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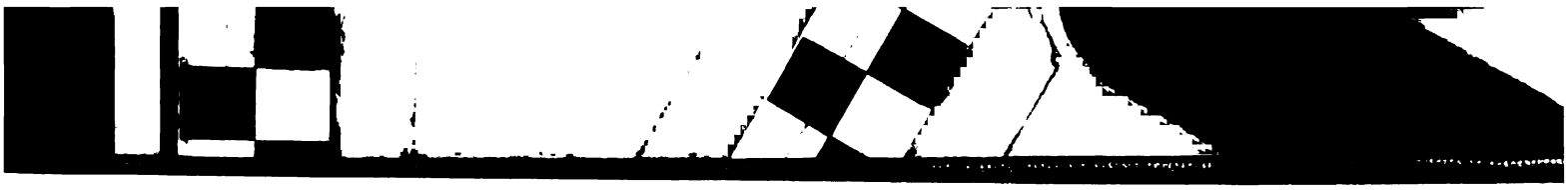

INFORMATION TECHNOLOGIES AS ANTECEDENTS OF DEMAND MANAGEMENT AGILITY AND SUPPLY CHAIN PERFORMANCE

By

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ABSTRACT

INFORMATION TECHNOLOGIES AS ANTECEDENTS OF DEMAND MANAGEMENT AGILITY AND SUPPLY CHAIN PERFORMANCE

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This research examines the role of information technologies in enhancing a firm's demand management (DM) agility. These impacts are being assessed for four types of IT applications (internal supply side, external supply side, internal demand side, and external demand side). Besides the direct impacts of IT applications we also assess the synergistic impact of corresponding business initiatives. The categorization of technologies and business initiatives into these four types is based on their functional nature, and their scope within the overall supply chain. Further, while speed of agility has been examined in prior research, this research goes a step forward by studying the role of information technology in enhancing the effectiveness of a firm's DM agility. To make it a comprehensive evaluation, both speed and effectiveness of DM agility are measured as a combination of three different dimensions– adaptive, entrepreneurial and responsive.

The results indicate complex dynamics for leveraging IT impacts. The study finds that different types of IT systems have different ways in which they impact DM agility. Also, the nature of their synergistic interaction with the corresponding business initiative varies according to the nature of the technology. The research has both academic and managerial implications. Academically, this is the first attempt to establish the empirical impacts of IT systems on agility within a firm's demand management process. Also, the empirical analysis includes effectiveness along with the speed of agility. Finally, we

establish the impacts of agility on supply chain performance. The study also develops new managerial knowledge related to the impact of information technologies on responsiveness to changes in customer demand. The knowledge of the differences in the impacts of different IT systems, for example, will help managers leverage these IT systems appropriately and hence realize greater value. We present a detailed discussion of results and their implications.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

The digitization of supply chains has led to numerous business innovations and development of new models for managing physical information and financial flows (Bowersox et al. 1995; Rai et al. 2006; Sambamurthy et al. 2003). The introduction of information technologies often leads to superior performance of supply chains (Vickery et al. 2003). These technologies enhance the efficiency of work processes by facilitating superior execution of management processes through digitally-enabled work systems. For example, in the absence of the technological support, firms had to either rely on mass production of high volumes with high standardization or follow job production that led to high degree of customization but low volumes. However, enabled with its digital infrastructure, Dell Inc. simultaneously achieves the conflicting objectives of mass production and customization. Dell could simultaneously achieve these conflicting objectives as the customers could personalize their own electronic products that were assembled only after customer orders had been placed. The use of internet and advanced information technologies (IT) helped coordinate personalization of these mass customer orders before assembly. However, while the impacts of IT systems on fulfillment of customer demand are well documented in the popular press, little is known of the complex managerial dynamics that help some firms realize these superior impacts.

The impact of IT is also associated with superior business and service performance. For example, Dell not only leveraged its technologies for customization and superior order fulfillment but also realized superior operational performance. Dell reduced its inventory to only six days and has a negative cash conversion cycle for its

financial flows. It is thus no surprise that the firm's fulfillment of customer demand has gained increasing research attention. The increased interest to study demand fulfillment in supply chains is also due to the relatively little organizational attention to supply chains in last decade. For example, successful implementation of such initiatives, as supply chain partnering that are considered vital for business success, has been very restrictively adopted by only 50% of the respondents (Boddy et al. 1990). In general, there is a huge gap and hence opportunity to enhance the performance of supply chains. In a recent survey of North American manufacturers, Deloitte Consulting found that only 2% of the respondents regard their supply chains as world class (Li et al. 2005).

Supply chains have also become critical to performance due to the increase in competitiveness of business environments and enhanced importance given to satisfying customer demand (hypercompetition) (D'Aveni 1994; Sambamurthy 2000). New ways of serving customers, managing production, and communicating with partners have changed the way various supply chains manage customer demand (Boyer and Olson 2002; Brynjolfsson and Smith 2000; Kaplan and Sawhney 2000; Lee and Whang 2001). Efficiency in day-to-day operations is no more a sufficient metric for evaluating performance of a firm's supply chain (Lee 2004). It is realized that the firms now need to apply modern management principles to develop more advanced capabilities for rapidly managing customer demand. Thus, recent research has studied various supply chain capabilities such as absorptive capacity (Malhotra et al. 2005), supplier and customer side information capabilities (Barua et al. 2004), JIT (Banker et al. 2006), process integration (Rai et al. 2006), and customer and supplier participation (Banker et al. 2006). However, beyond these capabilities for superior operational performance, competitive performance

of organizations is crucially dependent on their capability to rapidly respond to the changes in customer demand (Teece et al. 1997). Therefore, in this research, our focus is on demand management agility which is the capability of the organization to rapidly respond to changes in customer demand. We study the impact of information technologies used in demand management processes on the creation of agility in a firm's demand management process.

Agility is the ability of the firm to respond to the demand changes due to changes in business conditions (Goldman et al. 1994). Agile performance has been recognized as vital for the firm's overall performance. For example, Sambamurthy et al. (2003) posited customer, partner, and operations agility as critical antecedents to overall performance. Agility is vital for the performance of the firm's supply chains and manufacturing operations (Swafford et al. 2006; Narasimhan et al. 2006). In this research, our focus is on the agility in a firm's demand management process we refer to as the demand management (DM) agility. While speed of response has gained attention and is the dominant conceptualization of agile response, the effectiveness of firm response is an important consideration as well. Thus, in this research, we focus on both the speed and effectiveness of DM agility. Further, we use the temporal nature of events and related firm response to define and assess three types for each of the two dimensions. Based on the timing of the firm's response, three types of DM agility defined in this research are adaptive DM agility, entrepreneurial DM agility, and resilient DM agility. Adaptive DM agility is related to the firm's capability to *concurrently* realign and adjust to demand fluctuations, while entrepreneurial DM agility is the firms' ability to *proactively* sense

and respond to changes in future demand. Finally, resilient DM agility is the ability of the firm to *retrospectively* respond to unexpected and unforeseen changes that effect demand.

The successful and modern supply chain organizations are harnessing advanced information technologies to create superior capabilities (Rai et al. 2006; Banker et al. 2006). These technologies have become necessary as the processes for demand management, procurement, order fulfillment, and delivery have become more complex and innovative features in products are increasing exponentially (Fisher 1997; Jap and Mohr 2002; Lee et al. 1997). Information technology has been found to be the most common factor that leads to effective supply chain practices (Bowersox and Daugherty 1987; 1995) and is a critical component of extended enterprises (Bowersox, and Daugherty 1995; Bowersox, Closs, and Stank 1999; Edwards, Peter, and Sharman 2001). The positive effect of information technologies on supply chain performance has further heightened the attention on the role of IT in supply chains (Vickery et al. 2003; Jayaram et al.2000). However, researchers have found that realizing superior value out of IT investments is associated with complex organizational dynamics (Barua and Mukhopadhyay 2000). Thus, this research explores underlying mechanisms by which information technologies create agile capabilities in the firm's demand management process.

Interaction of IT with the business initiatives has often been identified as one of the key mechanism to leverage IT and create organizational capabilities. The underlying argument for significant interactions is the core theme in the reasoning of the complementarities theory that has found support in studies of IT value (Barua and Mukhopadhyay 2000; Sambamurthy et al. 2003; Banker et al. 2006; Tanriverdi 2005;

Tanriverdi 2006). According to these researchers, the value impacts of IT are greater in the presence of related organizational initiatives. Complementarities have also been found to be relevant in the supply chains (Jayaram et al. 2000; Rai et al. 2006; Banker et al. 2006). Complementarities were also found earlier in the manufacturing operations for firms that made a transition from assembly line mass production systems to flexible manufacturing systems (CAD, CAM, etc.) (Milgrom and Roberts 1996; Parthasarthy and Sethi 1993). While most of this research has looked at the application level, we extend this research by evaluating complementarities at the process level. The process-level analysis is recommended as it aids the measurement of IT impacts at the level where they actually occur (Ray et al. 2005).

The study of complementarities gains special significance in today's business environment due to its strong link with the managers' ability to successfully manage their activity systems. Managing these activity systems often involves a set of interdependencies amongst the firms' activities (Milgrom and Roberts 1990; Levinthal 1997; Porter 1996). In order to take decisions within compressed time frames, organizational actors internalize these interdependencies as mental models (Siggelkow 2002). By studying complementarities, the goal of this research is to build the knowledge of the interdependencies related to demand management processes. These activity systems operate in highly complex business environments and are often managed through a complex interaction between advanced digital technologies and a set of related organizational practices. The interaction defined as complementarities, along with the IT systems, is proposed as an antecedent to agile demand management performance.

We study complementarities as a source of the agile capabilities to propose an overall model of governance of demand management processes. The model contributes by building new knowledge to enhance supply chain performance. Also, while the proposed model is motivated to address the enhanced efficiency of demand management process, it is also likely to aid the governance of IT systems and supply chain related activity systems.

To summarize, the key research question being addressed in this study is

1. "*How do IT and demand management initiatives impact the speed and effectiveness of DM agility in a firm's demand management process?*"

2. "*How do complementarities between IT and demand management initiatives impact the speed and effectiveness of DM agility in a firm's demand management process?*"

We next review the business value, organizational capability, supply chain process frameworks, and complementarities literature and based on these develop our research model. The development of research model is then followed by a brief introduction of the proposed measurement and analysis.

CHAPTER 2: LITERATURE REVIEW

Resource based view (RBV) has become the key theoretical basis for contemporary research analyzing impacts of IT on organizational performance. RBV, as proposed by Penrose (1959), defines a firm to be an administrative unit that has the explicit goal to efficiently allocate resources. Building on this early work, Petraf (1993) and Barney (1991) define resources as the source of a firm's competitive advantage. These resources may include the firm's tangible and intangible assets, management skills, organizational processes and routines, and the information and knowledge possessed by it. Barney (1991) proposed RBV as the alternate to strategic competitive forces model by Porter (1980). Barney argued that firm's resources are a source of competitive advantage if they possess four attributes - value, rarity, inimitability, and non substitutability. The argument for long-term competitive advantage of these resources assumes the inelasticity of their supply. Further, this inelasticity of supply is attributed to three organizational processes: 1. path dependence - some resources can only be developed over long period of time, 2. causal ambiguity - no clear knowledge of how to develop these resources and capabilities, and 3. social complexity - some resources do not have ready market availability for buying and selling.

Resource based view has been empirically tested for industry and firm-level attributes and the comparison of its relative effects has found greater applicability at the firm level compared with the industry level (Hansen and Wernerfelt 1989; Cool and Schendel 1988; McGahan and Porter 1997). Heterogeneity of resources leads to differing performance even within the same industry since resources across any two firms are always unique. This uniqueness is attributed to the differences in managerial

competencies and organizational structures across firms. Even though there has been empirical support, critics of RBV have raised issues related to its tautology in definition, equifinality (due to which different resource configurations might lead to same value), missing treatment of product markets, and limited prescriptive applicability (Priem and Butler 2001).

The key criticism related to the managerial irrelevance and missing treatment of product markets stems from the description of firms' resources as being limited and having fixed value over time. According to the critiques, RBV fails to incorporate the role of entrepreneurial effort that can lead to the development of new resources to match future demand shifts in product or factor markets (p.31: Priem and Butler 2001). Also, RBV falls short of defining how the firms can develop a particular resource position. This argument is even more significant in case of the IS resources since these usually do not have a direct impact on the firm's competitive advantage. Wade and Hulland (2004) cited this inapplicability of RBV to IS-related phenomenon to develop a category of resources. Developing on Day's (1994) framework, they extend the resource-based arguments for the impact of IT resources to categorize three kind of IS resources: Inside Out (Initiatives inside the firm that impact the firm's outside performance), Outside In (bring in knowledge from outside to inside the firm), and Spanning (organization wide resources). While various categories of IT resources have been defined, the mechanisms by which IT resources contribute to organizational performance are less understood. Since IT resources are primarily indirect contributors to the overall organizational objectives, an important goal is to study the mechanisms by which these resources contribute to the

overall firm performance. Two such mechanisms - resource picking and capability building – have gained attention in this stream of research (Makadok 2001).

Superior firm performance is often an outcome of the valuable resource and capability combinations. Hence, the knowledge of mechanisms to develop these resources and capability profiles has gained emphasis. Resource picking and capability building are often highlighted as two such mechanisms that lead to the creation of these profiles (Makadok 2001).

Development of resource profiles: Resource picking versus capability building

The resource-picking mechanisms define the *selection* of the valuable resources while capability-building processes relate to the *management* of these resources (Makadok 2001). For the former, the superior Ricardian rents accrue to the firms that are able to ex ante discern the marginal productivity of a resource in combination with current stock of firm resources and acquire them for a price less than this value (Barney 1986). Alternatively, the capability-building perspective, based on the Schumpeterian view (Schumpeter 1950), proposes that superior rents accrue because of the firm-specific capability-building processes that transform these resources to enhance firm productivity (Makadok 2001).

Recently, the capability-building perspective has gained greater traction with researchers as critical firm resources are often not available in open markets. These imperfect factor markets thus challenge the assumption that valuable resources can be *picked* from the open market. Certain resources, as know-how and reputation, have to be developed in house (Teece 1976, 1980; Dierickx and Cool 1989). Also, since all the firms

have access to same resources, a firm can gain competitive advantage through its ability to pick valuable resources. Thus, resource picking assumes that the firm has the *ability* to discern ex ante the ex post marginal value of the resource to the firm. For example, the firms' ability to acquire a balanced portfolio of IT resources requires superior capabilities for picking these at a price less than their value to the firm (Wheeler 2002; Feeny and Wilcocks 1998). These arguments indicate that resource-picking itself may be dependent on the superior managerial capabilities that distinguish the firms' ability to pick resources. Thus resource-picking does not address firm heterogeneity and does not address the mechanisms for use of the resources. On the other hand, capability-building perspective is different from resource picking, and addresses the dynamics in deployment of resource instead of focusing on their selection. For example, Amit and Shoemaker (1993: 35) assert:

"*Capabilities*, in contrast, refer to a firm's capacity to deploy *Resources*, usually in combination, using organizational processes, to affect a desired end. They are information-based, tangible or intangible processes that are firm-specific and are developed over time through complex interactions among the firm's *Resources*."

Capabilities are very specific to the resource combination used in their creation and hence may be particular to a firm. Since the motivation in this research is to study these value-creating principles to highlight firm heterogeneity in the use of IT, the capability-building perspective is adopted as the guiding framework for this research. We next elaborate on the dynamics related to the creation of organizational capabilities.

Organizational capabilities

Contemporary research in organizational strategy has defined various concepts that capture distinctive organizational abilities which are antecedents to superior performance.

These abilities have been defined through various notions such as competencies, capabilities, or routines, and have become sine-quo-non to the organization of modern day enterprise. The prime impetus for this newer conceptualization of organizing is the increased complexity in internal operations and a very rapidly changing external environment. These concepts highlight the evolutionary nature of firm activities and are markedly different from the resources that are assumed to be isolated determinants of value. It is assumed that the value of these resources is determined ex ante. However, modern organizations realize value only after the resources are acquired. Value-realization involves deployment of these resources in combination with other resources and organizational processes. The evolutionary concepts capture different aspects of the dynamics of this phenomenon. For example, Selznick (1957, 1996) has argued for the presence of 'distinctive competencies' that create a sense of common goal and purpose. Nelson and Winter (1982) proposed organizational routines for knowledge creation by combining tacit knowledge through path-dependent learning mechanisms. Similar arguments about the evolutionary nature of performance had been explored in the concept of absorptive capacity by Cohen and Levinthal (1990); combinative capabilities by Kogut and Zander (1992); and most recently, dynamic capabilities by Teece et al. (1997). Based on Nelson and Winter's earlier work on administrative and operational routines as self developing mechanism for organizational growth and performance, Teece et al. proposed the concept of dynamic capabilities. These were defined as 'the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments' (p.516). The proposed evolutionary arguments run counter to the neo classical assumption. The evolutionary and dynamic perspective refutes the notion of

deterministic and explicit organizational knowledge that can be ex ante modeled in the form of 'production function'. Similarly, the creation of value before the use of resources (as proposed by resource picking perspective) is also against the evolutionary view. Researchers have highlighted the role of complementarities as critical to explaining these arguments. Foss (1996) analyzes these evolutionary theories and suggests interdependencies (complementarities) as the key differentiating factor in these theories that challenged the independent nature of the factors proposed in neo classical view of the firm. Nelson and Winter (1982, p. 104) argue "skills, organizations, and technology are intimately *intertwined* in one functioning routine and it is difficult to say exactly where one ends and another begins." Similarly, Prahalad and Hamel (1990) in their description of core competencies note the presence of complementarities as "the collective learning in the organization, especially how to *coordinate* diverse production skills and integrate multiple streams of technologies'. The interaction between technology and organizational elements has also been theoretically framed in the concept of activity systems by Milgrom and Roberts (1990, 1995). Though the empirical testing of the effects is limited, it supports the existence of interdependencies. For example, Setia et al. (2006) found multiple interdependencies of technology with the organizations' initiatives as the source of superior value.

We build on an activity system perspective to explore the complementary processes that lead to the creation of superior capabilities and performance. This research is motivated to assess the importance of activity systems in realizing the impacts of information technology on performance. Next, we highlight the role of the

complementarities and other factors that contribute to the creation of organizational capabilities.

Capability building function

Teece et al. (1997) explain that the creation of capabilities is characterized by the firm-specific processes, positions, and paths.

"The competitive advantage of firms is seen as resting on distinctive processes (ways of coordinating and combining), shaped by the firm's (specific) asset positions (such as the firm's portfolio of difficult-to-trade knowledge assets and complementary assets), and the evolution path(s) it has adopted or inherited."

Firm's processes characterize the managerial and organizational paths in which things are done within the firm, and positions of the firm are related to their possession of current endowments of intellectual property, technology, complementary assets, customer base, and its external relations with the suppliers and customers. The organizations' learning mechanism may recursively follow the classical evolutionary mechanism of variation-selection –retention to build these dynamic capabilities (Zollo and Winter 2002; Helfat and Petrarf 2003; Grant 1996). A key insight from the research studying the development of capabilities (see Table 1) is that during capability building each firm uses different inputs of resources to develop specific capabilities. Helfat and Petrarf (2003) defined the timeline in the building of capabilities as a lifecycle of development. As each organization develops capabilities, it follows uniquely distinct pathways to combine resources during the capability-building lifecycle. The events in the lifecycle of a capability differ from the events in the other organization and hence the resulting capabilities are path specific.

