers (Anderson et al., 1994;

Wilkinson and Young, 1995; Ford, 1990; Sheth, 1996; Sheth and Sharma, 1997). Kalwani and Narayandas, (1995) add that firms are moving from the traditional approach of a one time cost based relationship with many suppliers to long term relationships with a few good suppliers. Dwyer et al. (1987) and Spekman (1988) concur with the above argument. Tomkins (2001) explored the role of trust and information-sharing in inter-organizational relationships.

The role of "commitment" and "trust" in relationship marketing and inter-organizational collaboration has been widely talked about since the late 80s (Morgan and Hunt, 1994; Dwyer et al., 1987; Young and Wilkinson, 1989). The purpose of strategic partnerships is to enable enhanced coordination in operations, R & D, product launching, and the like, between partners (Fulconis and Paché, 2005). There has been abundant literature since the 1990s on strategic supplier partnership in strategy literature.

In some industries, startups and partnership changes are expensive and time consuming and long-term contracts are preferred (Mason et al., 2002). Vonderembse & Tracey (1999) conducted a research study on the impact of supplier selection and involvement on manufacturing performance. They concluded that the level of supplier involvement in continuous improvement activities and in product development efforts is low in North American supply chains. Although many managers acknowledge the need for enhanced relationships in the channel, it is not being implemented consistently in the manufacturing sector. They also conclude that increased company/supplier involvement may have significant impact on supply chain performance.

Immediate supplier relationship activities play a vital role in developing effective SCM strategies (Wisner, 2003). Long-term relationship does not refer to any specific period of time, but rather, to the intention that the arrangement is not going to be temporary (Chen and Paulraj, 2004). Through close relationships supply chain partners are willing to (1) share risks and reward and (2) maintain the relationship on a long term basis (Landeros and Monczka, 1989; Cooper and Ellram, 1993; Stuart, 1993).

Furthermore, a considerable amount has been written documenting the integration of suppliers in the new product development process (Burt and Soukup, 1985; Clark and Fujimoto, 1991; Helper, 1991; Hakansson and Eriksson, 1993; Lamming, 1993; Hines, 1994; Ragatz et al., 1997; Dowlatshahi, 1998; 2000; Swink, 1999; Shin et al., 2000). De Toni and Nassimbeni (1999) found that a long-term perspective between the buyer and supplier increases the intensity of buyer–supplier coordination.

The Japanese supplier partnership system is widely discussed in the literature (Webster, et al., 2000; Gilbert, et al., 1994; Nishiguchi, 1994; Morris and Imrie, 1993; Schoenberger, 1982). Japanese companies in electronics, automobiles, and machinery industries began involving their suppliers in joint design with their customers (Nishiguchi and Brookfield, 1997).

To create a competitive advantage, SCM is increasingly emphasizing Interorganizational co-ordination of activities (Sheth and Sharma, 1997; Ballou et al., 2000).

Customer relationship is defined as “the entire array of practices that are employed for the purpose of managing customer complaints, building long-term relationships with customers, and improving customer satisfaction” (Li et al., 2006, p. 109). Noble (1997) and Tan et al. (1998) consider customer relationship management as an important component of SCM practices. Croxton et al. (2001) consider customer relationship and supplier partnership practices as key SCM practices.

An organization's customer relationship practices can affect its success in SCM efforts as well as its performance (Scott and Westbrook, 1991; Ellram, 1991; Turner, 1993). Successful SCM involves customer integration at the downstream and supplier integration at the upstream, considering that each entity in a supply chain is a supplier as well as a customer (Tan et al., 1999).

In this global competition and mass customization era, personalized attention and better relationship management with individual customers is of utmost importance for organizational success (Wines, 1996). Good relationships with trading partners, including customers are a key to successful SCM efforts by organizations (Moberg et al., 2002). Customer relationship has long been recognized as an internal component of an organization's marketing strategy to increase sales and profits (Bommer et al., 2001). Close customer relationship allows product differentiation from competitors, helps sustain customer loyalty, and elevates the value provided to customers (Magretta, 1998).

Immediate customer relationship activities have played a crucial role in developing effective SCM strategies (Wisner, 2003).

Information sharing refers to "the extent to which critical and proprietary information is communicated to one's supply chain partner" (Li et al., 2006, p. 110). Mentzer et al. (2000) mention that shared information can vary from strategic to tactical in nature. It could be pertaining to logistics, customer orders, forecasts, schedules, markets, or more.

Information sharing refers to the access to private data between trading partners thus enabling them to monitor the progress of products and orders as they pass through various processes in the supply chain (Simatupang and Sridharan, 2002). Simatupang and Sridharan (2005) bring forth some of the elements that comprise information sharing, including data acquisition, processing, storage, presentation, retrieval, and broadcasting of demand and forecast data, inventory status and locations, order status, cost-related data, and performance status. They further add that information sharing pertaining to key performance metrics and process data improves the supply chain visibility thus enabling effective decision making. Information shared in a supply chain is of use only if it is relevant, accurate, timely, and reliable (Simatupang and Sridharan, 2005). Information sharing with trading partners enables organizations to make better decisions and to take actions on the basis of greater visibility (Davenport et al., 2001).

In recent years, uncertainties have become a greater concern in supply chains. The direct consequences are increased inventories and the distortion of demand forecasts. Moreover, the distortion propagates through the supply chain and is amplified at each stage—the well known bullwhip effect (Lee et al., 1997). Through information sharing, the demand information flows upstream from the point of sales, while product availability information flows downstream (Lee and Whang, 2001; Yu et al., 2001) in a systematic manner. Moreover, information sharing ensures that the right information is available for the right trading partner in the right place and at the right time (Liu and Kumar, 2003).

According to Lummus and Vokurka (1999), in order to make the supply chain competitive, a necessary first step is to acquire a clear understanding of supply chain concepts and be willing to openly share information with supply chain partners.

Availability of accurate and up-to-date marketing data at every node within the supply chain is a key to create a seamless supply chain (Childhouse and Towill, 2003; Balsmeier and Voisin, 1996; Towill, 1997; Turner, 1993). Lalonde (1998) regards information sharing as one of key element that characterizes a strong supply chain relationship. Yu et al. (2001) point out that the negative impact of the bullwhip effect on a supply chain can be reduced or eliminated by sharing information with trading partners. Lalonde (1998) regards information sharing as a key to creating strong supply chain relationships.

Lau and Lee (2000) maintain that creating an environment for controlled sharing of business data and processes, improves information sharing effectiveness among trading partners. However, there is the reluctance on the part of organizations in the supply chain to share information with each other. Information is generally viewed as providing an advantage over competitors, and organizations resist sharing with their partners (Vokurka & Lummus, 2000) due to the fear of giving away competitive and sensitive information such as inventory levels, production schedules (Lancioni et al., 2000; Ballou et al., 2000; Croom et al., 2000).

2.3 Modularity-Based Manufacturing Practices

Modularity based manufacturing practices is defined as the application of unit standardization or substitution principles to product design, production process design and organizational design (Tu et al., 2004; Ulrich, 1995; Tu, 1999). Baldwin and Clark (2000) defined modules as units in a large system that are structurally independent of one another, but functionally integrated. Modularity-based manufacturing practices are a set of actions that enable firms to achieve modularity in product design, production process design, and organizational design (Tu et al., 2004). In general, modularity refers to “the degree to which a system’s components can be separated and recombined” (Schilling, 2000, p. 12). Schilling and Steensma (2001) suggested that systems will have higher degrees of modularity when their components can be disaggregated and recombined into new configurations with little loss of functionality. A complex system can be easily managed by dividing it into smaller modules and examining each piece separately. Tu et al. (2004) defined the construct modularity-based manufacturing practices, and developed a valid and reliable instrument to measure modularity based manufacturing practices. The same instrument has been adopted in this study. Modularization involves organizing complex products and processes efficiently (Baldwin and Clark, 1997), by breaking down large jobs into simpler parts so they can be “managed independently and yet operate together as a whole” (Mikkola and Larsen, 2004, p. 441).

The potential benefits of modularity include economies of scale, increased feasibility of product/components change, increased product variety and reduced lead time, decoupling tasks and ease of product upgrade, maintenance, repair, and disposal (Coronado et al., 2004).

The concept of modularity is commanding increasing attention from researchers because of its capability to cope with a turbulent manufacturing environment. Drucker (1990) predicted that the factory of the year 1999 would be determined by four principles. One of those principles is the modular organization of the manufacturing process (other three being statistical quality control, systems approach, and effective manufacturing accounting), which promises to combine the advantages of standardization and flexibility.

Operations management/management science research has treated modularity as a means to increase commonality across different product variants within a product family, i.e. to allow for the same component(s) to be used in multiple product variants, and when feasible, in all product variants (Evans, 1963).

Research in operations management/ management science has highlighted that modularity in product design may allow for the design of a loosely coupled production system in which different subassemblies can be made independently, and then rapidly assembled together in different ways, to build the final product configurations (Ernst and Kamrad, 2000; Novak and Eppinger, 2001). This reduces the order lead times.

Similarly, Schilling and Steensma (2001) suggested that systems will have higher degrees of modularity when their components can be disaggregated and recombined into new configurations with little loss of functionality. A complex system can be easily managed by dividing it into smaller modules and examining each piece separately.

Given the importance of modularity based manufacturing practices for responsiveness of organizations, a limited amount of empirical research has been done in this field. A careful literature review indicates that research on modularity-based manufacturing is scattered and mostly descriptive (Tu et al., 2004). Furthermore only a few existing empirical studies focus on product modularity and overlook the implications of modularity on production process design (i.e. process modularity) and organizational design (Tu et al., 2004)

The concept of modularity has drawn attention since about a decade now, due to its definitive advantage in coping with the environmental uncertainty (Tu, 1999). Professor Carliss Baldwin and Kim Clark of Harvard Business School are among the many proponents of modularity. Their article during the late 90's in Harvard Business Review cited the computer industry as the pioneer in promoting modularity. The computer industry has dramatically increased its rate of innovation through the use of modular designs. Baldwin and Clark (1997) regard modularity as a "strategy for organizing complex products and processes efficiently" (p. 86). They argue that it is modularity, more than any other technology that makes the rapid developments in computer industry possible. For manufacturers, modularity enables them to handle increasingly complex technology (Tu, 1999) and respond faster to changing customer demand by creating more variety of products from a set of common modules or subassemblies.

Several powerful forces are behind modularization: (1) the rate of technological change is accelerating, (2) customers, empowered by advanced computing and networking technologies, are demanding greater product variety at lower prices, and (3) technology-intensive products are becoming more complex (O'Grady, 1999).

Many companies have found that modularity has the potential to revolutionize their entire operation (O'Grady, 1999). The computer industry has been the leader in successful application of modularity principles. Software developers such as Oracle and SAP deliver a wide selection of software modules or "cartridges" that make it easier for companies to create custom applications (Marshall, 1996). IBM prototyped a modular storage system called “Collective Intelligent Brick” that is easily scalable by stacking storage cubes (Zimmerman, 2003).

There has been wide support in prior literature (Fisher, 1997, Lee, 2002) on the fact that product modularity enables the supply chain to be more responsive, by assisting in product postponement for as long as possible, and as close to the customer as possible.

The application of modularity principles in the manufacturing setting has traditionally focused mainly on designing modular products to satisfy customer needs. However, a careful review of the literature reveals a clear trend of taking a more systematic view, and applying modularity practices to every aspect of manufacturing system design. Tu et al. (2004) developed three dimensions of modularity based manufacturing practices, namely product modularity, process modularity, and dynamic teaming. Table 2.3.1 lists the three dimensions along with their definitions and supporting literature.

Table 2.3.1 List of Sub-Constructs for Modularity Based Manufacturing Practices

Constructs	Definitions	Literature
Product Modularity	"The practice of using standardized product modules so they can be easily reassembled / rearranged into different functional forms, or shared across different product lines" (Tu et al., 2004, p. 151)	Tu, 1999; Ulrich, 1995; Sanchez, 2000
Process Modularity	"The practice of standardizing manufacturing process modules so that they can be re-sequenced easily or new modules can be added quickly in response to changing product requirements" (Tu et al., 2004, p. 151)	Tu, 1999; Feitzinger and Lee, 1997
Dynamic Teaming	"The practice of using modular structures to reorganize manufacturing teams quickly and link them to necessary resources in response to product design or manufacturing process changes" (Tu et al., 2004, p. 152)	Tu et al., 2004; Tu, 1999; Galunic and Eisenhardt, 2001; Schilling and Steensma, 2001

Product Modularity is "the practice of using standardized product modules so they can be easily reassembled / rearranged into different functional forms, or shared across different product lines" (Tu et al., 2004, p. 151). Ulrich and Tung (1991) defined several basic types of modularity, including component sharing (the same module is used across multiple products), component swapping (different components are paired with the same basic product), mix modularity (mix different modules to form a new product), and bus modularity (new options can be added to a standard base by attaching new modules). The key to successful product modularization is product architecture, a scheme by which functional elements of a product are allocated to structurally independent physical components (Ulrich, 1995; Sanchez, 2000). An effective architecture is created when the interfaces between functional components are standardized and specified to allow the substitution of a range of components without requiring changes in the designs of other components (Garud & Kumaraswamy, 1995; Sanchez & Mahoney, 1996; Sanchez & Collins, 2001). For example, NeoSystems launched a new computer architecture called Modular Digital Architecture (MDA). For each hardware installation or upgrade, modules that include new features and accessories can be stacked on a base MDA module, just like stacking a home stereo system. General Motors announced the Yellowstone program, which is an attempt to build small cars profitably by using modularity and co-design with suppliers. Baldwin and Clark (1997) regard modularity as an emerging revolution as complex products can be built from "smaller subsystems" (p. 84) that are designed and manufactured independently and yet can "function together as a whole" (p. 84). Through modularization, modules will not only be shared across product lines, the number of different parts delivered to the assembly plants will also be greatly reduced. "The results are better-integrated designs with more value to the customer, an integrated quality focus, and reduced piece cost and investment" (Suzik, 1999).

Swaminathan (2001), however adds that too much part commonality can reduce product differentiation in the eyes of the customer leading to a cannibalization effect. Robertson and Ulrich (1998) differentiate external use standard parts from internal use and emphasize that an increase in the internal commonality does not contribute as much toward the cannibalization effect. For example, if commonality is introduced in the wire harness of different car models of a manufacturer, it is not easily noticed by customers (since these wires are hidden under the upholstery) and thus cannibalization effects are minimal. On the other hand, if the dashboards themselves (of these two car models) are standardized, then there is a greater amount of cannibalization taking place, adds Swaminathan (2001).

Process Modularity is defined as “the practice of standardizing manufacturing process modules so that they can be re-sequenced easily or new modules can be added quickly in response to changing product requirements” (Tu et al., 2004, p. 151). Feitzinger and Lee (1997) suggested that process modularity is based on three principles: (1) Process standardization: break down the process into standard sub-processes that produce standard base units and customization sub-processes that further customize the base units; (2) Process re-sequencing: reorder the sub-processes so that standard sub-processes occur first while customization sub-processes occur last (ex: Benetton case of re-sequencing knitting and dyeing of sweaters); (3) Process postponement: postponing customization sub-processes until a customer order is received or place those sub-processes in distribution centers to achieve maximum flexibility. Sanchez (1999) echoed similar thoughts of “late-point differentiation of products” using modular architecture. According to Pine (1993), the traditional tightly coupled production processes should be broken apart and modularized. An increasing number of manufacturers are starting to use modular assembly lines where workstations and conveyor units can be added, removed, or rearranged to create different process capabilities (Cooper, 1999).

According to Swaminathan (2001), a modular process is one where each product can be processed differently and stored in a semi-finished form. These products differ from each other based on the subset of operations that are performed on them. Any assemble to order process would classify as modular. Swaminathan (2001) further exemplifies that a semiconductor wafer fabrication (particularly application-specific integrated circuits) is modular in nature, “since the type of chip produced depends on the unique subset of operations performed on it” (p. 128). He further adds that Oil refining, is a non-modular process as it is a continuous process and inventory cannot be stored in a semi-finished form once the refining process starts. According to Swaminathan (2001), modular products are not necessarily always made by modular processes. The example of the biotech and pharmaceutical industry that make modular products, but use non-modular processes, is further illustrated in Swaminathan (2001). Many products in these industries can be derived by varying the mix of a small number of ingredients, which makes them modular. They are made, however, in continuous flow processes and thus inventory cannot be stored in semi-finished forms”. Process modularity has the potential for reengineering entire supply chains to enhance customization. Van Hoek and Weken (1998) specifically studied the effects of process postponement (postponed purchasing and postponed manufacturing) in the supply chain. Postponed purchasing requires that suppliers manage part of the inbound complexity associated with material flows by providing standardized modules. Postponed manufacturing extends the final modular assembly into distribution centers and even customer sites. The result is a more responsive supply chain that can satisfy individual customer needs without incurring higher production and inventory costs.

Dynamic Teaming is “the practice of using modular structures to reorganize manufacturing teams quickly and link them to necessary resources in response to product design or manufacturing process changes” (Tu et al., 2004, p. 152). This is an application of modularity principles to human resource management in manufacturing and to organizational process design.

Today's rapidly changing manufacturing environment requires a dynamic team structure that is different from traditional cross-functional teams. Pine et al. (1993) argue that cross-functional teams are usually tightly integrated to improve efficiency but lack flexibility. To achieve flexibility, companies should break apart tightly coupled teams and form loosely coupled networks of modular, flexible working units, so that these groups of people, processes, and technology can be easily reconfigured within the organization to meet the ever changing customer needs.

Galunic and Eisenhardt (2001) investigated a similar concept of modular organizational form, termed "dynamic community." They envisage corporate divisions and project teams as dynamic modules with distinctive capabilities, responsibilities, and resources that can be reconfigured to create new productive entities with shared culture and values that can adapt quickly to changing environments. Schilling and Steensma (2001) studied the adoption of modular organizational forms at the industry level. Their study included contract manufacturing (quickly adding temporary manufacturing capacity modules by contract), alternative work arrangements (employing workers on a short-term contract basis), and alliances (accessing critical capabilities the company lacks in-house through partnership with other firms). These practices are expected to generate more flexibility in the manufacturing system. Hoogeweegen et al. (1999) introduced the modular network design (MND) concept to explain how computer information technology enables virtual organizations to effectively reallocate production tasks and resources among modular virtual teams to cut costs and throughput time. While similar researches on dynamic teaming are scattered and may be at different levels of analysis, a theory of modular organizational form is clearly emerging.

Ketchen and Hult (2002) add that today's managers face an array of complex challenges, which requires them to keep pace with technological progress and cope with global competition. They further maintain that a modular form of organization is one tool to deal with these challenges. The authors compare modular organizational form with home building. A traditional home is a stable, cohesive object. Homes take a long time to build and once in place, adding to or otherwise modifying the home's basic structure requires a major effort. In contrast, modular homes can be readily assembled, broken apart, and reassembled to meet owner needs.

Daft and Lewin (1993) assert that there is an increasing trend of moving away from achieving mass production efficiencies, hierarchical and bureaucratic organizations that provided centralized control over activities. They further add that the shift is towards more flexible, learning organizations that continuously change and adapt to changes. They further add that these organizations “solve problems through interconnected coordinated self-organizing processes” (p. i) and teams, and which has been termed as ‘dynamic teams’ in this study. The dynamic teams are characterized by the ability to adapt and create change (i.e. highly flexible to adapt to change), that more fully use both human and technology resources, and that are global in scope (Daft and Lewin, 1993).

2.4 Supply Chain Responsiveness

Supply chain responsiveness is defined as the capability of promptness and the degree to which the supply chain can address changes in customer demand (Holweg, 2005; Prater et al., 2001; Lummus et al., 2003; Duclos et al., 2003).

In a rapidly changing competitive world, there is a need to develop organizations and supply chains that are significantly more flexible and responsive than the existing ones (Gould 1997, James-Moore, 1996). Firms need to aptly respond to changing customer needs so as to succeed in today's uncertain environment (Gerwin, 1987; Huber, 1984; Narasimhan and Das, 1999; Ward et al., 1998) as well as any disruptions in supply (Germain, 1989; Lee, 2004; Christopher and Peck, 2004). Although it would be interesting to study supply chain responsiveness from supply disruption perspective also, the current study focuses mainly on customer demand perspective.

To review the concept of supply chain responsiveness, we first need to review the supply chain flexibility concept. The supply chain flexibility has its roots in manufacturing flexibility of an organization. So we begin by a brief review of the manufacturing flexibility literature. Manufacturing flexibility is defined as the ability of the manufacturing system of an organization to adapt to change (Upton, 1994; Parker and Wirth, 1999; Lau, 1999). Manufacturing flexibility has been considered as a major competitive weapon for manufacturing organizations due to its ability to help cope with uncertain environments and turbulent markets. It has been argued in past literature that manufacturing flexibility is capable of providing organizations with the ability to change volume and mix of production, to rapidly and frequently develop new products, and to better respond to competition (Oke, 2005). Manufacturing flexibility has also been said to focus on the ability to adjust to changes in uncertainty with least penalties in time.

There has been extensive literature on the manufacturing flexibility concept and the survey reported by Sethi and Sethi (1990) lists more than 200 references. Some of the basic dimensions of manufacturing flexibility in the prior literature are - volume flexibility (the ability of the manufacturing system to vary aggregate production volume economically) (Slack, 1983; Browne et al., 1984; Sethi and Sethi, 1990; Gerwin, 1993), mix flexibility (the ability of the manufacturing system to switch between different products in the product mix) (Browne et al., 1984; Gerwin, 1993; Gupta and Somers, 1996), new product flexibility (the ability of the manufacturing system to introduce and manufacture new parts and products) (Browne et al., 1984; Gerwin, 1987; 1993; Taymaz, 1989; Gupta and Somers, 1996), process flexibility (the ability to change between the production of different products with minimal delay) (Parker and Wirth, 1999), and material handling flexibility (the ability of the material handling system to move material through the plant effectively) (Sethi and Sethi, 1990; Gupta and Somers, 1992). Slack (1983, 1987), Browne et al. (1984), Hyun and Ahn (1992), Suarez et al. (1996), Zhang et al. (2003), and Koste et al. (2004) are some of the studies on taxonomies of manufacturing flexibility. There is considerable disagreement among researchers on the definition of manufacturing flexibility.

The fact that a large amount of literature is available on flexibility and responsiveness of manufacturing systems, yet there been very little discussion on the relationship between these two concepts has been criticized in literature (Kritchanchai and MacCarthy, 1999; Matson and McFarlane, 1999). Some questions such as is a flexible manufacturing system also by default responsive, and what types of flexibility are needed for responsiveness have not been clearly addresses in prior literature (Holweg, 2005). This argument is also true for the distinction between supply chain responsiveness and supply chain flexibility. In this study we extend the definition of responsiveness to the supply chain level.

The supply chain flexibility concept focuses on the ability of the firm / supply chain to adapt to changes in business conditions (Gosain et al., 2004). Although the literature in the flexibility area (at logistics and supply chain levels) is accumulating over the past decade, including case study based research (Ferrin, 1994; Cunningham, 1996; Juga, 1996; Van Hoek et al., 1998), conceptual contributions (Lummus et al., 2003; Duclos et al., 2003; Andries and Gelders, 1995; Van Hoek, 2001), mathematical models (Garg and Tang, 1997; Waller et al., 2000), and survey research (Sanchez and Perez, 2005; Zhang et al., 2005; Daugherty et al., 1996; Emerson and Grimm, 1998), more work is required.

Supply chain flexibility refers to the ability of the supply chain to adapt to internal or external influences, whereas supply chain responsiveness is the ability of the supply chain to rapidly address changes and requests in the marketplace (Holweg, 2005). Supply chain flexibility extends the concept of flexibility of manufacturing systems to the entire supply chain. It encompasses not only the manufacturing (operations) flexibility, but also the flexibility of the different supply chain functions and processes, ex: supply, distribution and transportation (Lummus et al., 2003). Where “flexibility is the ability to switch between tasks” (Vokurka et al., 2002, p. 21), responsiveness is the ability to rapidly respond to unanticipated market changes (Goldman et al., 1994; Vokurka and Fliedner, 1998). Supply chain flexibility is a complex and multi-dimensional concept difficult to summarize (De Groote, 1994; Sarker et al., 1994; Upton, 1994; Gupta and Buzacott, 1996). The current study focuses on the – speed of response – in addition to the flexibility which is widely known as supply chain responsiveness (Holweg, 2005).

As obvious from the above discussion responsive comprises of both flexibility as well as speed. This fact has been strongly supported in prior literature (Fisher, 1997; Lee, 2002; Olhager, 1993, D' Souza and Williams, 2000, Holweg 2005; Holweg and Pil, 2001; Meehan and Dawson, 2002; Williamson, 1991; Prater et al., 2001; Towill and Christopher, 2002; Christopher and Peck, 2004; Gunasekaran and Yusuf, 2002; Christopher, 2000). Prater et al. (2001) further maintain that as the level of speed and more importantly flexibility increase, the level of supply chain responsiveness increases. Based on Prater et al. (2001), Duclos et al. (2003), and Lummus et al. (2003) who have identified the various components of supply chain flexibility and agility, we extend and modify those components to develop the construct supply chain responsiveness. We identify operations system responsiveness, logistics process responsiveness, and supplier network responsiveness as the three main components of supply chain responsiveness. Literature (ex: Christopher, 2000), emphasizes the need for supply chains (instead of individual organizations) to be responsive in order to attain competitive advantage. This was the prime motivation behind this study of supply chain responsiveness.

Aquilano et al. (1995) contend that "low cost, high quality and improved responsiveness (both delivery time and flexibility of product delivery)" (p. 447) are the three main strategic imperatives to stay competitive in this century (as cited in Duclos et al., 2003). Gupta and Goyal (1989), contend that being responsive is normally considered as an adaptive response to the environmental uncertainty. Bowersox et al. (1999) advocate the need for organizations to be responsive when the penalties associated with uncertainty are higher. These penalties for an organization could include costs of stocking out or carrying the wrong inventory and which can be mitigated through a responsive system, by adopting effective SCM practices as indicated and proposed in this study.

Table 2.4.1 provides the list of sub-constructs for supply chain responsiveness, along with their definitions and supporting literature.

Table 2.4.1 List of Sub-Constructs for Supply Chain Responsiveness

Constructs	Definitions	Literature
Operations System Responsiveness	The ability of a firm's manufacturing system to address changes in customer demand	Prater et al., 2001; Lummus et al., 2003; Duclos et al., 2003; Anderson and Lee, 2000; Radjou, 2000; Allnoch, 1997
Logistics Process Responsiveness	The ability of a firm's outbound transportation, distribution, and warehousing system (including 3PL/4PL) to address changes in customer demand	Prater et al., 2001; Lummus et al., 2003; Duclos et al., 2003; Bradley, 1997; Fuller et al., 1993; Richardson, 1998; Huppertz, 1999; Doherty, 1998; Swaminathan, 2001; Van Hoek, 2000
Supplier Network Responsiveness	The ability of a firm's major suppliers to address changes in the firm's demand	Prater et al., 2001; Lummus et al., 2003; Duclos et al., 2003; Jordan and Michel, 2000; Rich and Hines, 1997; Burt and Soukup, 1985; McGinnis and Vallorpa, 1999; Fisher et al., 2000; Bensaou, 1999; Mason et al., 2002; Cooper and Gardner, 1993; Choi and Hartley, 1996

Operations system responsiveness is defined as the ability of a firm's manufacturing system to address changes in customer demand. Operations system responsiveness includes both manufacturing and service operations. Duclos et al. (2003) and Lummus et al. (2003) in a conceptual study, emphasize that operations responsiveness at each node of the chain is an integral component of supply chain responsiveness. They further argue that in order to meet the end customer's needs, each entity in the supply chain must deliver the product or service in a timely and reliable manner.

The dimensions under this category would measure the responsiveness associated with a specific node (company) in the supply chain (Duclos et al., 2003; Lummus et al., 2003). This could be a supplier, a manufacturer, or a customer (or distributor). Anderson and Lee (2000) identified - the ability to be operationally responsive - as one of the components of successful supply chain strategy that add value to a firm. This includes the ability to rapidly configure or reconfigure assets and operations of the manufacturing system to react to consumer trends (Wu, 2001; Lummus et al., 2003), respond rapidly to changes in product volume and product mix demanded by customers, and effectively expedite emergency customer orders. As the supply chain responds to customer demand, supply chain member companies may be required to move quickly from the production of one product to another, or quickly change production levels for a given product. The responsiveness of the operations system would be the ability of the manufacturing and production to rapidly respond to unexpected events, and ability to rapidly accommodate special or non-routine customer requests. In doing so the vital ingredients needed are flexibility and speed of response (Holweg 2005; Holweg and Pil, 2001; Meehan and Dawson, 2002; Williamson, 1991) of the manufacturing system of each of the organizations operating within a supply chain. Some of the operations system responsiveness measures that have been identified to operationalize the construct include: operations system's ability to - rapidly adjust capacity to address demand changes, rapidly change manufacturing processes to address demand changes, rapidly reallocate people to address demand changes, rapidly reconfigure equipment to address demand changes, effectively expedites emergency customer orders, make rapid changes in product mix demanded by customers, and respond rapidly to changes in product volume demanded by customers.

Logistics process responsiveness is defined as the ability of a firm's outbound transportation, distribution, and warehousing system (including 3PL/4PL) to address changes in customer demand. The responsiveness in the logistic processes is a vital component in the success of a responsive supply chain strategy (Fawcett, 1992). Logistics and distribution management includes the activities of transportation of goods from suppliers to manufacturer to distribution centers to final point of consumption (Ricker and Kalakota, 1999; Duclos et al., 2003; Lummus et al., 2003). These activities include warehousing, packing and shipping, transportation planning and management, inventory management, reverse logistics, and order tracking and delivery. This study focuses on the outbound logistics of the focal firm. Fuller et al. (1993) suggest that a firm's logistics system is instrumental in creating value for its customers. This value creation for a firm's customers implies ensuring logistics flexibility (Duclos et al., 2003; Lummus et al., 2003) and speed within the supply chain to serve each distinct customer's needs. A typical response to uncertainty is to build flexibility into the supply chain. However being flexible needs to be supplemented by being apt in responding too. Responsiveness components in the logistics system include selecting logistics components that accommodate and respond to wide swings in demand over short periods, adjust warehouse capacity to address demand changes, handle a wide range of products, vary transportation carriers, have the ability to pack product-in-transit to suit discreet customers' requirements, and have the ability to customize products close to the customer (i.e. postponement); and do all of these speedily in order to gain a competitive advantage. It is vital that the firm has easy access to and is able to utilize different modes of transportation to be logistically flexible and thus responsive (Prater et al., 2001). Hise (1995) argues that flexibility is the key component of any logistics system configured to achieve responsiveness. He further states that companies need the capability to adjust logistic systems quickly to respond to changes in market needs and the necessitated product assortment. Prater et al. (2001) in his case study research presents the case study of Hewlett Packard, which reduced the uncertainty by designing the product appropriately so as to customize it only when individual orders arrive. Lummus et al. (2003) put forth some of the critical logistics process flexibility aspects of a supply chain, which are vital for supply chain responsiveness. These aspects have been adapted for logistics process responsiveness and are as follows: logistics system's ability to - rapidly respond to unexpected demand change, rapidly adjust warehouse capacity to address demand changes, rapidly vary transportation carriers to address demand changes, accommodate special or non-routine customer requests, and effectively delivers expedited shipments.

Supplier network responsiveness is defined as the ability of a firm's major suppliers to address changes in the firm's demand. A key to responsiveness is the presence of responsive and flexible partners upstream and downstream of the focal firm (Christopher and Peck, 2004). The ability of firms to react quickly to customer demand is dependent on the reaction time of suppliers to make volume changes.

Whenever disruptive causes such new technology, terrorist threats (Walker, 2005) or cut-throat competition tend to throw the supply chain haywire, the supply chain networks must be ready to react to any ripple effect. Slack (1991) argues that supplier networks are the essential building blocks of a flexible system. Some interviews with operations managers conducted at the European vehicle assembly plants of Volvo revealed that the lack of supplier network flexibility hampered the company's responsiveness (Holweg, 2005). Supplier network flexibility (Slack, 1991) and thus supplier network responsiveness is an important part of the supply chain responsiveness. Holweg and Pil (2001) argue that flexibility in the supplier network is an important ingredient of being responsive to changes in customer demand. Thus supplier network responsiveness is believed to be a dimension of supply chain responsiveness in this study. In order to have a competitive advantage, organizations need to meet the changing needs of customers by being able to rapidly supply products, including any demand changes in terms of product volume, mix, product variations, and new product introductions. Meeting these needs requires responsiveness in the supply chain at various stages from the raw materials to finished products to distribution and delivery. In order to be responsive the organizations should be able to select suppliers who can add new products quickly, and have suppliers make desired changes. Selecting suppliers who can introduce new products quickly can add responsiveness to a supply chain. Burt and Soukup (1985) suggested that failure to include suppliers' inputs in product development is a vulnerable aspect of supply chain management. McGinnis and Vallopra (1999) found that involving suppliers could make new product development a success. Fisher et al. (2000) found that for short lifecycle products, such as fashion apparel, retailers are most successful if they can work with suppliers who can provide initial shipments of product based on forecasts, but then rapidly increase production to the right style, color, size, etc. based on actual sales. They note that fast supply chains can produce products as they sell rather than worrying about accurate forecasts. These studies suggest that supplier selection based on product development capabilities and rapid deployment capabilities positively impact the delivery time of new products. Choi and Hartley (1996) found that the capability of suppliers to make product volume changes was a significant factor in supplier selection in the automotive industry. In certain industries, e.g. electronics; demand volatility poses a unique challenge to suppliers to vary output in line with demand. The increases or decreases in demand may come at a short notice and need to be sustained over some time period. Some of the measures of supplier network responsiveness include: major suppliers' ability to - change product volume in a relatively short time, change product mix in a relatively short time, consistently accommodate the firm's requests, provide quick inbound logistics to the firm, have outstanding on-time delivery record, and effectively expedite emergency orders.

2.5 Competitive Advantage

Competitive advantage is defined as the "capability of an organization to create a defensible position over its competitors" (Li et al., 2006, p. 111).

Tracey et al. (1999) argues that competitive advantage comprises of distinctive competencies that sets an organization apart from competitors, thus giving them an edge in the marketplace. They further add that it is an outcome of critical management decisions.

Competitive advantage traditionally involved the choice regarding the markets in which a firm would compete, defending market share in clearly defined segments using price and product performance attributes (Day, 1994). Today, however, competition is considered a “war of movement” (p. 62) that depends on anticipating and quickly responding to changing market needs (Stalk et al., 1992). Competitive advantage emerges from the creation of superior competencies that are leveraged to create customer value and achieve cost and/or differentiation advantages, resulting in market share and profitability performance (Barney, 1991; Coyne, 1986; Day and Wensley, 1988; Prahalad and Hamel, 1990). Sustaining competitive advantage requires that firms set up barriers that make imitation difficult through continual investment to improve the advantage, making this a long-run cyclical process (Day and Wensley, 1988). Porter's approach to competitive advantage centers on a firm’s ability to be a low cost producer in its industry, or to be unique in its industry in some aspects that are popularly valued by customers (Porter, 1991). Most managers agree that cost and quality will continue to remain the competitive advantage dimensions of a firm (D’ Souza and Williams, 2000). Wheelwright (1978) suggests cost, quality, dependability and speed of delivery as some of the critical competitive priorities for manufacturing. There is widespread acceptance of time to market as a source of competitive advantage (Holweg, 2005).

Price/cost, quality, delivery dependability, and time to market have been consistently identified as important competitive capabilities (Vokurka et al., 2002; Fawcett and Smith, 1995; White, 1996; Skinner, 1985; Roth and Miller, 1990; Tracey et al., 1999). ‘Time’ has been argued to be a dimension of competitive advantage in other research contributions (viz: Stalk, 1988; Vesey, 1991; Handfield and Pannesi; 1995, Kessler and Chakrabarti, 1996; Zhang, 2001). In a research framework, Koufteros et al. (1997) describe the following five dimensions of competitive capabilities: competitive pricing, premium pricing, value-to-customer quality, dependable delivery, and product innovation. These dimensions were further described and utilized in other contributions as well (Koufteros et al., 2002; Tracey et al., 1999; Rondeau et al., 2000; Roth and Miller, 1990; Cleveland et al., 1989; Safizadeh et al., 1996; Vickery et al., 1999, Li et al. 2006). Based on these studies, the five dimensions of competitive advantage construct used in this study are price/cost, quality, delivery dependability, product innovation, and time to market.

Competitive advantage has been operationalized in the existing literature (Koufteros et al., 1997; Zhang, 2001) and the measures have been adopted in this study with minor modifications. Based on the study of Koufteros (1995), Zhang (1997), and Li et al. (2006) the following five dimensions of competitive capability are used in this study. The list of these sub-constructs, along with their definition and supporting literature, are provided in Table 2.5.1

Table 2.5.1 List of Sub-Constructs for Competitive Advantage

Constructs	Definitions	Literature
Price/Cost	"The ability of an organization to compete against major competitors based on low cost / price" (Li et al., 2006, p. 120)	Koufteros, 1995; Wood et al., 1990; Miller et al., 1992, Hall et al., 1993; Rondeau et al., 2000
Quality	"The ability of an organization to offer product quality and performance that creates higher value for customers" (Koufteros, 1995)	Li et al., 2006; Gray and Harvey, 1992; Arogyaswamy and Simmons, 1993; Rondeau et al., 2000.
Delivery Dependability	"The ability of an organization to provide on time the type and volume of product required by customer(s)" (Li et al., 2006, p. 120)	Li et al., 2005; Hall, 1993, Koufteros et al., 1997; Rondeau et al., 2000
Product Innovation	"The ability of an organization to introduce new products and features in the market place" (Koufteros, 1995)	Li et al., 2006; Clark and Fujimoto, 1991; Rondeau et al., 2000.
Time to Market	"The ability of an organization to introduce new products faster than major competitors" (Li et al., 2006, p. 120)	Li et al., 2005; Stalk, 1988; Vesey, 1991; Handfield and Pannesi, 1995; Kessler and Chakrobarti, 1996.

1) Price/Cost. "The ability of an organization to compete against major competitors based on low price" (Li et al., 2006, p. 120).

2) Quality. "The ability of an organization to offer product quality and performance that creates higher value for customers" (Koufteros, 1995).

3) Delivery Dependability. "The ability of an organization to provide on time the type and volume of product required by customer(s)" (Li et al., 2006, p. 120).

4) Product Innovation. "The ability of an organization to introduce new products and features in the market place" (Koufteros, 1995).

5) Time to Market. “The ability of an organization to introduce new products faster than major competitors” (Li et al., 2006, p. 120).

To sum up, this chapter discussed the theoretical foundation of various constructs used in this research: SCM practices, modularity based manufacturing practices, supply chain responsiveness, and competitive advantage. In the next chapter, we present the research framework that describes the relationships between these constructs along with the development of research hypotheses.

CHAPTER 3: THEORETICAL FRAMEWORK AND HYPOTHESES DEVELOPMENT

When understanding the phenomenon of supply chain responsiveness, it is helpful to have a framework within which to work and from which testable hypotheses can be drawn. A theoretical framework enables predictions to be made about the SCM practices and modularity based manufacturing practices that affect supply chain responsiveness and competitive advantage of a firm. It enables observed business behavior to be evaluated and therefore provides better explanations of the motivations for the adoption of SCM practices and modularity based manufacturing practices and its desired consequences.

3.1 Theoretical Framework

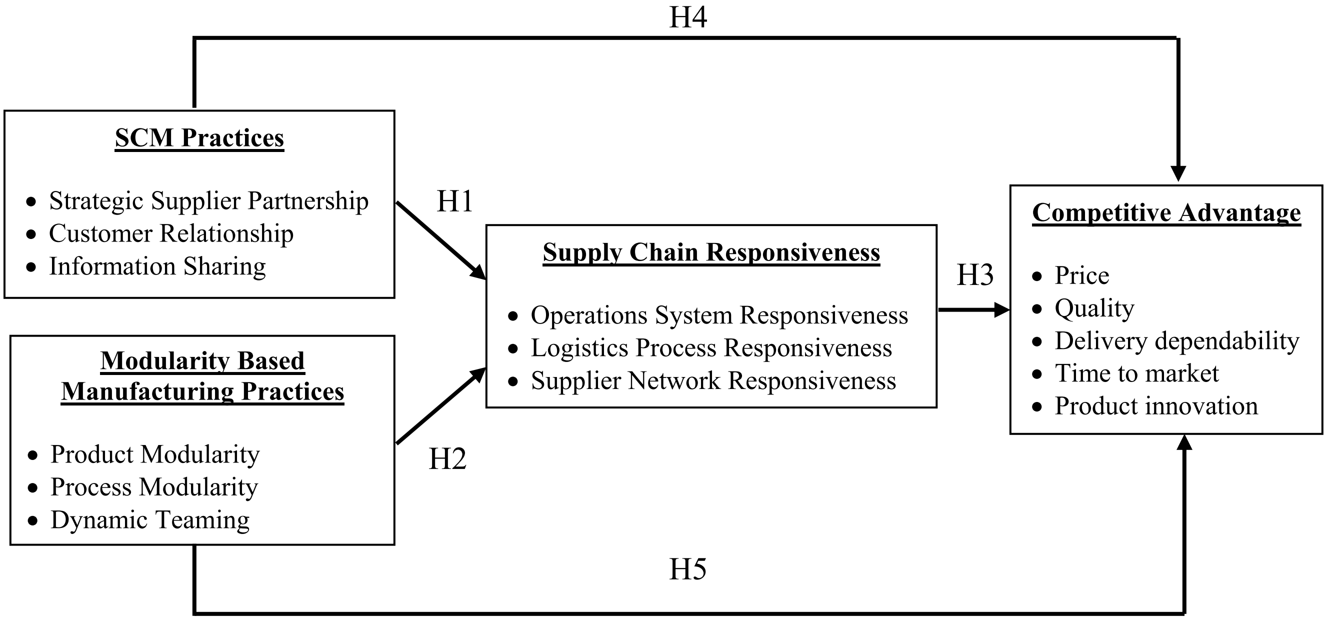
To better understand the effect of SCM practices and modularity based manufacturing practices on supply chain responsiveness, and supply chain responsiveness on competitive advantage, a framework is established which describes the causal relationships between SCM practices, modularity based manufacturing practices, supply chain responsiveness, and competitive advantage (Figure 3.1). The rationale underlying this research framework is as follows: The SCM practices (between organizations) of a firm will impact the supply chain responsiveness; also the modularity based manufacturing practices within an organization will impact the supply chain responsiveness. Finally supply chain responsiveness will impact the competitive advantage of a firm.