Table 1: Key studies in business value and capabilities perspective

Study	Key findings related to capabilities perspective	Context of Study
Teece et al. (1997)	Firms leverage their current asset positions to develop and renew superior capabilities that enable them to maintain competitiveness	Reviews the different frameworks in strategy and the role of firm's asset positions and evolutionary and co-evolutionary paths in the creation of superior process capabilities.
Picolli and Ives (2005)	Complementary resources with other IT related resources and characteristics, act as barriers to erosion of firms competitive position	Review of and abstracts of 648 articles from strategy, management and IS literature
Sambamurthy, Bharadwaj and Grover (2003)	IT resources and capabilities influence firm performance through three significant organizational capabilities - agility, digital options and entrepreneurial action; and three strategic processes- capability building, entrepreneurial action and co evolutionary adoption.	Highlights strategic mechanisms by which IT interacts with key processes, and firm knowledge and relationships.
Rai, Patnayakuni and Patnayakuni (2006)	Supply chain integration, encompassing the integration of physical, information and financial flows between firm and its supply chain partners, results in significant and sustained firm performance especially in operational excellence and revenue growth.	Survey of 432 firms in the manufacturing and retail industries selected from a random drawing of attendees of the Council of Logistics Management's (CLM) annual conference.
Eisenhardt and Martin (2000)	Dynamic capabilities are well-identified processes that are idiosyncratic in nature and path dependent in formation. These have significant commonalities across firms and are created through the learning mechanisms.	Based on the resource based view develops the concept of dynamic capabilities and analyzes the differences in their characteristics in different market dynamics.
Malhotra et al. 2005	Studies the complementarities between the Inter-organizational process mechanisms and partner interface directed information systems and their impact on the firm's absorptive capacity in the context of supply chains.	Exploratory study conducted in the context of RosettaNet consortium and used cluster analysis to characterize five different supply chain partner configurations (collectors, crunchers, connectors, coercers and collaborators.)
Banker et al. 2006	Studied the impact of three categories of manufacturing IT systems - resource planning systems (RPS), Operations management systems (OMS; and electronic data interchange system (EDI) on the firms JIT and customer and supplier partnering capabilities.	Analysis of survey, conducted by Industry Week and Price Waterhouse Coopers Consulting, of 1077 U.S. manufacturing plants in the standard industrial classification (SIC) code 20 to 39, and which employed over 100 people.

Table 1 (Cont'd)

Zollo and Winter (2002)	Proposes a structure for the formation and evolution of dynamic capabilities through the co evolution of three dynamic mechanisms: tacit accumulation of past experiences, knowledge articulation, and knowledge codification processes.	Draws from both the behavioral and cognitive traditions in organizational learning studies.
Makadok (2001)	Analyzes two strategic mechanisms of resource picking and capability building and their potential in creation of economic rents.	Develops a theoretical analytical model to analyze the conditions under which the two mechanisms are complements and substitutes.
Grant (1996)	Develops a knowledge based theory of organizational capability and highlights the mechanisms by which the knowledge is integrated within firms in order to create these capabilities	Builds upon the research into competitive dynamics, the resource based view, organizational capabilities, and organizational learning to explore development of 'dynamic' or 'flexible response capabilities' in hypercompetitive markets.

Paths to capabilities

The capability-building processes follow unique and idiosyncratic paths as they evolve in organizational work. Often three perspectives are used to explain the nature of the organizational action that creates these paths - rational actor perspective, situational control, and emergent perspective (Pfeffer 1982). According to the rational actor perspective, people and organizations exercise free choice after evaluating alternative course of actions. Situational control perspective argues that people and organizations behave in certain ways due to individual external forces and events. The emergent perspective argues that the behavior emerges in dynamic interactions between actors' internal motives and external circumstances. Building on these perspectives, it has been argued that the impacts of IT on organization are emergent in nature (Markus and Robey 1988). In the context of IT systems, Markus and Robey identified the first two

perspectives as technological and organizational imperative respectively. Both the views are deterministic in nature. The determinism implies that knowing the nature of the technological and organizational elements one can predict the transformation that will occur by the induction of technology. However, Markus and Robey, using the third perspective, argue that the transformation is emergent in nature and hence can not be predicted. Thus, IT transformation in organization is specific to the order in which these events emerge (path specific).

This path specificity is influenced both by the nature of the organization and the technology, the dynamics of which have been explained as the duality of technology by Orlikowski (1992). Orlikowski suggests that while the organization changes the form of the IT artifact, the artifact changes the form of the organization and a new overall system emerges as a result of the interaction between the two. Further, Orlikowski defined interpretive flexibility as the degree to which the users of IS are involved in its constitution during its development or use. The lesser the interpretive flexibility, as is common with most of the off-shelf supply chain applications bought by the organization, the greater the significance of idiosyncratic individual and organization actions in adoption of these systems to organizational processes.

Individual appropriation of technology and enactment to work either supports the existing way of doing things (inertia), applies the IT to augment the way things were done (application), or substantially alters the way of work (change) (Orlikowski 2000). While the appropriation mechanisms are at the level of the individual, they critically impact the organization's structure of signification (meaning), structure of domination (power), and structures of legitimation (norms) (Orlikowski 2000, Scott

2001). Thus the studies of paths by which IT systems are used in the organizations involve an individual-level analysis to understand the organizational impacts.

Also, researchers have concluded that the scientific measurement of path-specific phenomenon lends itself to an interpretive analysis, and the emergent change characterized through these paths is essentially measured using the process theories (Markus and Robey 1988). Due to these reasons, individual level of analysis, and process theory approach the processes (or paths) by which IS capabilities are created is *not* studied in this research. This reduces the functional form in (1) to $C_H = F_{CPB}(IT, Cm)$[1].

We next develop the individual components of the capability-building function starting with the resources that are complementary to the IT resources.

Complementarities

As noted before, the central notion in the development of capabilities is an activity system. Helfat and Petraf (2003) elaborated that capability building involves a team working with a set of inputs that are processed into unique capabilities. Other researchers have proposed the interdependence between the inputs and defined these inputs as complementary for the activity system. These complements are defined to have super additive synergies with each other. Formalizing the notion, Milgrom and Roberts (1995, p.181) define complementarities to exist between two things when "doing *more* of one thing *increases* the returns to doing *more* of another" (Italics in original). Thus, firms

[1] While the paths are excluded from the capability creation function being studied in this research they are indeed important parts of firms' capabilities. The argument that being specific to the organization the study of path is not generalizable is also not a strong one as the findings have been often generalized in the form of core lessons learned. For example, Clark et al. (1997) in their study of the creation of center of excellence for superior IS performance, define these paths in the form of lessons learned that include - use a "jump" approach, don't waiver from the vision, and manage employee anxieties - amongst others.

possessing these complementary resources not only see an additive value that is the sum of value due to these individual resources, but they realize incremental returns over and above this additive value (Wade and Hulland 2004; Tanriverdi 2006). In the presence of a complementary resource, overall value of the key resource is greater than the sum of the two (super additive value). However, it is not the value but also the cost function that may be suppressed due to the presence of the two complementary resources (sub additive costs) (Tanriverdi 2006). The complementary argument is also stated as the increase in marginal returns to a resource due to the presence of a complementary resource (Amir 2005: 638; Milgrom and Roberts 1995). The complementarities have been found in various domains of organizational phenomenon and include the interactions of related human resource practices (Ichinowski et al. 1997), debt and equity (Stenbacka and Tomback 2002), and plant inspection and supply inspections (Mayer et al. 2004) (also see Table 2).

Similar to the strategic literature, the notion of complementarities has been found to be widely applicable in the IS research. After findings of missing direct impacts of IT on firm performance, researchers have proposed that complementarities of IT with related organizational resources are essential to realize performance impacts (Barua and Mukhopadhyay 2000). In the initial application of complementarities to modern day organizations, Milgrom and Roberts (1990, 1995) found that the shift from mass production to lean manufacturing systems through adoption of computer based systems for production (as CAD, CAM, CIM et al.) led to a discontinuous change in the firms' activity systems. This often resulted in loss of performance as firms grappled to fit their existing human resource, production, and marketing strategies in the new production

paradigm. The many failures, as that of the General Motors (GM), were later analyzed to be due to the fact that complementary synergies in the related organizational resources were not addressed (Milgrom and Roberts 1995). The complementarities have since then been found between the firms with multi-business units (Tanriverdi 2006), shared knowledge and IT (Ray et al. 2005), flexible manufacturing systems, and organizational strategy and structure (Parthasarthy and Sethi 1993) (see Table 2). Complementary investments in organizational structure, strategies, and human resource practices have thus been proposed to be sine-qua-non for realizing the benefits of IT applications (Barua and Mukhopadhyay 2000; Wade and Hulland 2004; Milgrom and Roberts 1990, 1995)

The underlying theoretical rationale for the presence of the complementarities is that of synergy. Two resources with superior synergy are able to create super additive value, which is greater than the sum of the value created by each resource individually. Two different approaches are evident in the research evaluating these synergies between the resources. The first approach builds on the contingency/moderation perspective and proposes the interaction between distinct organizational variables (Oh and Pinnsoneault 2007; Donaldson 1996). The second approach studies the complementarities between whole configurations instead of the individual elements of these configurations (Sinha and Van de Ven 2005; Whittington et al. 1999; Drazin and Van de Ven 1985). While having a strong logical appeal, the application of second approach is valid only in the presence of holistic configurations that may be characterized as ideal types (Sinha and Van de Van 2005). Since most organizational phenomena are not pure arch types, the contingency approach has been the preferred choice of the researchers (Banker et al.

2006; Rai et al. 2006). Thus, following the general consensus, we model the complementarities as contingent interactions.

Table 2: Studies that elaborated and test the complementarities in organizational phenomenon

Study	Findings of complementary effects	Context of Study
Milgrom and Roberts (1995)	Proposes the fit between the firm's strategy structure and managerial processes. Develops on the notion of edgeworth complements and formalizes the supermodularity using lattice theory.	The shift of firms manufacturing systems from mass production to modern lean or flexible manufacturing
Parthasarthy and Sethi (1992)	Superior firm performance results when the firms strategy and choice of organizational structure are congruent with the competencies and constraints of the technological choices	Study of the advanced manufacturing technologies as CAD, CAM, automatic storage and retrieval systems and CIM.
Parthasarthy and Sethi (1993)	Empirical test of the differences in fit and hence the complementary effects of the firms manufacturing systems with its structure and strategy.	Flexible automation systems and different strategy type (quality leadership, flexibility leadership or low cost), structure (mechanistic or organic), shop floor personnel skills (specialized or diversified), design manufacturing workflows (sequential or parallel), and project teams and workgroups (rarely used versus often used)..
Milgrom, Quan and Roberts (1991)	Complementarities amongst a group of core activities and processes can account for emergence of persistent patterns of change even without usual assumptions about economies of scale	Develops on momentum theorem as the theoretical basis for developing the propositions.
Whittington et al. (1999)	Complementarities link contingencies to configurations. Beyond the reductionist one to one fit, firms realize greater effectiveness by simultaneously synchronizing multiple elements in the organizational domain.	
Ichinowski, Shaw and Prennushi (1997)	Several elements of high performance human resource practices are mutually complementary	Individual and team based incentives, extensive screening of new employees, employment security, job rotation and flexibility and labor communication are some of the HR initiatives evaluated.

Table 2 (Cont'd)

Ray, Muhanna and Barney (2005)	Complementarities between the shared knowledge and the technical IT skills, generic information technologies and level of IT investments differentiate the performance of firms' customer service processes	Survey data collected from matched sample analysis of respondents from 72 firms in health and insurance industry with over 100 employees.
Tarriverdi (2006)	Studies the relatedness and complementarities between multiple units in a firm. Use of common IT infrastructure technologies and IT management practices (relatedness) leads to sub additive cost synergies while complementarities between the two leads to super additive value synergies.	Analysis of data from 356 multi-business fortune 1000 firms.
Siggelkow (2002)	Studies the impact of misperceptions between the interconnected activities and finds that the misperceptions for complements are more costly than those for interactions amongst substitute products.	Theoretically models the impact of bounded rationality of decision makers, outdated mental models, and parochial interactive systems in tightly coupled systems.
Nambisan (2002)	Studies introduction of three complementary product integration strategies - value-added internal, add-on module and data interface- and their impact on a firms ability to integrate their new offering with the new and emerging complementary products.	Empirical analysis of data from 83 U.S. vendors of software development tools with an average of 11 million dollars in sales and 41 employees.
Stenbacka and Tombak (2002)	Studies the complementarities in the debt and new equity instruments of financing	Theoretical model followed by an empirical analysis of financial data for the eleven years from 1982-1992 on 3,119 publicly traded manufacturing and telecommunication firms in Standard and Poor's COMPUSTAT database.
Mayer Nickerson and Owan (2004)	Fins that 1. When the buyer cannot credibly commit to the intensity of his supply inspection, supply inspections and buffer inventories are complements of each other, but plant inspections are substitutes for these. 2. Supply inspections can increase the efficacy of plant inspection or vice versa (complementary effects) even if there are direct spillovers in learning.	Qualitative and quantitative analysis of 122 supply contracts from a large biotechnology firm in the San Francisco Bay area.

IT created organizational capabilities

The research in the information systems domain has identified IT as one of the key resource input in the capability-building processes of the firm. These created capabilities are the source of superior competitive advantage for the firm since they help

the firm acquire unique and valuable resource configurations for both the short and long term (Eishehardt and Martin 2000).

Our review of the literature is of the studies that use information technologies as an input to the capability-building process. The resulting capabilities are usually very different in nature. The literature on the capabilities to manage these information technologies suggests three different output capabilities that are created using the above proposed function (see equation 1), with IT as the key input resource (Rai et al. 2006; Banker et al. 2006; Sambamurthy et al. 2003; Feeny and Wilcocks 1998; Weill et al. 2002; Clemons and Row 1991). Specifically, IS capabilities, functional (supply chain) and process capabilities, and strategic capabilities are the three output capabilities that we now elaborate upon. The key distinction between these capabilities is the organizational domain to which the capabilities contribute in terms of resource development. Further, each capability differs from the other in terms of input paths, processes, and complementary resources that lead to its creation. We next review the studies and highlight these differences in these capability functions.

IS capabilities

IS capabilities are defined as the firms' ability to mobilize and deploy IT-based resources in combination or co-present with other resources and capabilities (Bharadwaj 2000). These IS capabilities help in superior management of IS activities and may include system design and software development, management of outsourced software development projects, planning of information assets, managing system implementation projects, and management of portfolio of IT assets (Zmud 1984; Feeny and Wilcocks

1998; Levina and Ross 2003; Ross et al. 1996). The notion of IS capabilities has gained increased emphasis in recent research studying business value of information technologies. This is primarily due to findings of missing impacts of IT on firm performance (Brynjolfsson and Hitt 1993). Dubbed the productivity paradox, the paradigm of missing impacts of IT has led the researchers to do an in-depth examination of the IS capabilities in the organizations. Firms with higher IS capability were found to outperform the firms in the control sample over many of the cost and profit related measures (Bharadwaj 2000). The capability-building function defined above differentiates IS capabilities from the IT assets. IS capabilities are superior abilities that help in the management of IT assets. We next review the literature that has studied the creation of IS capabilities.

The research studying the Information system capabilities has been largely focused on identification of IS capabilities that would influence the superior business performance. For example, Feeny and Wilcocks, building on the earlier work (most notably on CIO's assessment of IS capabilities (Earl and Feeny 1994; Feeny et al. 1992), IT imperatives in organization (Rockart et al. 1996), and the role of in-house IS function on outsourcing (Lacity et al. 1995)), describe nine core IS capabilities that encompass the three domains of business and IT vision, design of IT architecture, and delivery of IS services. These nine IS capabilities: 1.IS/IT leadership, 2. business systems thinking, 3. relationship building, 4. architecture planning, 5. making technology work, 6. informed buying, 7. contract facilitation, 8. contract monitoring, and 9. vendor development, span the strategy and enactment initiatives in the policy design, application, and delivery of the IS systems. Bharadwaj et al. (1998) conceptualized IS capability as the second-order

construct that is reflected in the six abilities of a firm measured as first order factors – IT business partnerships (IBP), external IT linkages (EIT), business IT strategic thinking (BIT), IT business process integration (BPI), IT Management (ITM), and IT Infrastructure (INF). Keen (1991) has associated two IS capabilities with the IS infrastructure - that of reach and range. Byrd (2001) defined IS infrastructure flexibility as the capability for connectivity, compatibility, and modularity of IT applications possessed by the firms. Clark et al. (1997), in their study at Bell Atlantic, looked at the change-ready capabilities to deliver IT based products, services, and business applications with short development cycle times. They found that these IS capabilities were ably supported by the superior design of the organizational structure, groupings of people including their roles, relationships and task assignments, and incentives and reward systems based on client evaluations (Clark et al. 1997). Others researchers have defined the hierarchy of IS capabilities in the order of increased architecture maturity (Ross 2003). These activities range from the application-focused silo capabilities to enterprise wide IT architectures, followed by data and process centric IT architectures, and finally modular architectures to support global standards with local differences.

Recent research has focused attention on the development of capabilities to manage the portfolio of IT investments. Initially proposed by Macfarlan (1981), portfolio management has most recently been espoused by Weill and Aral (2006). They define four categories of IT investments: infrastructural, informational, transactional, and strategic.

Weill and Aral (2006) call for organizations to manage the portfolio of IT applications through appropriate categorization. These categories of technologies may then be assessed differently. Weill and Aral propose to use discounted cash flow

methodology to assess their impacts. Likewise, organizations have started initiatives such as project management office whereby they develop various methodologies to better manage IT projects. However, not much research has looked at the idiosyncratic paths that impact these project management and portfolio management capabilities. Also, more organized works need to be done in highlighting the antecedents and elaborating on the fit in the nomological network of these IS capabilities. In this research we differentiate IS capabilities from strategic and functional and process capabilities, and our focus is on the application rather than the development of these IS capabilities.

Strategic capabilities

The role of IT in creation of strategic capabilities follows a business paradigm where proprietary information technologies were a source of competitive advantage for the firms. Due to their rare, inimitable, non-substitutable, and valuable characteristics, information systems as American Airline's SABRE, (Cash and Konsynski 1985; Hopper 1990) and American Hospital Supply's ASAP (Vitale 1990) by themselves were sources of superior competitive advantage. However, with the ubiquitous nature of information systems, IT resources are no more rare, inimitable, or non-substitutable. Researchers have thus highlighted the need to focus on the capabilities perspectives to study assimilation in the organizational processes of IT in combination with complementary resources and through idiosyncratic paths (Clemons and Row 1991).

One stream of research has studied the role of IT in strategic capability development and it has used the transaction cost theory as its basis. According to the studies in this stream of research, the governance mechanisms – market based or internal

to firm - entail different transaction costs (Coase 1937; Williamson 1975). IT systems help firms decrease these transaction costs (Gurbaxani and Whang 1991). Three IT effects are especially pertinent for the decrease in transaction costs: 1. Electronic communication effects – reduced communication costs and increased reach (time and distance), 2.Electronic brokerage effects –decreased cost of transactions and increased number and quality of alternatives, 3. Electronic (process) integration effects – increased degree of interdependence between participants in sequential business processes. Zaheer and Venkataraman (1994) applied this transaction cost analysis to find empirically-strong support for the impact of asset specificity and trust on the degree of electronic integration (defined as a form of quasi vertical integration) between partners. The impact of reciprocal investments, while positive, was found to be only weakly significant.

Besides the transaction costs approach, strategic capabilities have also been studied using the value chain perspective as well. Porter and Miller (1985) gave the guidelines for applying the value chain perspective to development of strategic capabilities from the information systems by adding value to a firm's value chain offerings. Lindsey et al. (1990) empirically studied the role of TELCOT system at Plains Cotton Cooperative Association (PCCA) to strategically enhance the value of firm's offerings. The system helped PCCA to replace the phone as a means to seek bids for its cotton. The electronic market, so established, helped move PCCA from being a merchant to a broker. The increase of information content to its products helped it to move up the value chain and offered a great strategic capability to PCCA.

Similarly, Beath and Ives (1986) developed a framework to classify the various information systems and their strategic advantage to the firms' pricing processes. These

strategic capabilities were proposed to be created due to the timeliness, content, and format of the information that were impacted by the information systems technology.