Figure 3.1 exhibits the theoretical model depicting the four constructs discussed in Chapter 2. The numbers next to each arrow correspond to the five hypotheses to be developed in this chapter.

The model (Figure 3.1) establishes direct, positive relationships between SCM practices of firm and supply chain responsiveness; modularity based manufacturing practices and supply chain responsiveness; and supply chain responsiveness and competitive advantage of a firm.

The following section will provide theoretical support for each hypothesis.

Figure 3.1 Theoretical Model



3.2 Research Hypothesis 1 (SCM Practices and Supply Chain Responsiveness)

Tully (1994) states that there exists evidence that firms are achieving flexibility, and thus responsiveness, through the use of SCM practices. Certain SCM practices directly impact the operational flexibility, and firms should use SCM practices to excel in attaining responsiveness (Narasimhan and Das, 1999).

Successful SCM can result in lower system inventories, a network of firms that responds more quickly to market changes, and products that more closely match customer expectations. Thus, firms pursuing differentiation, cost leadership, or quick response strategies, or combinations of these can all find benefits from value system or SCM (Porter, 1985).

Collaboration plays a key role in achieving responsiveness (Liu and Kumar, 2003). Liu and Kumar (2003) observed that collaborative practices such as 3PL, VMI, and CPFR between supply chain trading partners led to increased supply chain responsiveness (both flexibility and promptness of response). In a special report of logistics and transport (2003), information sharing and strategic supplier partnership practices have been highlighted as the critical steps to being responsive.

The need of today is close coordination with suppliers and customers, as customers demand faster timely and accurate deliveries (Mentzer et al., 2001). Generally, a single organization often may not be able to respond quickly to changing market requirements. Temporary alliances or partnerships with trading partners help to improve the flexibility and responsiveness of organizations (Gunasekaran and Yusuf, 2002).

Strategic supplier partnerships and early involvement of suppliers in the design process has been argued to enhance the responsiveness of organizations to design changes by customers (Power et al., 2001; Narasimhan and Das, 2000; Martin and Grbac, 2003). Close relationship with suppliers, has been empirically found to positively affect the volume flexibility, mix flexibility and new product flexibility dimensions of manufacturing flexibility (Suarez et al., 1995). Numerous studies have emphasized the importance of integrating suppliers, manufacturers, and customers so as to achieve supply chain responsiveness (Frohlich and Westbrook, 2001; Clinton and Closs, 1997; Storey, 2005; Gunasekaran and Yusuf, 2002; Fulconis and Pache, 2005; Van Hoek et al., 2001; Herrmann et al., 1995; Christopher, 2000; Smith and Barclay, 1997; Handfield and Nichols, 2002; Handfield et al., 1998). Working closely with suppliers to design or redesign products and processes, solve problems, as well as prepare back-up plans is critical in attaining supply chain responsiveness (Storey et al., 2005; Martin and Grbac, 2003; Sheth and Sharma, 1997; Tan et al., 1998; Araujo et al., 1999; Ghosh et al., 1997; Ellinger, 2000; Lambert and Cooper, 2000; Turner et al., 2000; Harris, 2005; Yusuf et al., 2004; Lee, 2004). Yusuf et al. (2003), found high correlation between the supplier partnership practices and responsiveness. Based on the results of an empirical study of purchasing managers in manufacturing firms, Narasimhan and Das (2000) found that the selection, development, and integration of suppliers was a key determinant of the manufacturing firm's responsiveness. To develop a responsive supply chain, continuous collaborative improvement among firms has become a strategic imperative (Noori, 2004). Business-to-business (B2B) electronic commerce (e-commerce) and increasingly competitive markets, are forcing firms to create and sustain long-term relationships with their suppliers so as to improve supply chain responsiveness. The case of Dell Inc. is a living example of supply chain practices such as strategic supplier partnership practice, close customer relationship practice, and information sharing from which Dell has largely benefited in terms of being more responsive to the final customer (Magretta, 1998). Working closely together organizations can eliminate wasteful time and effort (Balsmeier and Voisin, 1996).

Eisenhardt and Tabrizi (1994) looked at supplier involvement as one key factor in reducing product development times in the computer industry. One of the many advantages of supplier participation in new product development includes shorter project development lead times (Gupta and Souder, 1998; Clark, 1989).

A growing trend for strategic supplier partnership practice is for the purpose of reducing uncertainty and improving lead-time (Bleeke and Ernst, 1991; Whipple and Gentry, 2000), thus rapidly responding to change in business environment. Verstraete (2004) argues that building close and trustworthy relations with suppliers with efficient communication channels, results in increased supply chain responsiveness.

Lee et al. (1999) assert that companies are moving towards collaborative SCM in an effort to reduce the imbalances in information that result in “bullwhip effect”, while increasing their responsiveness to the changing market needs (Mentzer et al., 2000).

A sustained relationship between the firm and its customers is essential for attaining supply chain wide responsiveness (Storey et al., 2005; Mitchell, 1997; Christine, 1997). Close relationships with customers in a supply chain increases responsiveness to customers’ needs (Martin and Grbac, 2003, Sheth and Sharma, 1997; Tan et al., 1998; Araujo et al., 1999; Van Hoek et al., 2001; Christopher, 2000). Harris (2005) emphasizes close relations with customers, to be customer responsive. Lee (2004) asserts that close relations with customers and working together to design or redesign processes, components, and products as well as to prepare backup plans is critical in attaining supply chain wide responsiveness. For instance, Taiwan Semiconductor Manufacturing Company (TSMC), the world's largest semiconductor foundry, gives suppliers and customers proprietary tools, data, and models so they can execute design and engineering changes quickly and accurately. Yusuf et al. (2003), found high correlation between the customer relationship practices and responsiveness. Wal-Mart collaborated with Warner-Lambert to attain mutual benefits of collaborative planning, forecasting, and replenishment (CPFR) (Parks, 2001). Mutual benefits included an improvement in stock levels on Listerine (from 87% to 98 %), reduced lead times (21 to 11 days), reduced on-hand inventory (by two weeks), more consistent orders, and increase in sales (by USD 8.5 million). In a similar fashion instead of carrying excess inventory, General Electric (GE) collaborated with its retailers to respond to customer demand (Treacy and Wiersema, 1993).

Information sharing plays an important role in constructing a responsive supply chain network (Lau and Lee, 2000). Storey et al. (2005) assert that a great amount of visibility through the supply chain is required in order to attain supply chain responsiveness. This would it is argued, enable all the players in the supply chain "to see from one end of the pipeline to another in as close to real time as possible" (Storey et al., 2005, p. 244). It has been argued that information sharing between firms in a supply chain enable organizations to rapidly respond to market conditions (Martin and Grbac, 2003; Handfield and Nichols, 2002; Hult et al., 1996; Gosain et al., 2004). Information sharing practice in a supply chain increases responsiveness to customers' needs in a supply chain (Martin and Grbac, 2003, Sheth and Sharma, 1997; Tan et al., 1998; Araujo et al., 1999; Van Hoek et al., 2001; Christopher, 2000). Fawcett et al. (1996) consider information sharing as an antecedent to flexibility. Lambert and Cooper (2000) argue that information sharing between the supply chain entities encourages responsiveness of a firm's supplier network. Tan et al. (1998) found that information sharing between trading partners increased customer responsiveness of the firm. Information sharing between trading partners can reduce uncertainty and improve supply chain responsiveness (Christopher and Peck, 2004). Lee (2004) asserts that trading partners need to share information / data on changes in supply and demand continuously so they can respond quickly. He cites the example of Cisco which recently created an e-hub, which connects suppliers and the company via the Internet. This allows all the firms to have the same demand and supply data at the same time, to spot changes in demand or supply problems immediately, and to respond in a concerted fashion. Yusuf et al. (2003) found high correlation between data integration with other companies in a supply chain, and responsiveness. Sharing of information with partners is detrimental to supply chain flexibility (Gosain et al., 2004) and thus responsiveness.

Open sharing of information such as inventory levels, forecasts, sales promotion strategies, and marketing strategies reduces the uncertainty between supply chain partners (Andel, 1997; Lewis and Talalayevsky, 1997; Lusch and Brown, 1996; Salcedo and Grackin, 2000) shall thus enable firms to respond rapidly to unexpected events on either customer or supply side. According to Stein and Sweat (1998), information sharing between trading partners enables individual organizations to better understand the needs of the end customer thus facilitating quick response to market changes. Information sharing with suppliers has given Dell Company the benefits of faster cycle times, reduced inventory, and improved forecasts (Magretta, 1998; Stein and Sweat, 1998).

Simatupang and Sridharan (2005), contend that information sharing enables the supply chain members to make effective decisions to address product flows quickly thereby increasing responsiveness. For example, demand and inventory visibility can minimize stock-outs by accurately replenishing hot products (Fisher, 1997), thereby rendering more responsive partners to the changing customer demand.

Lummus and Vokurka (1999) emphasize the information sharing between trading partners in a supply chain to respond more quickly to consumer needs. The above arguments lead to:

Hypothesis 1: ‘*SCM practices’ of a firm is positively related to supply chain responsiveness.*

3.3 Research Hypothesis 2 (Modularity Based Manufacturing Practices and Supply Chain Responsiveness)

As uncertainty in supply and demand, markets and technology intensifies, more companies are adopting modular product and process architectures to cope with changing customer demands (Tu et al., 2004).

Feitzinger and Lee (1997) emphasize on both: effective SCM practices as well as the modularity based manufacturing practices as essential and vital for attaining cost effective responsiveness. Gunasekaran and Yusuf (2002), Abair (1997), Sharifi (1998), and Van Hoek et al. (2001), advocate the fact that modular product design is vital for attaining responsiveness.

Product modularity (or modular product design) provides the suppliers with the responsiveness that it needs to cater to the firm’s demand changes due to its ability to customize products quickly and inexpensively (Feitzinger and Lee, 1997; Hopwood, 1995; Mikkola and Larsen, 2004)

Many companies are exploring ways to do this to respond to constantly changing demands. Yang et al. (2004) affirm that having modules with standardized interfaces is of the most efficient options to achieve responsiveness in supply chains.

Modularity based manufacturing practices improves a company's flexibility by effectively meeting the changing needs of the customer, with quick response and greater product variety (Lee et al., 1993; Sanchez, 1999). In recent times the amount of research addressing product and process modularity has greatly increased. Increasing number of products are now being manufactured using modular parts and processes. Some of the companies that come to mind are Dell Computer, Hewlett-Packard (HP), Motorola, Toyota Motor Corporation National Bicycle Industry Company in Japan (NBIC), and the clothing manufacturer Benetton among others.

Modular architectures minimize the physical changes that are needed to achieve a functional change (Mikkola, 2003), thus enabling quick customer response.

There is a high degree of modularity based manufacturing practices across almost all industry segments today. Toyota is gearing itself to deliver a custom built car within five days of receiving the order (Simison, 1999). Dell promises delivery of a customized PC within a few days of receiving the order. Motorola delivers their made-to-order cellular phones the next day to customers anywhere in the United States. Proctor and Gamble once offered 13 different product designs in their pamper phases line to reflect the change in infants as they grow from newborns to toddlers (Pine, 1999). All this is the consequence of modular product and process designs which enables organizations and for that matter supply chains to rapidly respond to customer demand.

Feitzinger and Lee (1997) based on a case study of Hewlett Packard, observe that modularity based manufacturing practices leads to higher supply chain responsiveness as it gives the supply chain the ability to postpone differentiation as close to the customer as possible. Feitzinger and Lee (1997) cite the example of HP which due to its product modularity practice (viz: standardizing the basic/common components in the LaserJet printer and customizing the product close to the customer – as per demand) improved its responsiveness to customer demand. McCutcheon and Raturi (1994) suggested that modular product design is the best way to provide variety and speed, thereby leading to customer responsiveness, which occurs when customers demand greater variety, and reduced delivery times simultaneously.

Although the principles of modular production have been discussed for decades (Starr, 1965; Ulrich & Tung, 1991), their strategic potentials are only recently being rediscovered by many leading manufacturers as they seek improved responsiveness to compete in an increasingly uncertain marketplace (Sanchez and Collins, 2001; Ketchen and Hult, 2002; Pine, 1993).

Modular products can be disaggregated and recombined into new configurations with little loss of functionality, thus giving organizations the ability to rapidly configure a variety of products as customer demand changes. A complex system can thus be easily managed by dividing it into smaller modules and examining each piece separately.

By developing the ability to produce a wide variety of products through assembly of standardized modules, manufacturers can expect to significantly reduce uncertainty and complexity (Sanchez, 2000), thus reducing the time to respond. Drucker (1990) predicted that the factory of 1999 will be highly modular with products being built from standard component modules and processes, which shall allow rapid product changes and rapid response to market demands. Baldwin and Clark (1997, 2000) argue that it is modularity, more than any other technology that makes rapid developments in computer industry possible.

Modular products can be quickly assembled from individual component modules (i.e. assemble to order) thus enabling wide variety of products from a few common standard modules. Doing this enables firms to rapidly respond to changing customer demand with a lead time equal to that dictated by final assembly process near to the customer (Ulrich, 1995). Furthermore Ulrich (1995) contends that use of standard components can lower the lead time of product development as well as the lead time of the project (if component development would have been on the project critical path), once again adding to the responsiveness of the firm and effectively the supply chain as a whole.

In the automobile industry, Ford, GM, VW, and Chrysler are introducing modular assembly lines and modular cars to improve the responsiveness of production process (Suzik, 1999; Salerno, 2001). Modular design has also been an important factor in Microsoft's on-time delivery of its extremely complex Windows operating systems (Eisenhardt & Brown, 1998).

Studies have shown that modularity has significant impacts on a firm's supply chain (Tu et al., 2004). Ulrich and Tung (1991) detail the benefits of modularity which include - rapid product updating/modification, rapid product building (decreased order lead time) with increased variety, rapid design and testing – which implies that modularity leads to the responsiveness of the operations systems. Since modularity helps postpone the final assembly and customization of the final product as close to the customer in time it leads to logistics process responsiveness as well. Furthermore modularity assists organizations to source different modules from individual suppliers, instead of sourcing the whole product, this helps postponed purchasing of these modules or subassemblies (rather than purchasing whole product) thereby implying an improved supplier network responsiveness.

Product modularity and process modularity are crucial to agile manufacturing and provide a way to rapidly respond to changing customer requirements (Kidd, 1994). Baldwin and Clark (1997; 2000) suggest that modularity is an effective manufacturing strategy that enables firms to cope with rapidly changing customer requirements and increasing technical complexity, thus enabling organizations to achieve responsiveness.

Prater et al. (2001) in his case study research presents the case study of Hewlett Packard, which reduced the uncertainty by designing the product appropriately so as to customize it only when individual orders are received. This strategy is referred to as postponement and is a crucial part within the logistic structure (Hise, 1995). Thus product modularity has enabled HP to gain responsiveness to customer demand changes. Lee (2004) asserts that designing products so that they share common parts (i.e. product modularity) and processes (i.e. process modularity) initially and differ substantially only by the end of the production process is one of the most important ways to respond quickly to demand fluctuations, because it allows the firms to finish products only when they have accurate information on consumer preferences.

For manufacturers, modularity enables them to handle increasingly complex technology (Tu, 1999) and respond faster to changing customer demand by creating more variety of products from a set of common modules or subassemblies. By breaking up a product into modules, designers and producers have the flexibility so as to respond rapidly to any uncertainties (Baldwin and Clark, 1997).

As customers become more demanding, modularity based practices shall enable firms to design and operate production systems that can meet the specific needs of customers with speed (Tu et al., 2004).

Salvador et al. (2002) based on case studies, observes that modularity increases the responsiveness of suppliers of individual components thus enabling rapid assembly of the final product close to the customer, in time.

Process modularity enables re-sequencing / addition of new process modules to customize the products in response to changing customer demand, thus increasing the responsiveness of the supply chain (Tu et al., 2004). Product and process modularity leads to a responsive supply chain that can satisfy individual customer needs without incurring higher production and inventory costs (Van Hoek and Weken, 1998; Tu et al., 2004).

Firms can reorganize and reconfigure teams quickly and without loss of efficiency, so response time is short yet the quality of the product design and process execution are high (Tu et al. 2004). When companies form loosely coupled networks of modular, flexible working units, instead of tightly coupled teams, these groups of people, processes, and technology can be easily reconfigured to meet the ever changing customer needs and thus attain responsiveness in the operations system (Weick, 1990; Tu et al., 2004).

Traditional organizations have fairly stable boundaries, modular organizations can quickly be recast as needed as per the task thus increasing flexibility (Ketchen and Hult, 2002) and speed in responding to changes in business conditions. Thus to summarize modularity based manufacturing practices leads to overall supply chain responsiveness. The above arguments lead to:

Hypothesis 2: '*Modularity based manufacturing practices' of a firm is positively related to supply chain responsiveness.*

3.4 Research Hypothesis 3 (Supply Chain Responsiveness and Competitive Advantage)

The improvement of flexibility and speed of response has become increasingly important as a method to achieve competitive advantage (Upton, 1997; Martin and Grbac, 2003). Responsiveness to customer is critical to gaining competitive advantage (Williamson, 1991; Martin and Grbac, 2003). Ellinger (2000) argues that competitive advantage accrues to those firms who are responsive to the customer needs. Lummus et al. (2003) argue that in the future, as supply chains compete with other supply chains, organizations must understand that responsive supply chains will outperform those that are less responsive. Creating responsive supply chains has become a source of competitive advantage (Lau and Hurley, 2001).

Firms with more responsive supply chains will be more adaptive to demand fluctuations and will handle this uncertainty at a lower cost due to the shorter lead time (Randall et al., 2003). Yusuf et al. (1999) argues that lean manufacturing compromises responsiveness over cost-efficiencies, however agile manufacturers place equal importance on both cost and responsiveness. Cost and quality have been long incorporated into agile competitive bases (Yusuf et al., 1999). Gunasekaran and Yusuf (2002) emphasize that responsiveness without cost effectiveness is not a real competitive strategy. However Yusuf et al. (2003) found that cost and responsiveness do not go hand in hand. However due to visa-versa arguments, we maintain here that - on the whole - supply chain responsiveness and competitive advantage are positively related. Yusuf et al. (2003) found high correlation between the responsiveness and time to market, dependability, product innovation and quality.

Towill (1996) suggests that the effective engineering of cycle time reduction will lead to significant improvements in manufacturing costs and productivity. Towill (1996) further argues that reduction in lead times is the necessary condition for a responsive supply chain and which further reduces the time to market. Sharifi and Zhang (2001) and Aitken et al. (2002), emphasize that responsiveness in the supply chain is a source of competitive advantage. A 1997 study (Allnoch, 1997) of 225 manufacturers found that average companies required much more time to respond to changes in customer demand than did the leading manufacturers. In some cases, as much as eight times longer was required. The study also found that while leading manufacturers required two weeks to meet increased production requirements per customer demand, average companies required four weeks to four months. The result ? These leading companies outperformed their peers and realized huge cost savings and other competitive advantages. Thus we propose here, that supply chain responsiveness shall reduce the costs, while leading to competitive advantage for firms on other dimensions as well.

Being operationally responsive will enable organizations to compete based on cost, quality, time to market, and delivery dependability; responsiveness of a firm’s logistics (transportation and distribution) process will enable organizations to introduce new products faster than major competitors (i.e. increasing the time to market), and also lead to greater ability of a firm to provide on time the type and volume of product required by customers (i.e. increasing delivery dependability); responsiveness of a firm's supplier network will improve - the ability of the firm to rapidly introduce new products and features in the market place (i.e. compete based on product innovation and time to market), as well as improve a firm's ability to provide on time delivery (i.e. increase its delivery dependability) as these firms will be endowed with responsive suppliers.

A supply chain characterized by quick responsiveness to customers will be competitive in terms of time and quality (Li, 2002). The above arguments lead to:

Hypothesis 3: *Supply Chain Responsiveness is positively related to competitive advantage of a firm.*

3.5 Research Hypothesis 4 (SCM Practices and Competitive Advantage)

Effective SCM produces competitive advantage for a firm in that it is said to reduce costs (Martin and Grbac, 2003; Sheth and Sharma, 1997; Tan et al., 1998; Araujo et al., 1999). SCM practices have been found to be positively related to competitive advantage (price, quality, delivery dependability, product innovation, and time to market) in prior literature (ex: Li et al., 2006)

It has been pointed out that practicing SCM has become an essential requirement to staying competitive and growing profitably in today's global race (Power et al., 2001; Moberg et al., 2002).

Larson and Kulchitsky (1998), in an empirical study found that developing strategic supplier partnerships also lead to cost effectiveness of the focal firm. Christopher (1992) states that, the greater the collaboration, at all levels, between supplier and customer, the greater the likelihood that competitive advantage can be gained by organizations. Extensively coordination with suppliers and involving them in new product development process has been found to enhance the ability of organizations to develop successful new products, and thus gain competitive advantage in the marketplace (Ragatz et al., 2002; Twigg, 1998). Ragatz et al. (2002) found that supplier integration can reduce material costs and quality, product development time and cost, and manufacturing cost while improving functionality. Advantages of supplier participation in new product development include reduced project costs (Kessler, 2000; Clark, 1989), and improved perceived product quality (McGinnis and Vallopra, 1999; Ragatz et al., 1997). A long-term relationship with the supplier will have a lasting effect on the competitiveness of the entire supply chain (Choi and Hartley, 1996; Kotabe et al., 2003).

Sharing information (and data) with other parties within the supply chain can be used as a source of competitive advantage (Jones, 1998; Novack et al., 1995). Furthermore, Tompkins and Ang (1999) consider the effective use of pertinent, timely, and accurate information by supply chain members as a key competitive factor. Information sharing with suppliers has given Dell Corp. the benefits of faster cycle times (implying faster time to market), reduced inventory (implying reduced costs), and improved forecasts. Customers, for their part, have benefited by getting a higher-quality product at a lower price (Magretta, 1998; Stein and Sweat, 1998). The above arguments lead to:

Hypothesis 4: **'***SCM practices' of a firm is positively related to competitive advantage of a firm.*

3.6 Research Hypothesis 5 (Modularity Based Manufacturing Practices and Competitive Advantage)

By developing the ability to produce a wide variety of products through assembling standardized modules, manufacturers can expect to cut product development time (and thus improve time to market new products), and lower overall costs (Sanchez, 2000).

Drucker (1990) had predicted that the factory of 1999 will be highly modular with product being built from standard component modules and processes, which shall allow low cost production of ‘options’ or ‘special products’ in fairly small batches. Modularity results in better-integrated designs with more value to the customer, an integrated quality focus, and reduced piece cost and investment (Suzik, 1999). Use of existing standard components can lower the complexity and cost of products (due to no development resources needed) (Ulrich, 1995).

As customers become more demanding, managers must understand how to use modularity principles to design, and operate production systems that can meet the specific needs of the customers with speed, in large volumes so economies of scope are achieved, and at a cost that is close to mass produced goods (Tu et al., 2004). Designing products and processes into modules, is cost effective due to the use of standard base units and product customization when customer orders are received (Feitzinger and Lee, 1997; McCutcheon and Raturi, 1994).

The computer industry has dramatically increased its rate of innovation through the widespread adoption of modular designs (Baldwin and Clark, 1997). Baldwin and

Clark (1997) further contend that modularity and responsiveness are both instrumental in the heightened rate of innovation. The above arguments lead to:

Hypothesis 5: '*Modularity based manufacturing practices' of a firm is positively related to competitive advantage of a firm.*

In sum, this chapter provides a theoretical framework for understanding the practices influencing supply chain responsiveness and competitive advantage of a firm and develops five hypotheses based on literature review. The following chapter will discuss the research methodology for generating items for measurement instruments.

CHAPTER 4: INSTRUMENT DEVELOPMENT - ITEM GENERATION AND PILOT TEST

In this chapter, the instruments for this research are developed and tested. Instruments to measure SCM practices, modularity based manufacturing practices, and competitive advantage were adopted from previous studies with minor modifications (Li et al., 2005; Tu et al., 2004; Solis-Galvan, 1998; Li et al., 2006; Koufteros, 1995). Since these instruments have been tested in previous studies and were found to be valid and reliable, they will not be tested again in the pilot study. Instead, they will be revalidated in the large-scale analysis. The construct supply chain responsiveness has been newly developed in this research. Thus the instrument to measure supply chain responsiveness (consisting of operations system responsiveness, logistics process responsiveness and supplier network responsiveness) will be developed and pilot tested.

The development of the instrument was carried out in two stages. As per Churchill (1979), the content validity is enhanced if steps are taken to ensure that the domain of the construct is covered. In accordance with Churchill (1979), in the first pre-pilot stage (also called as the pre-testing stage), potential items were generated through a literature review and from construct definitions. Then the initial pool of items was pre-tested with six academicians, one practitioner and one doctoral student. Also the definitions of the sub-constructs - operations system responsiveness, logistics process responsiveness and supplier network responsiveness - were presented to these respondents to receive input on accuracy and modifications. Further the respondents were asked to provide feedback on representativeness, clarity, specificity, ease of understanding and interpretation of the questions. The respondents were also requested to provide instructions on the length of the questionnaire. Based on the feedback, items were modified or discarded, and definitions were modified to ensure that the domain of the construct is covered and thus strengthen the content validity. The second stage was scale development and testing through a pilot study using Q-sort method. Items placed in a common pool were subjected to required number of sorting rounds (three in our case) by the judges to establish which items should be in the various categories. The objective was to pre-assess the convergent and discriminant validity of the scales by examining how the items were sorted into various construct categories. Analysis of inter-judge agreement about the item placements identified both bad items as well as weakness in the original definitions of the constructs. The instruments were further refined based on Q-sort results. The Q-sort is then followed by the large scale survey which includes the validity and reliability tests using the data from large-scale sample and is described in detail in Chapter 5. Research hypotheses were then tested based on the large-scale data analysis.

4.1 Item Generation and Structured Interview (Pre-Pilot / Pre-test)

Proper generation of measurement items of a construct determines the validity and reliability of an empirical research. The very basic requirement for a good measure is content validity, which means the measurement items contained in an instrument should cover the major content of a construct (Churchill, 1979). Content validity is usually achieved through a comprehensive literature review and interviews with practitioners and academicians. A list of initial items for each construct was generated based on a comprehensive review of relevant literature. The general literature basis for items in the newly developed supply chain construct is briefly discussed below.

The items for Supply Chain Responsiveness (Operations Systems Responsiveness, Logistics Process Responsiveness, and Supplier Network Responsiveness) were generated through supply chain flexibility literature, manufacturing flexibility literature, supply chain agility literature, agile manufacturing literature, and customer responsiveness literature (Prater et al., 2001; Lummus et al., 2003; Duclos et al., 2003; Van Hoek, 2000; Fawcett, 1992; Fawcett et al., 1996; Fawcett and Smith, 1995; Lau, 1999; Emerson and Grimm, 1998; Martin and Grbac, 2003).

Once item pools were created, items for the various constructs were reviewed by six academicians and a doctoral student, and further re-evaluated through a structured interview with one practitioner. The focus was to check the relevance of each construct's definition and clarity of wordings of sample questionnaire items. Based on the feedback from the academicians and practitioners, redundant and ambiguous items were either modified or eliminated. New items were added whenever deemed necessary. The result was the following number of items in each pool entering Q-sort analysis (see Appendix A). There were a total of 3 pools and 18 items.

Supply Chain Responsiveness	
Operations System Responsiveness	7
Logistics Process Responsiveness	5
Supplier Network Responsiveness	6
Total	18

4.2 Scale Development: the Q-Sort Method

Items placed in a common pool were subjected to three Q-sort rounds by two independent judges per round. The objective was to pre-assess the convergent and discriminant validity of the scales by examining how the items were sorted into various factors or dimensions.

The basic procedure was to have relevant respondents representing the target population (in our case, purchasing/materials/supply chain/operations vice presidents and managers) act as judges and sort the items into several groups, each group corresponding to a factor or dimension, based on similarities and differences among items. An indicator of construct validity was the convergence and divergence of items within the categories. If an item was consistently placed within a particular category, then it was considered to demonstrate convergent validity with the related construct, and discriminant validity with the others. Analysis of inter-judge disagreements about item placement identified both bad items, as well as weakness in the original definitions of constructs. Based on the misplacements made by the judges the items could be examined and inappropriately worded or ambiguous items could be either modified or eliminated.

4.2.1 Sorting Procedures

One 3'' by 5" card was printed for each item. The set of cards for each construct were shuffled and given to the judges. The definitions of the constructs were also given to the judges. The judges were then asked to put each card under one of the constructs to the best of their knowledge. A "Not Applicable" category was also included to ensure that the judges did not force any item into a particular category. A pair of judges included a vice president and purchasing manager or a materials manager and purchasing manager to ensure that the perception of the target population is included in the analysis. Prior to sorting the cards, the judges were briefed with a standard set of instructions that were previously tested with a separate judge to ensure comprehensiveness and comprehensibility of the instructions. Judges were allowed to ask as many questions as necessary to ensure they understood the procedure.

4.2.2 Inter-Rater Reliabilities

To assess the reliability of the sorting conducted by the judges, three different measures were used. First, for each pair of judges in each sorting step, the inter-judge raw agreement scores were calculated. This was done by counting the number of items both judges agreed to place in a certain category. An item was considered as an item with agreement, though the category in which the item was sorted together by both judges may not be the originally intended category. Second, the level of agreement between the two judges in categorizing the items was measured using Cohen's Kappa (Cohen, 1960). This index is a method of eliminating chance agreements, thus evaluating the true agreement score between two judges. A description of the Cohen's Kappa concept and methodology is included in Appendix B. Third, item placement ratio (or Moore and Benbasat's (1991) "Hit Ratio") was calculated by counting all the items that were correctly sorted into the target category by the judges for each round and dividing them by twice the total number of items.

4.2.3 Results of First Sorting Round

In the first round, the inter-judge raw agreement scores averaged 83% (Table 4.2.3.1), the initial overall placement ratio of items within the target constructs was 91% (Table 4.2.3.2), and the Cohen's Kappa score averaged 0.74.

The calculation for Cohen's Kappa coefficient is shown below.

$$k = \frac{N_i X_{ii} - \sum_i (X_{i+} X_{+i})}{N_i^2 - \sum_i (X_{i+} X_{+i})} = \frac{(18)(15) - 116}{(18)(18) - 116} = 0.74$$

The calculation of the k is based on Table 4.2.3.1. N_i is the number of total items (18); X_{ii} is the total number of items on the diagonal, that is, the number of items agreed on by two judges (15); X_{i+} is the total number of the items on the i^th row of the table; and X_{+i} is the total number of items on the i^th column of the table (see Appendix B for the description of this methodology).

A summary of the first round inter-judge agreement indices is shown in the first column of Table 4.2.3.3. For Kappa, no general agreement exists with respect to required scores. However, several studies have considered scores greater than 0.65 to be acceptable (e.g. Vessey, 1984; Jarvenpaa, 1989). Landis and Koch (1977) have provided a more detailed guideline to interpret Kappa by associating different values of this index to the degree of agreement beyond chance. They suggest the following guideline:

Value of Kappa	Degree of Agreement Beyond Chance
.76 - 1.00	Excellent
.40 - .75	Fair to Good (Moderate)
.39 or less	Poor

Following the guidelines of Landis and Koch (1977) for interpreting the Kappa coefficient, the value of 0.74 indicates a moderate but almost excellent level of agreement (beyond chance) for the judges in the first round. This value is lower than the value for raw agreement which is 0.83. The level of item placement ratios averaged 0.91. For instance, the lowest item placement ratio value was 0.70 for the logistics process responsiveness, indicating a low degree of construct validity.

Table 4.2.3.1 Inter-Judge Raw Agreement Scores: First Sorting Round

		Judge 1			
Judge 2		**1**	**2**	**3**	**NA**
	1	**7**			
	2	**3**	**2**		
	3			**6**	
	NA				
Total Item Placement: 18		**Number of Agreements: 15**			**Agreement Ratio: 83 %**

1. **Operations system responsiveness**
2. **Logistics process responsiveness**
3. **Supplier network responsiveness**

Table 4.2.3.2 Items Placement Ratios: First Sorting Round

		Actual Categories					
		1	2	3	NA	Total	%
Theoretical Categories	1	14				14	100 %
	2	3	7			10	70 %
	3			12		12	100 %
Item Placements: 36		Hits: 33		Overall “Hit Ratio”: 91 %			

1. **Operations system responsiveness**
2. **Logistics process responsiveness**
3. **Supplier network responsiveness**

4.2.3.3 Inter-Judge Agreements

Agreement Measure	**Round 1**	**Round 2**
Raw Agreement	83%	100%
Cohen’s Kappa	74%	100%
Item Placement Ratio Summary		
Operations system responsiveness	100%	100%
Logistics process responsiveness	70%	100%
Supplier network responsiveness	100%	100%
Average	91%	100%

On the other hand, the constructs - operations system responsiveness and supplier network responsiveness - obtained a 100% item placement ratio, indicating a high degree of construct validity.

In order to further improve the Cohen's Kappa measure of agreement, an examination of the off-diagonal entries in the placement matrix (Table 4.2.3.2) was conducted. This was done in two parts: one part looked at clustering and the other part at scattering. The first part of the analysis revealed one moderate cluster involving two constructs (operations system responsiveness and logistics process responsiveness, with three items from the latter being classified into the former). An analysis of this cluster was conducted to identify ambiguous items (fitting in more than one category) or indeterminate items (fitting in no category), and were reworded. The second part of the analysis included looking for scattering. Scattering of a construct, raises concern for the level of its internal consistency. There was no scattering of items observed for any construct. Also, feedback from both judges was obtained on each item and incorporated into the modification of the items. Further the definitions of logistics process responsiveness and supplier network responsiveness were slightly modified based on the feedback from judges. Overall, two items were reworded, with none being deleted. The number of items for each construct remained unchanged after the first round of Q-sort:

Supply Chain Responsiveness	
Operations System Responsiveness	7
Logistics Process Responsiveness	5
Supplier Network Responsiveness	6
Total	18

4.2.4 Results of Second Sorting Round

Again, two judges were involved in the second sorting round, which included the reworded items after the first sorting round. In the second round, the inter-judge raw agreement scores averaged 100% (Table 4.2.4.1), the initial overall placement ratio of items within the target constructs was 100% (Table 4.2.4.2), and the Cohen's Kappa score averaged 1.00.

A summary of the second round inter-judge agreement indices is shown in the second column of Table 4.2.3.3.

Table 4.2.4.1 Inter-Judge Raw Agreement Scores: Second Sorting Round

	Judge 1				
Judge 2		1	2	3	NA
	1	7			
	2		5		
	3			6	
	NA				
Total Item Placement: 18		Number of Agreements: 18		Agreement Ratio: 100 %	

1. **Operations system responsiveness**
2. **Logistics process responsiveness**
3. **Supplier network responsiveness**

The value for Kappa coefficient of 1.00 is much higher than the value obtained in the first round (.74), indicating an excellent level of agreement for the judges in the second round. The level of item placement ratios averaged 1.00. All the three constructs - operations system responsiveness, logistics process responsiveness and supplier network responsiveness - obtained a 100% item placement ratio, indicating a high degree of construct validity.

Table 4.2.4.2 Items Placement Ratios: Second Sorting Round

	Actual Categories						
		1	**2**	**3**	**NA**	**Total**	**%**
Theoretical Categories	**1**	**14**				**14**	**100 %**
	2		**10**			**10**	**100 %**
	3			**12**		**12**	**100 %**
Item Placements: 36			**Hits: 36**		**Overall “Hit Ratio”: 100 %**		

1. **Operations system responsiveness**
2. **Logistics process responsiveness**
3. **Supplier network responsiveness**

The Cohen's Kappa measure of agreement is excellent in round two. There are no off-diagonal entries in the placement matrix (Table 4.2.4.2) revealing absence of any clustering or scattering. Feedback from the judges in round two led to the replacement of one item for supplier network responsiveness to capture the domain of the construct (for inbound logistics to the firm from the supplier). Further, four items were slightly modified based on comments from judges in round two.

A third round of Q-sort was further conducted. However, the results of the third round were similar to those obtained in the second sorting round, and thus they have not been reported in the study.

After the second Q-sort round the number of items for each construct remained unchanged (a total of 18 items into 3 pools) and were as follows:

Supply Chain Responsiveness	
Operations System Responsiveness	7
Logistics Process Responsiveness	5
Supplier Network Responsiveness	6
Total	18

At this point, we stopped the Q-sort method at round two, for the raw agreement score of 1.0, Cohen's Kappa of 1.0, and the average placement ratio of 1.0 which were considered an excellent level of inter-judge agreement, indicating a high level of reliability and construct validity. The resulting measurement scale for supply chain responsiveness is reported in Appendix C and will be used in the large-scale survey (Appendix D). Tests for the quantitative assessment of construct validity and reliability using the large-scale sample are presented in the next chapter.

CHAPTER 5: LARGE SCALE SURVEY AND INSTRUMENT VALIDATION

5.1 Large-Scale Data Collection Methodology

Data was collected using a large scale web-based survey. Quality of respondents and response rate are two important factors that influence the quality of an empirical study. Since this study has a supply chain management focus, the target respondents were the operations / manufacturing / purchasing / logistics / materials – vice presidents, directors and managers as these personnel were deemed to have the best knowledge in the supply chain area. Seven SIC codes are covered in the study: 22: Textile Mill products, 23: Apparel and other Textile Products, 25: Furniture and Fixtures, 34: Fabricated Metal Products, 35: Industrial Machinery and Equipment, 36: Electrical and Electronic Equipment, and 37: Transportation Equipment. These SIC codes were chosen as they predominantly represent the focus of this study; that is supply chain responsiveness, and modularity based manufacturing practices. Also these industries represent the core manufacturing industry (ex: transportation equipment, which include automobiles), most of them deal with modular products and processes (ex: textile products, furniture and fixtures, and once again automobiles), and the rest of them operate in a fast paced industry (ex: industry clockspeed is high for electronics and computer industries). The survey was confined to US only. The SIC codes and the target respondents were the two criteria when purchasing email lists. The e-mail lists were purchased from three different sources. These were the Council of Supply Chain Management (CSCMP), Rsateleservices.com, and Lead411.com. From CSCMP members' database - 1313 emails, from rsateleservices.com – 5846 emails, and from lead411.com - 1083 emails were purchased (8242 total names), based on the two criteria mentioned above. In order to increase the response rate, it was decided to remove duplicate names. The refinement resulted in a deletion of 316 names / emails, thus giving the researcher 7926 names.

Since the survey was sent by email, the email addresses had to be filtered by a server program to guarantee that the email addresses were valid according to certain standard. The undelivered emails were not counted in the final sample size since the respondents never received the survey. This resulted in the removal of 2200 names from the list. Accordingly the final mailing contained 5726 names.

The survey was conducted by the web-based method. To ensure a reasonable response rate, the survey was sent in three waves. The questionnaire with the cover letter indicating the purpose and significance of the study was emailed to target respondents. In the cover letter, the respondents were given three options to send their response: 1) online completion and submission: a web link was given so that they could complete the questionnaire online (http://www.businessfaculty.utoledo.edu/athatte/SCRSurvey.asp) and send it immediately; 2) download the hard copy online: a link to the questionnaire in .pdf file (http://www.businessfaculty.utoledo.edu/athatte/FINALSURVEY.pdf) was given and respondents could send it by fax or ask for a self-addressed stamped envelope; 3) request the hard copy by sending an email: they received in their regular mail a copy of the questionnaire along with a self-addressed stamped envelope.

There were 228 automated email replies mentioning that the person is out of office. These "out of office" emails were not counted in the final sample size. There were a total of 298 responses from the mailings. Of these responses, 4 questionnaires were submitted online with many unanswered questions, with an apology email indicating that they were unable to answer all questions because the questions were not applicable to their company, or they were inappropriate respondents, having realized that half way through filling the questionnaire. Therefore the final number of complete and usable responses was 294. This represents a response rate of 5.35% (calculated as **294/ (5726-228)**). Out of 294, the first wave produced 92 responses, and the second wave and the third wave generated 100 and 102 responses, respectively. In addition, out of those responses, 283 were received online and 11 were received via mail or fax.

5.2 Sample Characteristics of the Respondents and Organizations

This section will discuss sample characteristics in terms of the respondents (job title, job function, and years worked at the organization) and the organizations (years of implementing SCM program, the primary production system, industry, employment size, and annual sales).

5.2.1 Sample Characteristics of Respondents

The result is shown in Table 5.2.1.1.

Job Title: About half of the respondents (45%) are vice presidents, while 25% state they are directors and 19% are titled as managers. The rest of the respondents (11%) are CEO/president. Thus 81% of the respondents (CEOs, VPs, and directors) are high level executives, implying a high reliability of the responses received, as these executives have a wider domain (job responsibility) and administrative knowledge.

Job Function: 42 % of the respondents were corporate executives, 17 % choose SCM as their area of expertise, while 13% are responsible for distribution/logistics, 9% for manufacturing/production, while and 6% belonged to the operations area. While 4% of the respondents belonged to the purchasing area, transportation and materials accounted for about 1% each. The rest of the respondents (7%) belong to the “other” category. This distribution of respondents by job function implies that 50% of the respondents are related to the operations field in addition to 42% which are corporate executives (high level executives in either function), thereby signifying high reliability of the obtained responses.

Years Stayed at the Organization: 33% of the respondents indicate they have been with the organization over 10 years, 21% indicate having been at the organization between 6-10years, and 27% state their years stayed at the organization as between 2-5 years. Also the respondents with years stayed at the organization less than 2 years account for 19% of the sample.

Since majority of the respondents are senior level executives (CEO/president, vice presidents, and directors) (11+ 45 + 25 = 81%) it can be said that the data is more reliable. Figure 5.2.1.1 to 5.2.1.3 display the respondents by job titles, job functions, and years worked at the organization, respectively.

Table 5.2.1.1 Characteristics of the Respondents

1.	**Job Titles** (290)	
	CEO/President	10.69% (31)
	Vice President	44.83% (130)
	Director	25.17% (73)
	Manager	19.31% (56)
2.	**Job Functions** (291)	
	Corporate Executive	42.27% (123)
	Purchasing	4.47% (13)
	Manufacturing / Production	8.59% (25)
	Distribution / Logistics	13.06% (38)
	SCM	16.84 (49)
	Transportation	1.37% (4)
	Materials	0.69% (2)
	Operations	6.19% (18)
	Other	6.53% (19)
3.	**Years worked at the organization** (290)	
	Under 2 years	19.31% (56)
	2-5 years	26.55% (77)
	6-10 years	20.69% (60)
	Over 10 years	33.45% (97)

Figure 5.2.1.1 Respondents by Job Title

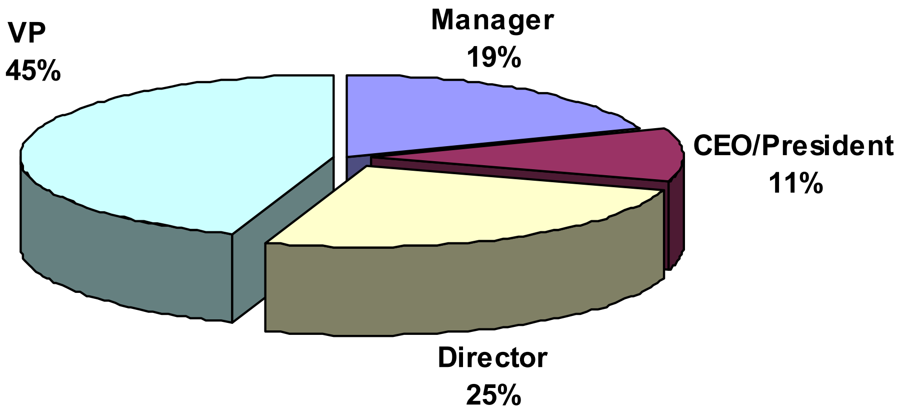


Figure 5.2.1.2 Respondents by Job Function

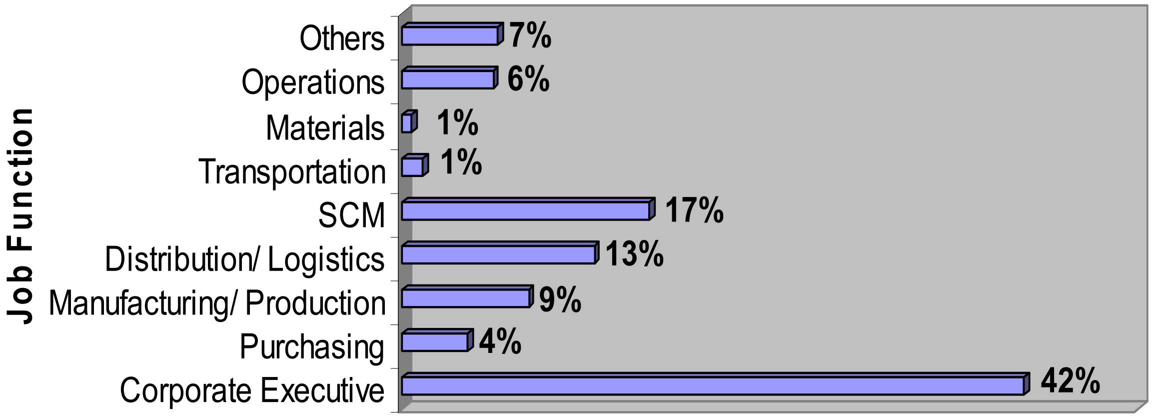
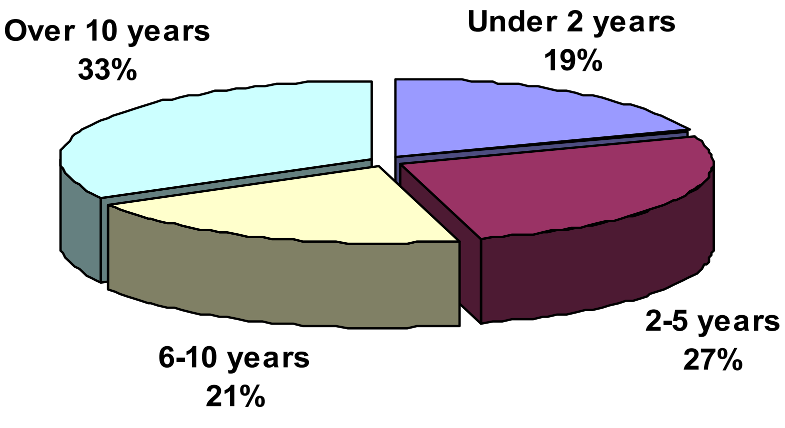


Figure 5.2.1.3 Respondents by Years Worked at the Organization



5.2.2 Sample Characteristics of Surveyed Organization

The result is shown in Table 5.2.2.1.

The Implementation of SCM Program: More than half the organizations surveyed (64%) have embarked upon a program aimed specially at implementing SCM, and the average length of the implementation is 4.15 years.

Primary Production System: 35% of the organizations use 'make-to-order' as primary production system; while 'make-to-stock', 'assemble to order', and 'engineer to order' account for 33%, 21%, and 11% respectively.

Industry (based upon SIC code): Most respondents (40%) indicate their organization is in the 'electrical and electronic equipment' industry; 10% of respondents are in the 'fabricated metal products' industry; the same number (10%) is in the 'industrial machinery' and 'equipment industry'; while 9% of them are in the 'transportation equipment' industry. Finally 3% and 1% of respondents are in the 'furniture and fixtures' and the 'apparel and other textile products' industry. The rest (27%) belong to the "other" category.

Number of Employees: The number of employees indicates the diversification of the organization ranging from the small size to the large size. 56% of the organizations have more than 1000 employees; another 9% of the organizations have between 501-1000 employees, further 12% of the organizations have between 251-500 employees and an equal number (12%) of them have between 101-250 employees. Also 7% and 4% of the organizations have between 51-100 employees and 1-50 employees respectively.

Annual Sales: More than half the organizations (71%) have annual sales exceeding 100million USD; 7% of the organizations have sales volume between 50-

100million USD; another 9% of the responding organizations have sales volume between 25-50million USD; while 7% of the organizations have annual sales between 10-25 million USD, 4% and 3% of the responding organizations have sales volume between 5-10million USD and under 5million USD, respectively.

Figures 5.2.2.1, 5.2.2.2, 5.2.2.3, and 5.2.2.4 display the surveyed organizations by primary production system, industry, number of employees, and annual sales, respectively. Overall, the diversification in industry type, company size, and experience in the operations field indicate that the survey has covered a wide range of organizations in different industries with different sizes and experiences, of which more than half of the organizations are large organizations with high annual sales.

Table 5.2.2.1 Characteristics of the Surveyed Organizations

1.	Organizations that have embarked upon a program aimed specially at implementing “Supply Chain Management” (294).	
	Yes:	63.27% (186)
	No:	36.73% (108)
	Average length of implementation: 4.15 years	
2.	Primary production system (283)	
	Engineer to Order	10.60% (30)
	Make to Order	35.69% (101)
	Assemble to Order	20.85% (59)
	Make to Stock	32.86% (93)
3.	Industry – SIC (278)	
	Textile mill Products (SIC 22)	0.00% (0)
	Apparel and Other Textile Products (SIC 23)	1.44% (4)
	Furniture and Fixtures (SIC 25)	2.52% (7)
	Fabricated Metal Products (SIC 34)	10.43% (29)
	Industrial Machinery and Equipment (SIC 35)	10.07% (28)
	Electrical and Electronic Equipment (SIC 36)	39.57% (110)
	Transportation Equipment (SIC 37)	9.35% (26)
	Other	26.62% (74)
4.	Number of employees (291)	
	1-50	4.12% (12)
	51-100	6.87% (20)
	101-250	12.03% (35)
	251-500	12.37% (36)
	501-1000	8.59% (25)
	Over 1000	56.01% (163)
5.	Annual sales in millions of $ (278)	
	Under 5	2.52% (7)
	5 to 10	3.60% (10)
	10 to <25	7.19% (20)
	25 to <50	8.99% (25)
	50 to <100	6.83% (19)
	>100	70.86% (197)

Figure 5.2.2.1 Organizations by Primary Production System

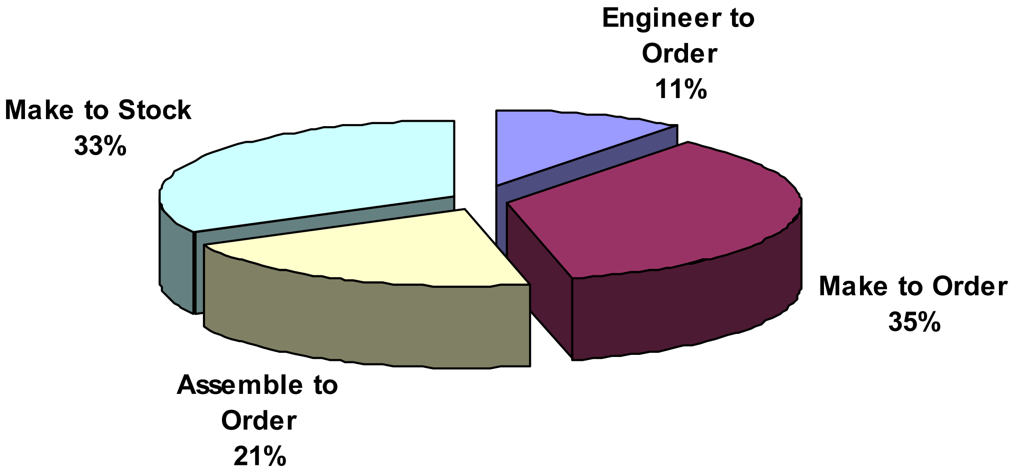


Figure 5.2.2.2 Organizations by Industry (SIC Codes)

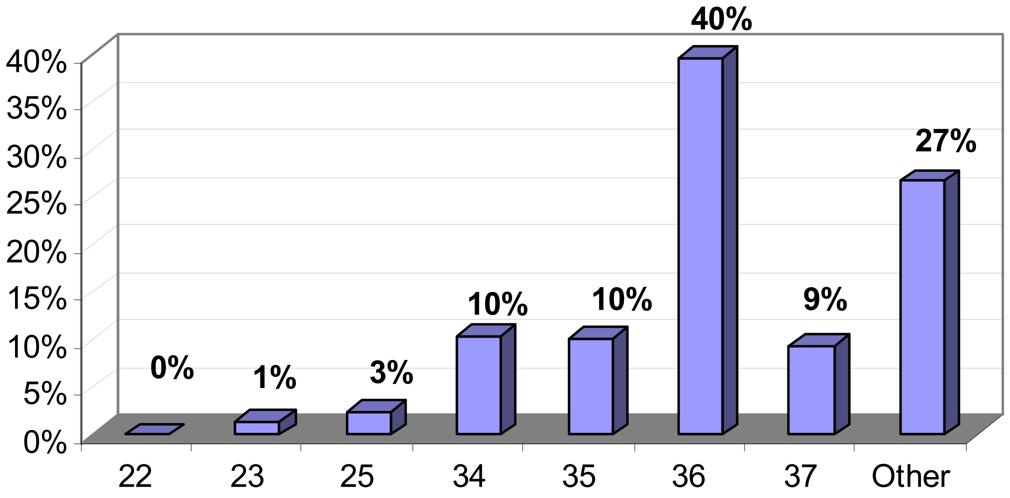


Figure 5.2.2.3 Organizations by Number of Employees

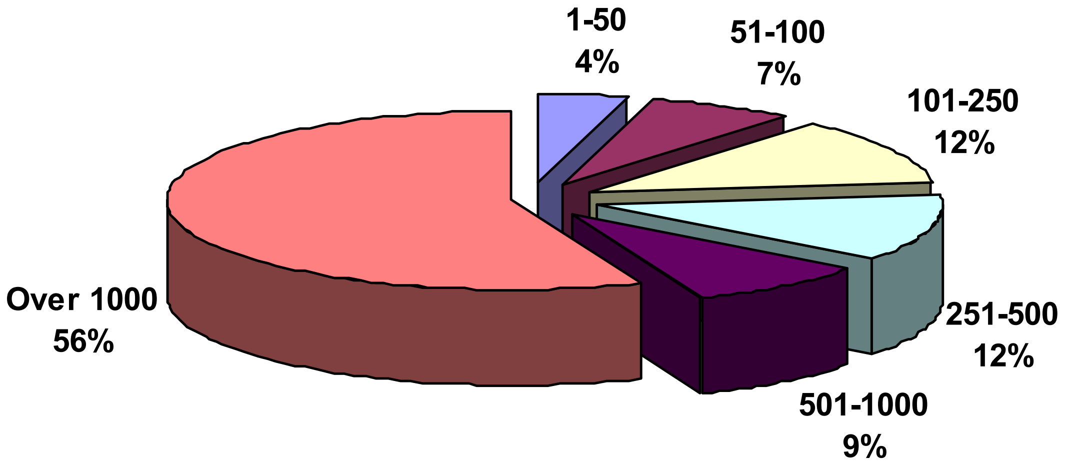
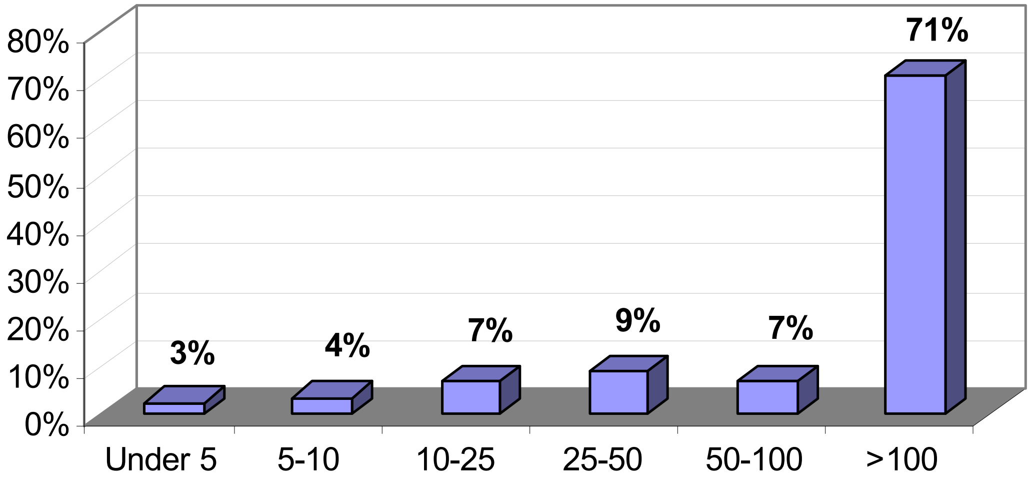


Figure 5.2.2.4 Organizations by Annual Sales (In millions of $)



5.3 Between-Response Comparison

One concern of the survey is that information collected from respondents might have a non-response bias. This research did not investigate non-response bias directly, however a comparison was made between those subjects who responded after the initial e-mailing and those who responded to the second/third wave. Chi-square tests were used to make the comparisons. The results are shown in last column of Table 5.3.1. We can see no significant difference in industry type (based on SIC), employment size, and respondent's job title between these two groups. Thus it can be concluded that the non-response bias is not a cause for concern. Chi-square tests of independence were also performed to observe if the distribution of responses across SIC codes, employment size, and respondent's job title is independent of the three waves. The results are shown in Table 5.3.2. We observe that there is no significant difference in industry type (based on SIC), employment size, and respondent's job title between each of the three groups / waves. Thus it can be concluded that the distribution of responses across SIC codes, employment size and respondents job title is independent of the waves.

Table 5.3.1 Comparisons between First Wave and Second/Third Wave

Variables	First-wave	Second/Third wave	Second/Third wave	Chi-square Test
	Frequency (%)	Expected Freq. (%)	Observed Freq. (%)	
Industry - SIC (278)				
SIC 22	0 (0.0%)	0 (0.0%)	0 (0.0%)	χ^2=3.79 df=7 p>.10
SIC 23	2 (2.3%)	4 (2.3%)	2 (1.05%)	
SIC 25	2 (2.3%)	4 (2.3%)	5 (2.6%)	
SIC 34	9 (10.3%)	20 (10.3%)	20 (10.5%)	
SIC 35	7 (8.1%)	15 (8.1%)	21 (11.0%)	
SIC 36	36 (41.4%)	79 (41.4%)	74 (38.7%)	
SIC 37	8 (9.2%)	18 (9.2%)	18 (9.4%)	
Other	23 (26.4%)	50 (26.4%)	51 (26.7%)	
Number of Employees (291)				
1-50	4 (4.4%)	9 (4.4%)	8 (4.0%)	χ^2=5.0 df=5 p>.10
51-100	6 (6.6%)	13 (6.6%)	14 (7.0%)	
100-250	9 (9.9%)	20 (9.9%)	26 (13.0%)	
251-500	10 (11%)	22 (11%)	26 (13.0%)	
501-1000	7 (7.7%)	15 (7.7%)	18 (9.0%)	
Over 1000	55	121 (60.4%)	108 (54.0%)	
Job Title (290)				
CEO/President	11 (12.0%)	24 (12.0%)	20 (10.1%)	χ^2=5.12 df=3 p>.10
Vice President	37 (40.2%)	80 (40.2%)	93 (47.0%)	
Director	23 (25.0%)	50 (25.0%)	50 (25.3%)	
Manager	21 (22.8%)	45 (22.8%)	35 (17.7%)	

Note: Figures in parentheses are percentage;

The calculation formula $\chi^2 = \Sigma (f_o - f_e)^2 / f_e$

df = (number of categories in the variable -1)

Table 5.3.2 Comparisons between First, Second, and Third Wave

Variables	**First-wave**	**First-wave**	**Second wave**	**Second wave**	**Third wave**	**Third wave**	**Row Total**	**Chi-square Test**
	Observed Frequency	**Expected Frequency**	**Observed Frequency**	**Expected Frequency**	**Observed Frequency**	**Expected Frequency**		
Industry - SIC (278)								
22	0	0.00	0	0.00	0	0.00	0	χ^2=5.695 df = 14 p>.10
23	2	1.25	0	1.29	2	1.45	4	
25	2	2.19	2	2.27	3	2.54	7	
34	9	9.08	7	9.39	13	10.54	29	
35	7	8.76	10	9.06	11	10.17	28	
36	36	34.42	36	35.61	38	39.96	110	
37	8	8.14	7	8.42	11	9.45	26	
Other	23	23.16	28	23.96	23	26.88	74	
Column Total	**87**	**87**	**90**	**90**	**101**	**101**	**278**	
Number of Employees (291)								
1-50	4	3.75	2	4.25	6	4.00	12	χ^2=9.635 df = 10 p>.10
51-100	6	6.25	5	7.08	9	6.67	20	
101-250	9	10.95	14	12.39	12	11.67	35	
251-500	10	11.26	11	12.74	15	12.00	36	
501-1000	7	7.82	7	8.85	11	8.33	25	
Over 1000	55	50.97	64	57.69	44	54.33	163	
Column Total	**91**	**91**	**103**	**103**	**97**	**97**	**291**	
Job Title (290)								
CEO/President	11	9.83	12	11.65	8	9.51	31	χ^2=3.00 df = 6 p>.10
Vice President	37	41.24	50	48.86	43	39.90	130	
Director	23	23.16	30	27.44	20	22.40	73	
Manager	21	17.7	17	21.05	18	17.19	56	
Column Total	**92**	**92**	**109**	**109**	**89**	**89**	**290**	

The calculation formula $\chi^2 = \Sigma (f_o - f_e)^2 / f_e$

df = (row -1)*(column – 1)

5.4 Structural Equation Modeling Methodology

Before proceeding to the large scale instrument assessment, the structural equation modeling methodology and the major model evaluation indices are discussed.

Unlike the traditional statistical methods that can examine only a single relationship at a time, the structural equation modeling (SEM) method greatly expands the researchers' capability to study a set of interrelated relationships simultaneously. The first important step in SEM is to specify the two components: *Measurement Model* and *Structural Model.* SEM model specification must always be based on sound theory from existing literature. The need for theoretical justification in SEM is very important for the specification of dependence relationships, modifications to the proposed relationships, and many other aspects of model estimation (Hair et al., 1998).

Once the measurement and structural models are specified, the researcher must choose a computer program for model estimation and evaluation. One of the most widely used programs is AMOS 6 by James L. Arbuckle (1994-2006). There is no single statistical test that best describes the strength of a model. Instead, researchers have developed a number of goodness-of-fit measures to assess the results from three perspectives: 1) overall fit; 2) comparative fit to a base model; and 3) model parsimony. AMOS provides several statistics that can be used to evaluate the hypothesized model and also suggest ways in which the model might be modified, given sufficient theoretical justification.

Overall Fit Measures

The most fundamental measure of overall fit is the chi-square statistic (χ^2). Low values, which result in significance levels greater than 0.05, indicate that the actual and predicted input matrices are not statistically different, hence a good fit. However the χ^2 measure is often criticized for its over-sensitivity to sample size, especially in cases where the sample size exceeds 200 respondents (Hair et al., 1998). As sample size increases, this measure has a greater tendency to indicate significant differences for equivalent models. Thus the current study does not use the χ^2 measure.

AMOS provides a second measure of overall fit and is called the *goodness-of-fit index (GFI)*. GFI represents the overall degree of fit (the squared residuals from prediction compared to the actual data). GFI is not adjusted for the degrees of freedom. Its value ranges value from 0 (poor fit) to 1 (perfect fit). Generally, a GFI value of greater than 0.90 is considered as acceptable (Segars, 1997; Hair et al., 1998).

Another measure of overall fit is the *root mean square error of approximation (RMSEA)*. The RMSEA takes into account the error of approximation and is expressed per degree of freedom. This makes the index sensitive to the number of estimated parameters in the model. Values less than 0.05 indicate good fit, values as high as 0.08 represent reasonable errors of approximation in the population (Browne and Cudeck, 1993), values ranging from 0.08 to 0.10 indicate mediocre fit, and those greater than 0.10 indicate poor fit (MacCallum et al., 1996).

Comparative Fit Measures

This class of measures compares the proposed model to some baseline model (null model) – some realistic model that all other models should be expected to exceed. The null model, in most cases, is a single construct model with all indicators that perfectly measure the construct. One of the most popular measures is the *normed fit index (NFI),* which ranges from 0 (no fit at all) to 1 (perfect fit). A commonly recommended value is 0.90 or greater (Hair et al., 1998).

Parsimonious Fit Measures

This measure relates the goodness-of-fit of the model to the number of estimated coefficients required to achieve this level of fit. The basic objective is to diagnose whether the model fit has been achieved by over-fitting the data with too many coefficients. The most widely used measure of parsimonious fit, provided by AMOS is the *adjusted goodness-of-fit index (AGFI).* AGFI is an extension of GFI but adjusted by the ratio of degrees of freedom for the proposed model to the degrees of freedom for the null model. An AGFI value of 0.80 or greater is considered as acceptable (Segars and Grover, 1993).

Modification Indices

AMOS program provides modification indices that suggest possible ways of improving the model fit. However, it is important that any modifications performed must have sufficient theoretical justification.

Standardized Structural Coefficient

A standardized structural coefficient is also called as the effect size in SEM. Effect size is a name given to a family of indices that measure the magnitude of a treatment effect. These values are displayed above their respective arrows on the arrow diagram specifying the model. The interpretation is similar to regression: if a standardized structural coefficient is 0.5, then the latent dependent will increase by 0.5 standard units for each unit increase in the latent independent. In AMOS, the standardized structural coefficients are labeled as standardized regression weights, which are similar to the coefficients used to test the strength of relationships. Unlike significance tests, these indices are independent of sample size. Effect size is commonly used to compliment structural equation modeling (SEM) because SEM is a large-sample technique. Two hundred is the minimum required size of the sample; thus larger sample sizes are more appropriate. The effect size helps researchers to differentiate between statistical significance and practical significance, when the test of a relationship deals with a large-sample size. Table 5.4.1 shows the recommended values of effect size by Cohen (1988 and 1990, pp.1309). The structural paths and loadings of substantial strength (not just statistically significant) should be at least 0.371 to be considered large indicating 13.8% of variance in the dependent variable (DV) that is accounted by the independent variable (IV). Standardized paths should be at least 0.148 in order to be considered meaningful or medium effect. Meehl (1990) argues that anything lower may be due to what he terms the crud factor where everything correlates to some extent with everything else because of a complex unknown network of genetic and environmental factors. For example, a path of 0.10 represents a one-percent explanation of variance and thus, portrays a mediocre relationship. In summary, the effect size of 0.371 or above is considered large, between 0.100 and 0.371 is considered medium and 0.1 or below is considered small.

Table 5.4.1 Standardized Structural Coefficient and % Variation Explained

Cohen's Standard	**Standardized Structural Coefficients/ Effect Size (r)**	**% Variation in DV explained by IV (r^2)**
	0.707	0.500
	0.689	0.474
	0.669	0.448
	0.648	0.419
	0.625	0.390
	0.600	0.360
	0.573	0.329
	0.545	0.297
	0.514	0.265
	0.482	0.232
	0.447	0.200
	0.410	0.168
Large	0.371	0.138
	0.330	0.109
	0.287	0.083
Medium	0.243	0.059
	0.196	0.038
	0.148	0.022
Small	0.100	0.010
	0.050	0.002
	0.000	0.000

5.5 Large-scale Instrument Assessment Methodology

Instrument assessment is an important step in testing the research model. CFA (confirmatory factor analysis) using AMOS software is performed for the measurement models, which is then followed by the structural model displaying the hypothesized relationships. It was decided to first test the measurement model and then the structural model, to avoid any interactions between the measurement and the structural model, and as proposed by Gerbing and Anderson (1988). The purification of the measurement models was done only to the new construct in the study - supply chain responsiveness - as measures for the other constructs: SCM practices (Li et al., 2005), modularity based manufacturing practices (Tu et al., 2004), and competitive advantage (Li et al., 2006; Li et al., 2005; Koufteros, 1995) are adopted from previous literature and have already been validated therein. We however report the reliabilities of the constructs that have been adopted from prior literature (along with the reliabilities for the same as obtained in this study) after we present the large-scale instrument validation results for the construct 'Supply Chain Responsiveness'. The reliabilities for the borrowed constructs have been reported in sections 5.6.2 (SCM Practices), 5.6.3 (Modularity Based Manufacturing Practices), and 5.6.4 (Competitive Advantage).

Convergent validity, discriminant validity, and reliability are important for construct validity (Ahire et al., 1996; Ragunathan and Ragunathan, 1994). Also, as per the guidelines of Bagozzi (1980) and Bagozzi and Phillips (1982), the important properties for measurement to be reliable and valid include content validity, construct validity (convergent and discriminant validity), reliability (internal consistency or scale consistency of operationalization), validation of second-order construct (we use the T coefficient), and predictive validity (we use the construct level correlation analysis). Structural equation modeling (AMOS) was used for convergent (measurement model) and discriminant (two factors at a time) validity and is discussed in detail shortly. Reliability estimation is performed after convergent and discriminant validity because in the absence of a valid construct, reliability may not be relevant (Koufteros, 1999).

Following are the discussions of content validity, convergent validity, discriminant validity, reliability analysis, and construct level correlation analysis (for predictive validity).

Content validity is enhanced if steps are taken to ensure that the domain of the construct is covered (Churchill, 1979). An instrument has content validity if there is a general agreement among the subjects and researchers that the measurement items do cover all the important aspects of the variable being measured. The evaluation of content validity is a rational judgmental process not open to numerical justification. Content validity mainly rests on appeals to reason regarding the adequacy with which important content has been sampled and on the adequacy with which the content has been cast in the form of test items (Nunnally, 1978). Content validity is assessed in two ways in this study. First, a comprehensive literature review was conducted to define the variables and constructs, and generate an initial list of items to ensure that domain of the construct is covered (Nunnally, 1978). Secondly, a Q-sort method was conducted as a pilot study for scale development and testing (Appendix B).

Convergent validity is defined as the extent to which the measurement items converge into a theoretical construct. The traditional method employed for evaluation of construct validity of measurement scales is confirmatory factor analysis. In this study, one of the most widely used SEM (structural equation modeling) software called AMOS was utilized. Using AMOS, it is possible to specify, test, and modify the measurement model. Model-data fit was evaluated based on multiple fit indices. The overall model fit indices include goodness of fit index (GFI), adjusted goodness of fit index (AGFI), and root mean square error of approximation (RMSEA). GFI indicates the relative amount of variance and covariance jointly explained by the model. AGFI differs from GFI in that it adjusts for the number of degrees of freedom in the model. A GFI and AGFI score in the range of 0.8 to 0.89 is considered as representing a reasonable fit; a score of 0.9 or higher is considered as evidence of good fit (Joreskog and Sorbom, 1989). The RMSEA takes into account the error of approximation and is expressed per degree of freedom, thus making the index sensitive to the number of estimated parameters in the model; a value of less than 0.05 indicates a good fit, a value as high as 0.08 represents reasonable errors of approximation in the population (Browne and Cudeck, 1993), a value ranging from 0.08 to 0.10 indicates mediocre fit, and values greater than 0.10 indicate poor fit (MacCallum et al., 1996). If the fit indices are not satisfactory, the modification indices are observed to check for any error term correlation. Those items, whose error terms are highly correlated with the error terms of other items measuring that variable, are further studied for logic and theoretical support for deletion. Items are deleted one at a time if there was a reason to do so, based on the criteria for model fit. Otherwise the item remained in the model. This process of purification of the measurement model was continued until an acceptable model fit was obtained.

Discriminant validity refers to the independence of the dimensions (Bagozzi and Phillips, 1982) or factors measuring one construct. Discriminant validity can be assessed using structural equation modeling methodology (Bagozzi and Phillips, 1982). In AMOS, it can be done by taking two factors (i.e. variables) at a time at one instance, and then having all items of the two constructs inserted into one single factor in the second instance. The chi-square values of running each instance thus obtained are noted. The constructs are considered to be distinct if the hypothesis that the two constructs together form a single construct is rejected. A difference between the chi-square value (df =1) of the two models must be greater than or equal to 3.84 for significance at $p < 0.05$ level so as to indicate support for the discriminant validity criterion (Joreskog, 1971).

Reliability (internal consistency) of the items comprising each dimension was examined using Cronbach's alpha (Cronbach, 1951). Following the guideline established by Nunnally (1978), an alpha score of higher than 0.70 is generally considered to be acceptable, whereas an alpha score of higher than 0.80 is considered a good measure of reliability.

Validation of second-order construct can be done using T-coefficient. T-coefficient tests for the existence of a single second-order construct that accounts for the variation in all its sub-constructs. For example, supply chain responsiveness is measured by operations system responsiveness, logistics process responsiveness, and supplier network responsiveness and each of these three sub-constructs is measured by several items. The question here is to test whether these three sub-constructs form a higher order construct - supply chain responsiveness. The T coefficient can be calculated as follows: suppose that model A (Figure 5.5.1) is comprised of four correlated first-order factors, and model B (Figure 5.5.2) hypothesizes the same four first-order factors and a single second order factor. The T coefficient then, is the ratio of chi-square of model A to the chi-square of model B which indicates the percentage of variation in the four first order factors in model A explained by the second-order factor in model B (Doll et al., 1995).

Figure 5.5.1 Sample First Order Model for T-coefficient Calculation (Model A)

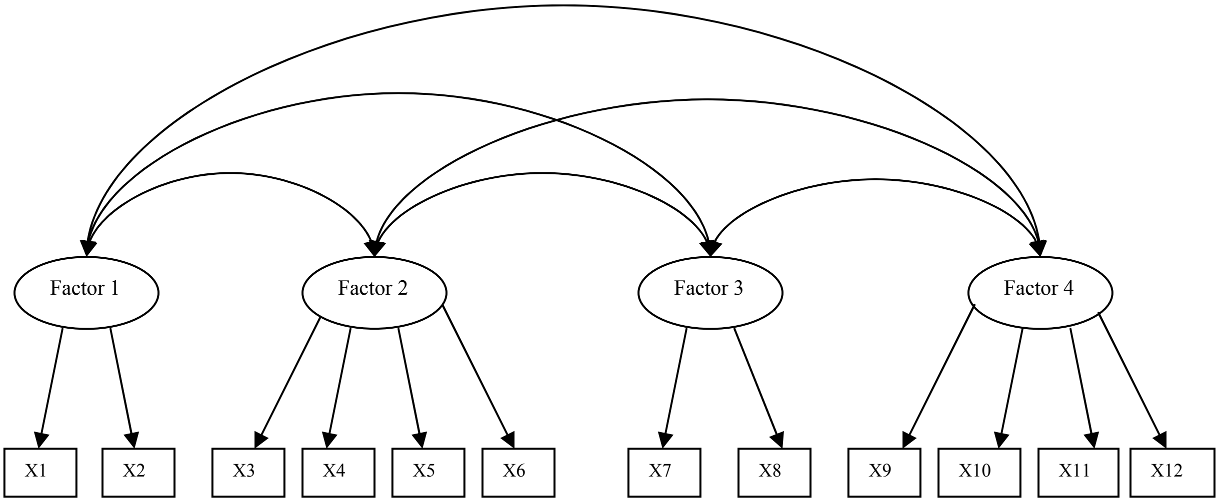
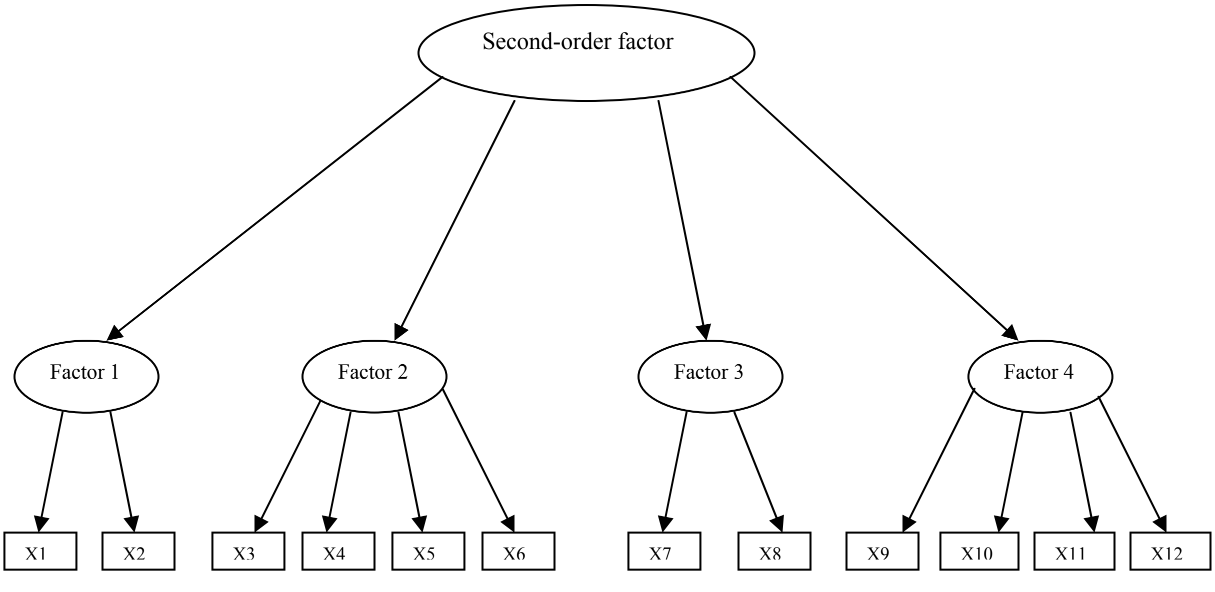


Figure 5.5.2 Sample Second Order Model for T-coefficient Calculation (Model B)



Although the fit index of model B is always a little worse than that of model A since more constraints have been added in the model B, a T coefficient higher than 0.8 may indicate the existence of a second-order construct since most of the variation shared by the first-order factors is explained by the single second-order factor.

A word of caution here however, in the case of three correlated first-order factors, a second-order model has the same degrees of freedom and chi-square as that of the first-order model, thus T coefficient equals 1.0, which has no meaning (Doll et al., 1995). In this situation, an indirect way is to look at the standardized coefficient (γ) for each sub-construct. If all of them are statistically significant, a second-order can be considered.

Construct level correlation analysis was performed between the second order constructs to check for preliminary statistical validity of the hypotheses. A composite score was calculated for each construct to get an aggregate score for that construct. Pearson correlation was then run between these higher order constructs.

5.6 Large-Scale Measurement Results

The following section presents the large-scale instrument validation results for the construct Supply Chain Responsiveness (SCR). For SCR construct, the instrument assessment methodology described in the previous section was applied. In presenting the results of the large-scale study, the following acronyms were used to number the questionnaire items in each sub-construct.

SCR	**Supply Chain Responsiveness**
OSR	Operations System Responsiveness
LPR	Logistics Process Responsiveness
SNR	Supplier Network Responsiveness

For the above construct, the instrument assessment methodology described in the previous section will be applied, and tables will be provided to present the results: 1) Convergent validity; 2) Discriminant validity; 3) Reliability; and 4) The final set of measurement items for the construct.

5.6.1 Supply Chain Responsiveness

The Supply Chain Responsiveness construct was initially represented by three dimensions and 18 items, including Operations system Responsiveness (OSR) (7 items), Logistics Process Responsiveness (LPR) (5 items), and Supplier Network Responsiveness (SNR) (6 items).

Convergent Validity: In this step, the 18 SCR items were submitted to a measurement model analysis to check model fit indices for each sub-construct (Table 5.6.1.1). The initial model fit indices for OSR consist of GFI = 0.866, AGFI = 0.732, and RMSEA = 0.182. The initial measurement model for OSR is shown in Figure 5.6.1.1. These indices show no where near a reasonable fit; therefore further model modification was carried out based on modification indices (MI). MI represents both measurement error correlations and item correlations (multicollinearity). MI shows evidence of misfit between the default model and the hypothesized model. MI is conceptualized as a chi-square statistic with one degree of freedom (Joreskog and Sorbom, 1989). Therefore the threshold of MI is 4 chi-square statistics at a 0.05 significance level. High MI represents error covariances meaning that one item might share variance explained with another item (commonality) and thus they are redundant. The remedial action for error covariances is to delete such an item which has high error variance.

Based on the modification indices, 2 items (OSR2 and OSR6) were dropped one at a time. The concept of OSR2 – rapid change in product mix is already captured in part by OSR1 – operations system responds rapidly to changes in product volume, and in part by OSR 7 – operations system rapidly adjusts capacity, and therefore was dropped. The concept of OSR6 – operations system rapidly changes manufacturing processes, is already partially captured by OSR3 – operations system effectively expedites emergency customer orders, and was therefore dropped in the next phase. The new model fit indices improved significantly to GFI = 0.989, AGFI = 0.968, and RMSEA = 0.045. The final measurement model for OSR is shown in Figure 5.6.1.2.