Finally, researchers have studied organizational processes that lead to the creation of these capabilities. Clemons and Row (1991), building on Teece's (1986) work on economics of innovation, defined the creation of these strategic capabilities to be due to the combination with the complementary resources. While IT was proposed to lower the cost of vertical and horizontal firm transactions, it is only in combination with the complementary resources that affect the value of the coordinated resource and occurs through economies of scale and scope. Equating flexibility with real options, Tallon and Kraemer (2003) found significant impact of IT flexibility, a lower-level capability, on creation of higher order strategic flexibility. Similarly, both IT and strategic flexibility were found to be the lower-order capabilities that lead to the creation of higher-order capability of strategic alignment (defined as fit between the information systems and business strategy).

Allen and Boynton (1991) approached the strategic role of information systems from the perspective of efficiency and flexibility and defined the development of two types of capabilities – low road and high road. The former espouses a more diffuse role of IS in the organization while the latter is associated with building a more central and independent IS architecture. IT has also been found to be an essential ingredient to creation of pre-empting capabilities (Kettinger and Grover 1994), enhancing stickiness by building greater switching costs (Bakos 1991; Feeny 1988), and developing flexibility (Kettinger and Grover 1994) and response capabilities (Feeny and Ives 1990).

Recent research has highlighted the role of IT resources and capabilities in creating lower-order digital options and higher-order agile capabilities (Sambamurthy et al. 2003). Based on the entrepreneurial processes and options perspective, Sambamurthy et al. suggest that IT systems, along with the complementary processes, have superior strategic impacts . Superior managerial and entrepreneurial processes are suggested to be responsible for the firm realizing the value by appropriately selecting and performing these strategic actions. Also, Weill et al. (2002) studied the impact of lower-order IT infrastructure capability demand on strategic agility. The role of IT in creating other strategic capabilities has also been studied for environmental scanning and market responsiveness (Weill and Vitale 2001), fulfilling information requirements (Roberts and Wood 2002), and flexibility (Monteiro and Macdonald 1996).

While strategic capabilities have been well researched using the various perspectives elaborated above, information systems themselves are no more restricted to the strategic realm and are an important part of the other organizational activity systems. Recent research has thus focused on the contributions of IT to various functional departments and processes. In line with this increasing trend, the focus in this research is to study the creation of process capabilities.

Organization's functional and business process capabilities

In the literature, the third type of capability created by the IT resources is related to a specific functional area or a business process. These capabilities are specific to the context in which the IT applications are implemented. Similar to the IT systems, the various complementary factors, paths, and processes are also idiosyncratic to this context.

The notable work in the area of functional and business process capabilities has looked at the customer service processes, new product development, and supply chain capabilities (Ray et al. 2005, Barua et al. 2004, Rai et al. 2006; Pavlou and Sawy 2006).

For example, Pavlou and Sawy (2006) studied the role of IT in creation of competitive advantage in new product development (NPD). They studied IT-leveraging competencies in NPD due to the effective use of process/resource management, knowledge management, and cooperative work systems. These IT-leverage competencies were found to impact reconfigurability (measured as absorptive capacity, market orientation, coordination capability, and collective mind). Reconfigurability is defined by them as an NPD capability that leads to the NPD competencies which are customer-related, technical, and managerial in nature.

In the domain of supply chains, Rai et al. (2006) studied the role of integration of firm's financial, physical, and information flows with that of the partners. They found that the integration of data consistency and cross functional application integration led to the creation of the functional capability – supply chain process integration, that is determined by the extent of financial, physical, and information integration of the firm with its partners. After controlling for consumer demand predictability and firm size, this supply chain capability was found to lead to superior operational excellence and revenue growth. Similarly, Banker et al. (2006) studied two capabilities in the firm's manufacturing operations. In their longitudinal study, they found the impact of three categories of information systems - resource planning systems, operations management systems, and EDI - on Just-in-time (JIT) and customer and supplier partnering capabilities.

Supply chain absorptive capability is another capability that has been studied in the firms' supply chains. Malhotra et al. (2005) found the positive impact of partner interface directed information systems in creating absorptive capabilities in firms' supply chain. The study, conducted in the Rosettanet consortium, found that these information systems implemented along with the inter-organizational process mechanisms lead to enhanced capability of the organization to absorb knowledge due to greater externalization, internalization, socialization, and routinization. Similarly, Barua et al. (2004) examined the customer and supplier side digitization of supply chains and elaborated on their role in the creation of organizational information capabilities. Mass customization is another capability that has been studied in the context of firms' supply chains (Kotha 1995; Pine 1993)

These process level capabilities assess the firms' ability to act rapidly and effectively and enhance process performance (Teece et al. 1997). Agility of the organization has more recently been identified as one such capability that helps firm to sense and respond to changed business conditions. In this research, our focus is on this capability that helps the firm to respond with speed and effectiveness to the changes in customer demand.

To summarize, while IS capabilities focus upon the management of various tasks performed by IS professionals, strategic capabilities are rooted in the resource based, Schumpeterian, or competitive analysis views (Porter 1980, Barney 1991, Schumpeter 1934). On the other hand, functional and process capabilities address the IT impact from the perspective of an activity system. Thus, each functional area or process has an interlinked set of activities that need to be synchronized with the information

technologies for the creation of superior performance. Often these activities are organized within a function or a business process. Various functions and processes that have gained attention of IS researchers in the recent past include customer service processes (Ray et al. 2005) and new product development processes (Pavlou and Sawy 2006). In this research, we study how the use of IT enhances the firm's ability to respond to customer demand changes.

Supply Chain Processes

The supply chain organization encompasses the management of the set of activities of the firm that include logistics (Simchi-Levi, Kaminsky, and Simchi-Levi 2000), procurement (Moncska, Trent and Handfield 1998) or operations management, and the interface of these activities. Various process frameworks are defined to comprehensively envisage the set of supply chain activities (Lambert et al. 2005; Bowersox et al. 2006; Srivastava et al. 1999).

Supply chain process frameworks

The identification and definition of the processes in these frameworks is closely linked to the definition of the supply chains adopted by them. These definitions of the supply chain systems differ in terms of the *scope* – the extent to which it supports the organization's corporate strategy; *intra and inter company connectedness* – the degree of formal and informal contact amongst employees across the departments and with the supply chain partners; or *the source of value addition* - either through reduction in

operating cots, reduction in working capital, increase in asset efficiency, or by increasing revenue (Lambert et al. 2005).

For example, while the Global Supply Chain Framework (GSCF) is strategic in nature and espouses relationship management and cross functional integration to enhance the overall EVA, the Supply Chain Operations Reference (SCOR) framework is more transactional in nature and aims to minimize cost and maximize asset utilization (see Lambert et al. 2005 for more detailed comparison). This distinction in these frameworks is reflected in the nature of the identified processes and sub processes. We included the three frameworks for supply chain processes proposed by GSCF, and SCOR. The description of the process is similarly also given in Bowersox et al. (2006). Besides these, two other frameworks were developed by Srivastava et al. (1999) and Melnyk et al. (2000), but as pointed by Lambert et al. (2005), both of these do not have enough description of the processes and hence are not considered further in the study.

GSCF: Global Supply Chain Forum

Global Supply Chain Forum was started in 1994 by executives from a group of multi-national companies who developed a definition of supply chain management. According to GSCF, supply chain management is "the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders" (Lambert, Cooper, and Pagh 1998, p. 1). Three primary elements are defined for the implementation of these into the supply chain organizations: the supply chain network structure, the supply chain business processes, and the management components. The supply chain network structure

is comprised of the member firms with which key processes are to be linked. The GSCF proposes 8 different business processes (see Table 3).

Table 3: Description of the GSCF Processes

Customer Relationship Management - provides structure for development and maintenance of relationships with customers (Croxton et al. 2001).
Customer Service Management - helps firms to develop a single point of contact for providing information to customers and for administering the product service agreements (Bolumole, Knemeyer, and Lambert 2003).
Demand Management - provides supply chains with structure for managing customer requirement and includes reduction of demand variability and increase of supply chain flexibility (Croxton et al. 2002).
Order Fulfillment - develops a structure for fulfilling customer requirements and includes network design to meet customer requests at minimum total delivered cost (Croxton 2003).
Manufacturing Flow Management - activities necessary to obtain, implement and manage movement of products through the plants in supply chain (Goldsby and Garcia-Dastugue 2003).
Supplier Relationship Management - helps define activities to develop and maintain relationships with suppliers (Croxton et al. 2001).
Product Development and Commercialization - defines activities for the joint development of new products with the active participation of suppliers and customers (Rogers, Lambert, and Knemeyer 2004).
Returns Management - defines the management of activities related to reverse logistics including gate keeping, and avoidance (Rogers et al. 2002).

Each of these processes is further divided into a set of strategic sub-processes. These sub processes -provide more details for managing the processes and specify a set of operational sub-processes for implementation of each. These sub-processes are at the

level of specific activities that need to be undertaken by the firm. The GSCF framework also includes the management components - planning and control, work structure, organization structure, product flow facility structure, information flow, management methods, power and leadership structure, risk and reward structure, and culture and attitude - that support the processes (Cooper, Lambert, and Pagh 1997).

SCOR: Supply Chain Operations Reference

The SCOR framework was developed by the Supply-Chain Council (SCC), a nonprofit organization that was founded by Pittiglio, Rabin, Todd, and McGrath (PRTM), a consulting company, and AMR Research in 1996. Initially, SCOR included four business processes: plan, source, make, and deliver, and added Returns, as the fifth process in 2001. These five processes defined by SCOR are as described in Table 4.

Table 4: Description of SCOR Processes

Plan - development of a roadmap to match demand with supply. The plan specifies the course of action for meeting sourcing, production, and delivery requirements.
Source - activities that are related to the procurement of goods and services to meet planned and actual demand.
* Make - activities that help produce goods and services to meet planned or actual demand.
* Deliver - provides finished goods and services to meet planned or actual demand, typically including order management, transportation management, and distribution management.
* Return - activities related with the returning or receiving returned products.

SCOR defines four level of details for each of these processes (Bolstorff and Rosenbaum 2003; Supply-Chain Council 2003). At Level one is defined the number of supply chains as well as metrics to be used. Planning and execution processes in material flow are defined at level two. Inputs, outputs, and flow of transactional element are defined at level three and level four defines the implementation details of these supply chain processes.

According to the SCOR model, each process is associated with three components: business process reengineering, benchmarking, and analysis of best practices (Supply-Chain Council 2003, p. 1). The three components help the firms transform their supply chain processes to the next stage. Business process reengineering (BPR) helps define the current state of process and this forms the basis for transformation of this process. Benchmarking helps develop the metrics of performance for the proposed transformation, and the best practices analysis studies and identifies management practices and software solutions of the successful performers and helps the firm to match them in the transformation.

Another process model by Bowersox, Closs, and Stank (1999) (that was further developed by Melnyk, Stank, and Closs (2000)) proposes eight supply chain processes - Demand Planning Responsiveness, Customer Relationship Collaboration, Product/Service Development Launch, Manufacturing Customization, Life Cycle Support, Order Fulfillment/Service Delivery, Supplier Relationship Collaboration, and Reverse Logistics.

The processes are not all executed in parallel and often can be temporally ordered. This is because of the linearity nature of products and services conversion from raw material stage to consumption phase. Shapiro et al. (1992) elaborated this linearity in their description of the order flow throughout the organization. Thus, as summarized by the SCOR framework, the organizations start with the planning phase. It is at this phase that the firm interacts with its customers. Often, given less emphasis in the contemporary research although repeatedly emphasized in the theoretical works, the demand planning process is the context of study for this present research. The process is highlighted to be critical in all the three frameworks.

Also, in our analysis we view these processes from the focal firms' perspective. The alternate is to study processes from the point of origin to the point of consumption. This latter view does not recognize the firm boundary to be delimiting and views the overall supply chain network as the level of analysis. However, since our focus is on the firm level heterogeneity and capability-building processes, we adopt the firm level rather network view and study the supply chain processes at the focal firm.

Demand management process

The management of customer demand in an organization poses extreme challenges. These challenges mostly arise because demand management entails coordination and collaboration between different entities both inside and outside the firm. The interface of multiple influences within supply chain and marketing or production often creates scope for errors in meeting customer demand, due to lack of communication. Lee (2001) defines an insightful example to elucidate the complexities involved in activities related to demand management process. A few years ago, Hewlett-

Packard (HP) lost the sales of its Pavilion computer on Christmas as supply chain department did not realize that the marketing department has launched a promotional scheme to compete with offerings from its competitors - Compaq and Packard Bell. In this case, the lack of adequate communication between the supply chain and marketing departments led to lack of inventories and a big loss of demand for HP. Similar to the adverse impacts of lack of communication, the demand management may falter due to the lack of initiatives to align the production strategy of firm with that of its suppliers and share information within the firm. Similarly, Dell uses its internet based communication and collaborative work practices to coordinate with both the customers and suppliers to match the demand with the supply.

The organizations that are best able to counter the demand related challenges rely on both superior information technologies and business initiatives to coordinate and align demand with the supply. Further, they also use these technologies and initiatives in their external interaction. We categorize the use of these information technologies and initiatives across the two dimensions based on the following criterion: 1. Are these external to the firm or internal to it? 2. Are these related to the demand side (customer or marketing related) or supply side (supply chain, production related)? (see Figure 1). Next, we elaborate these four quadrants for both the business initiatives and information technologies.

Figure 1: Two dimensions of technologies and processes critical in demand management process

		Scope of Technology/ Initiative	
		Internal	**External**
Functionality	**Supply Side**	**Supply Chain Coordination**	**Supplier Information Sharing**
	Demand Side	**Demand Management and Marketing**	**POS Data Collection**

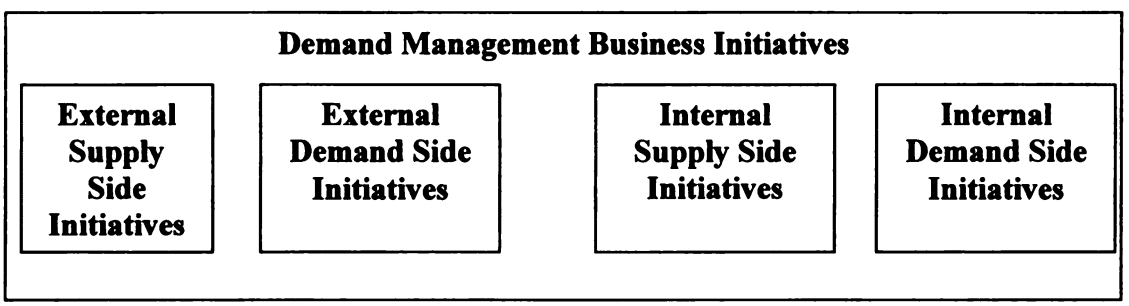
Demand Management Business Initiatives

Based on these two dimensions, we identify the four key demand-management initiatives (Figure 2):

1. Internal supply side initiatives – These initiatives include the activities related to internal coordination of supply. An example of these initiatives is integration of information related to production schedules, sourcing plans, route plans, and profit margins in assessing the planning and coordination of demand management activities. Similarly, incorporating changes in supply chain structures, such as inclusion of new

suppliers or plan capacities, as part of one's demand planning initiatives that are important for appropriate responsiveness from the firm is an example of internal supply side initiative. Similar to the acquisition of information, it is also important to share and coordinate information related to demand across the various function. Frequency of sales and operations planning (S&OP) done as part of joint planning between operations and marketing is another initiative that helps enhance the coordination efforts between the firms (Crum and Palmatier 2004, Lapide 2007). Finally, frequent sharing of demand-related changes with production, sourcing, logistics, and finance helps to enhance the coordination across functions.

Figure 2: Demand management initiatives that impact a firm's influence in meeting customer demand



2. External supply side initiatives – These activities are related to sharing information and planning with external suppliers. Given the key role played by the external suppliers in production of goods and services, information sharing with them is a critical aspect of a firm's ability to manage customer demand (Malhotra et al. 2005, Lee et al. 1997). The firms may share various types of information with suppliers,

including demand shifts, market demand changes, details of its upcoming products and services, and planned production outlays (Malhotra et al. 2005).

3. Internal demand side initiatives – These initiatives include the internal marketing related activities. Frequency with which a firm is able to integrate the information from its marketing department that aids demand planning is a critical aspect of creating demand projections and plans. Aiding the demand management related technologies is the information about the related marketing instruments such as promotions, special events, new outlets (Lee 2001), or marketing events, or information about competitor's activities, and newer substitutes that is often not revealed from the statistical algorithms used for planning and forecasting.
4. External demand side initiatives – These activities are related to the external customer related initiatives. These initiatives are primarily based on the information obtained from analyzing the data from customers and planning of demand based on this data. Some examples include automatic replenishment initiatives including vendor managed inventory (VMI), data collection regarding customer preferences and interests (Jaworski and Kohli 1993), sales insights into customer demands used to develop new products and services, and customize existing offerings.

Demand Management Information Technologies

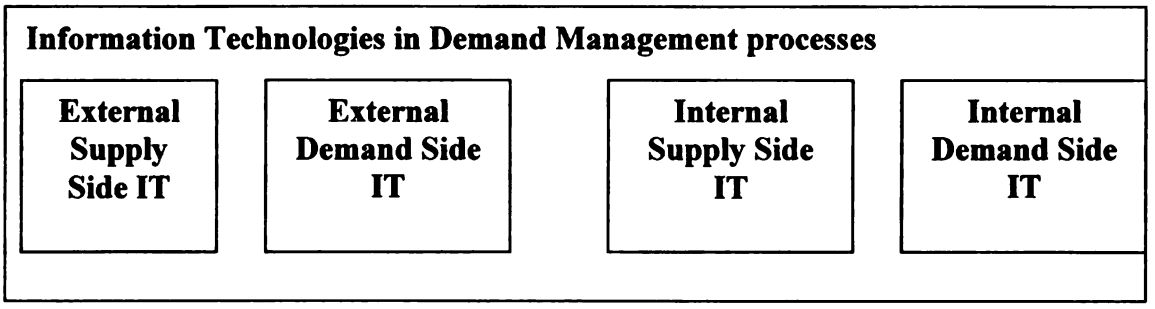
Technology plays an important role in coordination of activities within a firm (Gurbaxani and Whang 1991). Hence, we now examine the information technologies that are related to the four categories of initiatives discussed above. For each of the demand management initiatives, we evaluate matching demand management information

technologies (IT) (see Figure 3). These technologies, related to each of these initiatives, are:

1. Internal supply side IT (for coordination): Technologies can play an important part in the coordination of information across departments. Given the amount of information that needs to be coordinated, digital means are the best measures to accommodate the granularity and details of this information. The use of such information technologies for coordinating the information across the logistics, supply chain, sourcing, and finance functions is considered critical. In this research we assess the frequency with which the firm uses these information technologies to manage the customer demand through internal supply-side initiatives.
2. External supply side IT (related to sharing information with suppliers): These IT systems help firm to manage its demand management activities across its external suppliers, and technologies in this group include extensible markup language (XML), and electronic data interchange (EDI) for complete and real time visibility into the suppliers systems, partner related information systems, and group collaboration systems (Asgekar 2003)
3. Internal demand side IT (used for planning and forecasting demand). These technologies help integrate and bring in information from the firm's internal marketing department. These technologies, are critical for the development of responsive demand plans and include IT systems used for creating and changing products for new and short life cycle products, data mining, and scenario management,.

4. External demand side technologies (customer related). The technologies are used for bringing in the data from the customer outlets and include POS data collection technologies such as RFID, and Bar coding. (Fish and Forrest 2007)

Figure 3: Information Technologies used for demand management



Demand Management (DM) Agility

Agility has become an important organizational characteristic due to the rapidly changing organizational environment which calls for greater responsiveness of the firm. It is defined as "the ability to detect opportunities for innovation and seize those competitive market opportunities by assembling requisite assets, knowledge, and relationships with speed and surprise." (Sambamurthy et al. 2003; D'Aveni 1994).