Figure 5.6.1.1 Initial Measurement Model for Operations System Responsiveness (OSR)

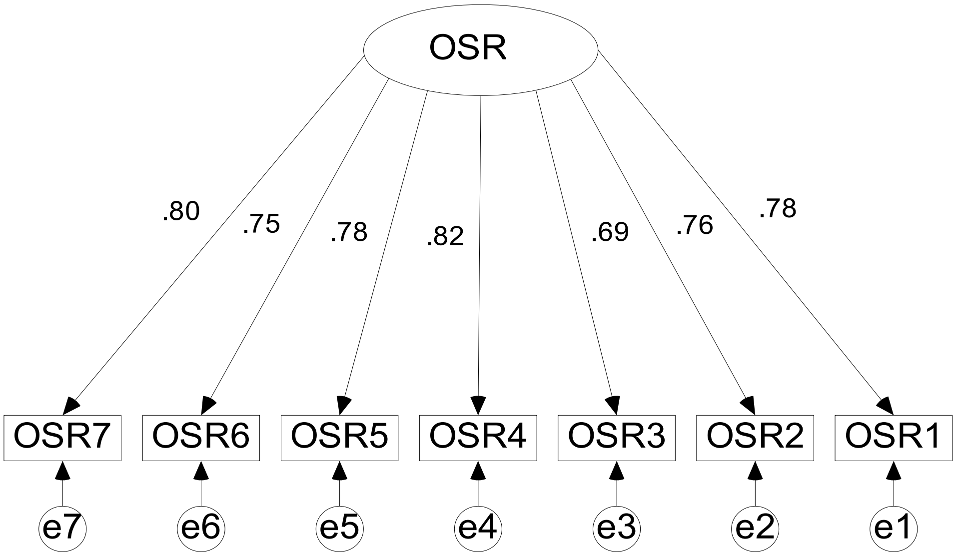
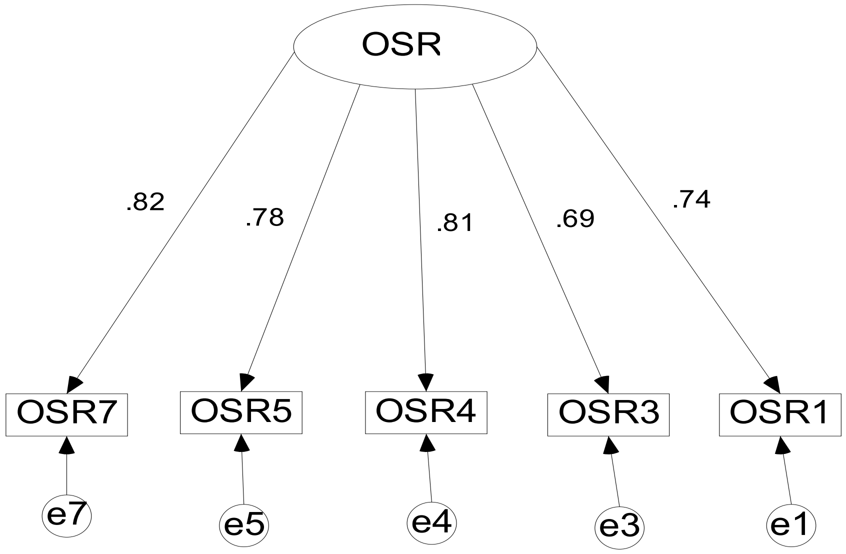


Figure 5.6.1.2 Final Measurement Model for Operations System Responsiveness (OSR)



The initial model fit indices for LPR consist of GFI = 0.926, AGFI = 0.777, and RMSEA = 0.181. The initial measurement model for LPR is shown in Figure 5.6.1.3.

These indices show unreasonable fit; therefore further model modification was carried out to get rid of both – measurement error correlations and item correlations (multicollinearity). Based on the modification indices, one item (LPR4) was dropped. The concept of LPR4 – logistics system rapidly accommodates special or non-routine customer requests, is already partially captured by LPR5 - logistics system effectively delivers expedited shipments, and partially by LPR1 - logistics system responds rapidly to unexpected demand change, and therefore LPR4 was dropped. The new model fit indices improved significantly to GFI = 0.996, AGFI = 0.98, and RMSEA = 0.025. The final measurement model for LPR is shown in Figure 5.6.1.4.

Figure 5.6.1.3 Initial Measurement Model for Logistics Process Responsiveness (LPR)

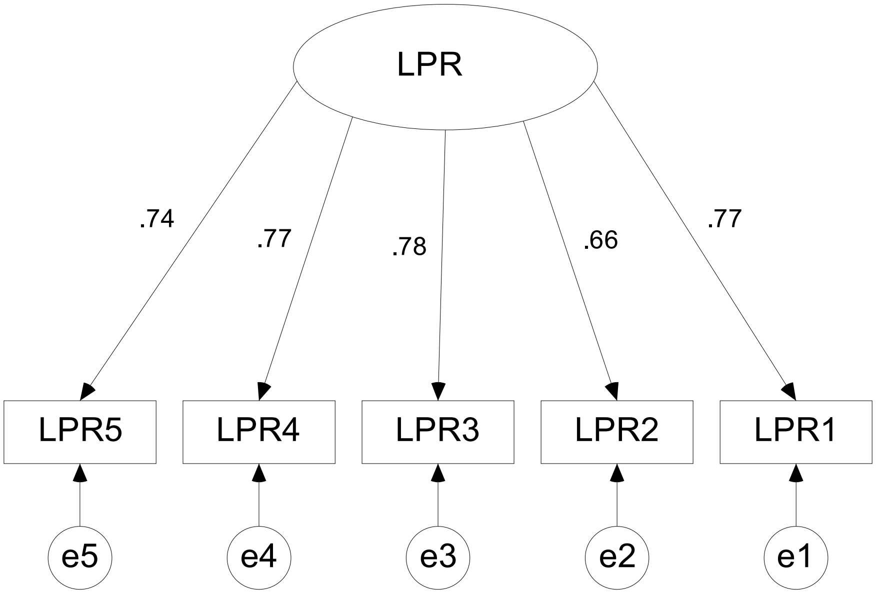
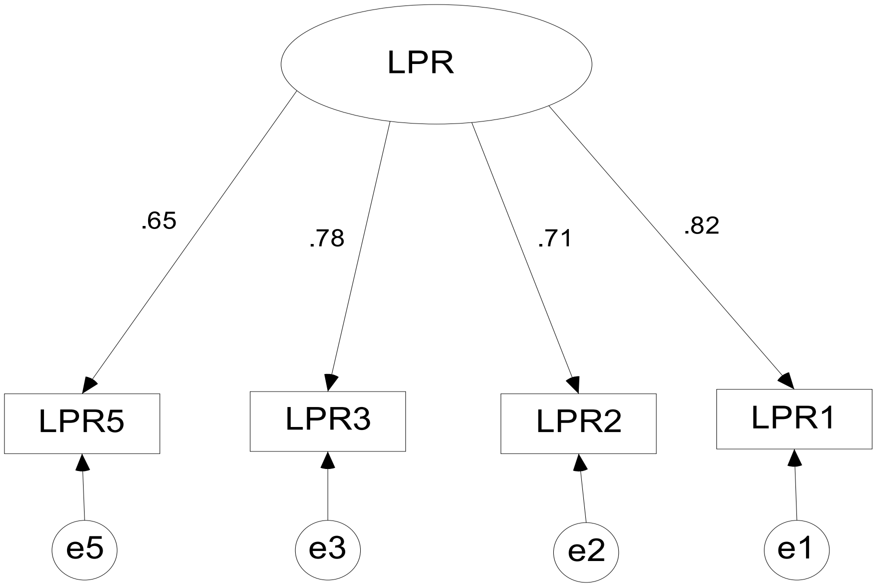


Figure 5.6.1.4 Final Measurement Model for Logistics Process Responsiveness (LPR)



The initial model fit indices for SNR consist of GFI = 0.822, AGFI = 0.584, and RMSEA = 0.272. The initial measurement model for SNR is shown in Figure 5.6.1.5. These indices show unreasonable fit; therefore further model modification was carried out to improve model fit indices. Based on the modification indices 2 items (SNR1 and SNR6) were dropped one at a time. The concept of SNR1 – major suppliers quickly change product volume is already captured in part by SNR2 – major suppliers quickly change product mix, and in part by SNR3 – major suppliers consistently accommodate requests, and there for SNR1 was dropped. Also the concept of SNR6 – major suppliers effectively expedite emergency orders is already partially captured by SNR5 – major suppliers have outstanding on-time delivery record, and was therefore dropped in the next phase.

Figure 5.6.1.5 Initial Measurement Model for Supplier Network Responsiveness (SNR)

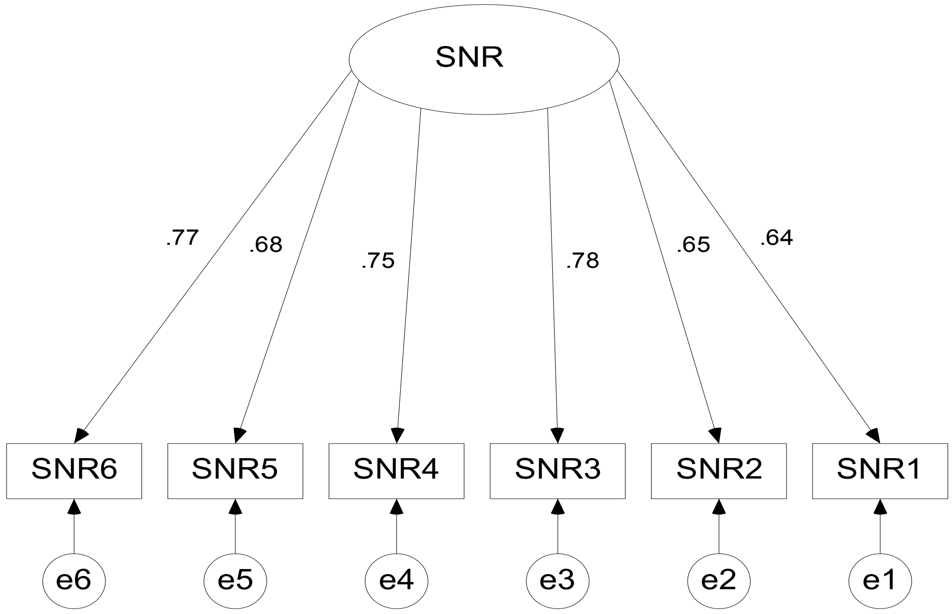
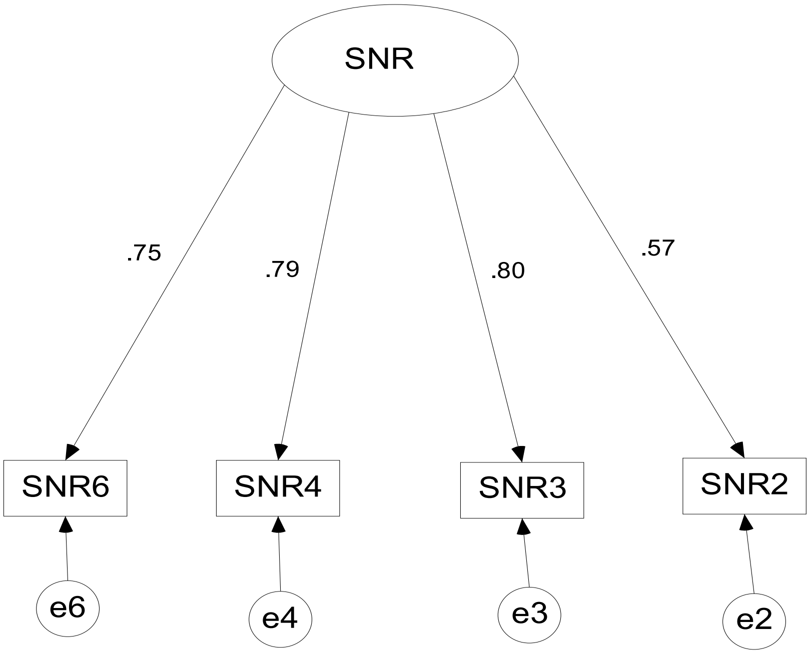


Figure 5.6.1.6 Final Measurement Model for Supplier Network Responsiveness (SNR)



The new model fit indices improved significantly to GFI = 0.993, AGFI = 0.963, and RMSEA = 0.064. The final measurement model for SNR is shown in Figure 5.6.1.6. Although the loading of SNR2 is relatively low, it was decided to keep the item as the product mix aspect is captured well in the item as well as the overall model fit is good.

Table 5.6.1.1 Model Fit Indices for Supply Chain Responsiveness

Coding	Items	Initial Model Fit	Final Model Fit
Operations System Responsiveness (OSR)			
OSR1	Our operations system responds rapidly to changes in product volume demanded by customers.	GFI = 0.866 AGFI = 0.732 RMSEA = 0.182	GFI = 0.989 AGFI = 0.968 RMSEA = 0.045
OSR2	Our operations system responds rapidly to changes in product mix demanded by customers. *		
OSR3	Our operations system effectively expedites emergency customer orders.		
OSR4	Our operations system rapidly reconfigures equipment to address demand changes.		
OSR5	Our operations system rapidly reallocates people to address demand changes.		
OSR6	Our operations system rapidly changes manufacturing processes to address demand changes. *		
OSR7	Our operations system rapidly adjusts capacity to address demand changes.		
Logistics Process Responsiveness (LPR)			
LPR1	Our logistics system responds rapidly to unexpected demand change.	GFI = 0.926 AGFI = 0.777 RMSEA = 0.181	GFI = 0.996 AGFI = 0.98 RMSEA = 0.025
LPR2	Our logistics system rapidly adjusts warehouse capacity to address demand changes.		
LPR3	Our logistics system rapidly varies transportation carriers to address demand changes.		
LPR4	Our logistics system rapidly accommodates special or non-routine customer requests. *		
LPR5	Our logistics system effectively delivers expedited shipments.		
Supplier Network Responsiveness (SNR)			
SNR1	Our major suppliers change product volume in a relatively short time. *	GFI = 0.822 AGFI = 0.584	GFI = 0.993 AGFI = 0.963
SNR2	Our major suppliers change product mix in a relatively short time.		
SNR3	Our major suppliers consistently accommodate our requests.		

SNR4	Our major suppliers provide quick inbound logistics to us.	RMSEA = 0.272	RMSEA = 0.064
SNR5	Our major suppliers have outstanding on-time delivery record with us. *		
SNR6	Our major suppliers effectively expedite our emergency orders.		

* Items were dropped from the initial model

Discriminant Validity: Table 5.6.1.2 shows the results for discriminant validity. The differences between chi-square values of all pairs and the corresponding single factors are statistically significant at $p< 0.0001$ level thus indicating high degree of discriminant validity among constructs.

Table 5.6.1.2 Discriminant Validity - Pair-wise/single-factor comparison of chi-square values for Supply Chain Responsiveness

Construct	**OSR** (χ^2)			**LPR** (χ^2)		
	Pair-wise	Single-factor	Dif.	Pair-wise	Single-factor	Dif.
OSR						
LPR	50.9	310.4	**259.5**			
SNR	41.6	321.8	**280.2**	26.3	330.8	**304.5**

Reliability: Cronbach's alpha was used to measure the reliability of the hypothesized individual sub-constructs OSR, LPR, and SNR. A commonly used value for acceptable reliability is 0.70 (Hair et al., 1998). More reliable measures give greater confidence that the individual indicators are all consistent in their measurements, and therefore, the model is repeatable. The Cronbach's α scores for OSR, LPR, and SNR are

0.878, 0.825, and 0.818 respectively. All α scores are higher than 0.80 and thus depict a good measure of reliability. Table 5.6.1.3 gives the items forming the scales of OSR, LPR and SNR with the corresponding reliabilities.

Table 5.6.1.3 Reliability Analysis for Supply Chain Responsiveness

Code Names	Measurement Items	α
Operations System Responsiveness (OSR)		
OSR1	Our operations system responds rapidly to changes in product volume demanded by customers.	**α = 0.878**
OSR3	Our operations system effectively expedites emergency customer orders.	
OSR4	Our operations system rapidly reconfigures equipment to address demand changes.	
OSR5	Our operations system rapidly reallocates people to address demand changes.	
OSR7	Our operations system rapidly adjusts capacity to address demand changes.	
Logistics Process Responsiveness (LPR)		
LPR1	Our logistics system responds rapidly to unexpected demand change.	**α = 0.825**
LPR2	Our logistics system rapidly adjusts warehouse capacity to address demand changes.	
LPR3	Our logistics system rapidly varies transportation carriers to address demand changes.	
LPR5	Our logistics system effectively delivers expedited shipments.	
Supplier Network Responsiveness (SNR)		
SNR2	Our major suppliers change product mix in a relatively short time.	**α = 0.818**
SNR3	Our major suppliers consistently accommodate our requests.	
SNR4	Our major suppliers provide quick inbound logistics to us.	
SNR6	Our major suppliers effectively expedite our emergency orders.	

The final set of measurement items for the Supply Chain Responsiveness construct is shown in Table 5.6.1.4

Table 5.6.1.4 Supply Chain Responsiveness – Final Construct Measurement Items

Code Names	Measurement Items
Operations System Responsiveness (OSR)	
OSR1	Our operations system responds rapidly to changes in product volume demanded by customers.
OSR3	Our operations system effectively expedites emergency customer orders.
OSR4	Our operations system rapidly reconfigures equipment to address demand changes.
OSR5	Our operations system rapidly reallocates people to address demand changes.
OSR7	Our operations system rapidly adjusts capacity to address demand changes.
Logistics Process Responsiveness (LPR)	
LPR1	Our logistics system responds rapidly to unexpected demand change.
LPR2	Our logistics system rapidly adjusts warehouse capacity to address demand changes.
LPR3	Our logistics system rapidly varies transportation carriers to address demand changes.
LPR5	Our logistics system effectively delivers expedited shipments.
Supplier Network Responsiveness (SNR)	
SNR2	Our major suppliers change product mix in a relatively short time.
SNR3	Our major suppliers consistently accommodate our requests.
SNR4	Our major suppliers provide quick inbound logistics to us.
SNR6	Our major suppliers effectively expedite our emergency orders.

In addition, the reliabilities of the constructs ‘SCM practices’, ‘Modularity Based Manufacturing Practices’, and ‘Competitive Advantage’ that have been borrowed from past literature, along with the reliabilities as obtained in this study have been reported in the following sections 5.6.2, 5.6.3, and 5.6.4.

5.6.2 SCM Practices – Reliability Analysis

The construct ‘SCM practices’ has been adopted from Li et al. (2005, 2006). The reliabilities (Cronbach’s α) of the sub-constructs - strategic supplier partnership, customer relationship, and information sharing - that form the construct ‘SCM practices’ and as obtained from Li et al. (2005, 2006) are reported in Table 5.6.2.1. In addition, the reliabilities of the same as obtained in this study are also reported alongside in the same table. Both these reliabilities are above 0.80, depicting a good measure of reliability for the ‘SCM practices’ sub-constructs.

Table 5.6.2.1 Reliability Analysis for SCM Practices

Measurement Items	α (Li et al., 2005, 2006)	α (present study)
Strategic Supplier Partnership		
We consider quality as our number one criterion in selecting suppliers	**α = 0.86**	**α = 0.82**
We regularly solve problems jointly with our suppliers		
We have helped our suppliers to improve their product quality		
We have continuous improvement programs that include our key suppliers		
We include our key suppliers in our planning and goal- setting activities		
We actively involve our key suppliers in new product development processes		

Customer Relationship		
We frequently interact with customers to set reliability, responsiveness, and other standards for us	α = 0.84	α = 0.83
We frequently measure and evaluate customer satisfaction		
We frequently determine future customer expectations		
We facilitate customers' ability to seek assistance from us		
We periodically evaluate the importance of our relationship with our customers		
Information Sharing		
We inform trading partners in advance of changing needs	α = 0.86	α = 0.90
Our trading partners share proprietary information with us		
Our trading partners keep us fully informed about issues that affect our business		
Our trading partners share business knowledge of core business processes with us		
We and our trading partners exchange information that helps establishment of business planning		
We and our trading partners keep each other informed about events or changes that may affect the other partners		

5.6.3 Modularity Based Manufacturing Practices – Reliability Analysis

This construct has been adopted from Tu et al. (2004). The reliabilities of the sub-constructs – product modularity, process modularity, and dynamic teaming – that form the construct 'Modularity Based Manufacturing Practices', have been reported in Table 5.6.3.1. Also the reliabilities of the same as obtained in this study have also been reported alongside for comparison. Both these reliabilities are above 0.80, depicting a good measure of reliability for the 'Modularity Based Manufacturing Practices' sub-constructs.

Table 5.6.3.1 Reliability Analysis for Modularity Based Manufacturing Practices

Measurement Items	α (Tu et al., 2004)	α (present study)
Product Modularity		
Our products use modularized design	α = 0.83	α = 0.90
Our products share common modules		
Our product features are designed around a standard base unit		
Product modules can be reassembled into different forms		
Product feature modules can be added to a standard base unit		
Process Modularity		
Our production process is designed as adjustable modules	α = 0.82	α = 0.92
Our production process can be adjusted by adding new process modules		
Production process modules can be adjusted for changing production needs		
Our production process can be broken down into standard sub-processes that produce standard base units and customization sub-processes that further customize the base units		
Production process modules can be rearranged so that customization sub-processes occur last		
Dynamic Teaming		
Production teams that can be reorganized are used in our plant	α = 0.88	α = 0.95
Production teams can be reorganized in response to product/process changes		
Production teams can be reassigned to different production tasks		
Production team members can be reassigned to different teams		
Production team members are capable of working on different teams		

5.6.4 Competitive Advantage – Reliability Analysis

The construct has been adopted from Koufteros et al. (1997). Also, Li et al. (2006) validated the construct with a condensed set of measures (which have been borrowed in this study) under each sub-construct: Price/Cost, Quality, Delivery Dependability, Product Innovation, and Time to Market. The reliabilities of these sub-constructs which form the construct ‘Competitive Advantage’ have been reported in

Table 5.6.4.1. Also these reliabilities as obtained in this study have also been reported along side in the same table for comparison. The reliabilities of the previous studies and the ones obtained in this study are good (α > 0.8 for quality, delivery dependability, and product innovation). The reliabilities of the sub-constructs 'price' and 'time to market' are well above the acceptable values (i.e. α > 0.7, for prior studies as well as the current study).

Table 5.6.4.1 Reliability Analysis for Competitive Advantage

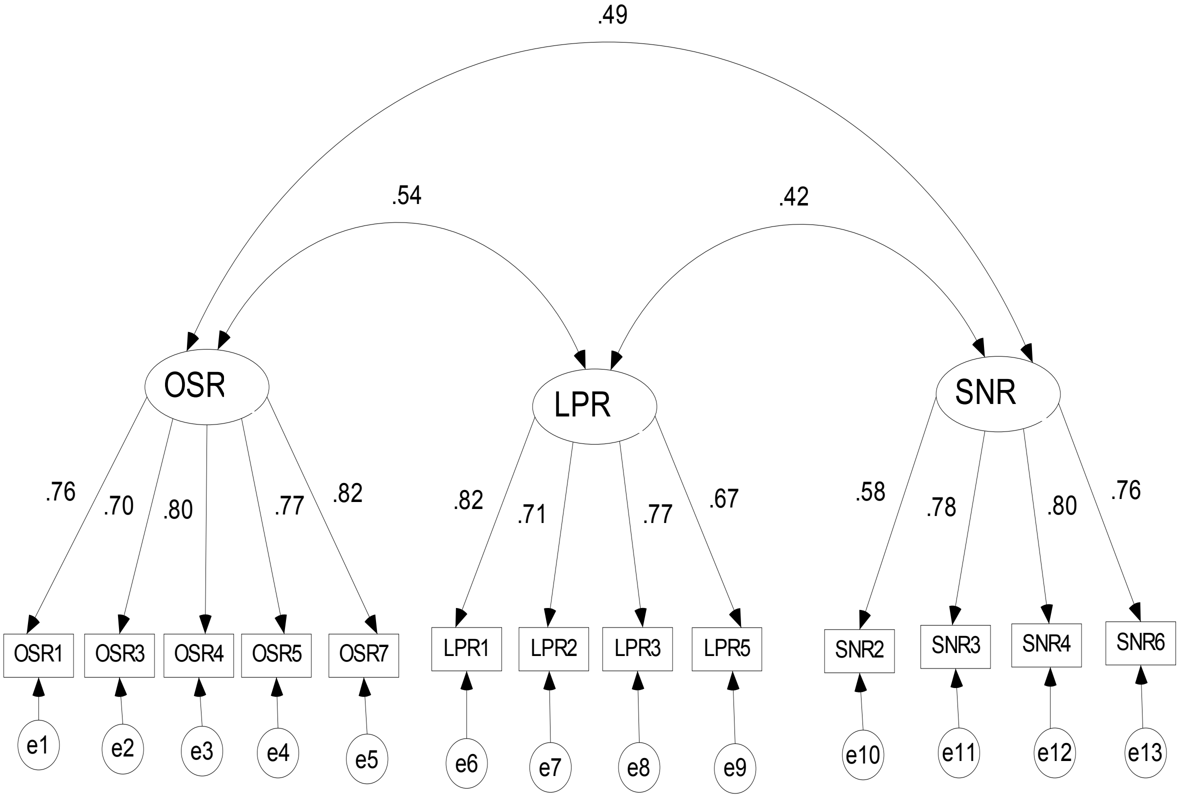
Measurement Items	α (Li et al., 2006)	α (present study)
Price		
We offer competitive prices	**α = 0.73**	**α = 0.79**
We are able to offer prices as low or lower than our competitors		
Quality		
We are able to compete based on quality	**α = 0.87**	**α = 0.88**
We offer products that are highly reliable		
We offer products that are very durable		
We offer high quality products to our customers		
Delivery Dependability		
We deliver customer orders on time	**α = 0.93**	**α = 0.91**
We provide dependable delivery		
Product Innovation		
We provide customized products	**α = 0.80**	**α = 0.82**
We alter our product offerings to meet client needs		
We cater to customer needs for "new" features		
Time to Market		
We are first in the market in introducing new products	**α = 0.76**	**α = 0.74**
We have time-to-market lower than industry average		
We have fast product development		

The sections 5.6.2, 5.6.3, and 5.6.4 above presented the reliabilities for the constructs that are adopted from prior studies. All the scales portray good or acceptable reliability measures. The next section 5.7 shall validate the second order construct ‘Supply Chain Responsiveness’ since it is newly developed in this research.

5.7 Validation of Second-order Construct

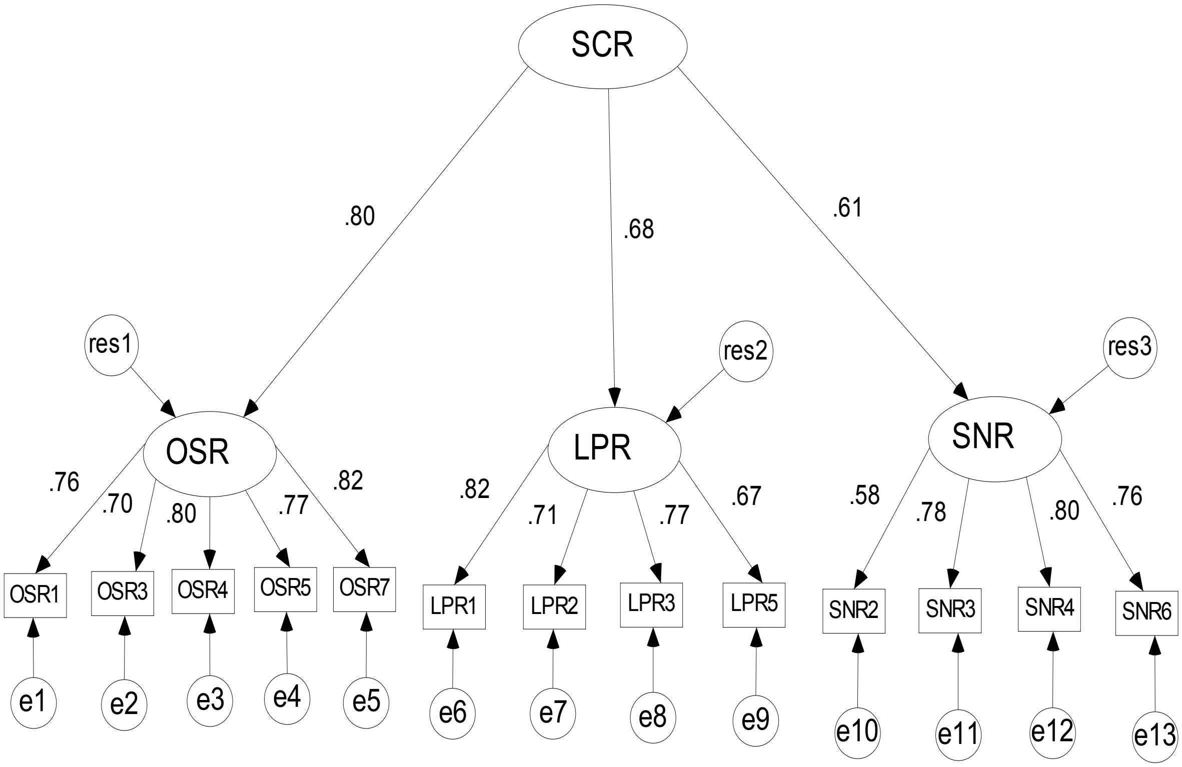
The validation of the second order construct is performed only for the newly developed construct ‘Supply Chain Responsiveness’, as the other constructs have been borrowed from past literatures and have already been validated therein. The next step is to calculate the T coefficient to test if the three sub-constructs (Operations System Responsiveness (OSR), Logistics Process Responsiveness (LPR), and Supplier Network Responsiveness (SNR)) underlie a single higher-order construct (Supply Chain Responsiveness (SCR)). However as discussed earlier, in the case of three correlated first-order factors, a second-order model has the same degrees of freedom and chi-square as that of the first-order model, thus T coefficient equals 1.0, which has no meaning (Doll et al., 1995). In this situation, we look at the standardized coefficient for each sub-construct. If all of them are statistically significant, a second-order construct can be considered. From Table 5.7.1, it can be seen GFI (0.952), AGFI (0.93) are well above 0.9, RMSEA (0.045) is below 0.05 and thus indicative of a very good model-data fit. Furthermore, the standardized coefficients for the three sub-constructs are 0.80 for OSR, 0.68 for LPR, and 0.61 for SNR, and are all statistically significant hence, the higher-order construct (SCR) can be considered. Figures 5.7.1 and 5.7.2 depict the first order measurement model and the second order measurement model for SCR construct, respectively.

Figure 5.7.1 First-Order Measurement Model for Supply Chain Responsiveness



$\chi^2 = 98.217$; df = 62; $\chi^2/df = 1.584$; GFI = 0.952; AGFI = 0.93; RMSEA = 0.045

Figure 5.7.2 Second-Order Measurement Model for Supply Chain Responsiveness



$\chi^2 = 98.217$; df = 62; $\chi^2/\text{df} = 1.584$; GFI = 0.952; AGFI = 0.93; RMSEA = 0.045

Table 5.7.1 Goodness of Fit Indices for First / Second Order Model for Supply Chain Responsiveness

Construct	Model	Chi-Square (df)	Chi-Square/df	GFI	AGFI	RMSEA
SCR	First / Second order	98.217 (62)	1.584	0.952	0.93	0.045

5.8 Construct-Level Correlation Analysis

In order for the measurement to be generalized, predictive validity or criterion-related validity must be performed by comparing the second order factor models with one or more external variables (criterion) known or believed to measure the attribute. Criterion-related validity is characterized by prediction to an outside criterion and by checking a measuring instrument, either now or future, against some outcome or measure (Kerlinger, 1986). In this study, the criterion used to test the predictive validity is dependent variable (also called as endogenous latent variable).

To check for preliminary statistical validity (predictive validity) of the 5 hypotheses presented in Chapter 3, the Pearson correlation (i.e. does not specify causal relationships) was used. Each construct was represented by a composite score, computed by taking the average scores of all items in a specific construct (i.e. average of all the items for a sub-construct as the score for the sub-construct; further the average of all the sub-constructs that comprised the higher order construct was calculated and this score was treated as the composite score for the higher order construct). The results are presented in Table 5.8.1. As evident from the table, all correlations are statistically significant at 0.01 level. Thus all hypothesized relationships of interest are statistically supported by the Pearson correlation. Further hypotheses testing using structural equation modeling (using AMOS) is discussed in the next chapter.

Table 5.8.1 Construct Level Correlation Analysis

Hypothesis	Independent Variable	Dependent Variable	Pearson Correlation
H1	SCM Practices (SCMP)	Supply Chain Responsiveness (SCR)	0.437**
H2	Modularity Based Manufacturing Practices (MBMP)	Supply Chain Responsiveness (SCR)	0.450**
H3	Supply Chain Responsiveness (SCR)	Competitive Advantage (CA)	0.429**
H4	SCM Practices (SCMP)	Competitive Advantage (CA)	0.442**
H5	Modularity Based Manufacturing Practices (MBMP)	Competitive Advantage (CA)	0.357**
** Correlation is significant at 0.01 level			

In summary, this chapter discussed the large scale survey methodology, non-response bias estimation, and the instrument validation using structural equation modeling (AMOS software). The following chapter shall discuss the detailed hypotheses testing using SEM.

CHAPTER 6: CAUSAL MODEL AND HYPOTHESES TESTING

This chapter tests the five hypotheses proposed in Chapter 3, by using the AMOS software for structural equation modeling. Although the bivariate correlations are statistically significant for all hypothesized relationships, it may not be true when all the relationships are put together in a multivariate complex model due to the interactions among variables. Since the measurement instruments for all four major constructs in the current study have already been validated in Chapter 5 (one new construct validated, the other three validated constructs being adopted from prior literature and as quoted in Chapter 5), the hypotheses can be tested in a much more rigorous manner using the structural equation modeling (SEM) framework.

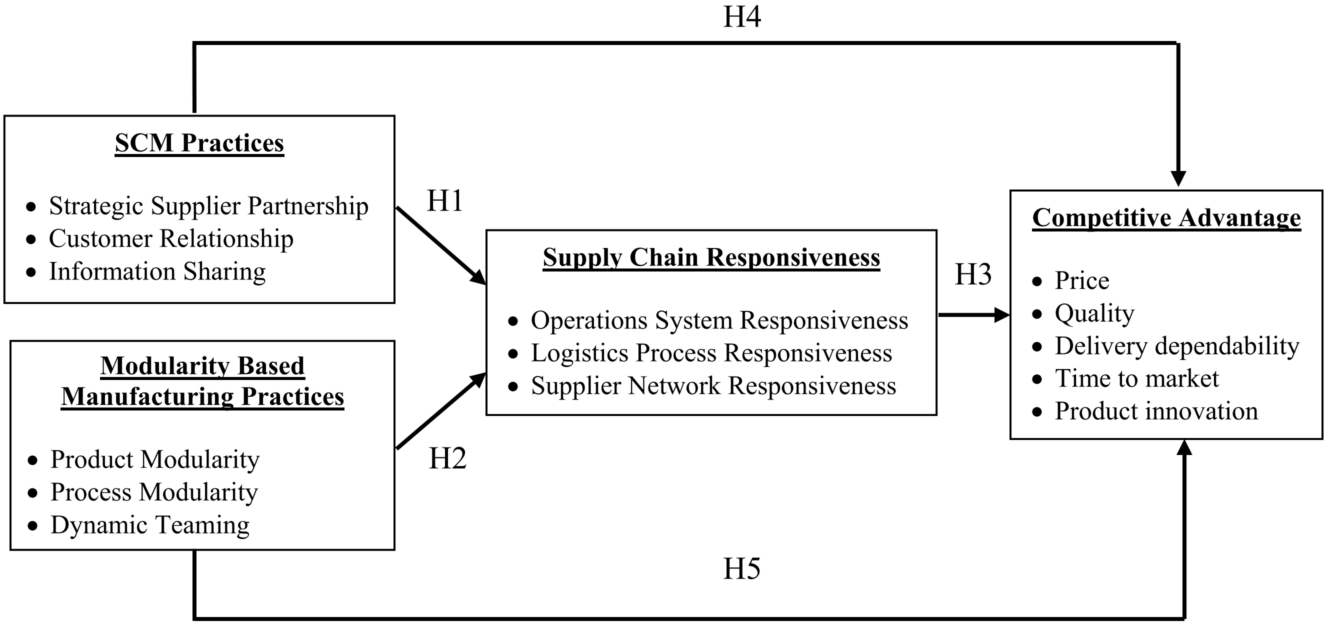
The development and application of SEM is considered to be a major methodological breakthrough in the study of complex interrelations among variables (Joreskog, 1970). SEM is widely recognized as a powerful methodology for capturing and explicating complex multivariate relations in social science data. It represents the unification of two methodological traditions: factor analysis originating from psychology and psychometrics, and simultaneous equations (path analytic) modeling originating from econometrics (Kaplan and Elliot, 1997). Therefore, the standard SEM is composed of two parts – the measurement model (a sub model in SEM that specifies the indicators of each construct and assesses the reliability of each construct for latter use in estimating the causal relationships) and the structural model (the set of dependence relationships linking the model constructs). Since the measurement properties of the instrument in the current study have already been evaluated through rigorous validity and reliability analysis, the SEM model described in this chapter will focus on path analysis using the AMOS structural model. The significance of each path in the proposed structural model will be tested and the overall goodness-of-fit of the entire structural equation model will be assessed as well.

6.1 Proposed Structural Model

The proposed structural model depicted in Figure 6.1 is a replica of the framework presented in Figure 3.1. There are four variables in the model: SCM Practices (SCMP), Modularity Based Manufacturing Practices (MBMP), Supply Chain Responsiveness (SCR), and Competitive Advantage (CA). SCMP and MBMP are regarded as independent (exogenous) variables, and SCR and CA are regarded as dependent (endogenous) variables.

The five hypotheses proposed in Chapter 3 are represented by the 5 causal relationships in the model. Hypothesis 1 is represented in Figure 6.1 by the relationship SCMP → SCR; Hypothesis 2 is represented by the relationship MBMP → SCR; Hypothesis 3 is represented by the relationship SCR → CA; Hypothesis 4 is represented by the relationship SCMP → CA; and Hypothesis 5 is represented by the relationship MBMP→ CA.

Figure 6.1 Theoretical Framework



6.2 Structural Model Testing Results

The hypothesized relationships are now ready to be tested based on the structural model specified in Figure 6.1. The model fit properties are evaluated using the fit statistics discussed in Chapter 5. The composite score computed for each construct at the end of Chapter 5 was used as input to the structural modeling process.

6.2.1 Initial Structural Modeling Results

Figure 6.2 displays the structural model and Figure 6.3 shows the path analysis resulting from the initial AMOS structural modeling analysis. More detailed results are presented in Table 6.2.1. Out of 5 hypothesized relationships, 4 were found to be significantly supported. Hypotheses 1, 2, and 4 all were significant at the 0.001 level.

Hypothesis 3 was significant at 0.05 level (t-value = 2.354). The t-value for Hypothesis 5 was 0.714, which is not significant at the 0.05 level. Therefore all research hypotheses except Hypothesis 5 are supported by the AMOS structural modeling results. Out of the 4 supported relationships, 3 relationships had a medium effect size and 1 relationship had a large effect size. Thus the effect size results confirm that the supported relationships have both statistical and practical significance, which is crucial in providing both theoretical and managerial implications. The initial model fit measures are GFI = 0.963, RMSEA = 0.056, and AGFI = 0.932. GFI was above the recommended minimum value of 0.90; AGFI was much above the recommended minimum value of 0.80; RMSEA was very close to the recommended value of 0.05 indicating a good fit. These results present an initial good fit of the proposed model to the data. The implications of the one insignificant relationship are also discussed later in this chapter.

Figure 6.2 Structural Model

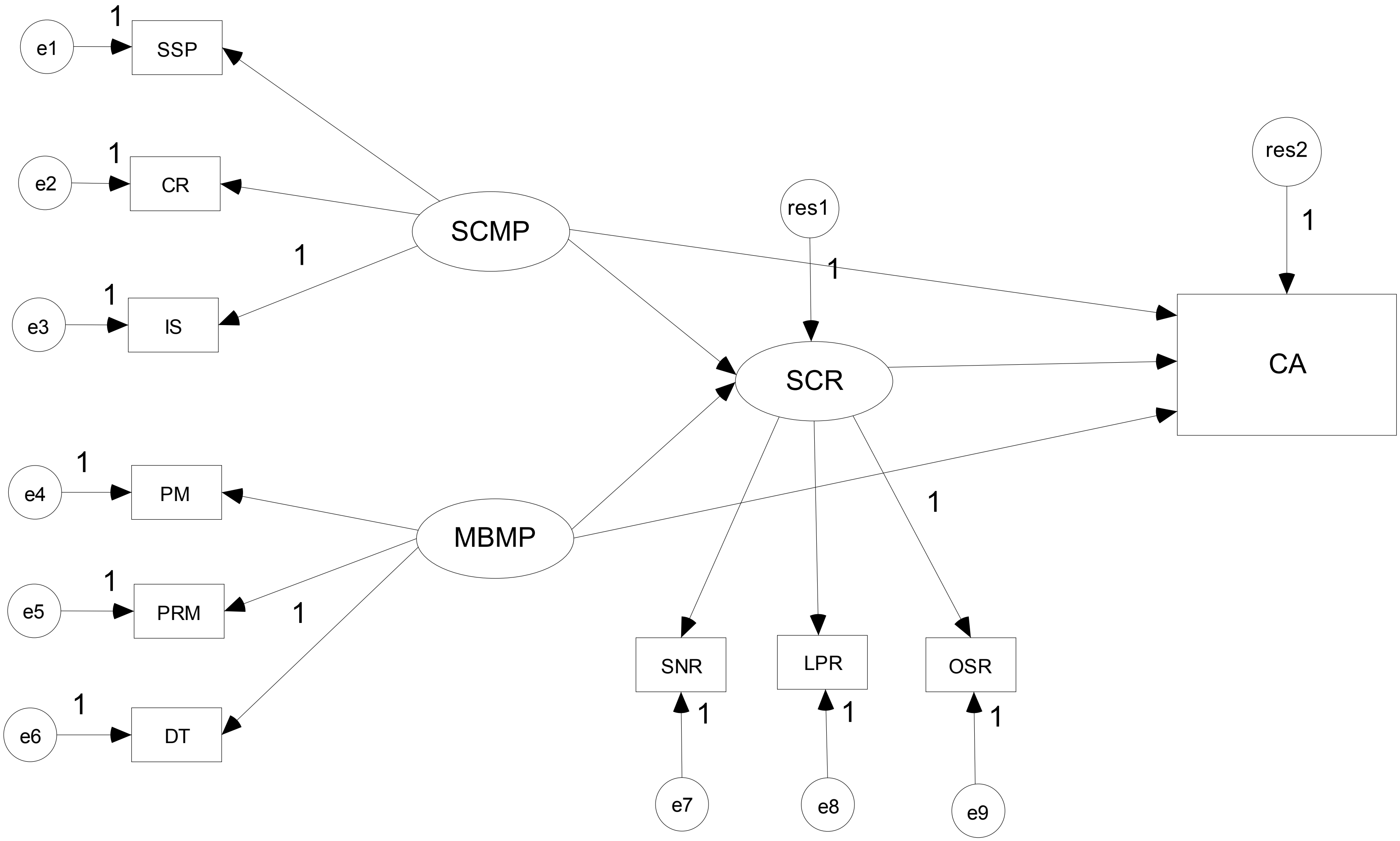
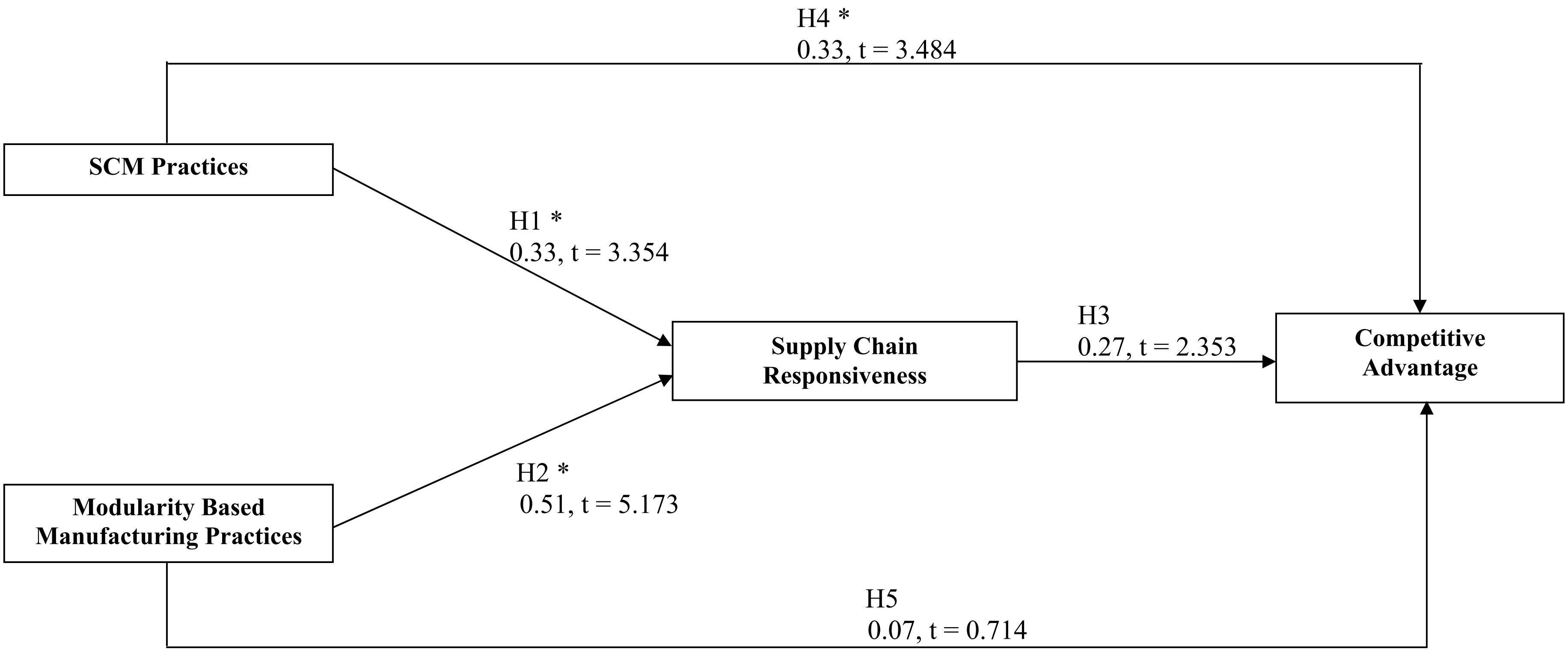


Figure 6.3 Path Analysis Results



GFI = 0.963, AGFI = 0.932, and RMSEA = 0.056, * Significance at < 0.001

Table 6.2.1 Initial AMOS Structural Modeling Results

Hypotheses	Relationship	AMOS Coefficients	Effect Size	t-value	P	Support
H1	SCMP → SCR	0.33	Medium	3.354	***	Yes
H2	MBMP→ SCR	0.51	Large	5.173	***	Yes
H3	SCR → CA	0.27	Medium	2.353	0.019	Yes
H4	SCMP→ CA	0.33	Medium	3.484	***	Yes
H5	MBMP→ CA	0.07	Small	0.714	0.475	No
GFI = 0.963 AGFI = 0.932 RMSEA = 0.056 *** P < 0.001						

6.3 Discussion of Structural Modeling and Hypotheses Testing Results

The previous sections reported the structural modeling and hypotheses testing results on the proposed model. To summarize, 4 out of 5 hypothesized relations (Hypotheses 1, 2, 3, and 4) were significant. Hypotheses 1, 2, and 4 were significant at 0.001 level and Hypothesis 3 was significant at the 0.05 level. One hypothesized relation (Hypothesis 5) was not significantly supported. The final AMOS structural model displayed very good fit to the data.

However, statistical significance and model fit are not ultimate objectives of academic research. They are just the means to achieve the end, which is better understanding of the subject under investigation and discovery of new relationships. The results from this research can be used by both academicians in further exploring and testing the causal linkages in supply chain responsiveness study, and practitioners for guiding the implementation of SCM practices and modularity based manufacturing practices, and the evaluation of supply chain responsiveness and thus competitive advantage of the firm. Therefore, the practical and theoretical implications of the results of each hypothesis are discussed as follows:

Hypothesis 1: **‘***SCM practices’ of a firm is positively related to supply chain responsiveness.*

Hypothesis H1 was found to be significant and thus supported. This indicates that the higher the level of SCM practices by a firm, the higher the level of its supply chain responsiveness. In other words ‘SCM practices’ of a firm has a direct positive influence on supply chain responsiveness. It empirically confirms the theoretical notion that a well-managed and well-executed supply chain directly leads to improved supply chain responsiveness. This is in line with Michael Dell's (of Dell computers) view of being and staying responsive (Magretta, 1998). He highlights three significant factors in achieving responsiveness, namely working closely with suppliers, constant flow of information between supply chain partners, and close customer relations. Engaging in sharing of accurate information such as production schedules, inventory data, demand forecasts, etc. by organizations with their partners shall improve visibility and enable supply chain entities to respond rapidly to unexpected events on either customer or supply side. This would enable them to respond quickly to the changing customers needs. As emphasized in prior literature (Martin and Grbac, 2003, Tan et al., 1998; Van Hoek et al., 2001) having close relationships with customers in a supply chain, involving them in joint problem solving, and taking their inputs for the product design, shall increase responsiveness of organizations to the customers' needs. Having strategic partnerships with suppliers shall reduce uncertainty and improve lead-time thus enabling firms to rapidly respond to any changes in the business environment. This finding is also supported by Yusuf et al's (2003) study, which shows high correlation between the supplier partnership practices and responsiveness.

Hypothesis 2: '*Modularity Based Manufacturing Practices' of a firm is positively related to supply chain responsiveness.*

Hypothesis H2 was found to be significant and thus supported. This indicates that the higher the level of modularity based manufacturing practices by a firm, the higher the level of its supply chain responsiveness. In other words 'modularity based manufacturing practices' of a firm has a direct positive influence on supply chain responsiveness. The significance of Hypothesis 2 empirically confirms that having modular products and processes could indeed improve the responsiveness of supply chains. This is in agreement with Baldwin and Clark's (1997) argument that by breaking up a product into modules, designers and producers have the flexibility to respond rapidly to any uncertainties. The empirical results of this study demonstrate to the managers, the benefits of modularity which include – rapid product updating/modification, rapid product building (decreased order lead time) with increased variety, rapid design and testing – which implies that modularity leads to the responsiveness of the operations systems. Modularity shall assist organizations to source different modules from individual suppliers, instead of sourcing the whole product, this helps postponed purchasing of these modules or subassemblies (rather than purchasing a whole product) thereby improving the ability of suppliers to design, produce, and deliver standard/modular parts quickly. This implies that modularity based manufacturing practices improve the supplier network responsiveness in a supply chain. The support for hypothesis 2 is also in accordance with Tu et al.'s (2004) argument that firms that can reconfigure and reorganize production teams quickly, without loss of efficiency, can minimize the manufacturing response time without compromising on the quality of product design or process execution.

Hypothesis 3: *Supply Chain Responsiveness is positively related to competitive advantage of a firm.*

Hypothesis H3 was found to be significant and thus supported. The AMOS results supported hypothesis 3 at the 0.05 level, and so did the construct level correlation analysis results in Chapter 5 (Table 5.8.1) at the 0.01 level of significance. There is significant positive correlation between supply chain responsiveness (SCR) and competitive advantage (CA). This finding empirically confirms the assertion in the literature that a responsive supply chain could provide an organization with competitive advantage on dimensions such as quality, delivery dependability, product innovation, and time-to-market. For managers this implies that being operationally responsive will, enable organizations to introduce new products faster than major competitors (i.e. increasing the time to market), and improve the firm's ability to provide on time the type and volume of product required by customers (i.e. improve delivery dependability). Responsiveness of a firm's supplier network will improve - the ability of the firm to rapidly introduce new products and features in the market place (i.e. compete based on product innovation and time to market), as well as improve a firm's ability to provide on time delivery (i.e. improve its delivery dependability).

Hypothesis 4: **'***SCM practices' of a firm is positively related to competitive advantage of a firm.*

Hypothesis H4 was found to be significant and thus supported. This indicates that the higher the level of SCM practices by a firm, the higher the level of its competitive advantage. In other words 'SCM practices' of a firm has a direct positive influence on its competitive advantage. The successful SCM implementation will improve the organization's performance on cost, quality, dependability, flexibility, and time-to-market, and give the organization a defensible position over its competitors through the coordination of inter-organizational activities along the supply chain. This backs the argument from prior literature (Li et al., 2005), that by adopting effective SCM practices firms can gain greater competitive advantage.

Hypothesis 5: '*Modularity Based Manufacturing Practices' of a firm is positively related to competitive advantage of a firm.*

Hypothesis H5 was found to be non-significant and thus not supported. This indicates that a firm's modularity based manufacturing practices do not positively influence its level of competitive advantage. This implies that modularity cannot improve the competitive advantage of a firm by itself, but only when it is supplemented by other best industry practices which, when combined together can give the organization a defensible position over its competitors.

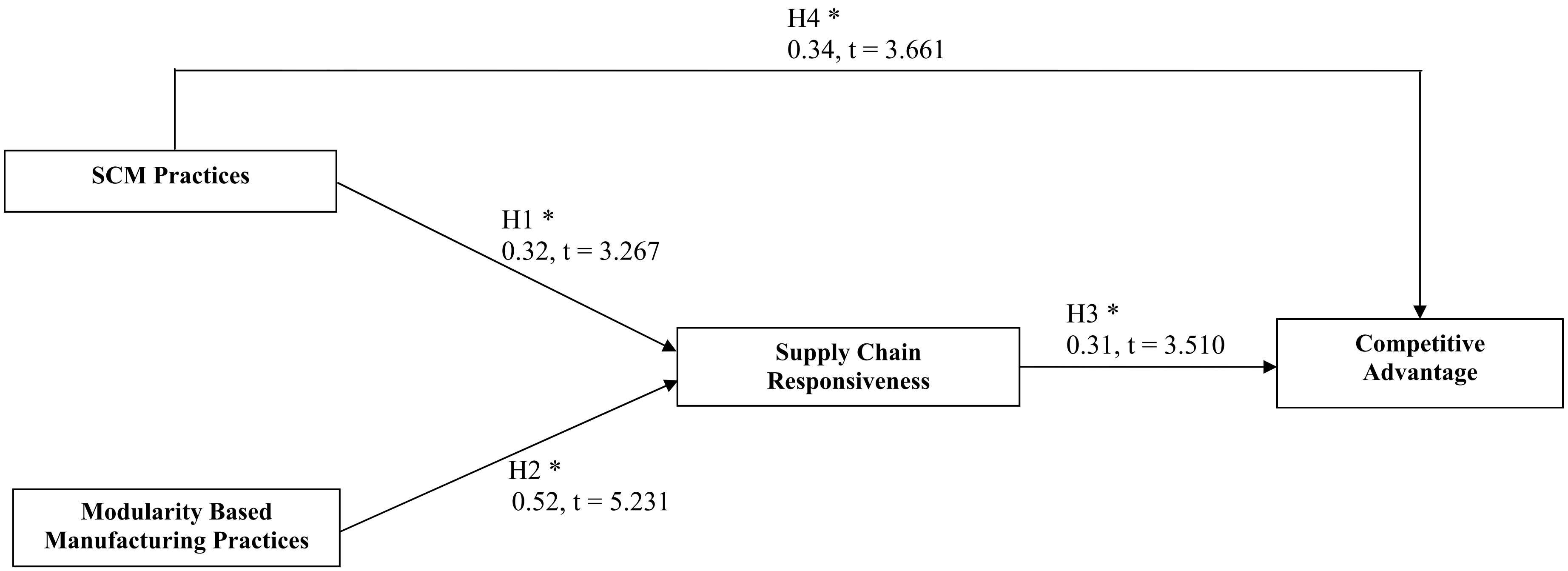
6.4 Revised Structural Model

After revising the structural model by removing the one insignificant relationship (H5), the model was tested again using AMOS. The results are presented in Figure 6.4 and Table 6.4.1. All paths have a t-value of greater than 2.0 and are significant at the 0.001 level. Out of the 4 supported relationships, 3 relationships have a medium effect size and 1 relationship has a large effect size. Thus the effect size results confirm that the supported relationships have both statistical and practical significance, which is crucial in providing both theoretical and managerial implications. The fit indices of the revised structural model indicate a good fit: GFI = 0.962 was greater than the minimum 0.90 level; AGFI = 0.933 was much above the recommended minimum value of 0.80; RMSEA = 0.055 was very close to the recommended value of 0.05 indicating a good fit.

Table 6.4.1 Revised Structural Modeling Results

Hypotheses	**Relationship**	**AMOS Coefficients**	**Effect Size**	**t-value**	**P**	**Support**
H1	SCMP → SCR	0.32	Medium	3.267	***	Yes
H2	MBMP → SCR	0.52	Large	5.231	***	Yes
H3	SCR → CA	0.31	Medium	3.510	***	Yes
H4	SCMP → CA	0.34	Medium	3.661	***	Yes
GFI = 0.962 AGFI = 0.933 RMSEA = 0.055 *** P < 0.001						

Figure 6.4 Revised Path Analysis Results



GFI = 0.962, AGFI = 0.933, and RMSEA = 0.055, * Significance at < 0.001

6.5 Summary of Results

Overall, the results indicate that higher levels of SCM practices by a firm will lead to both improved supply chain responsiveness, as well as higher levels of competitive advantage of a firm. The results also show that modularity based manufacturing practices positively influence supply chain responsiveness. In addition, supply chain responsiveness will lead to competitive advantage of a firm. However, the findings do not support the direct impact of modularity based manufacturing practices on competitive advantage of a firm.

In order to explore, understand, and further analyze in greater depth, the specific practices that affect supply chain responsiveness and competitive advantage, dimension-level data analysis is needed. This type of analysis shall enable researchers to gain insight into the specific dimensions that are influential in achieving the desired results. The next chapter (chapter 7) discusses in-depth data analyses on a dimension level.

CHAPTER 7: DIMENSION LEVEL ANALYSIS

Chapters 5 and 6 dealt with large scale instrument validation and hypotheses testing respectively, using structural equation modeling. As observed in chapter 6, four of the five hypothesized relationships were supported. These were: positive relationship between SCM practices and supply chain responsiveness, positive relationship between modularity based manufacturing practices and supply chain responsiveness, positive relationship between supply chain responsiveness and competitive advantage, and positive relationship between SCM practices and competitive advantage. However it would be interesting to investigate the effects of various sub-constructs (within a larger construct) on the dependent variables - supply chain responsiveness and competitive advantage. Such a detailed analysis shall contribute towards providing more meaningful research implications. A good example of this argument is as follows: what are the specific SCM practices that lead to higher levels of supply chain responsiveness in terms of operations system responsiveness, logistics process responsiveness, and supplier network responsiveness; what are the specific modularity based manufacturing practices that lead to higher levels of supply chain responsiveness in terms of operations system responsiveness, logistics process responsiveness, and supplier network responsiveness; what specific dimensions of supply chain responsiveness lead to higher levels of competitive advantage in terms of price, quality, delivery dependability, product innovation, and time to market; what specific SCM practices lead to higher levels of competitive advantage in terms of price, quality, delivery dependability, product innovation, and time to market. To answer these questions a dimension-level statistical analysis is needed.

A dimension-level analysis was performed using regression analysis (discussed in section 7.1), followed by multivariate analysis of variance (MANOVA – discussed in section 7.3). The regression analysis was instrumental in indicating whether the independent variables - SCM practices (SCMP) and modularity based manufacturing practices (MBMP) - significantly predict the dependent variables – supply chain responsiveness (SCR) and competitive advantage (CA) - and if they do what are the specific dimensions within SCMP (i.e. strategic supplier partnership, customer relationship, and information sharing) and MBMP (i.e. product modularity, process modularity, and dynamic teaming) that predict the dimensions within SCR (i.e. operations system responsiveness, logistics process responsiveness, and supplier network responsiveness) and CA (price, quality, delivery dependability, product innovation, and time to market). Also a dimension level analysis was carried out for the prediction of CA by SCR.

A MANOVA was deemed to be the appropriate test here for two reasons: first there was some correlation found between the DVs (dimensions of competitive advantage), and second all five dimensions of competitive advantage (i.e. price, quality, delivery dependability, product innovation, and time to market) were considered for analysis at one single time thus resulting in more than one dependent variable, in which case MANOVA would be the appropriate test.

7.1 Regression Analysis Results

7.1.1 Dimension-Level Analysis for Supply Chain Responsiveness

Stepwise multiple regression is often used in studies that are exploratory in nature (Aron and Aron, 1999). In our study we have a set of predictors (individual dimensions of MBMP; individual dimensions of SCMP) and want to explore as to which specific independent variables (IVs) make meaningful contributions to the overall prediction of SCR. The structural equation modeling results depict that modularity based manufacturing practices predict supply chain responsiveness to a large extent, whereas SCM practices predict supply chain responsiveness to a moderate extent.

A stepwise regression analysis is performed to determine what dimensions of MBMP (i.e. product modularity (PM), process modularity (PRM), and dynamic teaming (DT)) and SCMP (i.e. strategic supplier partnership (SSP), customer relationship (CR), and information sharing (IS)) are significant predictors of SCR (composite score). These regressions were carried out independently first for the MBMP dimensions on SCR, followed by the SCMP dimensions on SCR.

The results are tabulated and discussed in the order of significance of predictors of SCR (i.e. MBMP followed by SCMP), as evident from the results of section 6.2.1 (chapter 6).

7.1.1.1 MBMP (dimension level) – Supply Chain Responsiveness (composite score)

The stepwise regression results shown in Table 7.1.1.1 indicate an overall model of two dimensions of MBMP (namely DT and PRM) that reasonably predict SCR, $R^2 = 0.249$, $R^2_{adj} = 0.244$, $F(2,291) = 48.324$, $p < 0.001$. The model accounted for 24.4%

(R^2_{adj}) of the variance in SCR. A summary of regression coefficients is presented in Table 7.1.1.2 and indicates that only two dimensions of MBMP in the order DT (β = 0.317) and PRM (β = 0.250), significantly predict SCR (composite score). From these results it is clear that product modularity (PM) does not contribute significantly to the prediction of SCR. These are interesting findings and shall be more meaningful if analyzed on the individual dimensions of supply chain responsiveness.

Table 7.1.1.1 Dimension Level Stepwise Regression Results
Model Summary for MBMP Dimensions on SCR

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. DT	0.453	0.205	0.202	0.205	75.354	< 0.001	1	292
2. PRM	0.499	0.249	0.244	0.044	17.132	< 0.001	1	291

Table 7.1.1.2 Coefficients for MBMP Dimensions (DT and PRM) on SCR

	B	β	t	p
DT	0.221	0.317	5.249	0.000
PRM	0.170	0.250	4.139	0.000

We now proceed to the stepwise regression of SCMP dimensions on the dependent variable SCR, as it is evidently the second significant predictor of SCR (chapter 6 - section 6.2.1).

7.1.1.2 SCM Practices (dimension level) – Supply Chain Responsiveness (composite score)

The stepwise regression results shown in Table 7.1.1.3 indicate an overall model of all the three dimensions of SCMP (in the order IS, SSP and CR) that reasonably predict SCR, $R^2 = 0.194$, $R^2_{adj} = 0.186$, $F(3,290) = 23.271$, $p < 0.001$. The model accounted for 18.6% (R^2_{adj}) of the variance in SCR. A summary of regression coefficients is presented in Table 7.1.1.4 and indicates the three dimensions of SCMP in the order IS ($\beta = 0.223$), SSP ($\beta = 0.203$), and CR ($\beta = 0.128$), that significantly predict SCR (composite score).

Table 7.1.1.3 Dimension Level Stepwise Regression Results
Model Summary for SCMP Dimensions on SCR

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. IS	0.373	0.139	0.136	0.139	47.157	< 0.001	1	292
2. SSP	0.426	0.182	0.176	0.043	15.147	< 0.001	1	291
3. CR	0.440	0.194	0.186	0.012	4.457	< 0.05	1	290

Table 7.1.1.4 Coefficients for SCMP Dimensions (IS, SSP, and CR) on SCR

	B	β	t	p
IS	0.185	0.223	3.551	0.000
SSP	0.167	0.203	3.365	0.001
CR	0.104	0.128	2.111	0.036

Following the above dimension-level analysis MBMP and SCMP on summated SCR score, it is further of interest as to what dimensions within MBMP and SCMP significantly predict the dimensions within SCR. We therefore first carry out a dimension-level stepwise regression analysis of MBMP dimensions as IVs (PM, PRM, and DT) on each individual dimension of SCR as a DV (operations system responsiveness (OSR), logistics process responsiveness (LPR), and supplier network responsiveness (SNR)). This is followed by a stepwise regression analysis of SCMP dimensions (as IVs) on each individual dimension of SCR (as a DV). The results are as follows:

7.1.1.3 MBMP (dimension level) – Supply Chain Responsiveness (dimension level)

The stepwise regression results for the dimension-level analysis of MBMP dimensions (PM, PRM, and DT) on individual SCR dimensions (OSR, LPR, and SNR) are shown in Table 7.1.1.5 – Table 7.1.1.9.

Table 7.1.1.5 Dimension Level Stepwise Regression Results
Model Summary for MBMP Dimensions on OSR

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. DT	0.476	0.227	0.224	0.227	85.747	< 0.001	1	292
2. PRM	0.512	0.262	0.257	0.035	13.743	< 0.001	1	291

Table 7.1.1.6 Coefficients for MBMP Dimensions (DT and PRM) on OSR

	B	β	t	p
DT	0.339	0.356	5.939	0.000
PRM	0.206	0.222	3.707	0.000

From these results (Tables 7.1.1.5 and 7.1.16) it is clear that only two dimensions of MBMP in the order DT (β = 0.356) and PRM (β = 0.222), significantly predict OSR. However, product modularity (PM) does not contribute significantly to the prediction of OSR. A closer look at the measurement items of process modularity (PRM) and dynamic teaming (DT) reveal that these items are very closely associated with the shop floor and manufacturing / operations aspects of the overall responsiveness. Thus they have been found to be positively related to operations system responsiveness (OSR). Also product modularity (PM) is theoretically a strong candidate to contribute to the responsiveness of organizations, as these organizations can quickly make a variety of products from numerous modules. However, the results here do not support this fact. A plausible explanation is that product modularity affects the 'assembly responsiveness' dimension of supply chain responsiveness. This dimension has not been considered in this research and shall be interesting to study in future research. In addition, another convincing explanation to this effect is that product modularity directly impacts the postponement of manufacturing, which in turn affects supply chain responsiveness. This relationship shall be interesting to test in future studies.

Table 7.1.1.7 Dimension Level Stepwise Regression Results
Model Summary for MBMP Dimensions on LPR

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. DT	0.286	0.082	0.079	0.082	26.006	< 0.001	1	292
2. PRM	0.312	0.097	0.091	0.016	5.029	< 0.05	1	291

As observed in Table 7.1.1.7 the results are not significant ($R^2_{adj} = 0.091$) to draw conclusions with regards to logistics process responsiveness (LPR). It is desired that R^2_{adj} be at least 0.10 (i.e. the given IV/s explain at least 10% of the variance in DV) so as to draw any substantial inferences. It is thus evident that none of the dimensions of MBMP predict LPR. A convincing explanation for this result is that product modularity, process modularity, and dynamic teaming are more manufacturing and product related and within the firm. Outbound logistics is post manufacturing and outside the firm (given the fact that most logistics activities of transportation, distribution, and warehousing are carried out by third parties proficient in doing so). Thus the logistics process responsiveness is not being affected by either of product modularity, process modularity, or dynamic teaming practices.

Table 7.1.1.8 Dimension Level Stepwise Regression Results
Model Summary for MBMP Dimensions on SNR

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. PRM	0.313	0.098	0.095	0.098	31.603	< 0.001	1	292
2. DT	0.345	0.119	0.113	0.021	6.956	< 0.01	1	291

Table 7.1.1.9 Coefficients for MBMP Dimensions (PRM and DT) on SNR

	B	β	t	p
PRM	0.174	0.219	3.342	0.001
DT	0.141	0.173	2.637	0.009

From these results (Tables 7.1.1.8 and 7.1.1.9) it is clear that only two dimensions of MBMP in the order PRM (β = 0.219) and DT (β = 0.173), significantly predict SNR. As observed, product modularity (PM) does not contribute significantly to the prediction of SNR. A close look at the process modularity (PRM) measurement items reveals that the intent is to have the process as modules, such that these processes can be rearranged and re-sequenced to create products as per customer demand. Due to the re-sequencing capability of the processes, raw materials can be ordered as needed (dictated by the products manufactured by these processes), rather than ordering all at once (i.e. at the beginning of production, had it been a single integrated process). This ordering of materials in small quantities based on process modules, is likely to increase the responsiveness of suppliers. To further understand as to how and why 'dynamic teaming' (DT) affects supplier network responsiveness (SNR), we wait for the item level regression analyses of DT items on SNR.

We now proceed to perform and analyze the regression results of SCMP dimensions (as IVs) on individual dimensions of SCR (as individual DVs) in the following section 7.1.1.4.

7.1.1.4 SCM Practices (dimension level) – Supply Chain Responsiveness (dimension level)

The stepwise regression results for the dimension-level analysis of SCMP dimensions (SSP, CR, and IS) on individual SCR dimensions (OSR, LPR, and SNR) are shown in Table 7.1.1.10 – Table 7.1.1.14.

Table 7.1.1.10 Dimension Level Stepwise Regression Results
Model Summary for SCMP Dimensions on OSR

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. CR	0.295	0.087	0.084	0.087	27.841	< 0.001	1	292
2. SSP	0.339	0.115	0.109	0.028	9.119	< 0.01	1	291

Table 7.1.1.11 Coefficients for SCMP Dimensions (CR and SSP) on OSR

	B	β	t	p
CR	0.251	0.227	3.817	0.000
SSP	0.201	0.180	3.020	0.003

From these results (Tables 7.1.1.10 and 7.1.1.11) it is clear that only two dimensions of SCMP in the order CR (β = 0.227) and SSP (β = 0.180), significantly predict OSR. However, information sharing (IS) does not contribute significantly to the prediction of OSR. The results imply that having close customer and supplier relations develop a better understanding between trading partners thus increasing a firm's ability to rapidly respond to demand changes by customer.

Table 7.1.1.12 Dimension Level Stepwise Regression Results
Model Summary for SCMP Dimensions on LPR

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. IS	0.285	0.082	0.078	0.082	25.911	< 0.001	1	292
2. CR	0.310	0.096	0.090	0.015	4.693	< 0.05	1	291

As observed in Table 7.1.1.12 the results are not significant ($R^2_{adj} = 0.090$) to draw conclusions with regards to logistics process responsiveness. It is desired that R^2_{adj} be at least 0.10 (i.e. the given IV/s explain at least 10% of the variance in DV) so as to draw any substantial inferences. It is thus evident that none of the dimensions of SCMP predict LPR. The reasoning for this would be the same as that provided for Table 7.1.1.7.

Table 7.1.1.13 Dimension Level Stepwise Regression Results
Model Summary for SCMP Dimensions on SNR

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. SSP	0.339	0.115	0.112	0.115	37.870	< 0.001	1	292
2. IS	0.390	0.152	0.146	0.037	12.849	< 0.001	1	291

Table 7.1.1.14 Coefficients for SCMP Dimensions (SSP and IS) on SNR

	B	β	t	p
SSP	0.233	0.242	4.004	0.000
IS	0.210	0.216	3.585	0.000

From these results (Tables 7.1.1.13 and 7.1.1.14) it is clear that only two dimensions of SCMP in the order SSP ($\beta = 0.242$) and IS ($\beta = 0.216$), significantly predict SNR. As observed, customer relationship (CR) does not contribute significantly to the prediction of SNR. The results emphasize the fact that nourishing long term mutually beneficial relationships with suppliers and sharing quality information in real time throughout the supply chain leads to more responsive suppliers.

7.1.2 Item-Level Analysis for Supply Chain Responsiveness

We now analyze the effect of specific items (constituting the significant predictor dimensions) on the dependent variable SCR, and further also on its significant dimensions (OSR and SNR) to gain an insight into the specific practices that impact one or more SCR dimensions. In this section stepwise regression analyses are performed with all items that measure the predictors (that are significant in predicting the DV - as depicted in the previous section 7.1.1) as IVs and the corresponding DV. This analysis is performed one predictor dimension items at a time on the corresponding DV. The results are tabulated and discussed in the order of significance of predictors of SCR, as evident from the previous section 7.1.1.

7.1.2.1 MBMP (item level) – Supply Chain Responsiveness (composite score)

In section 7.1.1.1, DT is the first dimension within MBMP that reasonably predicted SCR (summated score). To better understand the specific practices or measures within DT that truly predict SCR, we now perform a stepwise multiple regression with the items or measures of DT as IVs and SCR (summated score) as a DV. The stepwise regression results are shown in Tables 7.1.2.1 and 7.1.2.2.

Table 7.1.2.1 Item-Level Stepwise Regression Results
Model Summary for DT Items on SCR

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. DT3	0.438	0.192	0.189	0.192	69.220	< 0.001	1	292
2. DT1	0.450	0.202	0.197	0.011	3.885	< 0.05	1	291

Table 7.1.2.2 Coefficients for DT Items (DT3 and DT1) on SCR

	B	***β***	***t***	***p***
DT3	0.219	0.329	4.324	0.000
DT1	0.090	0.150	1.971	0.05

From these results (Tables 7.1.2.1 and 7.1.2.2) it is clear that only two items of DT in the order DT3 (β = 0.329) and DT1 (β = 0.150), significantly predict SCR on the whole (i.e. summated score). As observed, the other three items measuring dynamic teaming (viz: DT2, DT4, and DT5) do not contribute significantly to the prediction of SCR.

In section 7.1.1.1, PRM is the second predictor within MBMP that predicts SCR (summated score). To better understand the specific practices or measures within PRM that truly predict SCR, we now perform a stepwise multiple regression with the items or measures of PRM as IVs and SCR (summated score) as a DV. The stepwise regression results are shown in Tables 7.1.2.3 and 7.1.2.4.

Table 7.1.2.3 Item-Level Stepwise Regression Results
Model Summary for PRM Items on SCR

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. PRM2	0.398	0.158	0.155	0.158	54.993	< 0.001	1	292
2. PRM5	0.425	0.181	0.175	0.023	8.007	< 0.01	1	291

Table 7.1.2.4 Coefficients for PRM Items (PRM2 and PRM5) on SCR

	B	β	t	p
PRM2	0.182	0.294	4.566	0.000
PRM5	0.105	0.182	2.830	0.005

From these results (Tables 7.1.2.3 and 7.1.2.4) it is clear that only two items of PRM in the order PRM2 (β = 0.294) and PRM5 (β = 0.182), significantly predict SCR on the whole (i.e. summated score). The other three items measuring process modularity (viz: PRM1, PRM3, and PRM4) however, do not contribute significantly to the prediction of SCR.

7.1.2.2 SCM Practices (item level) – Supply Chain Responsiveness (composite score)

In section 7.1.1.2 IS is the first dimension within SCMP that reasonably predicted SCR (summated score). To better understand the specific practices or measures within IS that truly predict SCR, we now perform a stepwise multiple regression with the items or measures of IS as IVs and SCR (summated score) as a DV. The stepwise regression results are shown in Tables 7.1.2.5 and 7.1.2.6.

Table 7.1.2.5 Item-Level Stepwise Regression Results
Model Summary for IS Items on SCR

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. IS1	0.374	0.140	0.137	0.140	47.388	< 0.001	1	292
2. IS3	0.408	0.167	0.161	0.027	9.500	< 0.01	1	291

Table 7.1.2.6 Coefficients for IS Items (IS1 and IS3) on SCR

	B	*β*	*t*	*p*
IS1	0.185	0.263	4.095	0.000
IS3	0.144	0.198	3.082	0.002

From these results (Tables 7.1.2.5 and 7.1.2.6) it is clear that only two items of IS in the order IS1 (β = 0.263) and IS3 (β = 0.198), significantly predict SCR on the aggregate level (i.e. summated score for SCR). The other four items measuring information sharing (viz: IS2, IS4, IS5, and IS6) do not contribute significantly to the prediction of SCR.

In section 7.1.1.2, SSP is the second dimension within SCMP that reasonably predicts SCR (summated score). To better understand the specific practices or measures within SSP that truly predict SCR, we now perform a stepwise multiple regression with the items or measures of SSP as IVs and SCR (summated score) as a DV. The stepwise regression results are shown in Tables 7.1.2.7 and 7.1.2.8.

Table 7.1.2.7 Item-Level Stepwise Regression Results
Model Summary for SSP Items on SCR

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. SSP4	0.272	0.074	0.071	0.074	23.238	< 0.001	1	292
2. SSP2	0.315	0.099	0.093	0.026	8.242	< 0.01	1	291
3. SSP6	0.338	0.114	0.105	0.015	4.946	< 0.05	1	290

Table 7.1.2.8 Coefficients for SSP Items (SSP4, SSP2, and SSP6) on SCR

	B	β	t	p
SSP4	0.070	0.135	2.029	0.043
SSP2	0.103	0.151	2.340	0.020
SSP6	0.077	0.141	2.224	0.027

From these results (Tables 7.1.2.7 and 7.1.2.8) it is clear that only three items of SSP in the order SSP2 ($\beta = 0.151$), SSP6 ($\beta = 0.141$), and SSP4 ($\beta = 0.135$), significantly predict SCR on the aggregate level (i.e. summated score for SCR). The other three items measuring strategic supplier partnership (viz: SSP1, SSP3, and SSP5) do not contribute significantly to the prediction of SCR.

In section 7.1.1.2, CR is the third dimension within SCMP that predicts SCR (summated score) to a small extent. To better understand the specific practices or measures within CR that truly predict SCR, we now perform a stepwise multiple regression with the items or measures of CR as IVs and SCR (summated score) as a DV. The stepwise regression results are shown in Tables 7.1.2.9 and 7.1.2.10.

Table 7.1.2.9 Item-Level Stepwise Regression Results
Model Summary for CR Items on SCR

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. CR4	0.288	0.083	0.080	0.083	26.437	< 0.001	1	292
2. CR2	0.019	0.102	0.096	0.019	6.288	< 0.05	1	291

Table 7.1.2.10 Coefficients for CR Items (CR4 and CR2) on SCR

	B	***β***	***t***	***p***
CR4	0.150	0.225	3.697	0.000
CR2	0.090	0.153	2.508	0.013

From Table 7.1.2.9 we observe that R^2_{adj} is 0.096, which is marginally lower than and almost equal to the cutoff (0.10) for interpretation of the regression results. We therefore go ahead with the interpretation of the results of CR items on SCR. From these results (Tables 7.1.2.9 and 7.1.2.10) it is clear that only two items of CR in the order CR4 (β = 0.225) and CR2 (β = 0.153), significantly predict SCR on the aggregate level (i.e. summated score for SCR). The other three items measuring customer relationship (viz: CR1, CR3, and CR5) do not contribute significantly to the prediction of SCR.

Having analyzed the effects of specific items that significantly predict SCR, we now proceed towards the item-level regression analyses on the significant dimensions of SCR (OSR and SNR), one DV at a time. In this section stepwise regression analyses are performed with all items that constitute the predictors - that are significant in predicting the DV - as depicted in the previous sections 7.1.1.3 and 7.1.1.4 - as IVs and the corresponding DV (specific significant dimension of SCR, namely OSR or SNR). This analysis is performed one predictor dimension items at a time on the corresponding DV. The results are tabulated and discussed in the order of significance of predictors of SCR dimensions, as evident from the previous sections 7.1.1.3 and 7.1.1.4. The results are as follows:

7.1.2.3 MBMP (item level) – Supply Chain Responsiveness (dimension level)

In section 7.1.1.3, DT is the first dimension within MBMP that reasonably predicted OSR. To explore the specific practices or measures within DT that truly predict OSR, we now perform a stepwise multiple regression with the items or measures of DT as IVs and OSR as a DV. The stepwise regression results are shown in Tables 7.1.2.11 and 7.1.2.12.

Table 7.1.2.11 Item-Level Stepwise Regression Results
Model Summary for DT Items on OSR

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. DT3	0.461	0.213	0.210	0.213	78.991	< 0.001	1	292
2. DT5	0.479	0.229	0.224	0.016	6.116	< 0.05	1	291

Table 7.1.2.12 Coefficients for DT Items (DT3 and DT5) on OSR

	B	β	t	p
DT3	0.242	0.267	2.835	0.005
DT5	0.209	0.233	2.473	0.014

From these results (Tables 7.1.2.11 and 7.1.2.12) it is clear that only two items of DT in the order DT3 (β = 0.267) and DT5 (β = 0.233), significantly predict OSR. The other three items measuring dynamic teaming (viz: DT1, DT2, and DT4) however, do not contribute significantly to the prediction of OSR.

In section 7.1.1.3, PRM is the second predictor within MBMP that predicts OSR. To better explore the specific practices or measures within PRM that truly predict OSR, we now perform a stepwise multiple regression with the items or measures of PRM as IVs and OSR as a DV. The stepwise regression results are shown in Tables 7.1.2.13 and 7.1.2.14.

Table 7.1.2.13 Item-Level Stepwise Regression Results
Model Summary for PRM Items on OSR

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. PRM3	0.397	0.158	0.155	0.158	54.631	< 0.001	1	292
2. PRM1	0.420	0.176	0.170	0.018	6.501	< 0.05	1	291

Table 7.1.2.14 Coefficients for PRM Items (PRM3 and PRM1) on OSR

	B	β	t	p
PRM3	0.186	0.222	2.552	0.011
PRM1	0.177	0.222	2.550	0.011

From these results (Tables 7.1.2.13 and 7.1.2.14) it is clear that only two items of PRM, PRM3 (β = 0.222) and PRM1 (β = 0.222) together significantly predict OSR. The other three items measuring process modularity (viz: PRM2, PRM4, and PRM5) do not contribute significantly to the prediction of OSR.

In section 7.1.1.3, PRM is the first predictor within MBMP that predicts SNR. To better explore the specific practices or measures within PRM that truly predict SNR, we now perform a stepwise multiple regression with the items or measures of PRM as IVs and SNR as a DV. The stepwise regression results are shown in Tables 7.1.2.15 and 7.1.2.16.

Table 7.1.2.15 Item-Level Stepwise Regression Results Model Summary for PRM Items on SNR

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. PRM5	0.307	0.094	0.091	0.094	30.406	< 0.001	1	292
2. PRM2	0.340	0.116	0.110	0.022	7.088	< 0.01	1	291

Table 7.1.2.16 Coefficients for PRM Items (PRM5 and PRM2) on SNR

	B	β	t	p
PRM5	0.139	0.206	3.073	0.002
PRM2	0.129	0.178	2.662	0.008

From these results (Tables 7.1.2.15 and 7.1.2.16) it is clear that only two items of PRM, in the order PRM5 (β = 0.206) and PRM2 (β = 0.178), significantly predict SNR. From these results it is clear that the other three items measuring process modularity (viz: PRM1, PRM3, and PRM4) do not contribute significantly to the prediction of SNR.

In section 7.1.1.3, DT is the second dimension within MBMP that predicted SNR. To explore the specific practices or measures within DT that truly predict SNR, we now perform a stepwise multiple regression with the items or measures of DT as IVs and SNR as a DV. The stepwise regression result is shown in Table 7.1.2.17.

Table 7.1.2.17 Item-Level Stepwise Regression Results
Model Summary for DT Items on SNR

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. DT4	0.283	0.080	0.077	0.080	25.936	< 0.001	1	292

As observed in Table 7.1.2.17 the results are not significant (R^2_{adj} = 0.077) to draw conclusions. It is desired that R^2_{adj} be at least 0.10 (i.e. the given IV/s explain at least 10% of the variance in DV) so as to draw any substantial inferences. It is thus evident that none of the items of DT predict SNR.

We now proceed to perform and analyze the regression results of SCMP items (of significant predictor dimensions as IV) on individual SCR dimensions (viz: OSR and SNR) as evident from section 7.1.1.4.

7.1.2.4 SCM Practices (item level) – Supply Chain Responsiveness (dimension level)

In section 7.1.1.4, CR is the first dimension within SCMP that predicts OSR to a small extent. To better understand the specific practices or measures within CR that truly predict OSR, we now perform a stepwise multiple regression with the items or measures of CR as IVs and OSR as a DV. The stepwise regression result is shown in Table 7.1.2.18.