Other related definitions of agility have been proposed since the construct is still in its initial stages of application to organizational phenomenon. For example, Sharrifi and Zhang (1999) define agility as "the ability to cope with unexpected challenges, to survive unexpected threats of the business environment, and to take advantages of changes as opportunities." Researchers studying agility have emphasized that firm's ability to respond is a key measure of agility (Dove 2001; Overby et al. 2006; Zaheer and Zaheer 1997). In this research we study the firm's response capabilities to meet customer demand as a measure of their demand management (DM) agility.

The agility of the organization is intricately linked with the agility of its order management cycle (Swafford et al. 2006; Shapiro et al. 1992). It is thus not surprising that agility in the firm's order management cycle or its supply chain is often studied as a critical part of the organizational agility (see Sambamurthy et al. 2003; Swafford et al. 2006). For example, Narsimhan et al. (2006) surveyed 354 manufacturing plants in two phases and did a cluster analysis to distinguish low, lean, and agile performers. They compared the adoption of various supply chain best practices across the groups and found that agile performers are at par with lean performer group on statistical quality control and benchmarking. However, these agile performers rated higher in the adoption of practices such as supplier-base rationalization, customer orientation, integrated product design, supplier development, manufacturing strategy integration, cellular manufacturing, supplier information sharing, supplier partnerships, strategic supplier selection, JIT flow, TQM, and workforce development.

. However, in supply chain literature, there has been more than proportional emphasis on the supply side agility. Particularly, wide research attention has been given to the manufacturing agility that is defined by the researchers at Iaccoca Institute of Lehigh University as "...A manufacturing system with extraordinary capabilities (Internal capabilities: hard and soft technologies, human resources, educated management, information) to meet the rapidly changing needs of the marketplace (speed, flexibility, customers, competitors, suppliers, infrastructure, responsiveness). A system that shifts quickly (speed and responsiveness) among product models or between product lines (flexibility), ideally in real-time response to customer demands (customer needs and wants)" Youssef (1992). Alternatively, manufacturing agility is also defined as the

"capability of an organization, that is developed by proactively establishing virtual manufacturing with an efficient product development system, to (i) meet the changing market requirements, (ii) maximize customer service level, and (iii) minimize the cost of goods, with an objective of being competitive in a global market and for an increased chance of long-term survival and profit potential" (Gunasekaran and Yusuf, 2002).

Agility has been associated with many related concepts, such as flexible manufacturing (Bolwijn et al., 1986), lean manufacturing (Womack et al., 1990), time-based competition (Stalk and Hout, 1990), and fast-cycle innovation (Tidd et al., 1997). Researchers have also emphasized that agility is related to the introduction of advanced information technologies and organizational initiatives in lean manufacturing. Swafford et al. (2006) differentiate agility (a capability that is externally oriented) from flexibility (a competency that is internally focused) and emphasize the latter to be an antecedent. However, the proposed distinction between competencies and capabilities is not so clear in the strategic management literature which has often used these concepts interchangeably. Williamson (1975) commented that it would be only with time that the meaning of these words will emerge distinctly. Further, other researchers have defined manufacturing and logistic flexibility to be a part of agility. Similarly, lean manufacturing practices and agile practices are often not so clearly differentiated. While some researchers have defined these to be antecedents in a firms strategy (i.e. being agile follows being lean), others have proposed that firms can follow both together (see Narsimhan et al. 2006). Yet others have termed the joint strategy as being 'leeagile' (Goldsby et al. 2003). To summarize, the manufacturing literature has defined agility to be arising of the newer paradigm of production and hence the comparisons are with the

traditional concepts of flexibility and lean production. While there has been considerable attention to agility in the manufacturing research, there is little attention to the concept of agility in the firms' demand side operations (Stank and Lackey 1997). In this research, we assess a firm's response to changes in customer demand as a measure of the agility of its demand management processes (Overby et al. 2006).

We propose demand management agility to be a measure of firm's responsiveness to changes in customer demand. We propose a more holistic view that transcends the focus on manufacturing, and instead focuses on the agility in demand management operations.

Further, the temporal dimension forms the basis of our conceptualization of DM agility. Three different types of DM agility are studied based on the timing of the firm's response.

Adaptive, Resilient, and Entrepreneurial

While agility is the overall ability to have superior response mechanisms to defend or gain enhanced competitive advantage due to changes in business environment, it is the timing of the response that differentiates the three kinds of DM agility. Our assessment is based on timing of the events that affect demand for a firm's products. The APICS framework defines these three time periods based on the time at which the event occurs in the firm's production cycle (Crum and Palmatier 2004). Our conceptualization of DM agility is with reference to these three time periods. We contend that the overall DM agility is a sum total of these three components i.e. firms with high values for these three types will have greater demand management (DM) agility.

The adaptive DM agility assesses the firm's response to the events that occur after the demand plans have been finalized but the production on them has not yet begun. The response actions as these are common in the case of regulatory or political changes that may impact the business conditions and hence affect competitiveness of firms' products. Similarly, the changes in customer demand patterns, for example due to a new competitor launch or another business event, might affect the demand for a firm's products.

Unlike adaptive DM agility, resilient DM agility measures the firm's response in the time period when the execution on demand plans has begun and some value has already been added to the products. These variations in demand arise due to general business condition such as changes in business activity, and a competitor's product launch. The business practices of information sharing and close working relationship with suppliers and rapid constant collaboration with marketing and sales intelligence facilitate the actions that are requisite for adequate response.

Entrepreneurial DM agility is the ability of the firm to sense before-hand business opportunities and challenges. The events are invariably still the same and may include introduction of new technologies or changes in the regulative or business environment. A contrasting example of entrepreneurial DM agility was demonstrated by Dell when it adopted the Internet to develop a model to meet customer demand only after it was realized. Even the order to the suppliers was sent only after the customer has placed its order leading to a very efficient system of production. Entrepreneurial DM agility is aided by the use of responsive technologies and business initiatives that help a firm to respond to these events.

Two dimensions of DM agility: speed and effectiveness

We include in our research, all three DM agility types. These three types are all measured for the two dimensions of DM agility –*speed and effectiveness*-that have now gained importance in industry. While the speed of response is an important indicator of the firm's agility and has often been identified as the only dimension (Zain et al. 2005), this research goes beyond the assessment of mere speed of response and also studies the effectiveness of firm's response. While the speed of response is a critical indicator of overall performance, effectiveness is equally important, if not more. Let us consider an example of a hypothetical cell phone manufacturer, Johnsung Pvt. Ltd. Johnsung might see a huge fluctuation in the demand for its cell phones due to the launch of iPhone by Apple. Given the speed of the technology markets, it is imperative for Johnsung to respond to Apple's launch, with say a new phone, as quickly as possible. However, merely 'getting there' with a new phone won't suffice, as it would be hard for Johnsung to then position it's product differently from it's other competitors. Thus, it is as important for Johnsung to have an effective response to Apple's launch as it is to have a speedy response. In this research, we assess both these dimensions of agility separately.

Supply Chain Performance

Performance metrics have gained increased attention as these help align and measure the performance of diverse partners who all contribute to the same supply chains. As the competition in current business environments is between supply chains rather than the individual firms, it becomes imperative to standardize the measures of performance for each firm. In the supply chain, the performance measures used have been categorized according to the various dimensions. These dimensions include

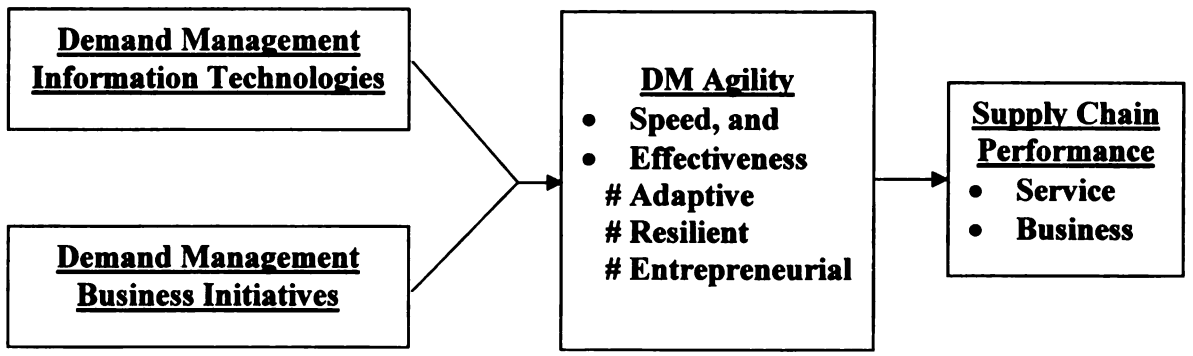
quantitative versus qualitative (Beamon 1999, Chan 2003); supply chain attributes of cost, quality, delivery, flexibility, visibility, and trust (Schönsleben 2004, Gunasekaran et al. 2001, Chan 2003); focus as strategic, tactical, or operational (Gunasekaran et al. 2001); or the supply chain process (e.g. the processes in SCOR framework such as plan, and deliver) to which the measures relate (Chan and Qi 2003, Huang et al. 2004 Li et al. 2005, Shepherd and Günter 2006). In this research, our focus is on two types of performance measures - service related and overall business related- in the context of supply chains. We study the two as *service performance and overall business performance*.

In the next section we elaborate on the relationships between these constructs and develop the research framework.

CHAPTER 3: RESEARCH FRAMEWORK

As more activities are digitized, the efficiency of various work systems within the demand management processes is increased. The enhanced speed of communication and an increased ability for collaborative work poses a challenge and offers an opportunity to enhance the response capabilities of these processes. However, the creation of enhanced capabilities requires concerted organizational initiatives involving alignment of multiple demand management activities in line with the new technologies. We build on these arguments and explain the proposed research model (Figure 4) below:

Figure 4: Research model for demand management and supply chain performance



Demand Management (DM) Agility

DM agility is the capability of the supply chain to quickly respond to the technological, regulative or business related events. These events might affect a firm's ability to plan or fulfill demand. Two key dimensions of DM agility studied in this research are speed and effectiveness with which the firm responds to the changes in demand. Further, based on the timing of firm's response, DM agility is defined to be of three types. For the events that occur after the operational and production plans have been finalized, but not executed, the firm's response is characterized as adaptive DM agility. The response to events that happen during the normal course when the demand plans are

being operationalized is defined as resilient DM agility. Proactive sensing of demand changes in future to redefine customer products and offerings is defined as entrepreneurial DM agility. The cumulative level of the three types together determines the extent to which the firm is considered agile. The firm that possesses more of the three types of agilities in its demand management process is more agile than others.

Performance Impacts

The examples of such business events that either challenge or offer new opportunities to firms are abundant in nature. These include changes in the customer demand patterns, popularization of new alternates to the firm's products and services, regulatory changes that affect the profitability of the firm's products etc. The ability of the firm to respond to these events determines its ability to fulfill the customer orders. The firms that are quickly able to respond to the changes in the business environment realize greater chances of fulfilling customer orders. Further, these firms also realize greater customer satisfaction as they excel at the demand management and fulfillment activities. Thus, we propose:

H 1a: The speed of DM agility will lead to greater service performance

Further, as the firms see a change in the pattern of the customer demand, a speedy response is essential to maintain the market position. According to the models of strategy that emphasize the exploitation of market power (Porter 1980; Shapiro 1992), firms ability to earn superior rents by impeding the competitive forces in product markets is hurt due to these adverse events. While the managers may resort to strategic moves and Short-term tactics (for example, by forcing the channel partners to stock up redundant

inventories), these have been condemned by the researchers as short lived and tactical in nature (Teece et al. 1997: p. 513). According to these researchers a firm's competitive advantage, and hence performance, is based primarily on its ability to manage the new business scenario by doing more enduring work in developing capabilities that help reacquire their competitive position in the changed business scenario. The speed of DM agility is one such capability that helps the firm to quickly regain its competitive advantage in the marketplace, and hence

H 1b: The speed of DM agility will lead to greater business performance

However, besides the speed of DM agility, it is imperative for a firm to be effective in its response strategies. For example, not only a speedy response but also effectiveness is essential when launching a product in response to a competitor's product launch. Thus, the quality of order fulfillment (and not just the time taken to fulfill them) is a determinant of a firm's effectiveness. Firms that are able to achieve greater effectiveness in their response to the changed business conditions are more likely to exceed the expectations and reduce complaints of the customer, thus realizing superior service performance. Hence, we propose

H 2a: The effectiveness of DM agility will lead to greater service performance

While the regulatory technological or business events affect the value, rarity, inimitability, or non-substitutability of existing resources, and firm's gain competitive advantage by responding to the changed scenario (Teece et al. 1997). The quality of the firm's response and hence its impact in the competitive marketplace is not determined by a mere speedy response from the firm. Instead, a well coordinate and effective response is

essential for meaningful reconfiguration of resources. The firms' ability to gain competitive advantage and capture superior rents is based on their ability to reconfigure valuable, rare, and inimitable resources. Thus, effective DM agility is a direct precursor to the business performance in the modern day business environment, where the disruptions are a norm rather than exception. And we propose:

H 2b: The effectiveness of DM agility will lead to greater business performance

Demand Management Information Technologies

The role of IT in firms' demand management process is becoming more and more critical. Two distinct capabilities contribute to this growing interest in IT systems. The first is related to their technological superiority over the manual processes, and second relates to the business capability encoded in the IT artifact. The technological superiority of firms' technologies arises due to the associated digitization of processes, which enhances the data storage capacity, transmission capacity, and processing capacity (Culnan and Markus 1987; Huber 1990). The use of technologies helps digitize indicators for plant performance, forecasts, production plans and inventory, and point of sales data, making it easier for different partners in the supply chain to simultaneously process, transfer, and store these vital inputs for demand management. The advanced capabilities of digital technologies also help enhance the communication capabilities by decreasing the cost and effort in communication (Rice and Blair 1984) and enhancing the precision and selectivity in participation of group members (Culnan and Markus 1987; Sproull and Kiesler 1986). For example, use of group collaborations systems helps the product design departments and firms' suppliers to collaboratively work on redesigning products based on consumer response. Thus the digital capabilities of IT systems lessen the overall time-

span and effort required in coordination and transactions (Gurbaxani and Whang 1991). This helps firms to respond to sudden changes, in the customer buying patterns or to match a competitor's offering (for example, through collaboration in product development or dynamic management of demand).

The second factor that makes the IT systems superior is related to the business capability encoded in them. The use of these systems helps routinization of complex tasks in order fulfillment activities. These IT systems bring in external information in the form of decision models of experts that helps enhance the quality of decision making (Huber 1990; Zmud 1983). For example, a sophisticated forecasting algorithm can be bought off the shelf instead of being developed and implemented in house that would call for recruiting various researchers at different levels where the forecasting needs to be done. Similarly, the industry best practices may be coded into the information systems giving ready access for firms to utilize these in their own business activities. For example, the complex algorithms for supply chain optimizations available through information systems can be easily routinized into the lower decision-making levels without physically involving an expert at the level (Huber 1990). This ability to routinize has been highlighted by the researchers as essential for the development of organizational capabilities (Teece et al. 1997). According to them, the ability of the firms to respond to the changing business conditions, especially in the low and moderately dynamic business environments, is directly dependent on the extent of routinization of the organizational activities (Eisenhardt and Martin 2000).

As business activities are routinized, the managerial attention is freed and can be applied to contemplating response strategies to changes in the business environment. Also, routines may facilitate creative experimentation to find new ways of doing work and hence facilitate innovative and effective response to threats and opportunities. For example, in their case study at Volvo, Holmqvist and Stefansson (2006) found the impact of RFID on increasing the creative opportunities in the firm's supply chains. Information technologies such as RFID help firms to monitor in real time the flow of products and services and hence help fast and effective alignment of demand forecasts to real sales. Thus, based on the above reasoning, we propose that the adoption of the four types of information technologies (internal supply side, external supply side, internal demand side, external demand side) in the firms supply chains would help firms develop speed and effectiveness of DM agility.

H 3a: ***The greater use of demand management IT will lead to greater speed of DM agility.***
H 3b: ***The greater use of demand management IT will lead to greater effectiveness of DM agility.***

Demand Management Business Initiatives

Over the last fifty years, the supply chains have grown from being within the boundaries of the firm (example the vertically integrated Ford River Rouge Plant) to being a complex network of multiple suppliers. The products sourced from these suppliers have evolved from being mere commodities to more specialized parts that are critical to the sourcing of a firm's products. Effective demand planning and management in contemporary supply chains thus includes the supplier's performance. Thus, a critical component for the firm to realize superior performance of its demand management process is related to the use of demand planning initiatives that enhance its ability to share information and collaborate

with suppliers. Sheffi (2005) describes an incident in the semiconductor industry that very succinctly summarizes the role of business initiatives in the demand management of the firm. A small fire at the Philips' Albuquerque plant in New Mexico that fabricated semi conductor chips went totally unnoticed by the media. The fire was put off in less than ten minutes by firefighters and staff. While it was overtly not a major incident, the soot, water and panicking firefighters did enough to destroy millions of semi conductor chips to be used in cell phones. This was astutely caught by Nokia by noticing a pattern in the disruption of supplies from Philips. Over the next weeks Nokia engaged in continuous discussion with Philips to assess the impact on its ability to meet demand forecasts and soon concluded that there is likely to be huge variance in its ability to meet demand for cell phones in future. Following this assessment Nokia captured the existing worldwide supply of semiconductor chips by contracting with other suppliers. Erickson, another customer of Philips and fierce competitor of Nokia, on the other hand, was satisfied by the explanation from Phillips and waited. By the time Erickson realized the extent of the problem it had lost its worldwide supply, and hence the ability to meet the demand of the cell phones. While the story has been often told, it emphasizes how demand management involves a closely managed relationship with suppliers, and continuous flow of information between partners.

Since in a supply chain value often lies outside of the firm boundaries, the arms length market arrangements that might be efficient for one time transaction are not suitable for transacting within the network of supply chains. To operate within the boundaries of the firm and at the same time integrate the knowledge of the external

partners with their own supply chain, firms adopt various information sharing initiatives. These business initiatives help monitor and integrate a large amount of the information required for the management of demand planning and fulfillment activities. Complete visibility of suppliers' production and demand schedules, for example enhances the accuracy of firm's forecasting processes and helps them sense any discrepancy in planned production schedules (Lee et al. 1997).

Similarly, the modern day organizations have greater inputs from the other departments (e.g. sourcing, and logistics) to develop and evaluate the demand plans. In line are also the initiatives for real time coordination with the point of sale outlets. These various initiatives are studied as the demand management initiatives.

While in the traditional supply chains the means to respond to the changed business conditions was redundant inventory (safety stock) or redundant capacity, the modern day supply chains instead resort to dynamic managerial action. Managerial action has gained even more emphasis after the adoption of such supply side initiatives as lean manufacturing which has reduced the inventories, even for critical parts, to near zero. Thus, the goal of modern day organizations is to develop superior organizational capabilities as DM agility (the ability to respond to changed business conditions), rather than having redundant capacities as buffer. The development of DM agility for managing customer demand is thus based on the firm's response to these changed business conditions.

Impact on DM Agility

Rapid changes in business environment call for continuous changes in product designs and real time demand management. Similar to technologies, various demand

management initiatives often help firms respond to the changes. For example, many years of industry wide experience and practice has led to the development of such supply side methodologies as Just-in-time (JIT) production, cellular manufacturing, quick response (QR) initiatives, and lean principles. These practices facilitate rapid response by the firm in its manufacturing functions and have been found to impact manufacturing agility (Narasimhan et al. 2006). Similar to these supply side practices, various demand practices are detrimental to fast response and agility in supply chains.

The rationale for the effect of these practices on DM agility of the firm is the vast managerial experience that is codified into these practices. These practices, such as VMI initiatives and S & OP planning (Crum and Palmatier 2004, Lapide 2007, Hewitt 2001), have been applied and refined by their successful and not so successful adaptations by various firms. These previous experimentations have helped capture the tacit learning in their application and codified these in the form of best practices, formal procedures, and management techniques. The knowledge related to 'what works and what does not' is available in the management literature and the practitioners' experiences. Further, besides learning from outside the firm, various initiatives involve tapping the wide knowledge and experience within the firm. It is well known that experience facilitates a deeper understanding of the activities and hence helps in the development of more complex and effective routines (Argote 1999; Zander and Kogut 1995). Further, the complex routines that evolve through learning and experience are often defined as the source of dynamic response capabilities (Nelson and Winter 1982; Zollo and Winter 2002; Teece et al. 1997). Thus, the various demand management practices (such as those that involve sharing and coordinating information across partners, or within the functional

departments of a firm) facilitate a coordinated and quick response from the firm in case of a demand change due to business events such as changed business conditions or other regulative events that lead to changes in consumer demand.

Further, the role of demand management practices in enhanced agility is also due to the *division of labor* aspect. As organizations are limited in their information processing abilities, some of the work practices are better done outside of the firm, or within the firm but in different departments (such as logistics, sourcing etc.). These vendor firms/allied departments are able to realize economies of scope in their learning and performance of these activities and hence develop specialized competencies. This might facilitate DM agility as each firm can focus on its own core competence and hence enhance the speed and effectiveness with which a firm can respond (Hamel and Prahalad 1994). However, effective business initiatives are needed to coordinate the work done across these departments and integrate it with the firm's demand management efforts.

While the demand management initiatives are lesser known, the impact of various supply side initiatives on supply chain agility has been well established. Christopher and Towill (2001), for example, document these effects. They categorize the initiatives into actions, programs and principles, and study initiatives as setup time reduction, cross functional teams, process management, standardization, lean practices, flexible and response, postponement, rapid fulfillment. Similarly other manufacturing practices that have been attributed to agility include supplier alliances, high skill employee training, customer sensing, and sales linkages (Brown and Bessant 2003; Prince and Kay 2003; Nagel and Bhargava 1994). McCullen and Towill (2001) have argued for highly skilled workers, partnership arrangements and closer relationships with suppliers, and JIT

manufacturing as being associated with greater agility. The empirical research has found these effects. Narsimhan et al. (2006) for example, surveyed 354 manufacturing plants in two phases and did a cluster analysis to find the impact of various supply chain best practices on the agility of the plant operations. They found that agile performers are at par with lean performer group on statistical quality control and benchmarking. However, for other practices (supplier base rationalization, customer orientation, integrated product design, supplier development, manufacturing strategy integration, cellular manufacturing, supplier information sharing, supplier partnerships, strategic supplier selection, JIT flow, TQM, and workforce development), the agile performers were associated with a greater degree of implementation of these initiatives than the firms in lean or low performer groups. Similar to these earlier studies of the supply side agility we proposed the impact of the four types of demand management initiatives (internal supply side, external supply side, internal demand side, external demand side) on both the dimensions of demand management agility:

H 4a: ***The greater use of demand management initiatives will lead to greater speed of DM agility.***
H 4b: ***The greater use of demand management initiatives will lead to greater effectiveness of DM agility***

Complementarities between the use of demand management IT and initiatives

While routinization of process is aided by the information technologies and supply chain practices (hypothesis 2 and 3 above), these two themselves are intricately linked. The demand management practices are heavily aided by the digitization of information. For example, the automatic replenishment programs rely heavily on the real time data captured using bar coding or RFID technologies and transferred over the telecom networks. The realization of superior performance, however, involves complex

dynamics to realize synergies between the two. These dynamics are often explained using complementarities theory according to which the IT systems are not able to realize desired effects in the absence of their alignment with the existing strategy, structure and activities of the firms (Barua and Mukhopadhayay 2000; Milgrom and Roberts 1990, 1995). This is because even though the IT systems have embedded business routines these routines are generic in nature and need to be customized to the firm specific business processes. The synchronization with demand management processes, that are a set of complex mechanisms for managing supply chains, thus is essential for realizing IT value.

This interdependence between the IT and demand management practices is intricately linked to the notion of an activity systems. The synchronization of IT with the business practices helps realize super additive effects in the activity systems (Wade and Hulland 2004; Milgrom and Roberts 1990). For example, the demand management process for forecasting is more responsive if the firm leverages the capability to frequently run IT aided simulations and optimization routines. The overall value realization of both the IT and forecasting initiatives together is much more than the additive effect of having either one of them (i.e. $V_{AB} > V_A + V_B$).

These super additive value synergies arise only when the synchronization of the two resources in the activity systems occurs after repeated adaptations and retention of the mechanisms with best results (Zollo and Winter 2002). After, the digital capabilities of IT systems are routinized through these complex adaptations with the demand management practices the organization develops a rich knowledge and know-how (often tacit in nature) which is path dependent. This knowledge is often in the form of complex

routines specifying interdependencies between the available IS capabilities and the knowledge of the demand management practice. The organizational actors, aided with these routines, are able to do quick mental simulations of the various cause and effect sequences that might be evoked in case of sudden change in business conditions (Siggelkow 2002; Weick 1979). The mental models, so developed for managing demand, are not a result of the combined knowledge of the IT know how and demand management processes but an intertwined set of routines and rules that are co-produced during the application of IT systems to demand management processes. This unique familiarity and knowledge to develop organizational knowledge affects the institutional structures related to signification, legitimation and domination. Thus, the knowledge and learning gives the overall activity system codes for action through the norms, power structures and rules of action that result from the institutionalization of combined application of IT technologies and supply chain practices (Scott 2001). The end result is a set of complex routines that give the organization ability to quickly respond to changes in the business conditions (Teece et al. 1997; Eisenhardt and Martin 2000). Hence, we propose the impact of four types of complementary interactions (internal supply side, external supply side, internal demand side, external demand side) between the IT and corresponding initiatives as:

H 5a: ***The greater complementarities between demand management IT and initiatives will lead to greater speed of DM agility***

H 5b: ***The greater complementarities between demand management IT and initiatives will lead to greater effectiveness of DM agility.***

CONTROLS

The responsiveness of a supply chain is well established to vary according to the external environmental conditions as well (Mendelson and Pillai 1998, 1999, Pavlou and

Sawy 2006). Industry turbulence for example, may influence performance as well as DM agility. Thus, we control for turbulence in assessing the DM agility and performance of the firm. We also control for the impact of other exogenous factors on a firm's capabilities and their impact on performance. Similar to Rai et al. (2006) we control for the size of the organization (Hitt 1999). Further we also control for the product volume. Finally, given the surge and impact of postponement strategies, we also control for the extent to which the firm uses postponement initiatives in its operations (Li e al. 2005). Postponement can help firm to meet with such demand changes that occur even as the firm has planned its production but not yet finalized the customized aspects. Hence, it can be an important factor in a firm's ability to meet customer demand changes.

In the next chapter, we define the details of the research methods used to test the hypotheses, as depicted in Figures 5 and 6.

Figure 5: Determinants of speed of DM agility and its impact on supply chain performance

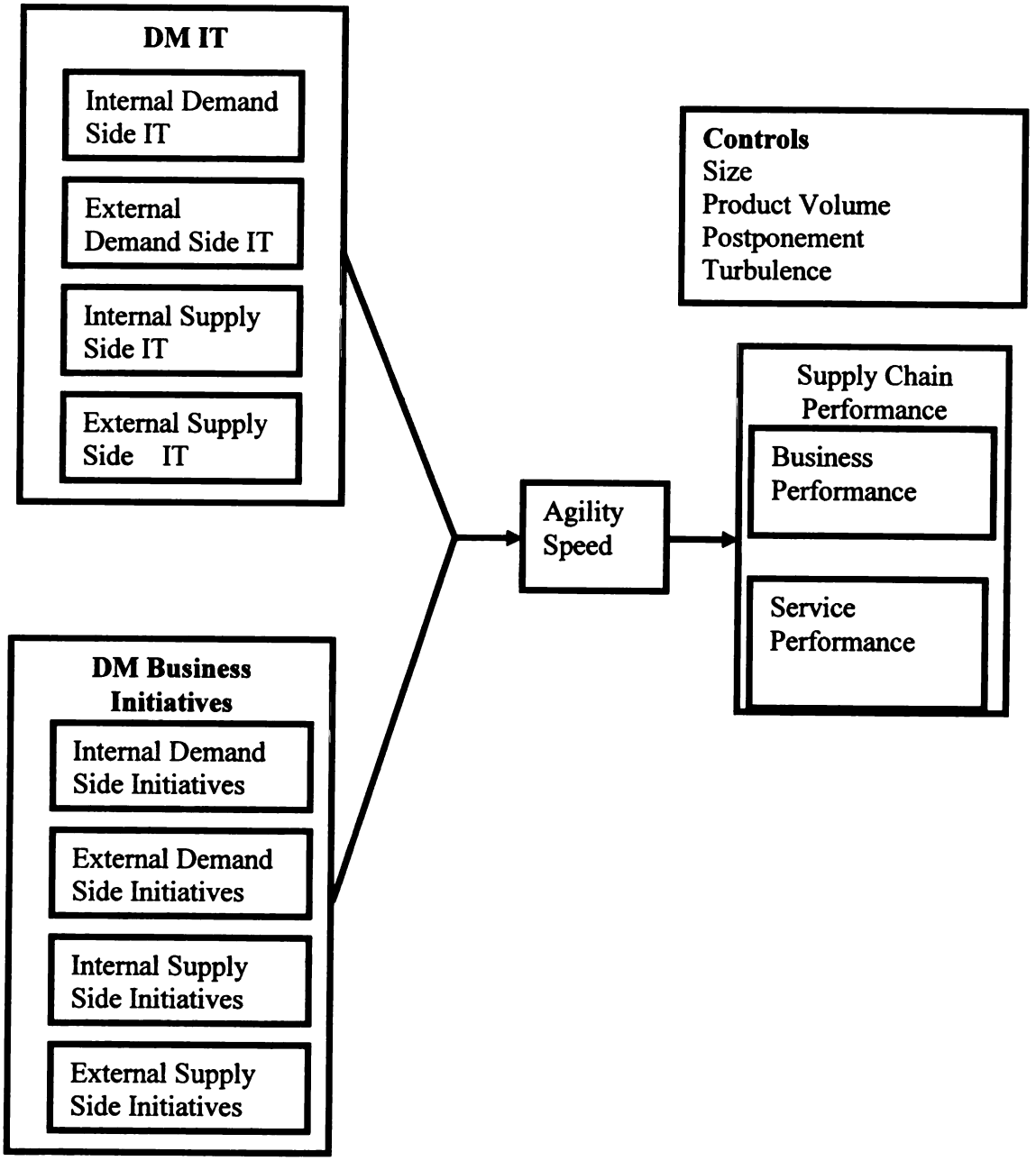
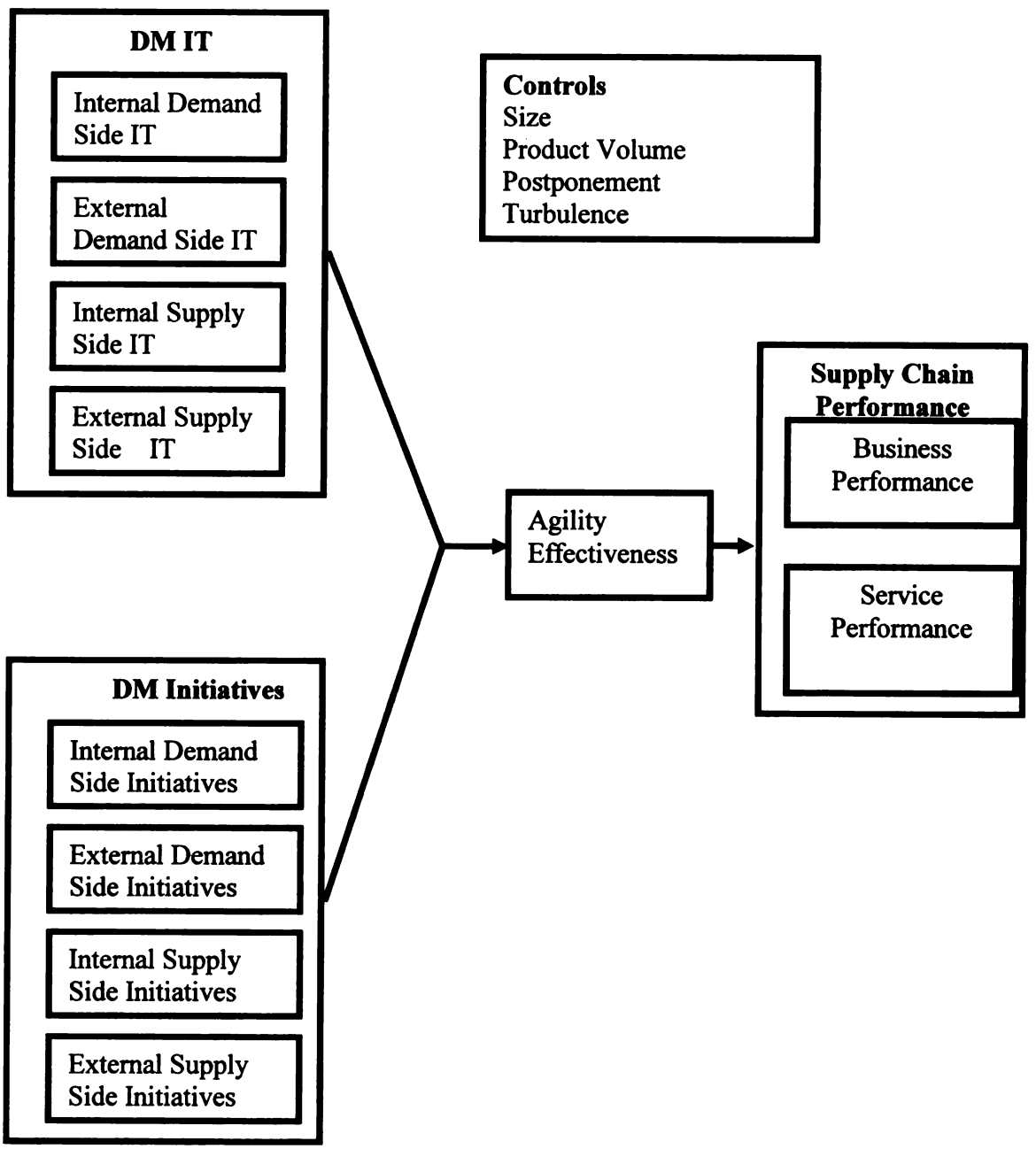


Figure 6: Determinants of effectiveness of DM agility and its impact on supply chain performance



CHAPTER 4: RESEARCH METHODS

Data for testing the hypotheses was gathered through a large scale survey of supply chain managers responsible for demand management. Given the lack of any secondary data that could help us get an in depth information about the usage of these technologies and initiatives, survey was considered the most important way to examine the hypotheses. Further, given that certain variables, such as resilient, adaptive, and entrepreneurial DM agility, are being assessed for the first time in the literature, we wanted a broad-based survey instead of case-based or a limited interview to enhance the range of firms giving inputs.

Data Collection

Sample and populations

The data for the study was collected through a survey of the professionals in the supply chain. The members of the Association for Operations Management (APICS) were used as the target population. Participation was sought only if a manager had significant interaction with demand management in their job. APICS has gained increased attention by researchers in the field of information systems (Bharadwaj et al. 2007). Given our interest to measure the actual use of technologies and initiatives, APICS members were considered to be especially suitable for collecting data to assess our research questions since they have the most representative set of respondents responsible for demand planning and fulfillment as compared with other member organizations such as Council of Supply Chain Management Professionals (CSCMP) which was found to have relatively greater representation of strategic managers.

A pilot study was conducted before the main data collection. A panel of ten working professionals and academicians with varied backgrounds took the survey and gave suggestions on improve the clarity, meaning, composition, and ordering of the survey. The suggestions lead to the addition and rewording of items being used in the scales. The respondents were also asked to time themselves and majority of the respondents took less than twenty minutes to finish the survey.

Email was used to solicit participation from the respondents. The average click through rates for the surveys conducted by APICS is 3% and average open rate (i.e. the percentage of people who opened the email) is 22%. The invitation for participation was received and opened by 1283 respondents and 303 respondents clicked on the survey link. This leads to an open rate of 29.3% and click through rate of 6.7% both of which are higher than the average rate typical of surveys done by APICS. After the two mail email reminders a total of 159 members' responses were received for the survey leading to a 14.7% conversion or response rate. This is a significantly high rate because there is a very niche segment of supply chain managers who work in demand management. Response bias was tested by assessing the difference in the size of the firms responding in the first stage of emailing (early respondents), and those responding after second and third follow-up emails (late respondents). There was no significant difference in size and hence response bias was ruled out. The various job profiles represented include customer service manager & planning manager, demand analyst, supply chain planner, supply chain analyst, and director of logistics, etc. The average numbers of employees in the firms that participated are 7622. However, besides these large firms there are many small

firms in the sample as well and the number of employees of the firms vary from a minimum of 1 to a maximum of 350,000 (see Table 5 for more details).

Table 5: Number of Employees in firms in the sample

Number of Employees	Frequency	Percentage
Less Than 100	20	13.3
100 – 249	18	12.0
250-499	19	12.7
500-999	17	11.3
1000-2499	32	21.3
2500-4999	16	10.7
Greater than 5000	28	18.7
Total	150	

Measures

Since the context of demand management has not been explored in IS research previously, a number of measures were developed anew for this study. Two distinguished professors, one an expert in the field of information systems and the other in the field of logistics and demand management, along with the author of the dissertation developed these measures following an iterative approach. We started with the existing measures and modified these according to the demand management context. For over six months the team was engaged in brainstorming and discussion regarding the constructs and items that best reflect the measures. In the end, we developed items for each of the constructs by customizing the theoretical underpinning from existing literature to fit the context of demand management. The existing measures were used as the starting point but most of the items were developed anew. Wherever possible, existing measures were adopted and customized as well.

Based on this exercise, items for information technologies and corresponding demand management initiatives were developed for all four types: Internal supply side, external supply side, internal demand side, and external demand side. Most of the technology constructs were developed anew but our operationalization was similar to that of Pavlou and Sawy (2006). Further, we assessed the frequency of use of information technologies, and demand management initiatives. Frequency was considered a good indicator of extent of use, given the ubiquitous nature of technologies, and considering the need to constantly reevaluate one's demand plans. Likert type scale with the range of 1 to 7 was used for response of the survey items.

Measures for Internal Supply Side IT and Initiatives

Given the focus on coordination in the internal supply chain, our items for the internal supply chain were based on the coordination initiatives (Malone and Crowston 1994). We assessed the frequency of use of information technologies to facilitate coordination between demand management function and other functions such as production, logistics, finance, and marketing (see Table 6). We also assessed the extent to which information technologies supported the sales and operations (S & OP) planning which is critical element of demand planning and management. The respondents were asked to rate the frequency of use of information technologies in their demand management process (Table 6). Similarly, for the business initiatives, respondents were asked to rate the frequency of use for their largest product line. Business initiatives assessed were those used by the firm to assimilate and use the information from across the departments and communicate demand related changes back to them (see Table 6).

Table 6: Internal supply side information technologies and initiatives

INTERNAL SUPPLY SIDE IT **ITINCO1**: IT applications to coordinate demand management activities with activities of production department **ITINCO2**: IT applications to coordinate demand management activities with activities of sourcing department **ITINCO3**: IT applications to coordinate demand management activities with activities of logistics department **ITINCO4**: IT applications to coordinate demand management activities with the activities of the finance department **ITINCO5**: IT applications (such as those used in Sales and Operations Planning (S&OP) meetings) to facilitate coordination between supply chain and marketing. **INTERNAL SUPPLY SIDE INITIATIVES** **We acquire and integrate the following information in our activities to meet changes in customer demand** **INTIAQI1**[#2]: Operational production information (e.g. production schedules) **INTIAQI2:** Operational sourcing information (e.g. sourcing contracts) **INTIAQI3:** Operational logistics information (e.g. route plans) **INTIAQI4:** Operational finance information (e.g. profitability of market segments) **INTIAQI5:** Changes in supply chain structure (e.g. addition of new plant capacities, addition or dropping of partner companies). **INICOM:** We communicate changes in demand forecasts or customer preferences to the following in our organization[3]: a. The production function. b. The sourcing function. c. The logistics function. d. The finance function.