Table 7.1.2.18 Item-Level Stepwise Regression Results Model Summary for CR Items on OSR

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. CR4	0.256	0.065	0.062	0.065	20.438	< 0.001	1	292
2. CR2	0.292	0.085	0.079	0.020	6.296	< 0.05	1	291

As observed in Table 7.1.2.18 the results are not significant ($R^2_{adj} = 0.079$) to draw conclusions. It is desired that R^2_{adj} be at least 0.10 (i.e. the given IV/s explain at least 10% of the variance in DV) so as to draw any substantial inferences. It is thus evident that none of the items of CR predict OSR.

In section 7.1.1.4, SSP is the second dimension within SCMP that predicts OSR to a small extent. To better understand the specific practices or measures within SSP that truly predict OSR, we perform a stepwise multiple regression with the items or measures of SSP as IVs and OSR as a DV. The stepwise regression result is shown in Table 7.1.2.19.

Table 7.1.2.19 Item-Level Stepwise Regression Results Model Summary for SSP Items on OSR

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. SSP4	0.217	0.047	0.044	0.047	14.404	< 0.001	1	292
2. SSP1	0.246	0.060	0.054	0.013	4.164	< 0.05	1	291

As observed in Table 7.1.2.19 the results are not significant ($R^2_{adj} = 0.054$) to draw conclusions. It is desired that R^2_{adj} be at least 0.10 (i.e. the given IV/s explain at least 10% of the variance in DV) so as to draw any substantial inferences. It is thus evident that none of the items of SSP predict OSR.

In section 7.1.1.4, SSP is the first dimension within SCMP that reasonably predicts SNR. To better understand the specific practices or measures within SSP that truly predict SNR, we now perform a stepwise multiple regression with the items or measures of SSP as IVs and SNR as a DV. The stepwise regression results are shown in Tables 7.1.2.20 and 7.1.2.21.

Table 7.1.2.20 Item-Level Stepwise Regression Results
Model Summary for SSP Items on SNR

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. SSP2	0.325	0.106	0.103	0.106	34.478	< 0.001	1	292
2. SSP6	0.363	0.132	0.126	0.026	8.774	< 0.01	1	291

Table 7.1.2.21 Coefficients for SSP Items (SSP2 and SSP6) on SNR

	B	β	t	p
SSP2	0.206	0.257	4.341	0.000
SSP6	0.112	0.175	2.962	0.003

From these results (Tables 7.1.2.20 and 7.1.2.21) it is clear that only two items of SSP in the order SSP2 (β = 0.257) and SSP6 (β = 0.175), significantly predict SNR. The other four items measuring strategic supplier partnership (viz: SSP1, SSP3, SSP4, and SSP5) do not contribute significantly to the prediction of SNR.

In section 7.1.1.4, IS is the second dimension within SCMP that reasonably predicted SNR. To better understand the specific practices or measures within IS that truly predict SNR, we now perform a stepwise multiple regression with the items or measures of IS as IVs and SNR as a DV. The stepwise regression results are shown in Tables 7.1.2.22 and 7.1.2.23.

Table 7.1.2.22 Item-Level Stepwise Regression Results
Model Summary for IS Items on SNR

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. IS1	0.308	0.095	0.091	0.095	30.502	< 0.001	1	292
2. IS3	0.347	0.120	0.114	0.026	8.440	< 0.01	1	291

Table 7.1.2.23 Coefficients for IS Items (IS1 and IS3) on SNR

	B	β	t	p
IS1	0.165	0.201	3.037	0.003
IS3	0.163	0.192	2.905	0.004

From these results (Tables 7.1.2.22 and 7.1.2.23) it is clear that only two items of IS in the order IS1 (β = 0.201) and IS3 (β = 0.192), significantly predict SNR. The other four items measuring information sharing (viz: IS2, IS4, IS5, and IS6) do not contribute significantly to the prediction of SNR.

Having analyzed all the specific practices that lead to specific supply chain responsiveness dimensions, we now proceed to analyze the practices and responsiveness components that lead to competitive advantage of a firm on various dimensions.

7.1.3 Dimension-Level Analysis for Competitive Advantage

The structural equation modeling results in chapter 6 clearly highlight the non-significance of MBMP in predicting CA (as given by the non-significant and low effect size). MBMP has therefore been dropped from further analyses on a dimension/item level with respect to CA. A stepwise regression analysis is performed to determine what dimensions of SCMP (i.e. strategic supplier partnership (SSP), customer relationship (CR), and information sharing (IS)) and SCR (i.e. operations system responsiveness (OSR), logistics process responsiveness (LPR), and supplier network responsiveness (SNR)) are significant predictors of CA. These regressions were carried out independently first for SCMP dimensions on CA, and then followed by SCR dimensions on CA.

The results are tabulated and discussed in the order of significance of predictors of CA (i.e. SCMP followed by SCR), and as evident from the results of section 6.2.1 (chapter 6).

7.1.3.1 SCM Practices (dimension level) – Competitive Advantage (composite score)

The stepwise regression results shown in Table 7.1.3.1 indicate an overall model of two dimensions of SCMP (namely CR and SSP) that reasonably predict CA, $R^2 = 0.201$, $R^2_{adj} = 0.196$, $F(2,291) = 36.643$, $p < 0.001$. The model accounted for 19.6% (R^2_{adj}) of the variance in CA. A summary of regression coefficients is presented in Table 7.1.3.2 and indicates that only two dimensions of SCMP in the order CR ($\beta = 0.304$) and SSP ($\beta = 0.234$), significantly predict CA (composite score).

Table 7.1.3.1 Dimension Level Stepwise Regression Results Model Summary for SCMP Dimensions on CA

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. CR	0.392	0.154	0.151	0.154	53.171	< 0.001	1	292
2. SSP	0.449	0.201	0.196	0.047	17.171	< 0.001	1	291

Table 7.1.3.2 Coefficients for SCMP Dimensions (CR and SSP) on CA

	B	β	t	p
CR	0.177	0.304	5.377	0.000
SSP	0.138	0.234	4.144	0.000

From these results it is clear that information sharing (IS) does not contribute significantly to the prediction of CA. One can argue that although IS is found to be non instrumental in the prediction of CA, having close customer and supplier relations includes collaborating and assisting one another with vital, on time, and quality information.

We now proceed to the stepwise regression of SCR dimensions on the dependent variable CA, as it is evidently the second significant predictor of CA (chapter 6 - section 6.2.1).

7.1.3.2 Supply Chain Responsiveness (dimension level) – Competitive Advantage (composite score)

The stepwise regression results shown in Table 7.1.3.3 indicate an overall model of two dimensions of SCR that reasonably predict CA, $R^2 = 0.181$, $R^2_{adj} = 0.176$, $F(2,291) = 32.246$, $p < 0.001$. The model accounted for 17.6% (R^2_{adj}) of the variance in CA. A summary of regression coefficients is presented in Table 7.1.3.4 and indicates the two dimensions of SCR in the order OSR ($\beta = 0.316$), and SNR ($\beta = 0.180$) that significantly predict CA (composite score). From these results it is clear that logistics process responsiveness (LPR) does not contribute significantly to the prediction of CA. One may argue that outbound logistics is post manufacturing and outside the firm (given the fact that most logistics activities of transportation, distribution, and warehousing are carried out by third parties proficient in doing so). Thus the logistics process responsiveness does not contribute directly to the creation of competitive advantage of a firm. Operations system responsiveness is within the domain of the firm, whereas supplier network responsiveness dictates much of the firm's ability to be responsive, and thus these two components of supply chain responsiveness predominantly predict competitive advantage.

Table 7.1.3.3 Dimension Level Stepwise Regression Results
Model Summary for SCR Dimensions on CA

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. OSR	0.394	0.155	0.152	0.155	53.644	< 0.001	1	292
2. SNR	0.426	0.181	0.176	0.026	9.318	< 0.01	1	291

Table 7.1.3.4 Coefficients for SCR Dimensions (OSR and SNR) on CA

	B	***β***	***t***	***p***
OSR	0.167	0.316	5.376	0.000
SNR	0.110	0.180	3.053	0.002

Following the above dimension-level analysis of SCMP and SCR on summated CA score, it is further of interest as to what dimensions within SCMP and SCR significantly predict the dimensions within CA. We therefore first carry out a dimension-level stepwise regression analysis of SCMP dimensions (SSP, CR and IS) as IVs on each individual dimension of CA (Price, Quality, Delivery Dependability, Product Innovation, and Time to Market) as a DV. This is followed by a stepwise regression analysis of SCR dimensions (operations system responsiveness (OSR), logistics process responsiveness (LPR), and supplier network responsiveness (SNR)) as IVs on each individual dimension of CA (as a DV). The results are as follows:

7.1.3.3 SCM Practices (dimension level) – Competitive Advantage (dimension level)

The stepwise regression results for the dimension-level analysis of SCMP dimensions (SSP, CR, and IS) on individual CA dimensions (price, quality, delivery dependability, product innovation, and time to market) are shown in Table 7.1.3.5 – Table 7.1.3.9.

Table 7.1.3.5 Dimension Level Stepwise Regression Results Model Summary for SCMP Dimensions on Price

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. IS	0.234	0.055	0.052	0.055	16.949	< 0.001	1	292

As observed in Table 7.1.3.5 the results are not significant ($R^2_{adj} = 0.052$) to draw conclusions. It is desired that R^2_{adj} be at least 0.10 (i.e. the given IV/s explain at least 10% of the variance in DV) so as to draw any substantial inferences. It is thus evident that none of the dimensions of SCMP predict the 'price' dimension of competitive advantage, when considered by itself.

Table 7.1.3.6 Dimension Level Stepwise Regression Results Model Summary for SCMP Dimensions on Quality

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. SSP	0.212	0.045	0.042	0.045	13.736	< 0.001	1	292
2. CR	0.241	0.058	0.051	0.013	4.000	< 0.05	1	291

As observed in Table 7.1.3.6 the results are not significant ($R^2_{adj} = 0.051$) to draw conclusions. It is desired that R^2_{adj} be at least 0.10 (i.e. the given IV/s explain at least 10% of the variance in DV) so as to draw any substantial inferences. It is thus evident that none of the dimensions of SCMP predict the 'quality' dimension of competitive advantage, when considered by itself.

Table 7.1.3.7 Dimension Level Stepwise Regression Results
Model Summary for SCMP Dimensions on Delivery Dependability

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. SSP	0.243	0.059	0.056	0.059	18.327	< 0.001	1	292
2. CR	0.280	0.079	0.072	0.020	6.171	< 0.05	1	291

As observed in Table 7.1.3.7 the results are not significant ($R^2_{adj} = 0.072$) to draw conclusions. It is desired that R^2_{adj} be at least 0.10 (i.e. the given IV/s explain at least 10% of the variance in DV) so as to draw any substantial inferences. It is thus evident that none of the dimensions of SCMP predict the 'delivery dependability' dimension of competitive advantage, when considered by itself.

Table 7.1.3.8 Dimension Level Stepwise Regression Results
Model Summary for SCMP Dimensions on Product Innovation

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. CR	0.277	0.077	0.074	0.077	24.289	< 0.001	1	292

As observed in Table 7.1.3.8 the results are not significant ($R^2_{adj} = 0.074$) to draw conclusions. It is desired that R^2_{adj} be at least 0.10 (i.e. the given IV/s explain at least 10% of the variance in DV) so as to draw any substantial inferences. It is thus evident that none of the dimensions of SCMP predict the 'product innovation' dimension of competitive advantage, when considered by itself.

Table 7.1.3.9 Dimension Level Stepwise Regression Results
Model Summary for SCMP Dimensions on Time to Market

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. IS	0.244	0.059	0.056	0.059	18.466	< 0.001	1	292
2. SSP	0.284	0.081	0.074	0.021	6.705	< 0.01	1	291
3. CR	0.305	0.093	0.084	0.012	3.953	< 0.05	1	290

As observed in Table 7.1.3.9 the results are not significant ($R^2_{adj} = 0.084$) to draw conclusions. It is desired that R^2_{adj} be at least 0.10 (i.e. the given IV/s explain at least 10% of the variance in DV) so as to draw any substantial inferences. It is thus evident that none of the dimensions of SCMP predict the 'time to market' dimension of competitive advantage, when considered by itself.

We now proceed to perform and analyze the regression results of SCR dimensions (as IVs) on individual dimensions of CA (as individual DVs) in the following section 7.1.3.4.

7.1.3.4 Supply Chain Responsiveness (dimension level) – Competitive Advantage (dimension level)

The stepwise regression results for the dimension-level analysis of SCR dimensions (OSR, LPR, and SNR) on individual CA dimensions (price, quality, delivery dependability, product innovation, and time to market) are shown in Table 7.1.3.10 – Table 7.1.3.15.

Table 7.1.3.10 Dimension Level Stepwise Regression Results
Model Summary for SCR Dimensions on Price

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. OSR	0.215	0.046	0.043	0.046	14.218	< 0.001	1	292

As observed in Table 7.1.3.10 the results are not significant ($R^2_{adj} = 0.043$) to draw conclusions. It is desired that R^2_{adj} be at least 0.10 (i.e. the given IV/s explain at least 10% of the variance in DV) so as to draw any substantial inferences. It is thus evident that none of the dimensions of SCR predict the 'price' dimension of competitive advantage, when considered by itself.

Table 7.1.3.11 Dimension Level Stepwise Regression Results
Model Summary for SCR Dimensions on Quality

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. LPR	0.192	0.037	0.034	0.037	11.161	< 0.001	1	292

As observed in Table 7.1.3.11 the results are not significant ($R^2_{adj} = 0.034$) to draw conclusions. It is desired that R^2_{adj} be at least 0.10 (i.e. the given IV/s explain at least 10% of the variance in DV) so as to draw any substantial inferences. It is thus evident that none of the dimensions of SCR predict the 'quality' dimension of competitive advantage, when considered by itself.

Table 7.1.3.12 Dimension Level Stepwise Regression Results Model Summary for SCR Dimensions on Delivery Dependability

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. SNR	0.320	0.102	0.099	0.102	33.230	< 0.001	1	292
2. OSR	0.364	0.132	0.126	0.030	10.069	< 0.01	1	291

Table 7.1.3.13 Coefficients for SCR Dimensions (SNR and OSR) on Delivery Dependability

	B	β	t	p
SNR	0.235	0.237	3.905	0.000
OSR	0.164	0.192	3.173	0.002

From these results (Tables 7.1.3.12 and 7.1.3.13) it is clear that only two dimensions of SCR in the order SNR (β = 0.237) and OSR (β = 0.192), significantly predict ‘delivery dependability’. However surprisingly, logistics process responsiveness (LPR) does not contribute significantly to the prediction of ‘delivery dependability’. A plausible explanation to this is that, logistics process responsiveness is outside of the focal firm and a characteristic of the logistic provider. Thus LPR is not in direct control of the organization per se. However OSR is a characteristic within the organization. Also SNR has been found to be crucial to delivery dependability because, in order to address changes in customer demand in a timely manner by a firm, much relies on its suppliers’ ability to address changes in its demand in a timely manner.

Table 7.1.3.14 Dimension Level Stepwise Regression Results
Model Summary for SCR Dimensions on Product Innovation

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. OSR	0.293	0.086	0.083	0.086	27.474	< 0.001	1	292

As observed in Table 7.1.3.14 the results are not significant ($R^2_{adj} = 0.083$) to draw conclusions. It is desired that R^2_{adj} be at least 0.10 (i.e. the given IV/s explain at least 10% of the variance in DV) so as to draw any substantial inferences. It is thus evident that none of the dimensions of SCR predict the 'product innovation' dimension of competitive advantage, when considered by itself.

Table 7.1.3.15 Dimension Level Stepwise Regression Results
Model Summary for SCR Dimensions on Time to Market

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. OSR	0.262	0.069	0.066	0.069	21.540	< 0.001	1	292

As observed in Table 7.1.3.15 the results are not significant ($R^2_{adj} = 0.066$) to draw conclusions. It is desired that R^2_{adj} be at least 0.10 (i.e. the given IV/s explain at least 10% of the variance in DV) so as to draw any substantial inferences. It is thus evident that none of the dimensions of SCR predict the 'time to market' dimension of competitive advantage, when considered by itself.

7.1.4 Item-Level Analysis for Competitive Advantage

We now analyze the effect of specific items (constituting the significant predictor dimensions) on the dependent variable CA, and further also on its dimensions (price, quality, delivery dependability, product innovation, and time to market) to understand the specific practices and responsiveness criteria that improve the competitive advantage of a firm on various dimensions. In this section stepwise regression analyses are performed with all items that measure the predictors (that are significant in predicting the DV - as depicted in the previous section 7.1.3) as IVs and the corresponding DV. This analysis is performed one predictor dimension items at a time on the corresponding DV. The results are tabulated and discussed in the order of significance of predictors of CA, as evident from the previous section 7.1.3.

7.1.4.1 SCM Practices (item level) – Competitive Advantage (composite score)

In section 7.1.3.1, CR is the first dimension within SCMP that reasonably predicted CA (summated score). To better understand the specific practices or measures within CR that truly predict CA, we now perform a stepwise multiple regression with the items or measures of CR as IVs and CA (summated score) as a DV. The stepwise regression results are shown in Tables 7.1.4.1 and 7.1.4.2.

Table 7.1.4.1 Item-Level Stepwise Regression Results
Model Summary for CR Items on CA

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. CR5	0.342	0.117	0.114	0.117	38.763	< 0.001	1	292
2. CR4	0.377	0.142	0.136	0.025	8.494	< 0.01	1	291
3. CR1	0.396	0.157	0.148	0.015	5.118	< 0.05	1	290

Table 7.1.4.2 Coefficients for CR Items (CR5, CR4, and CR1) on CA

	B	β	t	p
CR5	0.086	0.190	2.790	0.006
CR4	0.073	0.153	2.286	0.023
CR1	0.067	0.143	2.262	0.024

From these results (Tables 7.1.4.1 and 7.1.4.2) it is clear that only three items of CR in the order CR5 (β = 0.190), CR4 (β = 0.153), and CR1 (β = 0.143) significantly predict CA on the whole (i.e. summated score). The other two items measuring customer relationship (viz: CR2 and CR3) do not contribute significantly to the prediction of CA.

In section 7.1.3.1, SSP is the second predictor within SCMP that predicts CA (summated score). To better understand the specific practices or measures within SSP that truly predict CA, we now perform a stepwise multiple regression with the items or measures of SSP as IVs and CA (summated score) as a DV. The stepwise regression results are shown in Tables 7.1.4.3 and 7.1.4.4.

Table 7.1.4.3 Item-Level Stepwise Regression Results Model Summary for SSP Items on CA

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. SSP2	0.300	0.090	0.087	0.090	28.856	< 0.001	1	292
2. SSP4	0.342	0.117	0.111	0.027	8.921	< 0.01	1	291

Table 7.1.4.4 Coefficients for SSP Items (SSP2 and SSP4) on CA

	B	β	t	p
SSP2	0.104	0.211	3.369	0.001
SSP4	0.070	0.187	2.987	0.003

From these results (Tables 7.1.4.3 and 7.1.4.4) it is clear that only two items of SSP in the order SSP2 ($\beta = 0.211$) and SSP4 ($\beta = 0.187$), significantly predict CA on the whole (i.e. summated score). The other four items measuring strategic supplier partnership (viz: SSP1, SSP3, SSP5, and SSP6) do not contribute significantly to the prediction of CA.

7.1.4.2 Supply Chain Responsiveness (item level) – Competitive Advantage (composite score)

In section 7.1.3.2, OSR is the first dimension within SCR that reasonably predicted CA (summated score). To better understand the specific practices or measures within OSR that truly predict CA, we now perform a stepwise multiple regression with the items or measures of OSR as IVs and CA (summated score) as a DV. The stepwise regression results are shown in Tables 7.1.4.5 and 7.1.4.6.

Table 7.1.4.5 Item-Level Stepwise Regression Results Model Summary for OSR Items on CA

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. OSR1	0.449	0.202	0.199	0.202	73.718	< 0.001	1	292

Table 7.1.4.6 Coefficients for OSR Items (OSR1) on CA

	B	β	t	p
OSR1	0.199	0.449	8.586	0.000

From these results (Tables 7.1.4.5 and 7.1.4.6) it is clear that only one item of OSR, OSR1 ($\beta = 0.449$), significantly predicts CA on the aggregate level (i.e. summated score for CA). The other four items measuring operations system responsiveness (viz: OSR3, OSR4, OSR5, and OSR7) do not contribute significantly to the prediction of CA.

In section 7.1.3.2, SNR is the second dimension within SCR that reasonably predicts CA (summated score). To better understand the specific practices or measures within SNR that truly predict CA, we now perform a stepwise multiple regression with the items or measures of SNR as IVs and CA (summated score) as a DV. The stepwise regression results are shown in Table 7.1.4.7.

Table 7.1.4.7 Item-Level Stepwise Regression Results Model Summary for SNR Items on CA

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. SNR4	0.285	0.081	0.078	0.081	25.827	< 0.001	1	292
2. SNR3	0.310	0.096	0.090	0.015	4.716	< 0.05	1	291

As observed in Table 7.1.4.7 the results are not significant ($R^2_{adj} = 0.090$) to draw conclusions. It is desired that R^2_{adj} be at least 0.10 (i.e. the given IV/s explain at least 10% of the variance in DV) so as to draw any substantial inferences. It is thus evident that none of the items of SNR predict CA.

Having analyzed the effects of specific items that significantly predict CA (cumulative score), we now proceed towards the item-level regression analysis on the dimensions of CA (price, quality, delivery dependability, product innovation, and time to market). As observed in section 7.1.3.4, 'delivery dependability' is the only dimension that is predicted by dimensions within SCR. None of the other dimensions of CA are predicted by any of the dimensions within SCMP or SCR. The results are tabulated and discussed in the order of significance of predictors of delivery dependability, as evident from the previous sections 7.1.3.3 and 7.1.3.4. The results are as follows:

7.1.4.3 SCM Practices (item level) – Competitive Advantage (dimension level)

As observed in section 7.1.3.3, none of the individual dimensions of SCM practices impact the individual dimensions of CA. Therefore it is pointless to further analyze the relationships between the dimension items of SCM practices and CA dimensions.

With this said we move to the item level regression analyses between SCR and CA in the following section 7.1.4.4.

7.1.4.4 Supply Chain Responsiveness (item level) – Competitive Advantage (dimension level)

In section 7.1.3.4, SNR is the first dimension within SCR that reasonably predicted ‘delivery dependability’. To explore the specific practices or measures within SNR that truly predict ‘delivery dependability’, we now perform a stepwise multiple regression with the items or measures of SNR as IVs and ‘delivery dependability’ as a DV. The stepwise regression results are shown in Tables 7.1.4.8 and 7.1.4.9.

Table 7.1.4.8 Item-Level Stepwise Regression Results
Model Summary for SNR Items on Delivery Dependability

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. SNR6	0.339	0.115	0.112	0.115	37.925	< 0.001	1	292

Table 7.1.4.9 Coefficients for SNR Items (SNR6) on Delivery Dependability

	B	β	t	p
SNR6	0.262	0.339	6.158	0.000

From these results (Tables 7.1.4.8 and 7.1.4.9) it is clear that only one item of SNR, SNR6 (β = 0.339), significantly predicts ‘delivery dependability’. The other three items measuring supplier network responsiveness (viz: SNR2, SNR3, SNR4) do not contribute significantly to the prediction of ‘delivery dependability’.

In section 7.1.3.4, OSR is the second predictor within SCR that predicts ‘delivery dependability’. To better explore the specific practices or measures within OSR that truly predict ‘delivery dependability’, we now perform a stepwise multiple regression with the items or measures of OSR as IVs and ‘delivery dependability’ as a DV. The stepwise regression results are shown in Tables 7.1.4.10 and 7.1.4.11.

Table 7.1.4.10 Item-Level Stepwise Regression Results
Model Summary for OSR Items on Delivery Dependability

Step	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	p	df_1	df_2
1. OSR1	0.332	0.110	0.107	0.110	36.119	< 0.001	1	292

Table 7.1.4.11 Coefficients for OSR Items (OSR1) on Delivery Dependability

	B	β	t	p
OSR1	0.238	0.332	6.010	0.000

From these results (Tables 7.1.4.10 and 7.1.4.11) it is clear that only one item of OSR, OSR1 (β = 0.332), significantly predicts ‘delivery dependability’. The other four items measuring operations system responsiveness (viz: OSR3, OSR4, OSR5, and OSR7) do not contribute significantly to the prediction of ‘delivery dependability’.

7.2 Summary of Regression Analysis Results

In this section the stepwise regressions analyses results are summarized and discussed under two sections based on the outcome variable. Section 7.2.1 discusses the summary of results and discussion for supply chain responsiveness and its dimensions. Section 7.2.1 discusses the summary of results and discussion for competitive advantage and its dimensions.

7.2.1 Summary of Results for Supply Chain Responsiveness

Table 7.2.1.1 summarizes the regression analyses results from all the previous sections in this chapter for - supply chain responsiveness and its dimensions - as the outcome variable/s.

Construct-level step wise multiple regression analysis results signify that 'modularity based manufacturing practices' reasonably predicts supply chain responsiveness. 'SCM practices' also moderately predicts supply chain responsiveness. The regression analyses results support structural equation modeling results.

Table 7.2.1.1 Summary of Regression Analyses Results for Supply Chain Responsiveness and its Dimensions

Predictor	**Outcome**	**R^2_{adj}**	**Sig. (*p*)**
Construct - Level Regression Analysis			
1. Modularity Based Manufacturing Practices (MBMP) 2. SCM Practices (SCMP)	Supply Chain Responsiveness (SCR)	0.278	0.000
Dimension - Level Regression Analysis			
<u>MBMP</u>: 1. Dynamic Teaming (DT) 2. Process Modularity (PRM)	Supply Chain Responsiveness (SCR)	0.244	0.000

Predictor	Outcome	R^2_{adj}	Sig. (*p*)
SCMP: 1. Information Sharing (IS) 2. Strategic Supplier Partnership (SSP) 3. Customer Relationship (CR)		0.186	0.000
MBMP: 1. Dynamic Teaming (DT) 2. Process Modularity (PRM)	Operations System Responsiveness (OSR)	0.257	0.000
SCMP: 1. Customer Relationship (CR) 2. Strategic Supplier Partnership (SSP)		0.109	0.000
MBMP: Practically NS*	Logistics Process Responsiveness (LPR)	0.091	0.000
SCMP: Practically NS*		0.090	0.000
MBMP: 1. Process Modularity (PRM) 2. Dynamic Teaming (DT)	Supplier Network Responsiveness (SNR)	0.113	0.000
SCMP: 1. Strategic Supplier Partnership (SSP) 2. Information Sharing (IS)		0.146	0.000
Item - Level Regression Analysis			
DT: 1. **DT3** (reassigning production teams to different production tasks) 2. DT1 (using production teams (in the plant) that can be reorganized)	Supply Chain Responsiveness (SCR)	0.197	0.000
PRM: 1. **PRM2** (adjusting production process by adding new process modules) 2. **PRM5** (rearranging production process modules so that customization sub- processes occur last)		0.175	0.000
IS: 1. **IS1** (informing trading partners of changing needs in advance by a firm) 2. **IS3** (trading partners of a firm, keeping the firm fully informed about issues that affect the firm's business)		0.161	0.000

Predictor	Outcome	R^2_{adj}	Sig. (*p*)
SSP: 1. **SSP2** (regularly solving problems jointly with suppliers) 2. **SSP6** (actively involving the key suppliers of a firm in new product development processes) 3. SSP4 (conducting continuous improvement programs by a firm that include its key suppliers)		0.105	0.000
CR: 1. CR4 (facilitating customers' ability to seek assistance from the firm) 2. CR2 (frequently measuring and evaluating customer satisfaction)		0.096	0.000
DT: 1. **DT3** (reassigning production teams to different production tasks) 2. DT5 (using production team members that are capable of working on different teams)	Operations System Responsiveness (OSR)	0.224	0.000
PRM: 1. PRM3 (production process modules that can be adjusted for changing production needs) 2. PRM1 (designing the production process as adjustable modules)		0.170	0.000
CR: Practically NS*		0.079	0.000
SSP: Practically NS*		0.054	0.000
PRM: 1. **PRM5** (rearranging production process modules so that customization sub-processes occur last) 2. **PRM2** (adjusting production process by adding new process modules)	Supplier Network Responsiveness (SNR)	0.110	0.000
DT: Practically NS*		0.077	0.000
SSP: 1. **SSP2** (regularly solving problems jointly with suppliers) 2. **SSP6** (actively involving the key suppliers of a firm in new product development processes)		0.126	0.000

Predictor	Outcome	R^2_{adj}	Sig. (*p*)
<u>IS</u>: 1. **IS1** (informing trading partners of changing needs in advance by a firm) 2. **IS3** (trading partners of a firm, keeping the firm fully informed about issues that affect the firm's business)		0.114	0.000

* Practically NS = Practically Not Significant (i.e. not practically significant, to draw any substantial inferences)

These results imply that organizations can achieve higher levels of supply chain responsiveness by having product, process and organizational modularity, as well as by implementing the said SCM practices.

The dimension-level stepwise regression analyses signify that with regards to the dimensions of 'modularity based manufacturing practices', 'dynamic teaming' is the predominant practice that improves supply chain responsiveness on a composite level (i.e. aggregate level) followed by process modularity practice. Also with regards to the dimensions of SCM practices, information sharing is the predominant practice that improves supply chain responsiveness on a composite basis, followed by strategic supplier partnership and customer relationship practices. It is further observed that dynamic teaming and process modularity in the same order are predominant in improving operations system responsiveness dimension of supply chain responsiveness. A plausible explanation for this result is that the specific dynamic teaming practices as well as process modularity practices are all associated with manufacturing and production on the shop floor, thus contributing toward increased operations system responsiveness. Furthermore dynamic teaming and process modularity in the reverse order are predominant in improving the supplier network responsiveness dimension of supply chain responsiveness. An explanation to this result could be that process modularity gives an organization greater flexibility in terms of sourcing various products that are needed for various sub processes from suppliers, rather than sourcing a whole product. This could improve the suppliers' responsiveness to the focal firm. Thus it can be said with a fair degree of confidence that dynamic teaming and process modularity practices are the predominant modularity based manufacturing practice dimensions that are key to the improvement of supply chain responsiveness as well as two of its dimensions - operations system responsiveness and supplier network responsiveness. The regression results also depict that product modularity does not in any way influence supply chain responsiveness or its dimensions, and can be researched in detail in the future.

As regards SCM practice dimensions, the regression results imply that by having close relations with customers as well as suppliers, organizations can improve its operations system responsiveness. Further, as expected the results signify that by developing close relations with suppliers and sharing information with supply chain partners by an organization increases the responsiveness of the suppliers of the said firm. Thus it can emphatically be said that strategic supplier partnership practice is the predominant SCM practice dimension that is instrumental in the improvement of supply chain responsiveness as well as two of its dimensions - operations system responsiveness and supplier network responsiveness.

Surprisingly the results also highlight that none of the SCM practice or modularity based manufacturing practice dimensions significantly affect or predict the logistics process responsiveness dimension of supply chain responsiveness and gives future researchers food for thought.

The item-level stepwise regression analyses results signify that DT3 (production teams can be reassigned to different production tasks) and DT1 (production teams that can be reorganized are used in our plant) are the two prime practices within dynamic teaming (DT) that positively impact the overall supply chain responsiveness on a composite basis. Also PRM2 (our products share common modules) and PRM5 (product feature modules can be added to a standard base unit) are the two key practices within process modularity (PRM) that enhance supply chain responsiveness on a composite basis. Furthermore, IS1 (we inform trading partners in advance of changing needs) and IS3 (our trading partners keep us fully informed about issues that affect our business) are the two practices within information sharing (IS) that positively impact supply chain responsiveness on a composite basis. In addition, SSP2 (we regularly solve problems jointly with our suppliers), SSP6 (we actively involve our key suppliers in new product development processes), and SSP4 (we have continuous improvement programs that include our key suppliers) are the three significant practices within strategic supplier partnership (SSP) that positively impact supply chain responsiveness on an aggregate level. Lastly, CR4 (we facilitate customers' ability to seek assistance from us) and CR2 (we frequently measure and evaluate customer satisfaction) are the two practices within customer relationship (CR) that positively impact supply chain responsiveness on an aggregate basis.

Further, we discuss the item-level analyses on the individual dimensions of supply chain responsiveness. DT3 (production teams can be reassigned to different production tasks) and DT5 (production team members are capable of working on different teams) are the two prime practices within dynamic teaming (DT) that positively impact operations system responsiveness (OSR) dimension of supply chain responsiveness. Also PRM3 (production process modules can be adjusted for changing production needs) and PRM1 (our production process is designed as adjustable modules) are the two key practices within process modularity (PRM) that positively influence the operations system responsiveness dimension. Although customer relationship (CR) and strategic supplier partnership (SSP) positively impact operations system responsiveness (OSR) on a dimension-level, they are not significantly instrumental in predicting OSR on an item-level.

PRM5 (production process modules can be rearranged so that customization sub-processes occur last) and PRM2 (our production process can be adjusted by adding new process modules) are the two practices within process modularity (PRM) that positively influence supplier network responsiveness (SNR) dimension of supply chain responsiveness. Although dynamic teaming (DT) positively impacts supplier network responsiveness (SNR) on a dimension-level, it is not significantly instrumental in predicting SNR on an item-level. SSP2 (we regularly solve problems jointly with our suppliers) and SSP6 (we actively involve our key suppliers in new product development processes) are the two practices within strategic supplier partnership (SSP) that positively impact the supplier network responsiveness dimension. Finally, IS1 (we inform trading partners in advance of changing needs) and IS3 (our trading partners keep us fully informed about issues that affect our business) are the two practices within information sharing (IS) that positively affect the supplier network responsiveness dimension.

To sum up, the practices in bold letters in Table 7.2.1.1 are the predominant item-level SCM practices and modularity based manufacturing practices that are repeatedly positively impacting supply chain responsiveness (on a composite basis), and one or more of its dimensions (viz: operations system responsiveness / supplier network responsiveness). These practices are as follows**:** DT3 (production teams can be reassigned to different production tasks), PRM2 (our products share common modules), PRM5 (product feature modules can be added to a standard base unit), IS1 (we inform trading partners in advance of changing needs), IS3 (our trading partners keep us fully informed about issues that affect our business), SSP2 (we regularly solve problems jointly with our suppliers), SSP6 (we actively involve our key suppliers in new product development processes). The results of the survey thus imply that organizations could greatly enhance their responsive on one or more of the said dimensions by the implementing these predominant practices. These implications are discussed in detail in the next chapter (Chapter 8).

7.2.2 Summary of Results for Competitive Advantage

Table 7.2.2.1 summarizes the regression analyses results from all the previous sections in this chapter for – competitive advantage and its dimensions - as the outcome variable/s.

Construct-level step wise multiple regression analysis results signify that 'SCM practices' reasonably predicts competitive advantage. Supply chain responsiveness also moderately predicts competitive advantage. The regression analyses results support structural equation modeling results. These results imply that organizations can achieve greater competitive advantage by implementing the said SCM practices and by increasing the supply chain responsiveness on the proposed dimensions.

The dimension-level stepwise regression analyses signify that with regards to the dimensions of supply chain responsiveness, customer relationship is the predominant practice that improves competitive advantage on a composite level (i.e. aggregate level) followed by strategic supplier partnership practice. Also with regards to the dimensions of supply chain responsiveness, operations system responsiveness is the predominant practice that improves competitive advantage on a composite basis, followed by supplier network responsiveness.

Table 7.2.2.1 Summary of Regression Analyses Results for Competitive Advantage and its Dimensions

Predictor	**Outcome**	**R^2_{adj}**	**Sig. (*p*)**
Construct - Level Regression Analysis			
1. SCM Practices (SCMP) 2. Supply Chain Responsiveness (SCR)	Competitive Advantage (CA)	0.259	0.000
Dimension - Level Regression Analysis			
SCMP: 1. Customer Relationship (CR) 2. Strategic Supplier Partnership (SSP)	Competitive Advantage (CA)	0.196	0.000
SCR: 1. Operations System Responsiveness (OSR) 2. Supplier Network Responsiveness (SNR)		0.176	0.000
SCMP: Practically NS*	Individual Competitive Advantage Dimensions	< 0.10	0.000
SCR: 1. Supplier Network Responsiveness (SNR) 2. Operations System Responsiveness (OSR)	Delivery Dependability	0.126	0.000
Item - Level Regression Analysis			

Predictor	**Outcome**	$\mathbf{R^2_{adj}}$	**Sig. (*p*)**
CR: 1. CR5 (periodically evaluating the importance of a firm's relationship with its customers) 2. CR4 (facilitating customers' ability to seek assistance from the firm) 3. CR1 (frequent interaction by the firm with its customers to set reliability, responsiveness, and other standards for the firm)	Competitive Advantage (CA)	0.148	0.000
SSP: 1. SSP2 (regularly solving problems jointly with suppliers) 2. SSP4 (conducting continuous improvement programs by a firm that include its key suppliers)		0.111	0.000
OSR: **OSR1** (the ability of the operations system of a firm to rapidly respond to changes in product volume demanded by customers)		0.199	0.000
SNR: Practically NS*		0.090	0.000
SNR: SNR6 (the ability of a firm's major suppliers to effectively expedite the firm's emergency orders)	Delivery Dependability	0.112	0.000
OSR: **OSR1** (the ability of the operations system of a firm to rapidly respond to changes in product volume demanded by customers)		0.107	0.000

* Practically NS = Practically Not Significant (i.e. not practically significant, to draw any substantial inferences)

It is further observed that none of the SCM practices dimensions predict any of the dimensions of competitive advantage ($R^2_{adj} < 0.10$). A plausible explanation for this fact could be that the variance explained by the independent variable (SCM practices) is significant when a cumulative score of the competitive advantage (dependent variable) is considered. This variance gets distributed when individual factors or dimensions of competitive advantage are taken as dependent variables in the regression analyses. It is further observed that supplier network responsiveness and operations system responsiveness in the same order are predominant in positively impacting delivery dependability dimension of competitive advantage. This can be explained as follows. Most logistics functions are outsourced to third parties. These third party logistics companies maintain and most often exceed their service levels to stay in business and beat competition. Therefore there is little scope for improvement on the logistics process responsiveness dimension. However operations system responsiveness (responsiveness of the manufacturing system of an organization) and supplier network responsiveness (responsiveness of suppliers of an organization) directly impact the speed of response of an organization in meeting customer demand and thus its ability to compete on the basis of delivery dependability.

The item-level stepwise regression analyses results signify that CR5 (we periodically evaluate the importance of our relationship with our customers), CR4 (we facilitate customers' ability to seek assistance from us), and CR1 (we frequently interact with customers to set reliability, responsiveness, and other standards for us), in the same order, are the three prime practices within customer relationship (CR) that positively impact the overall competitive advantage of the firm on a composite basis. Also SSP2 (we regularly solve problems jointly with our suppliers) and SSP4 (we have continuous improvement programs that include our key suppliers) are the two key practices within strategic supplier partnership (SSP) that enhance competitive advantage on a composite basis. Furthermore, OSR1 (our operations system responds rapidly to changes in product volume demanded by customers) is the only criterion within operations system responsiveness (OSR) that positively impacts competitive advantage on a composite basis. Although supplier network responsiveness (SNR) positively impacts competitive advantage (CA) on a dimension-level, it is not significantly instrumental in predicting CA on an item-level. These implications are elaborately discussed in the next chapter (Chapter 8)

We proceed to discuss the item-level analyses on the individual dimensions of competitive advantage (i.e. only delivery dependability dimension is significant here). SNR6 (our major suppliers effectively expedite our emergency orders) is the only criterion within supplier network responsiveness (SNR) that positively impacts delivery dependability dimension of competitive advantage. Also, OSR1 (our operations system responds rapidly to changes in product volume demanded by customers) is the only key criterion within operations system responsiveness (OSR) that positively influences the delivery dependability dimension of competitive advantage.

To sum up, OSR1 (our operations system responds rapidly to changes in product volume demanded by customers) is the predominant item-level supply chain responsiveness criterion that positively impacts competitive advantage on a composite basis, as well as its only impacted dimension ‘delivery dependability’. The results of the survey thus imply that organizations could greatly improve their competitive advantage both on an aggregate level as well as based on delivery dependability, by improving on the predominant operations system responsiveness criterion (OSR1).

7.3 MANOVA Results

Supply chain responsiveness is the construct that is newly developed and validated in this research. Moreover, supply chain responsiveness has been hypothesized to be positively related to competitive advantage (measured by five dimensions/sub-constructs: price, quality, delivery dependability, product innovation, and time to market) in this research. As a newly developed construct, it is of keen interest to further drill down into the impact of the dimensions of supply chain responsiveness on the dimensions of competitive advantage. We note here that, although operations system responsiveness (OSR) and supplier network responsiveness (SNR) have been found to be significant in predicting competitive advantage (CA) on a composite basis (section 7.1.3.2), regression analyses results have not indicated any significant prediction of measures/dimensions of competitive advantage (except delivery dependability) by supply chain responsiveness dimensions. However as discussed earlier, this could be attributed to the distribution of the variance explained by the IV on the DV when we go to the dimension level analyses from the construct level analysis, thus leading to the insignificance of these dimension level analyses. This section aims at understanding if the measures of competitive advantage when considered collectively and individually, significantly differ for high and low levels of the dimensions of supply chain responsiveness. In the same regard, the analyses will be restricted to the significant predictor dimensions of supply chain responsiveness (operations system responsiveness and supplier network responsiveness) that are instrumental in impacting competitive advantage, and as already discussed in the regression analysis section 7.1.3.2.