Measures for External Supply Side IT and Initiatives

The external supply side initiatives and information technology construct measures the extent to which the firm shares information and collaborates work with its external suppliers partners (Lee et al. 1997, Malhotra et al. 2005). The technologies, such as EDI and XML, or those used for collaboratively executing work processes, planning and, forecasting were assessed in this domain. Similarly, for initiatives we assessed the nature of information shared by the firm with its external suppliers (Malhotra et al. 2005)

[2] These items were dropped from the analysis after the factor analysis.
[3] The average across all four was used for analysis

(see Table 7). If we use the metaphor of a "pipeline" to conceptualize these technologies, then the demand management initiatives to share information act as the material that flows through these pipelines. Thus, mere pipelines may not specify and it would be essential to have both the material and pipeline together to realize their performance effects. Similar to internal supply side IT and initiatives we assessed the frequency of use for external supply side IT and initiatives.

Table 7: External supply side information technologies and initiatives

EXTERNAL SUPPLY SIDE IT
ITEXSP1: Electronic Data Interchange (EDI) to share demand related information (e.g. forecasts, volume or mix changes) with external suppliers **ITEXSP2:** Extensible Markup Language (XML) to share demand related information (e.g. forecasts, volume or mix changes) with external suppliers **ITEXSP3:** IT applications (such as application or desktop sharing) for simultaneously working in real time with external suppliers **ITEXSP4:** IT applications to synchronize production plans across the external suppliers **ITEXSP5:** IT applications for collaborative planning and forecasting of demand with external suppliers.
EXTERNAL SUPPLY SIDE INITIATIVES
We exchange the following with our external suppliers: **EXTSPI1:** Details of upcoming product or service related changes **EXTSPI2#:** Details of future promotion or marketing plans **EXTSPI3:** Information related to market demand trends or forecasts **EXTSPI4:** Information on demand shifts or changes in customer preferences **EXTSPI5:** Information about long-term production plans, capital investments or capacity utilization

Measures for Internal Demand Side IT and Initiatives

The measures for internal demand side IT and initiatives were created to assess the firm's technological and organizational competencies in assessing the demand for their products. The technologies used those used for forecasting of new, shorter lifecycle

products, and those that use analytics and data mining to forecast demand. These technologies were selected as demand forecasting is the core element to assess demand (Table 8). However, we also included the technologies that were used to tap into the marketing information about consumer demand matching with these technologies were the corresponding initiatives related to acquisition and integration of knowledge from the

Table 8: Internal demand side information technologies and initiatives

INTERNAL DEMAND SIDE IT

ITDMMG1: IT applications (such as analytics or data mining) for creating or changing demand plans
ITDMMG2: IT applications for creating or changing demand plans for products that are new, have short life cycle or strong seasonality patterns
ITDMMG3: IT applications for creating or changing demand plans for products that use scenarios management functionality (e.g. what if analysis)
ITDMMG4: Spread sheet applications to plan demand
ITDMMG5: IT applications (e.g. Intranet) to acquire marketing information relevant for creating or changing demand plans

INTERNAL DEMAND SIDE INITIATIVES

We acquire and integrate, from marketing department, information about:

MKTINI1: Marketing events (e.g. trade promotions, quantity discounts or trade deals) that impact demand for our products
MKTINI2: Business changes (e.g. new substitutes for our products) that impact demand for our products
MKTINI3: Competitor's activities (e.g. new product launches) that impact demand for our products
MKTINI4: Key changes in customer preferences that impact the demand for our products
MKTINI5: Changes in marketing strategies (e.g. product pricing or distribution channels) that impact the demand for our products

marketing department. The acquisition and integration of knowledge is a key component of organizational learning (Huber 1991, Hurley and Hult 1998, Lafferty and Hult 2001). Further, included is the information available with the marketing department regards the

external business conditions, and customer preferences (Jaworski and Kohli 1993, Slater and Nervar 1995, Kohli and Jaworski 1990) (see Table 8). Consistent with the previous measures frequency of use was assessed for internal demand side IT and initiatives as well.

Measures for External Demand Side IT and Initiatives

The external demand side measures assess the extent to which the firm is able to collect information regards customer sales and preferences. The items for technologies used in this domain included the bar coding and RFID technologies that are used to capture sales data, and other technologies to exchange customer data with the vendor managing the inventory (Table 9). However, the latter items were found to have significant cross

Table 9: External demand side information technologies and initiatives

EXTERNAL DEMAND SIDE IT
ITMKIN1: Bar Coding technologies to acquire customer sales data **ITMKIN2:** Radio Frequency Identification Tag (RFID) applications to acquire customer sales data **ITMKIN3#:** IT applications (such as EDI or XML) to share production data (e.g. inventory levels, and production schedules) with vendor managing automatic replenishment of customer sales **ITMKIN4#:** IT applications to share changes in demand plans with the vendor managing the automatic replenishment of customer sales
EXTERNAL DEMAND SIDE INITIATIVES
We use the following customer related practices: **CUSRELP1:** We analyze the sales information from customer sources (e.g. retail outlets) to anticipate changes in customer demand, **CUSRELP2:** We often talk with or survey those who can influence our customer sales (e.g. retailers, distributors) to anticipate changes in customer demand, **CUSRELP3:** We integrate sales information from customer sources (e.g. retail outlets) to plan our activities to meet changes in customer demand **CUSRELP4#:** We use automatic replenishment methods (such as Vendor Managed Inventory (VMI) initiatives) to meet changes in customer demand

loadings during the factor analysis (see below) and hence were dropped from future analysis.

Similarly, the initiatives included the extent to which the firms engaged with its customers in assessing the demand for its products. The survey items assessed how frequent was the firm in surveying its customers and including their information in its analysis and planning activities to meet demand. An item related to vendor managing the inventory was dropped from the analysis as similar to the items for technology it was found to have in appropriate loading.

Measures for DM Agility

DM agility was measured as the second-order formative construct and two different dimensions of response were measured: speed and effectiveness. It was considered essential to assess these two as separate dimensions due to the debates regards the usefulness of just assessing the speed with which the firm is able to respond to changes in its environment (Zain et al. 2005). Thus, according to the current thinking we also evaluated how effective the firm was in its response. Respondents were asked to rate the nature of their response on these two dimensions distinctly. The response for speed of DM agility was measured on a seven point scale with the following categorization: 1- Very Slow, 2-Slow, Somewhat slow, 4- Neutral, 5-Somewhat Fast, 6-Fast, 7-Very Fast. For effectiveness the following categorization was used: 1- Very Ineffective to 7-Very Effective.

The respondents were asked to think of cases where a demand fluctuation exceeded more than 20% of the product volume. This percentage was chosen as it is now considered to be a standard by the Council for Logistics Management to categorize a fluctuation as non random. Six different events were considered as a reason for this change in demand (see

Table 10), and the respondents were asked to rate their response to these events for both the speed and effectiveness of response.

Table 10: The events which call for an agile response from the firm

Ag1: Changes in general business environment (e.g. decline in economic activity) **Ag2:** Changes in regulative environment (e.g. increased taxation on raw materials that increases the cost of your products) **Ag3:** Changes in technological environment (e.g. that lead to cheaper substitutes for your products) **Ag4:** Competitor's new product launches (e.g. that offer more features than your products) **Ag5#:** Unplanned events by marketing department (e.g. trade promotions) **Ag6#:** Unplanned changes in marketing strategy (e.g. distribution channel or product pricing) for your products

Further, three different dimensions were assessed for agility- adaptive DM agility, entrepreneurial DM agility, and responsive DM agility. The formation of these dimensions was based on the framework created by APICS (Crum and Palmatier 2004). The critical difference between the three is based on the time (or the stage in demand cycle) when the firm has to respond. The respondents were explained that the three components differ in terms of the period when the changes in customer demand occur. Thus, adaptive agility is the firm's response during the,

"Period when the demand plans have been finalized but execution on them has not begun"

Similarly, resilient agility is the firm's response in the time period when

"Period when the execution on demand plans has begun and some value has already been added to the products"

Finally, entrepreneurial agility was defined as the firm's response to changes in

"Future demand periods for which the demand plans are not yet created"

Table 11: The items used for three types of agility

ADAPTIVE

Rate your response for the demand changes that occur DUE TO THE FOLLOWING REASONS in the PERIOD WHEN THE DEMAND PLANS HAVE BEEN FINALIZED BUT EXECUTION ON THEM HAS NOT BEGUN:

Ad1: Changes in general business environment (e.g. decline in economic activity)
Ad2: Changes in regulative environment (e.g. increased taxation on raw materials that increases the cost of your products)
Ad3: Changes in technological environment (e.g. that lead to cheaper substitutes for your products)
Ad4: Competitor's new product launches (e.g. that offer more features than your products)
Ad5#: Unplanned events by marketing department (e.g. trade promotions)
Ad6#: Unplanned changes in marketing strategy (e.g. distribution channel or product pricing) for your products

RESILIENT

Rate your response for the following demand changes that occur DUE TO THE FOLLOWING REASONS in the PERIOD WHEN THE EXECUTION ON DEMAND PLANS HAS BEGUN AND SOME VALUE HAS ALREADY BEEN ADDED TO THE PRODUCTS:

RA1: Changes in general business environment (e.g. decline in economic activity)
RA2: Changes in regulative environment (e.g. increased taxation on raw materials that increases the cost of your products)
RA3: Changes in technological environment (e.g. that lead to cheaper substitutes for your products)
RA4: Competitor's new product launches (e.g. that offer more features than your products)
RA5#: Unplanned events by marketing department (e.g. trade promotions)
RA6#: Unplanned changes in marketing strategy (e.g. distribution channel or product pricing) for your products

ENTREPRENURIAL

Rate your firm's response for the following demand changes that occur DUE TO THE FOLLOWING REASONS in the FUTURE DEMAND PERIODS FOR WHICH THE DEMAND PLANS ARE NOT YET CREATED:

EA1: Changes in general business environment (e.g. decline in economic activity)
EA2: Changes in regulative environment (e.g. increased taxation on raw materials that increases the cost of your products)

Table 11 (Cont'd)

EA3: Changes in technological environment (e.g. that lead to cheaper substitutes for your products)

EA4: Competitor's new product launches (e.g. that offer more features than your products)
EA5#: Unplanned events by marketing department (e.g. trade promotions)
EA6#: Unplanned changes in marketing strategy (e.g. distribution channel or product pricing) for your products

After explaining to them the differences in the three components of agility, respondents were asked to rate separately, for the three time periods, the speed and effectiveness of their response. They were asked to do this for the above mentioned six demand events leading to the eighteen questions (see Table 11). The last two events were not found to be significant for adaptive agility and hence were dropped from future analysis for all the types of agility.

Table 12: Measures of service and business performance

Service Performance
ServPr1: Perfect Order Fulfillment: The percentage of orders delivered "on time and in full" without any quality issues
ServPr2: Order Fulfillment Cycle Time: Amount of time from customer authorization of a sales order to the customer receipt of product.
ServPr3: The overall satisfaction of the customer with the demand fulfillment activities of the firm
ServPr4: Customer Expectations: The extent to which the firm's demand fulfillment activities exceed the expectations of the customer.
ServPr5: The performance of firm's demand fulfillment activities versus the competitor's activities in the category
ServPr6: Customer Complaints: The customer complaints (formal or informal) about the firm's demand fulfillment activities.

Business Performance
BusPer1: Total supply chain costs
BusPer2: Cash to cash cycle time: The number of days of working capital tied up in managing the supply chain.
BusPer3: Inventory Turnover (Ratio of sales to total inventory)
BusPer4: ROS: Return on Sales (Ratio of Net operating income to sales)
BusPer5: ROA: Return on Assets (Ratio of Net operating Income to aggregate total assets)
BusPer6: Sales Growth (Average rate of change of sales over the last three years)

Measures for Supply Chain Performance

Finally, supply chain performance was measured using the indicators of service and business performance that were based on the performances metrics produced by Supply Chain Operational Reference (SCOR) model (see Table 12). Likert type scale with the range of 1 to 7 was used for response of the survey items, and the respondents were asked to rate their performance with respect to their major competitor.

Finally, turbulence was measured using the scale from Jaworski and Kohli (1993) and Pavlou and Sawy (2006). Respondents were also asked about the size of the firm (number of employees). Further a seven point likert scale was used to assess the extent of postponement, and product volume (for the product they used to mark their responses).

Analysis

Data analysis was done in two stages. In the first stage we did a factor analysis to assess the appropriate factors underlying the constructs. Principal component analysis was used to extract the factors, with the criterion of eigenvalues greater than 1. Varimax rotation was used to create orthogonal factors. The items with cross loadings greater than 0.4 were dropped. The resulting set of factor structure revealed four factors each for demand management initiatives and technologies (see Table 13 and 14). Both dimensions of DM agility were assessed using a two factor structure. Firstly, each of the dimension was factored for three different types separately, and then in the second stage the factor scores for all the three types were used to extract the two dimensions – speed of DM agility and effectiveness of DM agility (see Table 15). Similarly, factor structures were assessed for the performance scale that revealed two set of underlying factors (Table 16). The communalities for most items were found to be greater than 0.5, however a few

items with communalities greater than 0.4 were retained while creating the final factors due to theoretical reasons. The only reason to drop the items was if they were found to have significantly high cross loadings. After each factor analysis we also calculated the Kaiser-Meyer-Olkin measure to assess sampling adequacy. In all the cases this was found to be greater than 0.5 hence indicating that the sample size is not a problem. Similarly, the Barlett's test of sphericity was found to be significant in all cases indicating that non-collinearity was not a problem in our case, and the factoring was appropriate. Similarly, no Heywood cases (i.e. items with loadings greater than 1) were found in any of the factor results. Following the factor analysis we assessed the reliabilities of each of the construct. The reliabilities were assessed for each of the factors and were found to be appropriate (see Table 17).

Table 13: Factor analysis for demand management initiatives

	Component			
	Internal Supply Side Initiatives	**External Supply Side Initiatives**	**Internal Demand Side Initiatives**	**External Demand Side Initiatives**
INTIAQI2	0.738	0.049	0.002	-0.139
INICOM	0.675	0.155	0.033	0.091
INTIAQI3	0.708	0.097	0.069	0.163
INTIAQI4	0.645	0.025	0.248	0.217
INTIAQI5	0.688	0.043	0.198	0.067
EXTSPI1	0.084	0.772	0.231	0.014
EXTSPI3	0.060	0.869	0.132	0.092
EXTSPI4	0.088	0.795	0.200	0.214
EXTSPI5	0.131	0.709	0.009	0.122
MKTINI1	0.139	0.047	0.751	0.250
MKTINI2	0.048	0.201	0.777	0.251
MKTINI3	0.095	0.138	0.791	0.245
MKTINI4	0.142	0.144	0.820	0.104
MKTINI5	0.181	0.164	0.832	0.199
CUSRELP1	0.124	0.149	0.319	0.747
CUSRELP2	0.059	0.130	0.341	0.769
CUSRELP3	0.151	0.168	0.235	0.833

Principal Component Analysis is used as the extraction method, and varimax method is used for rotation.

Table 14: Factor analysis for demand management technologies

	Component			
	Internal Supply Side IT	**External Supply Side IT**	**Internal Demand Side IT**	**External Demand Side IT**
ITINCO1	0.757	0.223	0.154	-0.077
ITINCO2	0.761	0.155	0.020	0.233
ITINCO3	0.690	0.375	0.002	-0.057
ITINCO4	0.678	0.019	0.240	0.225
ITINCO5	0.460	0.393	0.379	-0.282
ITEXSP1	0.283	0.469	0.073	0.328
ITEXSP2	0.184	0.665	0.033	0.390
ITEXSP3	0.160	0.632	0.301	0.063
ITEXSP4	0.170	0.834	0.118	0.099
ITEXSP5	0.268	0.560	0.244	0.269
ITDMMG1	0.383	0.163	0.597	0.218
ITDMMG2	0.395	0.115	0.577	0.278
ITDMMG3	0.222	0.222	0.611	0.255
ITDMMG4	0.006	0.008	0.749	-0.080
ITDMMG5	-0.076	0.348	0.546	0.127
ITMKIN2	0.074	0.134	0.082	0.741
ITMKIN3	0.037	0.263	0.193	0.682

Principal Component Analysis is used as the extraction method, and varimax method is used for rotation.

Table 15: First order and second order factor analysis for two dimensions of DM agility

First Order Factor Analysis : Speed of DM Agility					
Component		Component		Component	
	Adaptive Speed		Resilient Speed		Entrepreneurial Speed
AAS1	0.773	RAS1	0.837	EAS1	0.828
AAS2	0.770	RAS2	0.866	EAS2	0.872
AAS3	0.840	RAS3	0.878	EAS3	0.882
AAS4	0.831	RAS4	0.856	EAS4	0.861

First Order Factor Analysis : Effectiveness of DM Agility					
Component		Component		Component	
	Adaptive Effectiveness		Resilient Effectiveness		Entrepreneurial Effectiveness
AAE1	0.712	RAE1	0.852	EAE1	0.856
AAE2	0.743	RAE2	0.846	EAE2	0.867
AAE3	0.784	RAE3	0.892	EAE3	0.896
AAE4	0.741	RAE4	0.854	EAE4	0.855

Second Order Factor : Speed of DM agility	
	Speed of DM agility
Adaptive Speed	0.901
Resilient Speed	0.900
Entrepreneurial Speed	0.851

Second Order Factor :Effectiveness of DM agility	
	Effectiveness of DM agility
Adaptive Effectiveness	0.933
Resilient Effectiveness	0.861
Entrepreneurial Effectiveness	0.842

Principal Component Analysis is used as the extraction method, and varimax method is used for rotation.

Table 16: Factor analysis for Supply Chain performance

	Service Performance	Business Performance
ServPr1	0.857	0.245
ServPr2	0.805	0.296
ServPr3	0.865	0.258
ServPr4	0.849	0.284
ServPr5	0.868	0.316
ServPr6	0.766	0.257
BusPer1	0.188	0.803
BusPer2	0.238	0.798
BusPer3	0.218	0.746
BusPer4	0.367	0.788
BusPer5	0.284	0.824
BusPer6	0.243	0.570

Principal Component Analysis is used as the extraction method, and varimax method is used for rotation.