We first start with the general discussion of MANOVA, its advantages, and the procedure of conducting the analysis. MANOVA has several advantages over ANOVA (analysis of variance) (Tabachnick and Fidell, 1996). First, by measuring several DVs instead of only one, the chances of discovering what actually changes as a result of the differing treatments or characteristics (and any interactions) improve greatly. In our study we are interested in knowing what measures of competitive advantage are affected by operations system responsiveness and supplier network responsiveness. If we wanted to know what measures of competitive advantage are affected by operations system responsiveness, we improve our chances of uncovering these effects by including the measures of competitive advantage (price, quality, delivery dependability, product innovation, and time to market). A second advantage is that, under certain conditions, MANOVA can reveal differences that separate ANOVAs might not (Tabachnick and Fidell, 1996; Stevens, 1992). For example, assuming that we have a one-way design, with two levels on the IV and two DVs, if we were to conduct separate ANOVAs on the two DVs, the distributions for each of the two groups (and for the DV) might overlap sufficiently, such that a mean difference probably would not be found. However, when the two DVs are considered in combination with each other, the two groups may differ substantially and could result in a substantially significant difference between groups (Mertler and Vannatta, 2002).

The main difference between ANOVA and MANOVA is as follows: in ANOVA, the null hypothesis states that the population means are equal, whereas in MANOVA the null hypothesis states that the population mean vectors (for the combination of DVs) are equal. *ANOVA* tests whether mean differences among *k* groups on a *single DV* are significant, or likely to have occurred by chance. *MANOVA* tests whether mean differences among *k* groups on a *combination of DVs* are significant, or likely to have occurred by chance. There are several available test statistics for MANOVA, which include Wilks' Lambda (λ), Pillai's Trace, Hotelling's Trace, and Roy's Largest Root. The most commonly used is the Wilks' Lambda. Wilks' λ ranges from zero to one. The smaller the value of λ, more is the evidence for treatment effects or group differences (Stevens, 1992).

In conducting a MANOVA, one first tests the overall multivariate hypothesis (null hypothesis) that the mean vectors of the combination of DVs are equal on all groups of the IV (Mertler and Vannatta, 2002). Mertler and Vannatta (2002) further state that, this is accomplished by evaluating the significance of the test associated with Wilks' λ. If the null hypothesis is retained (i.e. Wilks' λ test is not-significant), the researcher stops the interpretation of the analysis at this point, concluding that the treatments or conditions (i.e. IVs) have no effect on the DVs. However, if the overall multivariate test is significant (i.e. Wilks' λ test is significant), the researcher then proceeds to analyze as to which of the DVs is being affected by the IV(s). To accomplish this, the researcher conducts a series of univariate analyses of variance (ANOVAs) on the individual DVs. This will result in multiple tests of significance, and which will result in an inflated Type I error rate (Mertler and Vannatta, 2002). To counteract the potential of an inflated error rate due to multiple ANOVAs, an adjustment needs to be made to the alpha level for these univariate tests. This adjustment involves setting a more stringent alpha level for the test of each DV so that the alpha for the set of DVs does not exceed some critical value (Tabachnick and Fidell, 1996). That critical value for testing each DV is usually the overall α-level for the analysis (α = 0.05) divided by the number of DVs. For example, in this study we have five DVs (viz: five dimensions of competitive advantage - price, quality, delivery dependability, product innovation, and time to market) and want an overall α equal to 0.05, then each univariate test is to be conducted at α = 0.01, since 0.05/5 = 0.01. This rounding down of the α-level is necessary to create an overall alpha less that 0.05. All alphas can be set at the same level, or more important DVs can be given more liberal alphas (Tabachnick and Fidell, 1996).

Hair et al. (1998) suggest that a second analysis of the dependent variate is the stepdown test, which examines the significance of group differences while allowing for dependent variable inter-correlation. Such a stepdown analysis is useful in showing that the DVs have unique differences across the groups; that is showing that the DVs are not so highly correlated that there are no unique differences in one DV after the effects of other DVs are accounted for (Hair et al., 1998). Hair et al. (1998) suggest Roy-Bargman stepdown F test.

Regression analyses results highlight the significant dimensions of supply chain responsiveness (viz: operations system responsiveness (OSR) and supplier network responsiveness (SNR)) that are predominant in predicting competitive advantage. Thus for conducting MANOVA only these two dimensions of supply chain responsiveness (OSR and SNR) have been considered as two distinct IVs. The DVs are the five dimensions of competitive advantage (price, quality, delivery dependability, product innovation, and time-to-market). In our study, the results of MANOVA shall answer the following questions:

(1) Are there significant mean differences in competitive advantage of a firm (as measured by the combination of price, quality, delivery dependability, product innovation, and time to market) for high and low operations system responsiveness / supplier network responsiveness?

(2) Are there significant mean differences in competitive advantage of a firm based on low price, for high and low operations system responsiveness / supplier network responsiveness?

(3) Are there significant mean differences in competitive advantage of a firm based on high quality, for high and low operations system responsiveness / supplier network responsiveness?

(4) Are there significant mean differences in competitive advantage of a firm based on high delivery dependability, for high and low operations system responsiveness / supplier network responsiveness?

(5) Are there significant mean differences in competitive advantage of a firm based on high product innovation, for high and low operations system responsiveness / supplier network responsiveness?

(6) Are there significant mean differences in competitive advantage of a firm based on low time to market, for high and low operations system responsiveness / supplier network responsiveness?

It is desired that the homogeneity of covariance matrices or the homoscedasticity assumption (tested by Box's Test of equality of covariance matrices) is met to analyze the MANOVA results. If the assumption of homogeneity of variance-covariance is met (i.e. Box's test is non-significant when testing the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups), the Wilks' Lambda is interpreted, if not then Pillai's Trace is utilized when interpreting MANOVA results (Mertler and Vannatta, 2002). Pillai's Trace is a more robust multivariate test statistic and is typically used if homogeneity of variance-covariance is violated. When there are more than one quantitative correlated DVs (tested by Pearson correlation), a MANOVA is preferred.

Mertler and Vannatta (2002) summarize the analysis procedure for MANOVA, as follows:

(1) Evaluate Box's Test. If homogeneity of variance-covariance is assumed, utilize Wilks' Lambda statistic when interpreting the multivariate tests. If the assumption of equal variances is violated, use Pillai's Trace.

(2) Once the multivariate test statistic has been identified, examine the significance (F ratios and p values) of factor interaction (necessary if two or more IVs are included). Examine the significance (F ratios and p values) of each factor's main effect – if the results are significant, proceed to the next step; if not, stop.

(3) Examine the univariate tests (ANOVAs) of individual DVs – if any are significant, proceed to the next step; if not, stop.

(4) Perform Roy-Bargman stepdown F-test to support the results of ANOVA (Hair et al., 1998)

(5) Examine post hoc tests for the individual DVs.

7.3.1 MANOVA – Effect of Operations System Responsiveness on Competitive Advantage

Regression analyses results signify that operations system responsiveness is the first dimension within supply chain responsiveness that predicts competitive advantage on a composite basis. We therefore perform a one way MANOVA with operations system responsiveness dimension of supply chain responsiveness as IV (with two categories – high and low) and the five dimensions of competitive advantage (price, quality, delivery dependability, product innovation, and time to market) as five quantitative DVs. The operations system responsiveness scale was measured from 1 – not at all to 5 – to a great extent. A score of above 3 (i.e. 4 and 5) was treated as high, and a score of 3 or below was treated as low, for defining the two categories high and low.

It is desired that the DVs that are entered in the MANOVA analysis be correlated (Mertler and Vannatta, 2002; Hair et al., 1998). Therefore, before proceeding with the multivariate tests, Pearson correlation was performed to determine if the dependent measures (i.e. price, quality, delivery dependability, product innovation, and time to market) are significantly correlated. Table 7.3.1.1 shows the Pearson correlation results.

Table 7.3.1.1 Pearson Correlations for Competitive Advantage Dimensions

	Price	**Quality**	**Delivery Dependability**	**Product Innovation**	**Time to Market**
Price	1	0.180**	0.222**	0.069	0.207**
Quality	0.180**	1	0.214**	0.108	0.078
Delivery Dependability	0.222**	0.214**	1	0.030	0.230**
Product Innovation	0.069	0.108	0.030	1	0.238**
Time to Market	0.207**	0.078	0.230**	0.238**	1
** Correlation is significant at 0.01 level					

It is observed from the results above that there is some correlation between the five dimensions of competitive advantage (price, quality, delivery dependability, product innovation, and time to market). Since some correlation is observed, we proceed with the MANOVA tests.

The assumption of homogeneity of variance-covariance will be tested within MANOVA. Thus MANOVA was conducted utilizing the multivariate procedure in SPSS. The Box's Test (Table 7.3.1.2) is not significant and indicates that homogeneity of variance-covariance is fulfilled, $F(15,242285.4) = 1.498$, $p = 0.096$, so Wilks' Lambda test statistic will be used in interpreting the MANOVA results.

Table 7.3.1.2 Box's Test of Equality of Covariance Matrices for Operations System Responsiveness

Box's M	22.914
F	1.498
df1	15
df2	242285.4
Sig.	0.096

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

The multivariate test (Wilks' Lambda) is presented in Table 7.3.1.3. MANOVA results indicate that the combined DV of price, quality, delivery dependability, product innovation, and time to market, significantly differs for high and low levels of operations system responsiveness (Wilks' $\lambda = 0.858$, $F(5, 288) = 9.527$, $p = 0.000$, partial $\eta^2 = 0.142$). However, the multivariate effect size (η^2) is small, which reveals low strength in associations.

Table 7.3.1.3 Multivariate Test of Significance (Wilks' λ) for Operations System Responsiveness

Test Name	**Value**	**F**	**Hypothesis df**	**Error df**	**Sig. (*p*)**	**Partial Eta Squared**
Wilks' Lambda	0.858	9.527	5	288	0.000	0.142

Since the multivariate test was significant, we examine the ANOVA results (i.e. univariate tests of individual DVs). Univariate *ANOVA results* (Table 7.3.1.4) *were interpreted using a more conservative alpha level* (α = 0.05/5 = *0.01*) to counteract the potential of an inflated Type I error rate which can be caused due to multiple ANOVAs and as recommended by Tabachnick and Fidell (1996).

Table 7.3.1.4 ANOVA Summary Table for Operations Systems Responsiveness

Source	Dependent Variable	Sum of Squares	df	Mean Square	F	Sig. (*p*)	Partial Eta Squared
Operations System Responsiveness	Price	7.812	1	7.812	9.637	0.002	0.032
	Quality	0.030	1	0.030	0.095	0.759	0.000
	Delivery Dependability	7.434	1	7.434	16.085	0.000	0.052
	Product Innovation	11.313	1	11.313	16.568	0.000	0.054
	Time to Market	13.092	1	13.092	20.421	0.000	0.065

ANOVA results indicate that the competitive advantage of a firm based on low price ($F(1, 292) = 9.637$, $p < 0.01$, partial $\eta^2 = 0.032$), high delivery dependability ($F(1, 292) = 16.085$, $p < 0.001$, partial $\eta^2 = 0.052$), high product innovation ($F(1, 292) = 16.568$, $p < 0.001$, partial $\eta^2 = 0.054$), and low time-to-market ($F(1, 292) = 20.421$, $p < 0.001$, partial $\eta^2 = 0.065$), significantly differs for high and low levels of operations system responsiveness.

Although significant group differences were found for these four DVs, the effect sizes are small, indicating that a small proportion of variance in the individual abilities of a firm to compete based on**:** low price, high delivery dependability, high product innovation, and low time to market, is accounted for by operations system responsiveness. The ability of an organization to compete based on high quality does not significantly differ for high and low levels of operations system responsiveness ($F(1, 292) = 0.095$, $p= 0.759$, partial $\eta^2 = 0.000$).

Roy-Bargman stepdown F test was performed to support the results of ANOVA and to check for significance of group differences while allowing dependent variable inter-correlation. This test will assure the researcher that the IV – operations system responsiveness – does have significant separate effects on a particular DV that are unrelated to any other DV in the analysis. In short, it will assure the researcher that the effect of the IV on an individual DV is not due to the inter-correlation effect between the DVs, but by itself. A stepdown analysis, as shown in Table 7.3.1.5, shows that four variables – price ($F(1, 292) = 9.637$, $p< 0.01$), delivery dependability ($F(1, 290) = 12.443$, $p< 0.001$), product innovation ($F(1, 289) = 16.342$, $p< 0.001$), and time to market($F(1, 288) = 6.810$, $p= 0.01$)) have unique differences across high and low levels of operations system responsiveness; that is, the four variables are not so highly correlated with each other that there are no unique differences in each of them after the effects of the other three are accounted for.

Table 7.3.1.5 Roy-Bargman Stepdown F Tests for Operations System Responsiveness

Variable	Between-Groups Mean Square	Within-Groups Mean Square	Stepdown F	Degrees of Freedom		Significance of Stepdown F
				Between	Within	
Price	7.812	0.811	9.637	1	292	0.002
Quality	0.019	0.306	0.062	1	291	0.804
Delivery Dependability	5.386	0.433	12.443	1	290	0.000
Product Innovation	11.116	0.680	16.342	1	289	0.000
Time to Market	4.035	0.593	6.810	1	288	0.010

This result suggests that, level of operations system responsiveness has significant separate effects on the competitive advantage of a firm based on low price, that are unrelated to the competitive advantage of a firm based on**:** high delivery dependability, high product innovation, and low time to market. Similarly, we can add that, level of operations system responsiveness has significant separate effects on the competitive advantage of a firm based on high delivery dependability, that are unrelated to the competitive advantage of a firm based on**:** low price, high product innovation, and low time to market. In the same fashion, we can say that level of operations system responsiveness has significant separate effects on the competitive advantage of a firm based on high product innovation, that are unrelated to the competitive advantage of a firm based on**:** low price, high delivery dependability, and low time to market. Lastly, we add that level of operations system responsiveness has significant separate effects on the competitive advantage of a firm based on low time to market, that are unrelated to the competitive advantage of a firm based on: low price, high delivery dependability, and high product innovation. Therefore, after examining these results and tests, the researcher can safely conclude that high and low levels of operations system responsiveness, both collectively (as given by MANOVA results) and individually (as given by ANOVA results and further supported by Roy-Bargman stepdown F tests), significantly differ on the four variables: price, delivery dependability, product innovation, and time to market.

Table 7.3.1.6 tabulates the means and standard deviations of the DVs (competitive advantage based on: price, delivery dependability, product innovation, and time to market), by high and low categories / levels of operations system responsiveness. The means are significantly different for high and low levels of operations system responsiveness. These means (Table 7.3.1.6) signify that organizations can compete based on: low price, high delivery dependability, high product innovation, and low time to market, to a greater extent if they have high levels of operations system responsiveness. Thus we can conclude that operations system responsiveness has a positive impact on the ability of organizations to compete based on low price, high delivery dependability, high product innovation, and low time to market, but not on their ability to compete based on high quality. The practical implication of this result is that organizations could be compromising on product quality in order to be operationally responsive to customer demand. These implications are discussed in greater detail in the next chapter (Chapter 8).

Table 7.3.1.6 Means and Standard Deviations for Competitive Advantage Dimensions by Operations System Responsiveness

	Operations System Responsiveness	Mean	Std. Deviations
Price	Low	3.25	0.92
	High	3.58	0.89
Delivery Dependability	Low	4.04	0.71
	High	4.37	0.66
Product Innovation	Low	3.63	0.87
	High	4.04	0.79
Time to Market	Low	2.94	0.80
	High	3.37	0.80

7.3.2 MANOVA – Effect of Supplier Network Responsiveness on Competitive Advantage

Regression analyses results signify that supplier network responsiveness is the second dimension within supply chain responsiveness that predicts competitive advantage on a composite basis. We therefore perform a one way MANOVA with supplier network responsiveness dimension of supply chain responsiveness as IV (with two categories – high and low) and the five dimensions of competitive advantage (price, quality, delivery dependability, product innovation, and time to market) as five quantitative DVs. The supplier network responsiveness scale was measured from 1 – not at all to 5 – to a great extent. A score of above 3 (i.e. 4 and 5) was treated as high, and a score of 3 or below was treated as low, for defining the two categories high and low.

The assumption of homogeneity of variance-covariance will be tested within MANOVA. Thus MANOVA was conducted utilizing the multivariate procedure in SPSS. The Box's Test (Table 7.3.2.1) is not significant and indicates that homogeneity of variance-covariance is fulfilled, *F*(15,207776.9) = 0.784, *p* = 0.697, so Wilks' Lambda test statistic will be used in interpreting the MANOVA results.

Table 7.3.2.1 Box's Test of Equality of Covariance Matrices for Supplier Network Responsiveness

Box's M	12.003
F	0.784
df1	15
df2	207776.9
Sig.	0.697

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

The multivariate test (Wilks' Lambda) is presented in Table 7.3.2.2. MANOVA results indicate that the combined DV of price, quality, delivery dependability, product innovation, and time to market, significantly differs for high and low levels of supplier network responsiveness (Wilks' $\lambda = 0.914$, $F(5, 288) = 5.428$, $p = 0.000$, partial $\eta^2 = 0.082$). However, the multivariate effect size (η^2) is small and which implies that a small proportion of the variance in the combined DV (i.e. the competitive advantage of a firm based on**:** low price, high delivery dependability, high product innovation, and low time to market) is accounted for by supplier network responsiveness.

Table 7.3.2.2 Multivariate Test of Significance (Wilks' λ) for Supplier Network Responsiveness

Test Name	Value	F	Hypothesis df	Error df	Sig. (*p*)	Partial Eta Squared
Wilks' Lambda	0.914	5.428	5	288	0.000	0.086

Since the multivariate test was significant, we examine the ANOVA results (i.e. univariate tests of individual DVs). Univariate *ANOVA results* (Table 7.3.1.4) *were interpreted using a more conservative alpha level* ($\alpha = 0.05/5 = 0.01$) to counteract the potential of an inflated Type I error rate which can be caused due to multiple ANOVAs and as recommended by Tabachnick and Fidell (1996). ANOVA results indicate that the competitive advantage of a firm based on low price ($F(1, 292) = 8.105$, $p< 0.01$, partial $\eta^2 = 0.027$), high delivery dependability ($F(1, 292) = 18.784$, $p< 0.001$, partial $\eta^2 = 0.060$), and low time-to-market ($F(1, 292) = 7.044$, $p< 0.01$, partial $\eta^2 = 0.024$), significantly differs for high and low levels of supplier network responsiveness. Although significant group differences were found for these three DVs, the effect sizes are small, indicating that a small proportion of variance in the individual abilities of a firm to compete based on**:** low price, high delivery dependability, and low time to market, is accounted for by supplier network responsiveness. The ability of an organization to compete based on high quality ($F(1, 292) = 6.249$, $p= 0.013$, partial $\eta^2 = 0.021$) and high product innovation ($F(1, 292) = 0.650$, $p= 0.421$, partial $\eta^2 = 0.002$), does not significantly differ for high and low levels of supplier network responsiveness.

Table 7.3.2.3 ANOVA Summary Table for Supplier Network Responsiveness

Source	Dependent Variable	Sum of Squares	df	Mean Square	F	Sig. (*p*)	Partial Eta Squared
Supplier Network Responsiveness	Price	6.604	1	6.604	8.105	0.005	0.027
	Quality	1.926	1	1.926	6.249	0.013	0.021
	Delivery Dependability	8.606	1	8.606	18.784	0.000	0.060
	Product Innovation	0.468	1	0.468	0.650	0.421	0.002
	Time to Market	4.718	1	4.718	7.044	0.008	0.024

Roy-Bargman stepdown F test was performed to support the results of ANOVA and to check for significance of group differences while allowing dependent variable inter-correlation. This test will assure the researcher that the IV – supplier network responsiveness – does have significant separate effects on a particular DV that are unrelated to any other DV in the analysis. In short, it will assure the researcher that the effect of the IV on an individual DV is not due to the inter-correlation effect between the DVs, but by itself. A stepdown analysis, as shown in Table 7.3.2.4, shows that only two of the three significant variables from ANOVA results – price ($F(1, 292) = 8.11, p< 0.01$) and delivery dependability ($F(1, 290) = 12.193, p< 0.001$), have unique differences across high and low levels of supplier network responsiveness; that is, these two variables are not so highly correlated with the other DVs that there are no unique differences in each of them after the effects of the others are accounted for. However the DV time-to-market was found to be non-significant ($F(1, 288) = 1.91, p= 0.168$), and which implies that it is correlated with the other DVs to an extent that there are no unique differences in time-to-market after the effects of the other DVs are accounted. One can thus say that the significant effect of supplier network responsiveness on time to market is due to the inter-correlation effect between the DVs, and not by itself. Thus, after the Roy-Bargman stepdown F test, we can summarize that only the competitive advantage of a firm based on - low price and high delivery dependability - significantly differs for high and low levels of supplier network responsiveness.

Table 7.3.2.4 Roy-Bargman Stepdown F Tests for Supplier Network Responsiveness

Variable	Between-Groups Mean Square	Within-Groups Mean Square	Stepdown F	Degrees of Freedom		Significance of Stepdown F
				Between	Within	
Price	6.604	0.815	8.105	1	292	0.005
Quality	1.255	0.301	4.163	1	291	0.042
Delivery Dependability	5.283	0.433	12.193	1	290	0.001
Product Innovation	0.152	0.718	0.198	1	289	0.657
Time to Market	1.151	0.603	1.910	1	288	0.168

This result suggests that level of supplier network responsiveness has significant separate effects on the competitive advantage of a firm based on low price, that are unrelated to the competitive advantage of a firm based on: high delivery dependability, and low time to market. Similarly, we can add that, level of supplier network responsiveness has significant separate effects on the competitive advantage of a firm based on high delivery dependability, that are unrelated to the ability of an organization to compete based on**:** low price, and low time to market. Therefore, after examining these results and tests, the researcher can safely conclude that high and low levels of supplier network responsiveness, both collectively and individually, significantly differ on the two variables**:** price and delivery dependability.

Table 7.3.2.5 tabulates the means and standard deviations of the DVs (competitive advantage based on**:** price and delivery dependability, by high and low categories of supplier network responsiveness. The means are significantly different for high and low levels of supplier network responsiveness. These means (Table 7.3.2.5) signify that organizations can compete based on: low price and high delivery dependability, to a greater extent if they have high levels of supplier network responsiveness (i.e. highly responsive suppliers).

Table 7.3.2.5 Means and Standard Deviations for Competitive Advantage Dimensions by Supplier Network Responsiveness

	Supplier Network Responsiveness	Mean	Std. Deviations
Price	Low	3.25	0.90
	High	3.56	0.91
Delivery Dependability	Low	4.02	0.68
	High	4.37	0.67

Thus we can conclude that supplier network responsiveness has a positive impact on the ability of organizations to compete based on low price and high delivery dependability, but not on their ability to compete based on high quality, high product innovation, and low time to market.

7.4 Summary of MANOVA Results

MANOVA results bring forth the following interesting findings.

First, operations system responsiveness has a positive impact on the ability of organizations to compete based on *price*, *delivery dependability*, *product innovation*, and *time to market*, but not on their ability to compete based on quality.

Second, competitive advantage of a firm, both collectively and individually based on price, delivery dependability, product innovation, and time to market significantly differs for high and low levels of operations system responsiveness.

Third, supplier network responsiveness has a positive impact on the ability of organizations to compete based on *price* and *delivery dependability*, but not on their ability to compete based on quality, product innovation, and time to market.

Fourth, competitive advantage of a firm, both collectively and individually based on price, and delivery dependability, significantly differs for high and low levels of supplier network responsiveness.

To summarize, this chapter dealt with the dimension level data analyses. Several significant observations were made and discussed. The next chapter (Chapter 8) will conclude with the implications of the findings of this research, contributions, limitations, and recommendations for future research.

CHAPTER 8: SUMMARY AND RECOMMENDATIONS FOR FUTURE RESEARCH

This chapter discusses (1) a summary of research findings and major contributions; (2) implications for practitioners; (3) implications for researchers; (4) limitations of the research; and (5) recommendations for future research.

8.1 Summary of Findings

The current research represents one of the first large-scale empirical efforts to systematically investigate the causal relationships between SCM practices, modularity based manufacturing practices, supply chain responsiveness, and competitive advantage. It aims to answer the following important questions: 1) What are the key dimensions of supply chain responsiveness? 2) What SCM practices affect supply chain responsiveness and its dimensions? 3) What modularity based manufacturing practices affect supply chain responsiveness and its dimensions? 4) What SCM practices affect competitive advantage of the firm? 5) What supply chain responsiveness dimensions create competitive advantage for a firm? In doing so, several relationships were assessed at the sub-construct level, thus making the findings more meaningful (for decision makers), interesting (for future researchers), and complete.

As mentioned in the introduction, although supply chain responsiveness has been studied in past researches, very few of them have provided empirical evidence (most of the research being conceptual and case study based), and there is no comprehensive research model in the context of supply chain responsiveness. In this research, the developed research model considers the various practices between and within organizations that are correlated with the responsiveness of the supply chain and competitive advantage of a firm. The relationships between those practices and supply chain responsiveness and competitive advantage, are tested based on the data collected from 294 high level executives in the manufacturing field. The study contributes to our knowledge of supply chain responsiveness in a number of ways as elaborated in sections 8.1.1 – 8.1.8 below:

8.1.1 Valid and Reliable Instrument for Supply Chain Responsiveness Measurement

The study provides a valid and reliable measurement for the supply chain responsiveness construct. The scale has been tested through rigorous statistical methodologies including pretest, pilot-test using Q-sort method, confirmatory factor analysis, unidimensionality, reliability, and validation of second-order construct. The scale is shown to meet the requirements for reliability and validity and thus, can be used in future research. Such a valid and reliable scale has been otherwise lacking in the literature. The development of these measurements will greatly stimulate and facilitate the theory development in this field.

8.1.2 Theoretical Framework

This research provides a theoretical framework that identifies the detailed dimensions of supply chain responsiveness. This framework provides a foundation for future research. In the future, new constructs may be added to provide an in-depth understanding of supply chain responsiveness theory.

8.1.3 Tested Relationships at Construct Level

This study provides supporting evidences to the conceptual and prescriptive literature about previously untested statements regarding the relationship between SCM practices and supply chain responsiveness, as well as modularity based manufacturing practices and supply chain responsiveness. The results demonstrate that a higher level of modularity based manufacturing practices and SCM practices will lead to a higher level of supply chain responsiveness on an aggregate basis. This finding supports Feitzinger and Lee's (1997) case study based argument that both effective SCM practices as well as the modularity based manufacturing practices are essential and vital for attaining cost effective responsiveness.

Further, this study also provides supporting evidences to the literature on the relationships between SCM practices and competitive advantage (Li et al., 2006; Moberg et al., 2002) as well as supply chain responsiveness and competitive advantage (Lummus et al., 2003). The results demonstrate that a higher level of SCM practices and supply chain responsiveness will lead to a higher level of competitive advantage for a firm.

8.1.4 Tested Relationships between Practices and Supply Chain Responsiveness at Dimension Level

The empirical results of this study gave researchers a clear idea about the specific SCM practice dimensions and modularity based manufacturing practice dimensions that positively influence the responsiveness of supply chains on various dimensions. The results indicate that 'dynamic teaming' and 'process modularity' practices were most influential in increasing operations system responsiveness, supplier network responsiveness, and the overall supply chain responsiveness. However, the study did not find any relationship between product modularity and supply chain responsiveness. Also, information sharing and effective relationships with customers and suppliers will directly lead to higher levels of supply chain responsiveness. This finding supports prior literature (ex: Frohlich and Westbrook, 2001; Clinton and Closs, 1997; Gunasekaran and Yusuf, 2002; Van Hoek et al., 2001; Handfield and Nichols, 2002). In addition, effective relationships with customers and suppliers will positively influence a firm's ability to be operationally responsive to demand changes by customers. This finding is consistent with Magretta's (1998) case study analyses of Dell Corp. Also, effective relations with suppliers, and quality and timely information sharing (as found by Lambert and Cooper (2000) in their case study research) with trading partners in a supply chain were found to directly and positively lead to increased supplier responsiveness. This result suggests that organizations must select suppliers based on the potential for close long-term relationships and which is in accordance with Choi and Hartley's (1996) findings.

8.1.5 Tested Relationships between Practices and Supply Chain Responsiveness at Item Level

The empirical results uncovered the critical and predominant practices (at the item level) within the individual dimensions of ‘SCM practices’ and modularity based manufacturing practices that increase supply chain responsiveness on a composite/aggregate basis, as well as on a dimension level. The results reveal that the practice of reassigning production teams to different production tasks is the most important ‘dynamic teaming’ practice that increases the responsiveness of the manufacturing system of a firm, as well as the overall supply chain responsiveness (on an aggregate basis). Furthermore, the ability to adjust the production processes by adding new process modules, and the ability of the production process modules to be rearranged so that customization sub-processes occur last, are the two most important ‘process modularity’ practices that increase the responsiveness of a firm’s suppliers, as well as the overall supply chain responsiveness. The results also revealed that firms’ practice of informing its trading partners of its changing needs in advance, and the practice by trading partners of a firm (suppliers and customers), of keeping the firm fully informed about issues that affect the firm’s business, are the two most important ‘information sharing’ practices that positively impact the responsiveness of suppliers as well as the overall supply chain responsiveness. In addition, the results uncovered that regularly solving problems jointly with suppliers, and actively involving the key suppliers of a firm in new product development processes, are the two predominant ‘strategic supplier partnership’ practices that directly lead to a higher level of both supplier network responsiveness, as well as overall supply chain responsiveness. Also, the research identified the secondary practices, not as predominant as the practices mentioned above but significantly instrumental in leading to higher levels of supply chain responsiveness or its dimensions, as follows: while the practice of using production teams (in the plant) that can be reorganized is the ‘dynamic teaming’ practice that improves the overall supply chain responsiveness, the use of production team members that are capable of working on different teams is the ‘dynamic teaming’ practice that increases the responsiveness of the manufacturing/operations system. Further the results revealed that, use of production process modules that can be adjusted for changing production needs, and design of the production process as adjustable modules, are the two ‘process modularity’ practices that improve the operations system responsiveness of a firm. Furthermore, conducting continuous improvement programs by a firm that include its key suppliers, is the ‘strategic supplier partnership’ practice that increases the overall supply chain responsiveness. Finally, the results also indicate that the practices by a firm to facilitate customers’ ability to seek assistance from the firm, and to frequently measure and evaluate customer satisfaction, are the two ‘customer relationship’ practices that positively impact supply chain responsiveness on an aggregate basis.

8.1.6 Tested Relationships between Practices / Supply Chain Responsiveness and Competitive Advantage at Dimension Level

The empirical results of this study gave researchers an insight about the specific SCM practice dimensions and supply chain responsiveness dimensions that positively impact competitive advantage of a firm. The results show that ‘customer relationship’ and ‘strategic supplier partnership’ practices were most influential in increasing competitive advantage on an aggregate basis. However, the study did not find any relationship between information sharing and competitive advantage. Also, operations system responsiveness and supplier network responsiveness will directly lead to higher levels of competitive advantage. In addition, supplier network responsiveness and operations system responsiveness will positively influence a firm's ability to compete based on delivery dependability.

8.1.7 Tested Relationships between Practices / Supply Chain Responsiveness and Competitive Advantage at Item Level

The study uncovered the critical and predominant practices (at the item level) within the individual dimensions of 'SCM practices' as well as the measures within the individual dimensions of supply chain responsiveness that increase competitive advantage. The results reveal that, firms' practices of periodically evaluating the importance of their relationship with their customers, facilitating customers' ability to seek assistance from them, and frequently interacting with customers to set reliability, responsiveness, and other standards for the firm, are the most important 'customer relationship' practices that positively influence the overall competitive advantage for a firm (on an aggregate basis). Furthermore, regularly solving problems jointly with suppliers and conducting continuous improvement programs by a firm that include its key suppliers, are the two predominant 'strategic supplier partnership' practices that increase the overall competitive advantage of a firm. The empirical results reveal that the ability of the operations system of a firm to rapidly respond to changes in product volume demanded by customers is the single most important measure of 'operations system responsiveness' that increases the competitive advantage of a firm based on delivery dependability, as well as on an aggregate basis. Finally, the ability of a firm's major suppliers to effectively expedite the firm's emergency orders is the single most important measure of 'supplier network responsiveness' that directly leads to higher levels of overall competitive advantage of a firm.

8.1.8 Dimension Level Analyses for Competitive Advantage for High and Low Levels of Supply Chain Responsiveness

The results reveal that competitive advantage of a firm differs significantly both collectively and individually based on low price, high delivery dependability, high product innovation, and low time to market, for high and low levels of operations system responsiveness. That is, higher level of operations system responsiveness creates higher level of competitive advantage for a firm, collectively on four dimensions – low price, high delivery dependability, high product innovation, and low time to market - as well as individually on each of the said dimensions. In the literature there have been arguments on both direct as well as inverse relationship between responsiveness and cost/price. The results of this research support Randall et al.'s (2003) argument about inverse relationship, that firms with more responsive supply chains will be more adaptive to demand fluctuations and will handle this uncertainty at a lower cost / price due to the shorter lead time. To confirm the results of this study, the relationship between responsiveness and cost/price can be studied in greater depth in future research. Yusuf et al. (2003) found high correlation between the responsiveness and time to market, dependability, product innovation, and quality. This research partially supports the findings by Yusuf et al. (2003), as there was no support for the impact of operations system responsiveness on the ability of a firm to compete based on quality.

Secondly, the results disclose that competitive advantage of a firm differs significantly both collectively and individually based on low price and high delivery dependability for high and low levels of supplier network responsiveness. That is, higher level of supplier network responsiveness creates higher level of competitive advantage for a firm, collectively on two dimensions – low price and high delivery dependability - as well as individually on each of the said dimensions. However, there was no support for the impact of supplier network responsiveness on the ability of a firm to compete based on quality, product innovation, and time to market.

8.2 Implications for Practitioners

The results of this study have several important implications for practitioners.

First, as today's competition is moving from among organizations to between supply chains, more and more organizations are increasingly adopting SCM practices, in the hope for securing competitive advantage. 36% of the respondents (106 / 294) indicated that their firm has not embarked upon a program aimed specially at implementing supply chain management. Of the remaining 64% of the respondents, over 55% (97/178)) indicated that their firm has embarked on a supply chain management program for just three years or less. The findings of this research assure the practitioners that SCM is an effective way of competing, and the implementation of SCM practices does have a strong impact on supply chain responsiveness and competitive advantage of the firm.

Second, in today's fast paced global competition, organizations are in need of greater responsiveness, so as to rapidly meet customer needs. Moreover, responsiveness on all dimensions, namely, supply side, within the organization, and downstream is needed for total responsiveness of the firm. Supply chain responsiveness has been poorly defined and there is a high degree of variability (ranging from flexibility to agility) in people's mind about its meaning. The findings demonstrate to the practitioners the vital components of responsiveness, and ways of achieving them.

Third, the study provides organizations a set of valid and reliable measurements for evaluating, benchmarking, and comparing supply chain responsiveness at different nodes within the supply chain (i.e. raw material supplier, component supplier, assembler, sub-assembler, manufacturer, distributor, wholesaler, and retailer). The measurements developed in this research can capture the different aspects of supply chain responsiveness, thus not only enabling use by practitioners to identify the immediate outcomes of it, but also to understand its impacts on organizational performance.

Fourth, the study provides predominant and specific SCM and modularity based manufacturing practices that directly impact supply chain responsiveness on an aggregate basis, as well as on one or more of its dimensions, and as elaborately discussed in the summary of findings. Looking at the means (on a scale of 1 to 5, 5 being the maximum level of practice) of the predominant practices (of the responding firms) that are instrumental in increasing supply chain responsiveness, the study provides important suggestions with regards to the scope of improvement on each of the significant practices, in order to increase the supply chain responsiveness. The summary of key practices that positively influence supply chain responsiveness and / or one or more of its dimensions, is presented Table 8.2.1, in the increasing order of means.

Table 8.2.1 Scope for Improvement on Practice Levels Based on Means

	Practice	Mean	Outcome
1.	Process Modularity practice of a firm, of rearranging production process modules so that customization sub-processes occur last (PRM5)	2.8	SCR, SNR
2	Process Modularity practice of a firm, of adjusting production process by adding new process modules (PRM2)	3.0	SCR, SNR
3	Process Modularity practice of a firm, of designing the production process as adjustable modules (PRM1)	3.0	OSR
4	Process Modularity practice of a firm, of using production process modules that can be adjusted for changing production needs (PRM3)	3.1	OSR
5	Dynamic Teaming practice of a firm, of using production teams in the plant that can be re-organized (DT1)	3.1	SCR
6	Strategic Supplier Partnership practice of a firm, of actively involving its key suppliers in new product development processes (SSP6)	3.2	SCR, SNR
7	Information Sharing practice by trading partners of a firm, of keeping the firm fully informed about issues that affect the firm's business (IS3)	3.2	SCR, SNR
8	Dynamic Teaming practice of a firm, of reassigning production teams to different production tasks (DT3)	3.4	SCR, OSR
9	Information Sharing practice of a firm, of informing its trading partners of its changing needs in advance (IS1)	3.4	SCR, SNR
10	Dynamic Teaming practice of a firm, of using production team members that are capable of working on different teams (DT5)	3.5	OSR
11	Strategic Supplier Partnership practice of a firm, of conducting continuous improvement programs that include its key suppliers (SSP4)	3.6	SCR
12	Customer Relationship practice of a firm, of frequently measuring and evaluating customer satisfaction (CR2)	3.9	SCR
13	Strategic Supplier Partnership practice of a firm, of regularly solving problems jointly with its suppliers (SSP2)	4.1	SCR, SNR
14	Customer Relationship practice of a firm, of facilitating customers' ability to seek assistance from the firm (CR4)	4.1	SCR

Table 8.2.1 draws important implications in terms of improvement on current levels of practices by a firm, so as to increase supply chain responsiveness. It can thus be implied that the current mean levels of the practices of rearranging production process modules so that customization sub-processes occur last (2.8), and adjusting production processes by adding new process modules (3.0), suggest large scope for improvement of these 'process modularity' practices so as to increase both, the responsiveness of a firm's suppliers, and the overall supply chain responsiveness. Similarly, the current mean levels of 'process modularity' practices of designing the production process as adjustable modules (3.0), and using production process modules that can be adjusted for changing production needs (3.1), suggest large scope for improvement, so as to further enhance operations system responsiveness. In the similar fashion, Table 8.2.1 may be used to draw practical implications on the scope for improvement on the remaining practices, in order to attain increased supply chain responsiveness.

Fifth, the study provides predominant and specific SCM practices and supply chain responsiveness criteria that directly impact competitive advantage of a firm, and as elaborately discussed in the summary of findings. Looking at the means (on a scale of 1 to 5, 5 being the maximum level) of the predominant practices / measures of responsiveness (of the responding firms), that are instrumental in increasing competitive advantage of the firm, the study provides important suggestions with regards to the scope of improvement on each of the significant practices / measures of responsiveness, in order to improve competitive advantage. The summary of key practices / supply chain responsiveness criteria that positively influence competitive advantage is presented Table 8.2.2, in the increasing order of means.

Table 8.2.2 Scope for Improvement on Practice / Supply Chain Responsiveness Criterion Levels Based on Means

	Practice / SCR criterion	Mean	Outcome
1.	The ability of the operations system of a firm to rapidly respond to changes in product volume demanded by customers (OSR1)	3.5	CA, Delivery Dependability
2	The ability of a firm's major suppliers to effectively expedite the firm's emergency orders (SNR6)	3.5	Delivery Dependability
3	Strategic Supplier Partnership practice of a firm, of conducting continuous improvement programs that include its key suppliers (SSP4)	3.6	CA
4	Customer Relationship practice of a firm, of periodically evaluating the importance of its relationship with its customers (CR5)	4.0	CA
5	Customer Relationship practice of a firm, of frequent interaction with its customers to set reliability, responsiveness, and other standards for the firm (CR1)	4.0	CA
6	Customer Relationship practice of a firm, of facilitating customers' ability to seek assistance from the firm (CR4)	4.1	CA
7	Strategic Supplier Partnership practice of a firm, of regularly solving problems jointly with its suppliers (SSP2)	4.1	CA

Table 8.2.2 draws important implications in terms of improvement on current levels of practices / supply chain responsiveness criteria by a firm, so as to increase competitive advantage. It can thus be implied that the current mean levels of the ability of the operations system of a firm to rapidly respond to changes in product volume demanded by customers (3.5), suggests reasonable scope for improvement, so as to improve both, the competitive advantage of the firm based on delivery dependability, as well as on a composite basis. Similarly, the current mean level of the ability of a firm's major suppliers to effectively expedite the firm's emergency orders (3.5), suggests reasonable scope for improvement, so as to improve the competitive advantage of the firm based on delivery dependability. In the similar fashion, Table 8.2.2 may be used to

draw practical implications on the scope for improvement on the remaining practices, in order to attain increased competitive advantage.

Sixth, the research provides evidence to practitioners that by increasing the firms' operations system responsiveness, organizations can increase their capability to compete both collectively as well as individually based on low price, high delivery dependability, high product innovation, and low time to market. The study also provides evidence to practitioners that by increasing the firms' supplier network responsiveness, organizations can increase their capability to compete both collectively as well as individually based on low price, and high delivery dependability. This shall encourage firms, in this ever competitive business world, to boost their responsiveness, so as to attain higher competitive advantage, and stay ahead in business.

8.3 Implications for Researchers

First, the study provides inferences made from an instrument that is valid and reliable for the current study's context for evaluating the level of supply chain responsiveness, and tests the construct with the outcome - competitive advantage - of the firm. Although several previous studies discussed the responsiveness of firms, they were oriented toward customer responsiveness at a firm level. The instrument developed in this research captures three important aspects of supply chain responsiveness – operations system responsiveness, logistics process responsiveness, and supplier network responsiveness. Since practices are designed to achieve efficiency and responsiveness, the new instrument shall provide better guideline for researchers in the SCM area, and thus, can be considered as a strategic management tool.

Second, the study takes a look at the supply chain responsiveness at the firm level, by measuring the extent of a firm's ability on various dimensions to address changes in customer demand. The concept of supply chain responsiveness is difficult to measure; however, the degree to which demand changes are addressed at various nodes of a firm (viz: upstream, within the firm, and downstream) can be used as an indirect measure of this concept. This measure is useful to researchers who are interested in measuring supply chain responsiveness but cannot specify a sampling frame of the supply chain. Measuring supply chain responsiveness at the firm level provides an alternate way to study supply chain outcomes.

Third, the study provides a research framework that identifies positive and significant relationships between SCM practices, modularity based manufacturing practices, supply chain responsiveness, and competitive advantage. This framework (Figure 6.4) provides a foundation and insight for future researchers in the area of supply chain responsiveness.

8.4 Limitations of the Research

This research has extended past research in several ways, by building on past theoretical and empirical studies. Although this research has significant contributions from both theoretical and practical point of views, it also has some limitations, which are described below. The examination of those limitations will assist future researchers to work around them.

First, due to the limited number of observations (294), the revalidation of constructs was not carried out in this research. This needs to be addressed in future research. New mailing lists and research methods can be used to improve the response rate.

Second, in this research, individual respondents (high level executives from purchasing, operations, materials, and logistics functions) in an organization were asked to respond to complex SCM issues dealing with all the participants along the supply chain, including upstream suppliers and downstream customers. However, no person in an organization is in charge of the entire supply chain: for example, purchasing managers are mainly responsible for purchasing and supply side, and may be not in an appropriate position to answer the customer-related questions; the main area of manufacturing managers is production and they may not have enough knowledge of their suppliers and customers; similarly materials managers are mainly responsible for inventory and materials management, and they may not have enough knowledge of their customer. Therefore, the use of single respondent may generate some measurement inaccuracy.

Third, the response rate of 5.35%, even though comparable to similar studies, is considered low. Future research questionnaires may be directed through the top management (captive audience) to ensure higher response rates. The survey may also be endorsed by leading educational institutes / professional organizations / practitioners' councils and the like to guarantee higher response rates.

Fourth, the study is limited to the industries (SIC codes – 22, 23, 25, 34, 35, 36, 37) used for this research. This could limit generalizability of results to other industry types. Future research can extended / replicate the study for other industry types to enhance generalizability. Recommendations for future research will follow.

8.5 Recommendations for Future Research

This section discusses some interesting directions for future research based upon the limitations discussed above and careful considerations of the research potentials.

First, future research should revalidate measurement scales developed in this research by using similar reference populations. Such a validation shall confirm our measurement instrument and create generalizability for it.

Second, future research should conduct factorial invariance tests. Generalizability of measurement scales can further be supported by factorial invariance tests. Using the instrument developed in this research, one may test for factorial invariance across industries, across different organization size, and across organizations with different supply chain structure (such as supply chain length, organization's position in the supply chain, channel structure, and so on).

Third, future research should apply multiple methods of obtaining data. The use of single respondent to represent what are supposed to be intra/inter-organization wide variables may generate some inaccuracy, more than the usual amount of random error (Koufteros, 1995). Future research should seek to utilize multiple respondents from each participating organization in an effort to enhance reliability of research findings. Once a construct is measured with multiple methods, random error and method variance may be assessed using a multitrait-multimethod approach.

Fourth, future research can test the hypothesized structural relationships across countries. Thus various SCM practices for attaining supply chain responsiveness in different countries can be compared, and country-specific SCM issues can be identified.

Fifth, future research should consider other relevant factors not considered in this research. In the same regard additional dimensions of supply chain responsiveness such assembly responsiveness and inbound logistics responsiveness can be examined. Also additional SCM practices such as postponement and outsourcing can be examined. These factors will bring more important insights into the indirect effects of product modularity on supply chain responsiveness (that we found to be not significant), via postponement. Future research should also examine in detail the effects of various practices not considered in this research on logistics process responsiveness, and further the effects of logistics process responsiveness on other dimensions of competitive advantage not considered in this research.

Sixth, future research can study SCM issues at the supply chain level. Taking a complete supply chain as an example, it is of interest to investigate the various practices and mechanisms governing this supply chain, and how the SCM practices differ across supply chains operating in different industries (ex: electronic and computer, heavy machinery manufacturing, fashion and apparel, and consumer goods). Moreover, comparisons can be made between supply chains to identify the strength and weakness of each supply chain and also the best common SCM practices across the supply chain. Further recommendations can, thus, be made to improve the overall responsiveness of the whole supply chain.

Seventh, future research can expand the current theoretical framework by integrating new constructs from within and outside the field. For example, it will be interesting to study the effect of mass customization on supply chain responsiveness, indirect effect of modularity based manufacturing practices on supply chain responsiveness via mass customization. Also the study of direct and indirect (via competitive advantage) impact of supply chain responsiveness on organizational performance shall give the researchers interesting findings. Furthermore, it will be interesting to study the effect of environmental factors / uncertainty, and electronic commerce on supply chain responsiveness as well.

Eighth, canonical correlation can be used in future research to test the simultaneous relationship between the three measures of supply chain responsiveness with five measures of competitive advantage. Such an analysis shall provide more insight into and easy interpretation of the various relationships pertaining to competitive advantage of a firm. Canonical correlation analysis may also be used to test the simultaneous relationships between the SCM practices / modularity based practices and the three measures of supply chain responsiveness. By performing canonical correlation analysis in the future work shall enhance the quality of this research from a methodological point.

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APPENDIX A: MEASUREMENT ITEMS ENTERING Q-SORT

Supply Chain Responsiveness

Operations System Responsiveness

Our operations system responds rapidly to changes in product volume demanded by customers
Our operations system responds rapidly to changes in product mix demanded by customers
Our operations system effectively expedites emergency customer orders
Our operations system rapidly reconfigures equipment to address demand changes
Our operations system rapidly reconfigures people to address demand changes
Our operations system rapidly changes processes to address demand changes
Our operations system rapidly adjusts capacity to address demand changes

Logistics Process Responsiveness

Our logistics system responds rapidly to unexpected demand change
Our logistics system rapidly adjusts warehouse capacity to address demand changes
Our logistics system rapidly varies transportation carriers to address demand changes
Our logistics system rapidly accommodates special or non-routine customer requests
Our logistics system effectively delivers expedited shipments

Supplier Network Responsiveness

Our major suppliers change production volume in a relatively short time
Our major suppliers change production variety in a relatively short time
Our major suppliers consistently accommodate our requests
Our major suppliers promptly vary capacity to address our changing needs
Our major suppliers have outstanding on-time delivery record with us
Our major suppliers effectively expedite our emergency orders.

APPENDIX B: COHEN'S KAPPA AND MOORE AND BENBASAT COEFFICIENT

The Q-sort method is an iterative process in which the degree of agreement between judges forms the basis of assessing construct validity and improving the reliability of the constructs. The Q-sort method was devised by Nahm et al. (2002) as a method of assessing reliability and construct validity of questionnaire items that are generated for survey research. This method is applied as a pilot study, which comes after the pre-test and before administering the questionnaire items as a survey (Nahm et al., 2002). The method is simple, cost efficient and accurate and provides sufficient insight into potential problem areas in the questionnaire items that are being tested. The method consists of two stages. In the first stage, two judges are requested to sort the questionnaire items according to different constructs, based on which the inter-judge agreement is measured. In the second stage, questionnaire items that were identified as being too ambiguous, as a result of the first stage, are reworded or deleted, in an effort to improve the agreement between the judges. The process is carried out repeatedly until a satisfactory level of agreement is reached.

The following example describes the theoretical basis for the Q-sort method and the two evaluation indices to measure inter-judge agreement level: Cohen's Kappa (Cohen, 1960) and Moore and Benbasat's 'Hit Ratio" (Moore and Benbasat, 1991).

Let us assume that two judges independently classified a set of N components as either acceptable or rejectable. After the work was finished the following table was constructed:

		Judge 1		
		Acceptable	Rejectable	Totals
Judge 2	Acceptable	X_{11}	X_{12}	X_{1+}
	Rejectable	X_{21}	X_{22}	X_{2+}
	Totals	X_{+1}	X_{+2}	N

Xij = the number of components in the i^{th} row and j^{th} column, for i,j = 1,2.

The above table can also be constructed using percentages by dividing each numerical entry by N. For the population of components, the table will look like:

		Judge 1		
		Acceptable	Rejectable	Totals
Judge 2	Acceptable	P_{11}	P_{12}	P_{1+}
	Rejectable	P_{21}	P_{22}	P_{2+}
	Totals	P_{+1}	P_{+2}	100

Pij = the percentage of components in the i^{th} row and j^{th} column.

We will use this table of percentages to describe the Cohen's Kappa coefficient of agreement. The simplest measure of agreement is the proportion of components that were classified the same by both judges, i.e., $\Sigma_i P_{ii} = P_{11} + P_{22}$. However, Cohen suggested comparing the actual agreement, $\Sigma_i P_{ii}$, with the chance of agreement that would occur if the row and columns are independent, i.e., $\Sigma_i P_{i+}P_{+i}$. The difference between the actual and chance agreements, $\Sigma_i P_{ii} - \Sigma_i P_{i+}P_{+i}$, is the percent agreement above that which is due to chance. This difference can be standardized by dividing it by its maximum possible value, i.e., $100\% - \Sigma_i P_i + P_{+I} = 1 - \Sigma_i P_i + P_{+i}$. The ratio of these is denoted by the Greek letter kappa and is referred to as Cohen's kappa.

$$k = \frac{\Sigma_i P_{ii} - \Sigma_i (P_{i+} P_{+i})}{1 - \Sigma_i (P_{i+} P_{+i})}$$

Thus, Cohen's Kappa is a measure of agreement that can be interpreted as the proportion of joint judgement in which there is agreement after chance agreement is excluded. The three basic assumptions for this agreement coefficient are: 1) the units are independent, 2) the categories of the nominal scale are independents, mutually exclusive, and 3) the judges operate independently. For any problem in nominal scale agreement between two judges, there are only two relevant quantities:

p_o= the proportion of units in which the judges agreed
p_c= the proportion of units for which agreement is expected by chance

Like a correlation coefficient, k=1 for complete agreement between the two judges. If the observed agreement is greater than or equal to chance $K <= 0$. The minimum value of k occurs when $\Sigma P_{ii} = 0$, i.e.

$$\min(k) = \frac{- \Sigma_i (P_{i+} P_{+i})}{1 - \Sigma_i (P_{i+} P_{+i})}$$

When sampling from a population where only the total N is fixed, the maximum likelihood estimate of k is achieved by substituting the sample proportions for those of the population. The formula for calculating the sample kappa (k) is:

$$k = \frac{N_i Xii - \Sigma_i (X_{i+} X_{+i})}{N^2 - \Sigma_i (X_{i+} X_{+i})}$$

For kappa, no general agreement exists with respect to required scores. However, recent studies have considered scores greater than 0.65 to be acceptable (e.g. Vessey, 1984; Jarvenpaa 1989; Solis-Galvan, 1998). Landis and Koch (1977) have provided a more detailed guideline to interpret kappa by associating different values of this index to the degree of agreement beyond chance. The following guideline is suggested:

Value of Kappa	Degree of Agreement Beyond Chance
.76 - 1.00	Excellent
.40 - .75	Fair to Good (Moderate)
.39 or less	Poor

A second overall measure of both the reliability of the classification scheme and the validity of the items was developed by Moore and Benbasat (1991). The method required analysis of how many items were placed by the panel of judges for each round within the target construct. In other words, because each item was included in the pool explicitly to measure a particular underlying construct, a measurement was taken of the overall frequency with which the judges placed items within the intended theoretical construct. The higher the percentage of items placed in the target construct, the higher the degree of inter-judge agreement across the panel that must have occurred.

Moreover, scales based on categories that have a high degree of correct placement of items within them can be considered to have a high degree of construct validity, with a high potential for good reliability scores. It must be emphasized that this procedure is more a qualitative analysis than a rigorous quantitative procedure. There are no established guidelines for determining good levels of placement, but the matrix can be used to highlight any potential problem areas. The following exemplifies how this measure works.

Item Placement Scores

CONSTRUCTS		ACTUAL						
		A	B	C	D	N/A	Total	% Hits
THEORETICAL	A	26	2	1	0	1	30	87
	B	8	18	4	0	0	30	60
	C	0	0	30	0	0	30	100
	D	0	1	0	28	1	30	93

Item Placements: 120 Hits: 102 Overall “Hit Ratio”: 85%

The item placement ratio (the “Hit Ration”) is an indicator of how many items were placed in the intended, or target, category by the judges. As an example of how this measure could be used, consider the simple case of four theoretical constructs with ten items developed for each construct. With a panel of three judges, a theoretical total of 30 placements could be made within each construct. Thereby, a theoretical versus actual matrix of item placements could be created as shown in the table above (including an ACTUAL “N/A: Not Applicable” column where judges could place items which they felt fit none of the categories).

Examination of the diagonal of the matrix shows that with a theoretical maximum of 120 target placements (four constructs at 30 placements per construct), a total of 102 “hits” were achieved, for an overall “hit ratio” of 85%. More important, an examination of each row shows how the items created to tap the particular constructs are actually being classified. For example, row C shows that all 30-item placements were within the target construct, but that in row B, only 60% (18/30) were within the target. In the latter case, 8 of the placements were made in construct A, which might indicate the items underlying these placements are not differentiated enough from the items created for construct A. This finding would lead one to have confidence in scale based on row C, but be hesitant about accepting any scale based on row B. An examination of off-diagonal entries indicates how complex any construct might be. Actual constructs based on columns with a high number of entries in the off diagonal might be considered too ambiguous, so any consistent pattern of item misclassification should be examined.

APPENDIX C: MEASUREMENT ITEMS AFTER Q-SORT

Supply Chain Responsiveness

Operations System Responsiveness

Our operations system responds rapidly to changes in product volume demanded by customers
Our operations system responds rapidly to changes in product mix demanded by customers
Our operations system effectively expedites emergency customer orders
Our operations system rapidly reconfigures equipment to address demand changes
Our operations system rapidly reallocates people to address demand changes
Our operations system rapidly changes manufacturing processes to address demand changes
Our operations system rapidly adjusts capacity to address demand changes

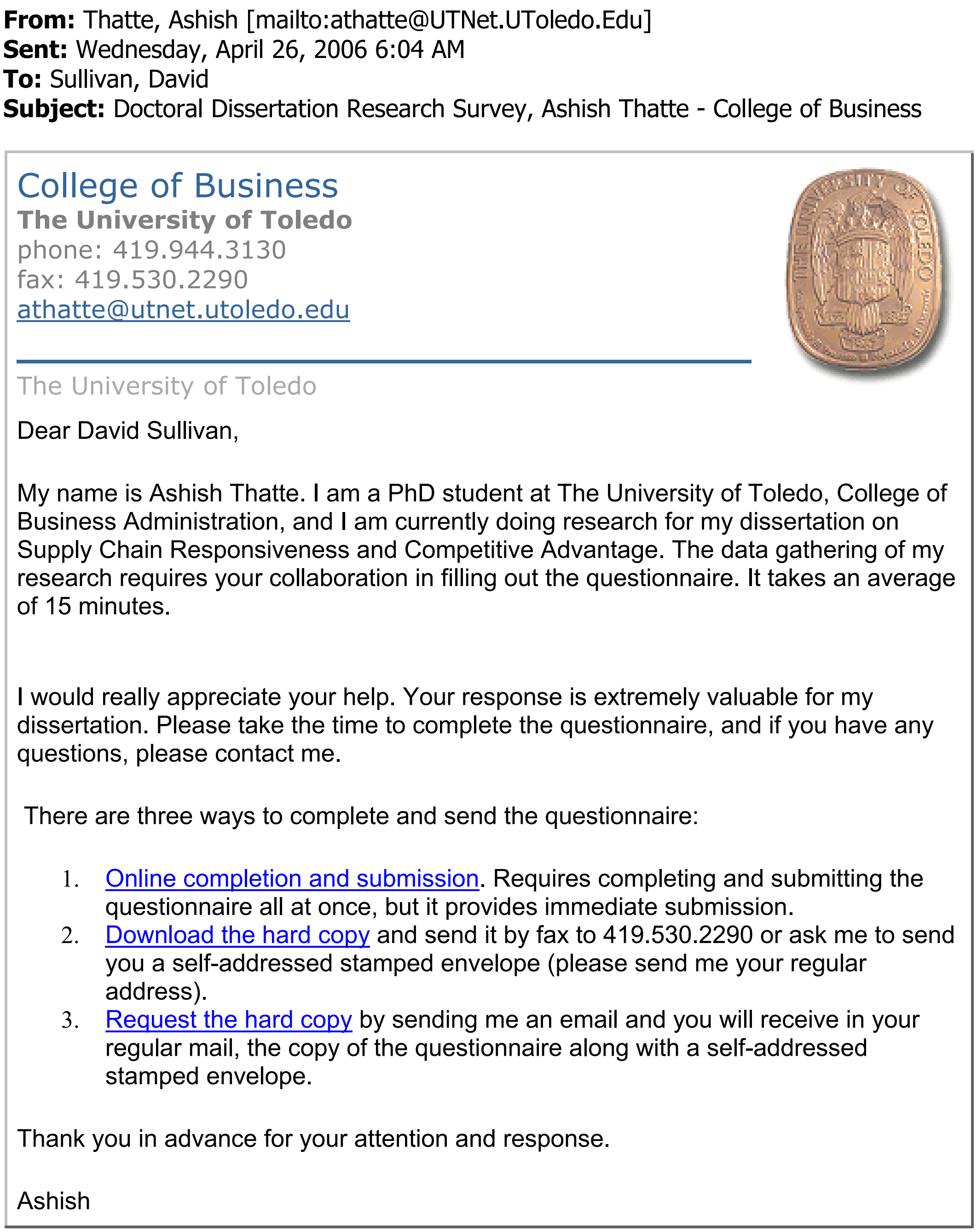
Logistics Process Responsiveness

Our logistics system responds rapidly to unexpected demand change
Our logistics system rapidly adjusts warehouse capacity to address demand changes
Our logistics system rapidly varies transportation carriers to address demand changes
Our logistics system rapidly accommodates special or non-routine customer requests
Our logistics system effectively delivers expedited shipments

Supplier Network Responsiveness

Our major suppliers change product volume in a relatively short time
Our major suppliers change product mix in a relatively short time
Our major suppliers consistently accommodate our requests
Our major suppliers provide quick inbound logistics to us
Our major suppliers have outstanding on-time delivery record with us
Our major suppliers effectively expedite our emergency orders.

APPENDIX D: SAMPLE EMAILS FOR DATA COLLECTION (COVER LETTER)



From: Thatte, Ashish [mailto:athatte@UTNet.UToledo.Edu]
Sent: Wednesday, April 26, 2006 6:04 AM
To: Sullivan, David
Subject: Doctoral Dissertation Research Survey, Ashish Thatte - College of Business

College of Business
The University of Toledo
phone: 419.944.3130
fax: 419.530.2290
athatte@utnet.utoledo.edu

The University of Toledo

Dear David Sullivan,

My name is Ashish Thatte. I am a PhD student at The University of Toledo, College of Business Administration, and I am currently doing research for my dissertation on Supply Chain Responsiveness and Competitive Advantage. The data gathering of my research requires your collaboration in filling out the questionnaire. It takes an average of 15 minutes.

I would really appreciate your help. Your response is extremely valuable for my dissertation. Please take the time to complete the questionnaire, and if you have any questions, please contact me.

There are three ways to complete and send the questionnaire:

1. Online completion and submission. Requires completing and submitting the questionnaire all at once, but it provides immediate submission.
2. Download the hard copy and send it by fax to 419.530.2290 or ask me to send you a self-addressed stamped envelope (please send me your regular address).
3. Request the hard copy by sending me an email and you will receive in your regular mail, the copy of the questionnaire along with a self-addressed stamped envelope.

Thank you in advance for your attention and response.

Ashish

This email was sent personalized to each member in the database.

(FOLLOW-UP EMAIL)

From: Thatte, Ashish [mailto:athatte@UTNet.UToledo.Edu]
Sent: Wednesday, April 26, 2006 6:04 AM
To: Sullivan, David
Subject: Doctoral Dissertation Research Survey, Ashish Thatte - College of Business - Reminder II

College of Business
The University of Toledo
phone: 419.944.3130
fax: 419.530.2290
athatte@utnet.utoledo.edu

The University of Toledo

Dear David Sullivan,

This is a follow-up email to request you to fill out my doctoral dissertation questionnaire. My name is Ashish Thatte. I am a PhD student at The University of Toledo, College of Business Administration, and I am currently doing research for my dissertation on Supply Chain Responsiveness and Competitive Advantage. The data gathering of my research requires your collaboration in filling out the questionnaire.

I would be very thankful if you can take 15 minutes of your time and fill out the questionnaire for my research. Your response is extremely valuable for my dissertation. If you have any questions, please contact me.

There are three ways to complete and send the questionnaire:

4. Online completion and submission. Requires completing and submitting the questionnaire all at once, but it provides immediate submission.
5. Download the hard copy and send it by fax to 419.530.2290 or ask me to send you a self-addressed stamped envelope (please send me your regular address).
6. Request the hard copy by sending me an email and you will receive in your regular mail, the copy of the questionnaire along with a self-addressed stamped envelope.

Thank you in advance for your attention and response. This will be the last email sent to you.

Ashish

This email was sent personalized to each member in the database.

APPENDIX E: LARGE-SCALE MAIL SURVEY QUESTIONNAIRE

A SURVEY OF SUPPLY CHAIN RESPONSIVENESS, SCM PRACTICES AND COMPETITIVE ADVANTAGE

General Instructions and Information

- This survey is being conducted by Ashish Thatte, a Ph.D. candidate, The University of Toledo
- This research will study the effect of Supply Chain Responsiveness and SCM practices of a firm on a firm's Competitive Advantage. We hope to determine various critical practices of a firm for attaining supply chain responsiveness and their effect on competitive advantage of the firm.
- Please answer **all** questions. There is no right or wrong answer. Please provide your **best** estimate.
- If you would like to get a copy of the executive summary of results, please provide the information requested on the last page of the questionnaire.
- If you have any questions, please contact:

Ashish Thatte
College of Business
The University of Toledo
2801 West Bancroft Street, Toledo, OH 43606
Phone: (419) 944-3130
Fax: (419) 530-2290
Email: athatte@utnet.utoledo.edu

All RESPONSES WILL BE KEPT CONFIDENTIAL. DATA WILL BE USED FOR STATISTICAL ANALYSIS ONLY

Unless otherwise specifically requested, please use the following scale to answer each item:

1	2	3	4	5	6
Not at all	To a small extent	To a moderate extent	To a considerable extent	To a great extent	Not applicable

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Section I: Supply Chain Management (SCM) Practices

SCM practices – is defined as the set of activities undertaken by an organization to promote effective management of its supply chain through outsourcing, strategic supplier partnership, customer relationship, information sharing, postponement, and mass customization.

Please circle the number that accurately reflects the **extent of your firm's current level of SCM practices**.

EXTENT OF OUTSOURCING

Outsourcing is the practice of transferring internal business activities / operations of a firm to third parties.

Our firm outsources information systems	1	2	3	4	5	6
Our firm outsources manufacturing	1	2	3	4	5	6
Our firm outsources logistics (this includes transportation, distribution and warehousing)	1	2	3	4	5	6
Our firm outsources pre-sales customer care	1	2	3	4	5	6
Our firm outsources after sales support	1	2	3	4	5	6
Our firm outsources product design	1	2	3	4	5	6

STRATEGIC SUPPLIER PARTNERSHIP

Strategic Supplier Partnership is the long-term relationship between the organization and its suppliers. It is designed to leverage the strategic and operational capabilities of individual participating organizations to help them achieve significant ongoing benefits.

We consider quality as our number one criterion in selecting suppliers	1	2	3	4	5	6
We regularly solve problems jointly with our suppliers	1	2	3	4	5	6
We have helped our suppliers to improve their product quality	1	2	3	4	5	6
We have continuous improvement programs that include our key suppliers	1	2	3	4	5	6
We include our key suppliers in our planning and goal- setting activities	1	2	3	4	5	6
We actively involve our key suppliers in new product development processes	1	2	3	4	5	6

CUSTOMER RELATIONSHIP

Customer Relationship is the entire array of practices that are employed for the purpose of managing customer complaints, building long-term relationships with customers, and improving customer satisfaction.

We frequently interact with customers to set reliability, responsiveness, and other standards for us	1	2	3	4	5	6
We frequently measure and evaluate customer satisfaction	1	2	3	4	5	6
We frequently determine future customer expectations	1	2	3	4	5	6

Unless otherwise specifically requested, please use the following scale to answer each item:

1	2	3	4	5	6
Not at all	To a small extent	To a moderate extent	To a considerable extent	To a great extent	Not applicable

We facilitate customers' ability to seek assistance from us	1	2	3	4	5	6
We periodically evaluate the importance of our relationship with our customers	1	2	3	4	5	6

INFORMATION SHARING

Information sharing is the extent to which critical and proprietary information is communicated to one's trading partner.

We inform trading partners in advance of changing needs	1	2	3	4	5	6
Our trading partners share proprietary information with us	1	2	3	4	5	6
Our trading partners keep us fully informed about issues that affect our business	1	2	3	4	5	6
Our trading partners share business knowledge of core business processes with us	1	2	3	4	5	6
We and our trading partners exchange information that helps establishment of business planning	1	2	3	4	5	6
We and our trading partners keep each other informed about events or changes that may affect the other partners	1	2	3	4	5	6

POSTPONEMENT

Postponement is the practice of moving forward one or more operations or activities (making, sourcing, and delivering) to a much later point in the supply chain.

We delay final product assembly activities until customer orders have actually been received	1	2	3	4	5	6
We delay final product assembly activities until the last possible position (or nearest to customers) in the supply chain	1	2	3	4	5	6
We delay ordering of raw materials from suppliers until customer orders have actually been received	1	2	3	4	5	6
We delay some form of value-addition to the product until customer orders have actually been received	1	2	3	4	5	6

MASS CUSTOMIZATION

Mass Customization is the practice of producing customized products on a large scale at a cost comparable to mass produced products.

We customize products on a large scale	1	2	3	4	5	6
We add product variety without increasing cost	1	2	3	4	5	6
We customize products while maintaining a large volume	1	2	3	4	5	6

Unless otherwise specifically requested, please use the following scale to answer each item:

1	2	3	4	5	6
Not at all	To a small extent	To a moderate extent	To a considerable extent	To a great extent	Not applicable

Our setup cost for a different product is low	1	2	3	4	5	6
We add product variety without sacrificing overall production volume	1	2	3	4	5	6

Section II: Modularity Based Manufacturing Practices (MBMP)

MBMP – is defined as the application of unit standardization or substitution principles to manufacturing through product design, production process design, and dynamic teaming.

Please circle the number that accurately reflects the **extent of your firm's current level of modularity based manufacturing practices**.

PRODUCT MODULARITY

Product Modularity is the practice of using standardized product modules so they can be easily reassembled / rearranged into different functional forms, or shared across different product lines.

Our products use modularized design	1	2	3	4	5	6
Our products share common modules	1	2	3	4	5	6
Our product features are designed around a standard base unit	1	2	3	4	5	6
Product modules can be reassembled into different forms	1	2	3	4	5	6
Product feature modules can be added to a standard base unit	1	2	3	4	5	6

PROCESS MODULARITY

Process Modularity is the practice of standardizing manufacturing process modules so that they can be re-sequenced easily or new modules can be added quickly in response to changing product requirements.

Our production process is designed as adjustable modules	1	2	3	4	5	6
Our production process can be adjusted by adding new process modules	1	2	3	4	5	6
Production process modules can be adjusted for changing production needs	1	2	3	4	5	6
Our production process can be broken down into standard sub-processes that produce standard base units and customization sub-processes that further customize the base units	1	2	3	4	5	6
Production process modules can be rearranged so that customization sub-processes occur last	1	2	3	4	5	6

DYNAMIC TEAMING

Dynamic Teaming is the practice of using modular structures to reorganize manufacturing teams quickly and link them to necessary resources in response to product design or manufacturing process changes.

Production teams that can be reorganized are used in our plant	1	2	3	4	5	6
Production teams can be reorganized in response to product/process changes	1	2	3	4	5	6

Unless otherwise specifically requested, please use the following scale to answer each item:

1	2	3	4	5	6
Not at all	To a small extent	To a moderate extent	To a considerable extent	To a great extent	Not applicable

Production teams can be reassigned to different production tasks	1	2	3	4	5	6
Production team members can be reassigned to different teams	1	2	3	4	5	6
Production team members are capable of working on different teams	1	2	3	4	5	6

Section III: Responsiveness of Your Supply Chain

Supply Chain Responsiveness – is defined as the capability of promptness and the degree to which the supply chain can address changes in customer demand, through operations system responsiveness, logistics process responsiveness, and supplier network responsiveness.

Please circle the number that accurately reflects the **extent of your supply chain's current level of responsiveness.**

OPERATIONS SYSTEM RESPONSIVENESS

Operations System Responsiveness is the ability of a firm's manufacturing system to address changes in customer demand.

Our operations system responds rapidly to changes in product volume demanded by customers	1	2	3	4	5	6
Our operations system responds rapidly to changes in product mix demanded by customers	1	2	3	4	5	6
Our operations system effectively expedites emergency customer orders	1	2	3	4	5	6
Our operations system rapidly reconfigures equipment to address demand changes	1	2	3	4	5	6
Our operations system rapidly reallocates people to address demand changes	1	2	3	4	5	6
Our operations system rapidly changes manufacturing processes to address demand changes	1	2	3	4	5	6
Our operations system rapidly adjusts capacity to address demand changes	1	2	3	4	5	6

LOGISTICS PROCESS RESPONSIVENESS

Logistics Process Responsiveness is the ability of a firm's outbound transportation, distribution, and warehousing system (including 3PL/4PL) to address changes in customer demand.

Our logistics system responds rapidly to unexpected demand change	1	2	3	4	5	6
Our logistics system rapidly adjusts warehouse capacity to address demand changes	1	2	3	4	5	6
Our logistics system rapidly varies transportation carriers to address demand changes	1	2	3	4	5	6

Unless otherwise specifically requested, please use the following scale to answer each item:

1	2	3	4	5	6
Not at all	To a small extent	To a moderate extent	To a considerable extent	To a great extent	Not applicable

Our logistics system rapidly accommodates special or non-routine customer requests	1	2	3	4	5	6
Our logistics system effectively delivers expedited shipments	1	2	3	4	5	6

SUPPLIER NETWORK RESPONSIVENESS

Supplier Network Responsiveness is the ability of a firm's major suppliers to address changes in the firm's demand.

Our major suppliers change product volume in a relatively short time	1	2	3	4	5	6
Our major suppliers change product mix in a relatively short time	1	2	3	4	5	6
Our major suppliers consistently accommodate our requests	1	2	3	4	5	6
Our major suppliers provide quick inbound logistics to us	1	2	3	4	5	6
Our major suppliers have outstanding on-time delivery record with us	1	2	3	4	5	6
Our major suppliers effectively expedite our emergency orders	1	2	3	4	5	6

Section IV: Competitive Advantage of Your Firm

Competitive Advantage – is defined as the capability of an organization to create a defensible position over its competitors.

Please select the number that accurately reflects the **extent of your firm's competitive advantage on each of the following**.

We offer competitive prices	1	2	3	4	5	6
We are able to offer prices as low or lower than our competitors	1	2	3	4	5	6
We are able to compete based on quality	1	2	3	4	5	6
We offer products that are highly reliable	1	2	3	4	5	6
We offer products that are very durable	1	2	3	4	5	6
We offer high quality products to our customers	1	2	3	4	5	6
We deliver customer orders on time	1	2	3	4	5	6
We provide dependable delivery	1	2	3	4	5	6
We provide customized products	1	2	3	4	5	6
We alter our product offerings to meet client needs	1	2	3	4	5	6
We cater to customer needs for "new" features	1	2	3	4	5	6
We are first in the market in introducing new products	1	2	3	4	5	6
We have time-to-market lower than industry average	1	2	3	4	5	6
We have fast product development	1	2	3	4	5	6

Unless otherwise specifically requested, please use the following scale to answer each item:

1	2	3	4	5	6
Not at all	To a small extent	To a moderate extent	To a considerable extent	To a great extent	Not applicable

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Section V: Performance of Your Firm

Please circle the number that best describes **your firm's overall performance** as **compared to your industry average.**

1	2	3	4	5	6
Much below average	Below average	Average	Above average	Much above average	Do not know

Market share	1	2	3	4	5	6
Return on investment	1	2	3	4	5	6
The growth of market share	1	2	3	4	5	6
The growth of sales	1	2	3	4	5	6
Growth in return on investment	1	2	3	4	5	6
Profit margin on sales	1	2	3	4	5	6
Overall competitive position	1	2	3	4	5	6

Section VI: Demographic Information

For the following questions, please check the appropriate response.

1) Has your organization embarked upon a program aimed specially at implementing "Supply Chain Management"?

________ Yes ________ No.

If your answer is Yes, how long ? ______ years.

2) Type of Industry (SIC Code) your company is in:

	SIC	Description
☐	22	Textile mill products
☐	23	Apparel and other textile products
☐	25	Furniture and fixtures
☐	34	Fabricated metal products, except machinery and transportation equipment
☐	35	Industrial and commercial machinery and computer equipment
☐	36	Electronic, electrical equipment and components, except computer equipment
☐	37	Transportation equipment
☐	Other ________________________________	

3) Your company's primary production system is (choose the most appropriate one).

____Engineer to Order _______Make to Order

____Assemble to Order _______Make to Stock

4) Your company's primary process choice is (choose the most appropriate one).

_____Project _____Jobshop _____Batch

_____Line _____Continuous Processing

5) The number of product lines your firm makes_______

6) Company Website: _________________________

7) Number of employees in your company:

___ 1 -50 ___ 51-100 ___ 101-250

___251-500 ___ 501 -1000 ___ Over 1000

8) Average annual sales of your company in millions of $:

___ Under 5 ___5 to <10 ____10 to <25

___25 to <50 ___ 50 to <100 ____ >100

9) Your present job title:

____CEO/president _____Director

____Manager _____Other (please indicate_____)

10) Your present job function (mark all that apply):

_____ Corporate Executive

_____ Purchasing

_____ Manufacturing / Production

_____ Distribution

_____ Transportation

_____ Sales

_____ Other (please indicate _____________)

Unless otherwise specifically requested, please use the following scale to answer each item:

1	2	3	4	5	6
Not at all	To a small extent	To a moderate extent	To a considerable extent	To a great extent	Not applicable

11) The years you have worked for this company:

_____ under 2 years ______ 2-5 years
_____ 6-10 years ______over 10 years

12) Please mark the position of your company in the supply chain (mark all that apply).

_____ Raw material supplier
_____ Component supplier
_____ Assembler
_____ Sub-assembler
_____Manufacturer
_____Distributor
_____Wholesaler
_____ Retailer

13) Please circle the **<u>extent to which you agree or disagree</u>** with the following statements **<u>regarding inter-departmental collaboration within your firm</u>**

	1 Strongly disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree	6 Do not know
Our department works in close coordination with other departments	1	2	3	4	5	6
We consult other departments when making our work decisions	1	2	3	4	5	6
We collaborate with other departments in our day to day work	1	2	3	4	5	6

Please indicate if you would like to get a copy of the executive summary of results of this survey by filling in your address information below.

Your name: ___________________________
Company: ____________________________
Address: _______________________________
City: ________________ State: ______
Zip code: ________________
Tel: ________________ Fax: ______________
Email address: __________________________________

THANK YOU VERY MUCH FOR YOUR VALUABLE TIME

APPENDIX F: ACRONYMS USED FOR CODING OF ITEMS

Supply Chain Management Practices (SCMP)

Strategic Supplier Partnership	SSP
Customer Relationship	CR
Information Sharing	IS

Modularity Based Manufacturing Practices (MBMP)

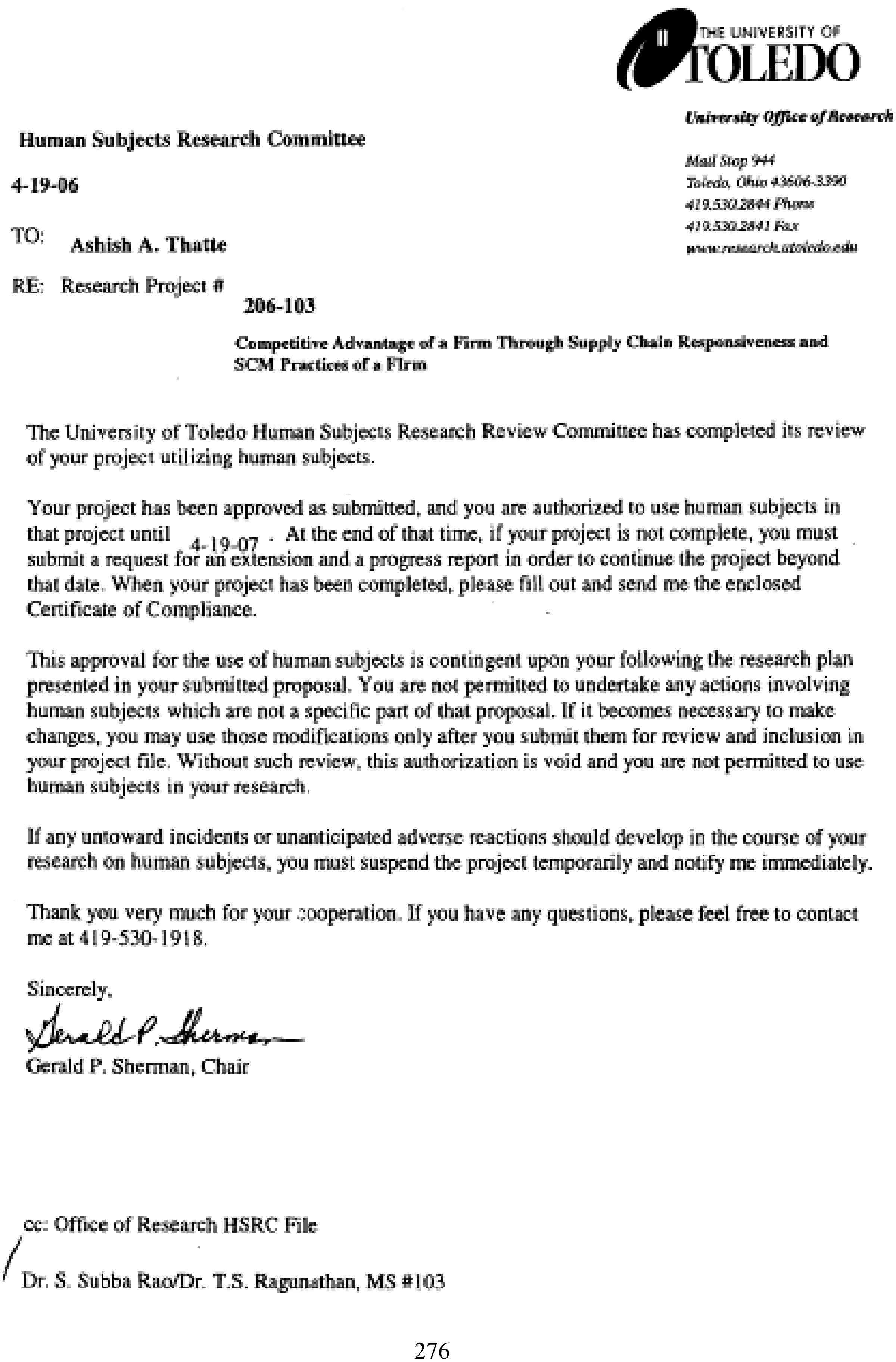
Product Modularity	PM
Process Modularity	PRM
Dynamic Teaming	DT

Supply Chain Responsiveness (SCR)

Operations System Responsiveness	OSR
Logistics Process Responsiveness	LPR
Supplier Network Responsiveness	SNR

Competitive Advantage (CA)

APPENDIX G: IRB FROM UNIVERSITY OF TOLEDO



THE UNIVERSITY OF TOLEDO

University Office of Research

Mail Stop 944
Toledo, Ohio 43606-3390
419.530.2844 Phone
419.530.2841 Fax
www.research.utoledo.edu

Human Subjects Research Committee

4-19-06

TO: **Ashish A. Thatte**

RE: Research Project # **206-103**

Competitive Advantage of a Firm Through Supply Chain Responsiveness and SCM Practices of a Firm

The University of Toledo Human Subjects Research Review Committee has completed its review of your project utilizing human subjects.

Your project has been approved as submitted, and you are authorized to use human subjects in that project until 4-19-07. At the end of that time, if your project is not complete, you must submit a request for an extension and a progress report in order to continue the project beyond that date. When your project has been completed, please fill out and send me the enclosed Certificate of Compliance.

This approval for the use of human subjects is contingent upon your following the research plan presented in your submitted proposal. You are not permitted to undertake any actions involving human subjects which are not a specific part of that proposal. If it becomes necessary to make changes, you may use those modifications only after you submit them for review and inclusion in your project file. Without such review, this authorization is void and you are not permitted to use human subjects in your research.

If any untoward incidents or unanticipated adverse reactions should develop in the course of your research on human subjects, you must suspend the project temporarily and notify me immediately.

Thank you very much for your cooperation. If you have any questions, please feel free to contact me at 419-530-1918.

Sincerely,

Gerald P. Sherman

Gerald P. Sherman, Chair

cc: Office of Research HSRC File

Dr. S. Subba Rao/Dr. T.S. Ragunathan, MS #103