Analysis Approach

Two separate models were assessed one for each dimension of speed and effectiveness of DM agility (see Figures 5 and 6). Since the equations were not independent, simultaneous equation modeling was used for analysis. Three equations (1, 2, and 3; and 4, 5, and 6) were simultaneously estimated in two model runs using three stage least square (3SLS) procedure. The three stage procedure is efficient as we propose a model where the endogenous variable in one equation is an exogenous variable in the other.

$$\mathbf{SERVPR} = \beta_0 \text{Constant} + \beta_1 \text{AGILSPEED} + \beta_2 \text{logSize} + \beta_3 \text{Turbulence} + \varepsilon 1 \quad \textbf{(1)}$$

$$\mathbf{BUSPR} = \beta_0 \text{Constant} + \beta_1 \text{AGILSPEED} + \beta_2 \text{logSize} + \beta_3 \text{Turbulence} + \varepsilon 2 \quad \textbf{(2)}$$

AGILSPEED = β_0 Constant + β_1 ITINCO + β_2 ITEXSP + β_3 ITDMMG + β_4 ITMKIN + β_5 INTIAQ + β_6 EXTSPI + β_7 MKTINI + β_8 CUSRELP+ β_9 ITINCO* INTIAQ + β_{10} ITEXSP* EXTSPI + β_{11} ITDMMG* MKTINI + β_{12} ITMKIN * CUSRELP + β_{13} logSize + β_{14} Turbulence + β_{15} Postponement + β_{16} PrdVolume + $\varepsilon 3$ **(3)**

and,

SERVPR = β_0 Constant + β_1AGILEFFECTIVE+ β_2 logSize + β_3 Turbulence + $\varepsilon 4$ **(4)**

BUSPR = β_0 Constant + β_1 AGILEFFECTIVE + β_2 logSize + β_3 Turbulence + $\varepsilon 5$ **(5)**

AGILEFFECTIVE = β_0 Constant + β_1 ITINCO + β_2 ITEXSP + β_3 ITDMMG + β_4 ITMKIN + β_5 INTIAQ + β_6 EXTSPI + β_7 MKTINI + β_8 CUSRELP+ β_9 ITINCO* INTIAQ + β_{10} ITEXSP* EXTSPI + β_{11} ITDMMG* MKTINI + β_{12} ITMKIN * CUSRELP + β_{13} logSize + β_{14} Turbulence + β_{15} Postponement + β_{16} PrdVolume + $\varepsilon 6$ **(6)**

where,

SERVPR: Service Performance
BUSPR: Business Performance:

AGILSPEED: Speed of DM Agility
AGILEFFECTIVE: Effectiveness of DM Agility:
ITINCO : Internal Supply Side IT
ITEXSP : External Supply Side IT
ITDMMG : Internal Demand Side IT
ITMKIN : External Demand Side IT
INTIAQ : Internal Supply Side Initiative
EXTSPI: External Supply Side Initiative
MKTINI : Internal Demand Side Initiative
CUSRELP: External Demand Side Initiative
logsize: Log of Number of employees
Turbulence: Turbulence
Postponement: Extent of Postponement
Prdvolume: Product Volume

In the case of these simultaneous equations the error term obtained from the regression of DM agility on demand management technology and initiatives $\varepsilon 3$ (or $\varepsilon 6$) might be correlated with the error of regression with performance as the regress and - $\varepsilon 1$ or $\varepsilon 2$(or $\varepsilon 4$ or $\varepsilon 5$). Thus the OLS might not have correct estimates of the standard errors and the

results might be biased. 3SLS is the systems counterpart of two-stage least squared method (2SLS) and uses full information while estimation.

Table 17: Reliabilities

Demand Management initiatives	
Internal Supply Side Initiatives	0.74
External Supply Side Initiatives	0.82
Internal Demand Side Initiatives	0.90
External Demand Side Initiatives	0.83
Demand Management IT	
Internal Supply Side IT	0.78
External Supply Side IT	0.80
Internal Demand Side IT	0.74
External Demand Side IT	0.68
First Order DM Agility	
Adaptive Speed	0.82
Resilient Speed	0.88
Entrepreneurial Speed	0.88
Adaptive Effectiveness	0.73
Resilient Effectiveness	0.88
Entrepreneurial Effectiveness	0.89
Second Order Agility	
Speed	0.86
Effectiveness	0.853
Supply Chain Performance	
Service performance	0.942
Business Performance	0.887

Table 18: 3SLS analysis of the two models for speed, and effectiveness of DM agility

		DM AGILITY SPEED Complementarities and Moderation Model		DM AGILITY EFFECTIVENESS Complementarities and Moderation Model	
		Coeff	Std Error	Coeff	Std Error
ServPr					
	DM agility	0.41***	0.144	0.493***	0.176
	Turbulence	-0.022	0.037	-0.04	0.04
	Log(Size)	-0.06	0.081	-0.003	0.084
	_cons	0.161	0.264	0.258	0.287
R Squared		0.06			0.04
Adj R Sq		0.041			0.03
BusPr					
	DM agility	0.419***	0.14	0.497***	0.162
	Turbulence	-0.021	0.036	-0.039	0.037
	Log(Size)	-0.039	0.079	0.013	0.077
	_cons	0.137	0.258	0.229	0.263
	R Squared	0.09			0.109
	Adj R Sq	0.071			0.091
DM agility					
	ITINCO	0.148**	0.073	0.073	0.069
	ITEXSP	0.228***	0.07	0.231***	0.067
	ITDMMG	0.142**	0.069	0.137**	0.065
	ITMKIN	-0.001	0.07	0.009	0.066
	MKTINI	0.149**	0.067	0.057	0.063
	EXTSPI	0.106	0.077	0.05	0.073
	CUSRELP	0.135	0.069	0.159**	0.066
	INTIAQI	0.103	0.069	0.053	0.065
	Log(Size)	0.02	0.032	0.057	0.032
	Turbulence	0.043	0.07	-0.045	0.069
	ITINCO*INTIAQ	0.037	0.076	0.036	0.071
	ITEXSP*EXTSPI	0.004	0.075	0.022	0.071
	ITMKIN*CUSRELP	0.05	0.063	0.128**	0.061
	ITDMMG*MKTINI	0.044	0.073	0.071	0.069
	Postponement	0.069	0.04	0.054	0.038
	Prdvolume	0.165**	0.056	0.141**	0.054
	_cons	-1.273***	0.368	-1.298***	0.357
	R Squared		0.334		0.287
	Adj R Sq		0.256		0.202

Note: A total of 150 observations were used for analysis

OLS was used to calculate the r-squared as 3SLS estimates might give erroneous estimates. All F statistics were found to be significant for the regression runs

** p< 0.05

*** p<.01

To estimate 3SLS parameters, the transpose of matrix of all observations is multiplied by each of the equation (similar to that done in 2SLS) and then the set of equations is estimated jointly. The results of the study are reported in Table 18. Two set of 3SLS regressions were run, one each for speed of DM agility and effectiveness of DM agility. For each run, all the three equations were estimated simultaneously.

Performance impacts:

The results indicate that service performance is significantly influenced by both speed of DM agility ($\beta = 0.41$; $p>0.01$) and effectiveness of DM agility ($\beta = 0.493$; $p<0.01$).

Table 19: Summary of results of Hypothesis Testing

Hypothesis	Impacts on supply chain Performance		Service Performance (Hyp a)	Business Performance (Hyp b)
1	Speed of DM Agility		Supported	Supported
2	Effectiveness of DM Agility		Supported	Supported
	Impacts on Agility		**Speed (Hyp a)**	**Effectiveness (Hyp b)**
		Internal Supply Side	Supported	Not Supported
		External Supply Side	Supported	Supported
		Internal Demand Side	Supported	Supported
3	Technology	External Demand Side	Not Supported	Not Supported
		Internal Supply Side	Not Supported	Not Supported
		External Supply Side	Not Supported	Not Supported
		Internal Demand Side	Supported	Not Supported
4	Initiative	External Demand Side	Not Supported	Supported
		Internal Supply Side	Not Supported	Not Supported
		External Supply Side	Not Supported	Not Supported
		Internal Demand Side	Not Supported	Not Supported
5	Complementarities	External Demand Side	Not Supported	Supported

Similarly, business performance is influenced by both speed (β = 0.419; $p<0.01$) and effectiveness (β = 0.497; $p<0.01$) dimensions of DM agility. Hypothesis 1 and 2 are thus fully supported (Table 19). For the speed and effectiveness dimensions of DM agility, the parameter coefficients were estimated simultaneously. The R squared for the two were 0.334 and 0.287 respectively (Adjusted R Square: 0.256 and 0.202 respectively).

Demand Management Information Technology Impacts

The effects of information technology are found to be relatively more significant for the two agile outcomes. For the speed of DM agility, external supply side IT (β = 0.228; $p<0.01$), internal supply side IT (β = 0.148; $p<0.01$), and internal demand side IT (β =0.142; $p<0.05$) are found to have significant impacts. Hypothesis H3a is thus supported with significant impacts of three out of four technologies on the speed of DM agility. For the effectiveness of DM agility dimension (Hypothesis 3b), external supply side IT (β = 0.231; $p<0.01$) and internal demand side IT (β = 0.137; $p<0.05$) are found to have positive impacts.

Demand Management Initiative Impacts

The hypothesis 4a and 4b have weak support (for both 4a and 4b one out of four initiatives were found to have a significant impact), with internal demand side initiatives influencing speed of DM agility (β = 0.149; $p<0.05$) and external demand side initiatives influencing effectiveness of DM agility (β = 0.159; $p<0.05$). Other initiatives are not found to have a significant impact on either speed or effectiveness of DM agility.

Complementarities Impacts

External demand side technologies are not found to have a direct impact on speed or effectiveness of DM agility; however, their complementarities with the corresponding

business initiatives are found to have a significant impact for effectiveness ($\beta = 0.128$; $p<0.05$) (H4a and H4b). [4]The other complementarities between technology and initiatives for internal demand side, internal supply side, and external supply side are not found to be significant, suggesting weak support for hypothesis 5a and 5b.

We also find significant impacts of product volume on both speed of DM agility ($\beta = 0.165$; $p<0.05$) and effectiveness of DM agility ($\beta = 0.141$; $p<0.05$) and marginally significant impacts of firm size on the two dimensions of DM agility.

Regression Diagnostics and Robustness Analysis

To test the validity of our results we did various tests. Firstly, we assessed the normality of the sample used for analysis using the Shapiro Wilks Lambda test. The residuals were used to assess the normality from both the tests and this was not found to be a problem in our analysis. Further, to test for the heteroskedasticity, we used the Breusch-Pagan test and the results rule out any threat to our analysis due to heteroskedasticity. Finally, we tested the specification using the Linktest and found that the models were appropriately specified with the given set of variables (hhat was found to be significant at $p<.05$ for all cases), and there was no gain in specification by the inclusion of another set of variables (hhat squared insignificant with $p>.10$ for all cases). To guard against plausible multicollinearity, we used the ORTHOREG procedure in SAS and the results were found to be consistent. PROCPOWER procedure was used to assess the power of the test and the power was found to be good (greater than 0.8). Finally, we also tested the interaction effects by using the standardized variables and the results are still found to be same.

[4] The external demand side complementarities were assessed as an interaction between external demand side IT and external demand side initiatives. Similarly, other complementarities were assessed as the interaction between the respective information technology and demand management business initiative.

CHAPTER 5: DISCUSSION AND CONCLUSIONS

The research tests the impacts of four different types of information technologies and business initiatives used in demand management process on organization's ability to respond to changes in customer demand. The four types of information technologies and initiatives studied in this research are based on two orthogonal dimensions: scope of technology/initiative and its functionality. Based on these two dimensions, four categories of IT and business initiatives are identified – internal supply side, external supply side, internal demand side, and external demand side. The impacts of these IT systems and initiatives on the ability of the firm to respond to customer demand changes (DM agility) are assessed in this research. Two different dimensions of DM agility are assessed. Firstly, we assess the speed of DM agility – how fast is the firm able to respond to changes in customer demand; and secondly effectiveness - how effective is the firm's response to these demand changes. The role of IT and business initiatives is assessed separately for these two types of firm response capabilities. The study finds the varying impact of IT, business initiatives, and their synergies across the domains.

External Supply Side

Direct impacts are found to be significant predictors of speed and effectiveness of DM agility for external supply side information technologies. These technologies are found to enhance both the speed and effectiveness of a firm's response. Thus, the ability of the firm to exchange information and digitally coordinate a process is found to significantly influence both the speed and effectiveness of their response to changes in customer demand (Lee et al. 1997). These information technologies that help exchange information with the external suppliers such (as EDI and XML), and that help a firm to

work simultaneously in real time with external suppliers, synchronize production plans, are all found to impact the speed and effectiveness with which the firm is able to respond to changes in customer demand. Similarly, technologies that aid the collaborative forecasting and replenishment are significant antecedents to DM agility. However, the impacts of corresponding initiatives are not found to be significant. Similarly, we don't find evidence of a significant interaction between the two. There are two possible alternatives for these missing impacts. Firstly, it is possible that the external supply side initiatives are hard wired into the technology itself. For example, it is plausible that the demand forecasting information to be shared is already programmed into the technology at the time of implementation and the technologies do not have more flexibility to customize the information that can be shared through them. Future research might test alternate model specifications to test these possibilities. The second possibility is that the value amplification in the IT impacts, in the presence of demand management business initiatives, is not linear in nature. The use of alternate methodologies in future research, such as that can detect non-linear relationships, might suggest a different outcome (Oh and Pinnsoneault 2007)

Internal demand side

Similar to external supply side IT, direct impacts are also found to be significant predictors of speed and effectiveness of DM agility for internal demand side technologies, i.e. the ability of the firm to use information technologies for planning, forecasting, and managing demand is a significant predictor of how well the firm is able to respond. Specifically, we examine the use of technologies for special product types

such as those with short life cycle, or those are new or are seasonal in nature. This indicates that effective planning and forecasting activities are critically influenced by the use of digital technologies (such as those used for analytics). The impact of internal demand management initiatives is also found to be significant for speed of DM agility (but not effectiveness of DM Agility). Thus initiatives to acquire information about the competitor's actions, business changes, and changing customer preferences from the marketing department are found to have an increased impact on the speed with which the firm is able to respond. Similarly, information regarding changes in marketing strategies or upcoming marketing events (such as promotions) helps enhance the speed with which the customer demand can be fulfilled. However, the complementary interaction between the two is not found to be significant for either. A possibility for missing impact is that since the use of these two types of technologies and business initiatives is highly intertwined, the synergistic impact is subsumed in the direct impacts. For example, while it can not be claimed that was so the case, it is possible that the nature of information being collected from the marketing department is based on the capabilities available in the technologies being used for predicting and forecasting demand. Hence, nothing is 'hidden' or unknown and our interaction effect (which assumes this underlying interaction between the two as a hidden source of value) is not found to be significant. Thus, future research might explore the relative impact of synergistic interaction based on the 'intertwinedness'. While our research did not test this element, our results indicate that this is an important concept to be explored while assessing synergies between technologies and processes. The presence of this factor will determine whether the locus of adaptation and the nature of coordination at the time of implementation of technology

into the works process have an influence on the significance of complementarities. Alternatively, the technology and process are located and implemented independently and their mutual effect would be seen in the interaction. IS research has not explored this dimension and future research would explore this dynamics related to digital complementarities.

External demand side

The mutual effect due to co-presence of technology and business initiatives is found to be significant in the case of external demand side IT and initiatives. These complementarities are found to influence the effectiveness with which the firm is able to respond to the customer demand changes. Thus, firms are able to respond effectively to changes in customer demand if they use technologies such as RFID or bar coding technologies to bring in customer-related information and combine these with active processing and assessment of customer interests. However, the direct impacts of these technologies are not significant on either the speed of DM agility or effectiveness of DM agility. Thus, the results indicate that while the technologies such as RFID may not have any direct impacts on their own, they do contribute to the effectiveness of DM agility in combination with the corresponding business initiatives, i.e. when the information brought in by these technologies is complemented by efforts to integrate it with the demand planning activities. Mere information technologies without any active business efforts to assess customer preferences or to integrate this information to examine and plan response to demand changes may not aid the DM agility of the firm. This is in stark contrast to the internal demand side and external supply side technologies that are found

to have an impact on their own. Prim facie it indicates that the sophistication of the technology and its life cycle might determine the extent to which the advantages of process initiatives have been inbuilt into the technology itself. However, more research is needed to determine the underlying factors that explain the differences in the nature of impacts across these different technology types.

Internal supply side

Finally, the technologies used in internal supply side for coordination with production with other functional areas are found to have a positive impact on the speed of a firm's response. Thus, the firm's ability to change their product profiles through a digitally-coordinated response within the firm affects its ability to speedily respond to changes in customer demand. However, these technologies are not found to have a significant impact on effectiveness. The complementary impacts of these technologies in the presence of corresponding business initiatives are not found to be significant either. The result suggests that following the interaction approach being used in the study, the hypothesis of synergistic relation between the supply chain technologies used within the firm and the corresponding business initiatives is not supported. This indicates that the IT and business initiative may not have a synergistic relationship. To further explore this unexpected finding, we used the alternate alignment (or matching) approach that has been proposed to study the relationship between contingent variables (Sabherwal and Kirs 1994; Chan et al. 1997; Oh and Pinnsoneault 2007). Using this approach from Oh and Pinnsoneault (1997), we operationalized the alignment as the absolute difference between the two contingent variables. These alignment factors were then used instead of the direct

impacts of independent variables as the antecedents in our research model (Oh and Pinnsoneault 1997). The analysis reveals that for internal supply chain technologies the impact is based on the alignment of these technologies with the corresponding business initiatives. Alignment effect is not found to be significant for any other pair of technology and initiatives. Thus, while the synergies are not obtained in the case of internal supply side IT, alignment is the key to realization of the impacts of the two. The technologies in this domain included the technologies for coordination with the logistics, finance, sourcing, and operations departments, and those used for sales and operations planning. The corresponding initiatives were those used to acquire and integrate operational information from these other departments and to communicate demand changes to them. The results of positive impact using the alignment approach allude to the importance of adjustment or matching between the two to synchronize the technology with the process. Thus, favorable results may not be obtained if the focus is on viewing the two (technology and business initiatives) as complements. i.e. the impact of one will not increase in the presence of the other (Milgrom and Roberts 1995). Instead the goal is to decrease the gap between the two. The greater the gap the worst the performance; very high use of one and very low use of other is better than the moderate use of both as the alignment is better in the latter case. While it is beyond the examination being done in this research, it would be worthwhile to explore the role of organizational culture and relative power dynamics between departments in influencing this alignment effect in case of the internal supply side technologies and initiatives.

To summarize, while external supply side IT and internal demand side IT have predominantly direct impacts, the impact of the other two types are contingent in nature.

While external demand side IT have synergistic influence with corresponding initiatives, the internal supply side IT have matching or alignment relationship with the corresponding initiatives. Thus, the results indicate that alternate pathways characterize the way IT impacts accrue in a given process. Assuming all technologies to have similar patterns of impacts may be a broad and unrealistic assumption. The reasoning, similar to the earlier assumption that was made with regards to the overall impacts of IT investments on firm performance, may not hold. Different types of IT systems might have very different pathways in which their impacts are realized on agile performance. While some of the IT systems might have a direct impact, others are found to have an impact only when considered with the corresponding business initiatives. Further, alignment perspective (studied for internal supply side technologies and initiatives) also corroborates the difference in the nature of relationship between the technology and initiatives. While we have indicated the presence of these differences, future research is needed to more thoroughly tease out how different perspectives pan out across different technology types and complements. Before elaborating on the contributions and implications of the study it is worth while to elaborate on its limitations.

LIMITATIONS

The study has two key limitations. Firstly, the data for the study was collected by surveying only a single respondent (the demand planning manager) within each organization. There might thus be respondent bias that cannot be ruled out. The dual respondents within organizations help reduce the variability due to personal preferences.

However, given that demand management is a niche field within a firm[5], we had to forego this option. While the research results would have been more robust in light of a dual response design, we believe that the results make significant contributions by exploring an area of research that has hitherto been very hard to study primarily due to the limited availability of people in this field of work. Thus, our single respondent design, while not ideal, helps optimize on the tradeoff between rigor and relevance for the context of demand management being studied in this research.

The second limitation of this research is that the research uses subjective measures for assessing agility. As common with survey approach, this leaves the possibility of differential interpretation by different firms. Though a pilot test was done to test the respondent, understanding the threat can never be ruled out in subjective measures. The objective measures to assess how well the firm responds was ruled out because of two primary reasons. First, given the unique definition of constructs, the record keeping of the firm of these measures is highly limited. Secondly, the comparison of these measures across firms would be highly erroneous due to different methodologies. Thus, while objective measures are a better indicator of true performance, in this context our subjective measures might do a better job of consistently assessing agility across the firms. Further, past research has concluded that managerial assessments are consistent with objective internal performance and also with external secondary data (Dess and Robinson 1984, Venkataraman and Ramanujam 1986).

[5] Author himself has worked in the domain and this assertion is based on his personal knowledge of the industry standards.

CONTRIBUTIONS

The research makes three key contributions to the IS literature. Firstly, it tests the role of different types of IT applications and differentiates four different types of complements. Results indicate that differences across technology types are important to consider. While prior research has focused on classification such as infrastructural IT, transformation IT, etc. (Aral and Weill 2007), this research looks at the role of four different functional applications in the context of demand management. The research not only establishes the contribution of IT to the demand management process but also highlights the nature of impacts of four different types of IT systems relevant to the demand management process.

Secondly, this research assesses DM agility not just as the speed of DM agility but also as the effectiveness of DM agility . As the results indicate, two types of IT (Internal demand side IT and External supply side IT) enhance both speed and effectiveness. Also, while internal supply side IT enhances speed of DM agility, they do not have any influence on the effectiveness. Similarly, neither speed nor effectiveness is influenced by the external demand side IT. However, effectiveness is influenced by the joint use of both external demand side technologies and initiatives. Thus, the research contributes by establishing different dimensions of DM agility, and more importantly, by assessing how different IT types have different effects on these two dimensions. While some IT systems might impact speed, others might impact effectiveness and a subset might have influence on both. Similarly, the results indicate that synergies between IT and initiatives may be important for effectiveness even when they are not found to be significant for speed of DM agility. We hope these findings will move the research

beyond mere assessment of how fast the firm was able to respond and explore the antecedents of the effectiveness dimension of a firm's response as well.

Finally, the research establishes the impact of DM agility on supply chain performance. We find positive impacts for both the speed of firm response and the effectiveness of firm response on the overall performance of the supply chain. The impacts are found to be significant for both the service and overall business performance. Given the widespread interest and attention to agility in the contemporary research (Sambamurthy et al. 2003), the empirical evidence demonstrating these effects is significant and has been overlooked till now. This result linking DM agility to firm performance will give further impetus to research that links the factors under which the agility might impact firm performance. Thus, this research would form the basis for future research to explore contingency factors that determine the role of agility in the firm performance.

MANAGERIAL IMPLICATIONS

The study has important implications to help managers in the field of demand management and order fulfillment. Given the increased competition in business markets, customer demand has increasingly gained greater significance. Ironically, the research focus has been limited to enhancing the performance of a firm's supply side and relations with partners. Given the very niche, yet highly important, role played by demand management, this research adds new knowledge that is highly valuable due to the limited scope of improvements by realizing supply side efficiencies.

Further, the research contributes to the managerial understanding of the role of information technologies in realizing greater responsiveness to changes in customer demand. Given the complexity identified by researchers in leveraging IT, the establishment of value pathways helps managers focus on appropriate actions required to realize value out of their IT investments. Siggelkow (2002) emphasizes that the knowledge of complex interactions between organizational variables is often internalized by managers for quick actions in compressed time frames that are typical of organizational work. Thus, our research identifies the critical pathways to value. For managerial relevance, the results indicate that while some technologies might have a direct impact, others might amplify responsiveness only in the presence of corresponding business initiatives. Specifically, we find that the internal demand side and external supply side technologies have direct impacts while the interaction with corresponding business initiatives is important for the internal supply side and external demand side technologies. While the internal supply side technologies need to be aligned with the corresponding business initiatives, the impact of external demand side is interactive and complementary in nature.

In conclusion, given the enhanced focus on process level of analysis, this research assesses the IT systems that lead to the creation of DM agility in the demand management process. The study finds that different types of IT systems have very different impacts on the performance of a firm's ability to respond to changes in customer demand. The nature of complementary interaction with the process element varies according to the nature of the technology as well. Further, the study also shows which IT

systems and their interactions are significant for speedy and effectiveness of DM agility respectively. Finally, the research empirically establishes the performance impacts of a firm's response capabilities, and will form the basis for future research on this topic.

REFERENCES

Allen, B.R., and Boynton, A.C. "Information architecture: In search of efficient flexibility," *MIS Quarterly* (15:4) 1991, p 435.

Amir, R. "Supermodularity and complementarity in economics: An elementary survey," *Southern Economic Journal* (71) 2005, pp 636-660.

Amit, R.H., and Schoemaker, P.J.H. "Strategic Assets and Organizational Rent," *Strategic Management Journal* (14) 1993, pp 33-46.

Aral, S., and Weill., P. "IT assets, organizational capabilities and firm Performance: How resource allocations and organizational differences explain performance variation," *Organization Science* (18:5), September-October 2007, pp 1-18.

Argote, L. *Organizational Learning. Creating, Retaining and Transferring Knowledge* Kluwer Academic Publishers, Norwell, MA, 1999.

Asgekar, V. "Event Management Graduates with Distinction," *Supply Chain Management Review*) 2003.

Bakos, J.Y. "A strategic analysis of electronic marketplaces," *MIS Quarterly* (15:3) 1991, p 295.

Banker, R.D., Bardhan, I.R., Lin, S., and Chang., H. "Plant Information Systems, Manufacturing Capabilities and Plant Performance," *MIS Quarterly* (30:2) 2006, pp 313-337.

Barney, J.B. "Strategic factor markets: Expectations, luck, and business strategy," *Management Science* (32:10) 1986, pp 1231-1124.

Barney, J.B. "Firm Resources and Sustained Competitive Advantage," *Journal of Management* (17:1) 1991, pp 99-120.

Barua, A., Konana, P., Whinston, A.B., and Yin, F. "An Empirical Investigation of Net-Enabled Business Value," *MIS Quarterly* (28:4) 2004, pp 585 – 620.

Barua, K., Mukhopadhyay, T. "Information technology and business performance: Past, present, and future.," in: *Framing the Domains of IT Management, Projecting the Future Through the Past,* R.W. Zmud. (ed.), Pinnaflex press, Cincinnati, OH, 2000, pp. 65-84.

Beamon, B.M. "Measuring Supply Chain Performance," *International Journal of Operations and Production Management* (19:3) 1999, pp 46-63.

Beath, C.M., and Ives, B. "Competitive Information Systems in Support of Pricing," *MIS*

Quarterly (10:1) 1986, p 84.

Bharadwaj, A.S. "A resource-based perspective on information technology capability and firm performance: An empirical investigation," *MIS Quarterly* (24:1) 2000, p 169.

Bharadwaj, A.S., Sambamurthy, V., and Zmud, R.W. "IT capabilities: theoretical perspectives and empirical operationalization," *The International Conference on Information Systems, Helsinki, Finland*) 1998, pp 378-385.

Bharadwaj, S., Bharadwaj, A., and Bendoly, E. "The Performance Effects of Complementarities Between Information Systems, Marketing, Manufacturing, and Supply Chain Processes," *Infomration Systems Research* (18:4) 2007, pp 437-453.

Boddy, D., Cahill, D., Charles, M., Fraser-Kraus, H., and Macbeth, D. "Success and failure in implementing partnering," *European Journal of Purchasing and Supply Management* (2:3) 1998, pp 143–151.

Bolstorff, P., and Rosenbaum, R. *Supply Chain Excellence: a Handbook for Dramatic Improvement Using the SCOR Model* AMACOM., New York, 2003.

Bolumole, Y.A., Knemeyer, A.M., and Lambert, D.M. "The Customer Service Management Process," *The International Journal of Logistics Management* (14:2) 2003, pp 15-31.

Bolwijn, P.T., Boorsma, J., Van Breukelen, Q.H., and Brinkman, S. *Flexible Manufacturing - Integrating Technological and Social Innovation* Elsevier Amsterdam., 1986.

Bowersox, D.J., Closs, D.J., and Cooper, M.B. *Supply Chain Logistics Management*, (2nd ed.) McGraw-Hill, New York, 2006.

Bowersox, D.J., Closs, D.J., and Stank, T. *2/'Supply Chain Integration a Reality* Council of Logistics Management, Oak Brook, IL, 1999.

Bowersox, D.J., and Daugherty, P.J. "Emerging Patterns of Logistics Organization," *Journal of Business Logistics* (8:1) 1987, pp 46-60.

Bowersox, D.J., and Daugherty, P.J. "Logistics paradigms: The impact of information technologies," *Journal of Business Logistics* (16:1) 1995, pp 65-80.

Boyer, K.K., and Olson, J.R. "Drivers of Internet Purchasing Success," *Production and Operations Management* (11:4) 2002, pp 180-198.

Brown, S., and Bessant, J. "The manufacturing strategy-capabilities links in mass customisation and agile manufacturing - an exploratory study," *International*

Journal of Operations & Production Management (23:7) 2003.

Brynjolfsson, E., and Hitt, L. "Paradox lost? Firm-Level Evidence on the Returns to Information Systems," *Management Science* (42:4) 1996, pp 541-558.

Brynjolfsson, E., and Smith, M.D. "Frictionless Commerce? A Comparison of Internet and Conventional Retailers," *Management Science* (46:4) 2000, p 563.

Byrd, T.A. "Information Technology, core competencies and sustained competitive advantage," *Information Resources Management Journal* (14 2) 2001, pp 27-36

Cash, J.I., and Kosynski, B.R. "IS Redraws Competitive Boundaries," *Harvard Business Review* (63:2) 1985, pp 134-142.

Chan, F. "Performance measurement in a supply chain," *International Journal of Advanced Manufacturing Technology* (21 7) 2003, pp 534-548.

Chan, F.T.S., and Qi, H.J. "An innovative performance measurement method for supply chain management," *Supply Chain Management: An International Journal* (8:3-4) 2003, pp 209-223.

Chan, Y., Huff, S., Barclay, D., and Copeland, D. "Business Strategic Orientation, Information Systems Strategic Orientation, and Strategic Alignment," *Information Systems Research* (8:2) 1997, pp 125-150.

Christopher, M., and Towill, D. "An integrated model for the design of agile supply chains," *International Journal of Physical Distribution & Logistics Management* (31:4) 2001, pp 235-247.

Clark, C.E., Cavanaugh, N.C., Brown, C.V., and Sambamurthy, V. "Building a Change Ready IS Organization at Bell Atlantic," *MIS Quarterly* (21:4) 1997.

Clemons, E.K., and Row, M.C. "Sustaining IT advantage: The role of structural differences," *MIS Quarterly* (15:3) 1991, p 275.

Coase, R. "The nature of the firm," *Economica* (4) 1937, pp 386-405.

Cohen, W.M., and Levinthal, D.A. "Absorptive capacity: a new perspective on learning and innovation," *Administrative Science Quarterly* (35) 1990, pp 128-152.

Cool, K., and Schendel, D. "Performance differences among strategic group members," *Strategic Management Journal* (9:3) 1988, pp 207–223.

Cooper, M.C., and Lambert, D.M., et al. "Supply Chain Management:More than a New Name for Logistics," *The International Journal of Logistics Management* (8:1) 1997, pp 1-14.

Croxton, K.L. "The Order Fulfillment Process," *The International Journal of Logistics Management* (14:1) 2003, pp 19-33.

Croxton, K.L., García-Dastugue, S.J., Lambert, D.M., and Rogers, D.S. "The Supply Chain Management Processes," *The International Journal of Logistics Management* (12:2) 2001, pp 13-36.

Croxton, K.L., Lambert, D.M., García-Dastugue, S.J., and Rogers, D.S. "The Demand Management Process," *The International Journal of Logistics Management* (13:2) 2002, pp 51-66.

Crum, C., and Palmatier, E.G. "Demand Collaboration: What's Holding us back?," *Supply Chain Management Review* (8:1) 2004, pp 54-61.

Culnan, M.J., and Markus, M.L. "Information technologies," in: *Handbook of Organizational Communication,* F.M. Jablin, L.L. Putnam, K.H. Roberts and L.W. Porter (eds.), Sage, London, 1987.

D'Aveni, R.A. *Hypercompetition: Managing the Dynamics of Strategic Maneuvering.* The Free Press, NY, 1994.

Day, G.S. "The Capabilities of Market-Driven Organizations," *Journal of Marketing* (58:4:October) 1994, pp 37-52.

Dess, G.S., R.B. Robinson. Measuring organizational performance in the absence of objective measures. *Strategic Management Journal* (5: 3) 1984, pp 265-273.

Dierickx, I., and Cool., K. "Asset stock accumulation and sustainability of competitive advantage," *Management Science* (35:12) 1989, pp 1504-1514.

Donaldson, L. *For Positivist Organization Theory: Proving the Hard Core* Sage, London, 1996.

Dove, R. *Response ability: the language, structure and culture of the agile enterprise* John Wiley & Sons, New York, 2001.

Drazin, R., and Ven, A.H.V.d. "Alternative Forms of Fit in Contingency Theory," *Administrative Science Quarterly* (30:December) 1985, pp 514-539.

Earl, M.J., and Feeny, D.F. "Is your CIO adding value? ," *Sloan Management Review* (35:3) 1994.

Edwards, P., Peters, M., and Sharman, G. "The effectiveness of information systems in supporting the extended supply chain," *Journal of Business Logistics* (22:1) 2001, pp 1-27.

Eisenhardt, K.M., and Martin, J.A. "Dynamic capabilities: What are they? ," *Strategic*

Management Journal (21) 2000, pp 1105-1121.

Feeny, D. "Creating and sustaining competitive advantage with IT," in: *Information Management: The Strategic Dimension,* M. Earl (ed.), Clarendon Press, Oxford, 1988.

Feeny, D.F., Edwards, B.R., and Simpson, K.M. "Understanding the CEO/CIO relationship," *MIS Quarterly* (16:4) 1992, pp 435-448.

Feeny, D.F., and Ives, B. "In search of sustainability: reaping long-term advantage from investments in information technology," *Journal of Management Information Systems* (7:1) 1990, pp 27-46.

Feeny, D.F., and Willcocks, L.P. "Core IS capabilities for exploiting information technology," *Sloan Management Review* (39:3) 1998, pp 9-21.

Fish, L.A., and Forrest, W.C. "A Worldwide Look at RFID," *Supply Chain Management Review*), April 2007.

Fisher, M.L. "What is the Right Supply Chain for Your Product?," *Harvard Business Review*:Mar-Apr.) 1997, pp 105-116.

Foss, N.J. "Knowledge-based approaches to the theory of the firm: Some critical comments," *Organization Science* (7) 1996, pp 470-476.

Goldman, S.L., Nagel, R.N., Preiss, K. *Agile Competitors and Virtual Organizations: Strategies for Enriching the Customer* Van Nostrand Reinhold, New York, NY, 1994.

Goldsby, T.J., and García-Dastugue, S.J. "The Manufacturing Flow Process," *The International Journal of Logistics Management* (14:2) 2003, pp 33-52.

Grant, R.M. "Toward a Knowledge-based Theory of the Firm," *Strategic Management Journal* (17:Winter Special Issue) 1996, pp 109-122.

Gunasekaran, A., Patel, C., and Tirtiroglu, E. "Performance measures and metrics in a supply chain environment," *International Journal of Operations & Production Management* (21 1-2) 2001, pp 71-87.

Gunasekaran, A., and Yusuf, Y.Y. "Agile manufacturing: a taxonomy of strategic and technological imperatives," *International Journal of Production Research* (40 6) 2002, pp 1357-1385.

Gurbaxani, V., and Whang, S. "The impact of information systems on organizations and markets.," *Communications of the ACM* (54:1) 1991, pp 59-73.

Hamel, G., and Prahalad, C.K. *Competing for the Future* Harvard Business School Press, Boston, 1994.

Hansen, G., and Wernerfelt, B. "Determinants of firm performance: The relative importance of economic and organizational factors," *Strategic Management Journal* (10) 1989, pp 399-411.

Helfat, C.E., and Peteraf, M.A. "The Dynamic Resource-based View: Capabilities Lifecycles," *Strategic Management Journal* (24:10) 2003, pp 997-1010.

Hewitt, F. "Supply Chains, Think Demand Pipelines," *Supply Chain Management Review* (5:28) 2001.

Hitt, L.M. "Information Technology and Firm Boundaries: Evidence from Panel Data," *Infomration Systems Research* (10:2) 1999.

Holmqvist, M., and Stefansson, G. "Mobile RFID - A Case from Volvo on Innovation in SCM " *System Sciences, HICSS '06. Proceedings of the 39th Annual Hawaii International Conference* (6) 2006, pp 141a-141a.

Hopper, M.D. "Rattling SABRE – new ways to compete on information," *Harvard Business Review*:May–June) 1990, pp 118–125.

Huang, S.H., S. K. Sheoran, et al. "A review and analysis of supply chain operations reference (SCOR) model," *Supply Chain Management: An International Journal* (9:1) 2004, pp 23-29.

Huang, S.H., Sheoran, S.K., and Wang, G. "A review and analysis of supply chain operations reference (SCOR) model," *Supply Chain Management: An International Journal* (9:1) 2004, pp 23-29.

Huber, G.P. "A theory of the effects of advanced information technologies on organizational design, intelligence, and decision making," *Academy of Management Review* (15:1) 1990, pp 47-71.

Hurley, R., and Hult, T. "Innovation, market orientation, and organizational learning: An integration and empirical examination," *Journal of Marketing* (62) 1998, pp 42-54.

Ichniowski, C., Shaw, K., et al. "The effects of human resource management practices on productivity: A study of steel finishing lines," *American Economic Review* (87:291-313) 1997.

Jap, S.D., and Mohr, J. "Leveraging Internet Technologies in B2B Relationships," *California Management Review* (44:4) 2002, pp 24-38.

Jaworski, B.J., and Kohli, A.K. "Market orientation: Antecedents and consequences,"

Journal of Marketing (57:7) 1993, pp 53-70.

Jayaram, J., Vickery, S.K., and Droge, C. "The effects of information system infrastructure and process improvements on supply-chain time performance," *International Journal of Physical Distribution & Logistics Management* (20:3/4) 1997, pp 314-330.

Kaplan, S., and Sawhney, M. "E-Hubs: The New Marketplaces," *Harvard Business Review*) 2000, pp 97-103.

Keen, P.G.W. *Shaping the Future: Business Design through Information Technology* Harvard Business School Press, Boston, MA, 1991.

Kettinger, W.J., and Grover, V. "Strategic information systems revisited: A study in sustainability and performance," *MIS Quarterly* (18:1) 1994, p 31.

Kogut, B., and Zander, U. "Knowledge of the firm, combinative capabilities, and the replication of technology," *Organization Science* (3) 1992, pp 383-397.

Kohli, A.K., and Jaworski, B.J. "Market Orientation: The Construct, Research Propositions and Managerial Implications," *Journal of Marketing* (54:4) 1990, pp 1-18.

Kotha, S. "Mass customization: Implementing the emerging paradigm for competitive advantage," *Strategic Management Journal* (16) 1995, pp 21-42.

Lacity, M.C., Willcocks, L.P., and Feeny, D.F. "IT Outsourcing: Maximize Flexibility and Control," *Harvard Business Review* (73:3) 1995, pp 84-93.

Lafferty, B.A., and Hult, G. "A synthesis of contemporary market orientation perspectives," *European Journal of Marketing* (35:1/2) 2001, pp 92-109.

Lambert, D.M., Cooper, M.C., and Pagh, J.D. "Supply Chain Management:Implementation Issues and Research Opportunities," *The International Journal of Logistics Management* (9:2) 1998, pp 1-19.

Lambert, D.M., Garcia-Dastugue, S.J., and Croxton, K.L. "An evaluation of processoriented supply chain management frameworks," *Journal of Business Logistics* (26:1) 2005, p 2547.

Lapide, L., and Davis, D. "The Supply Chain Management Applications Report, 2002–2007," pp. Retrieved February, 2003.

Lee, C.H. "Coordinated stocking, clearance sales, and return policies for a supply chain " *European Journal of Operational Research* (131:3) 2001, pp 491-513.

Lee, H., Padmanabhan, V., and Whang, S. "Information Distortion in a Supply Chain: The Bullwhip Effect," *Management Science* (43:4) 1997, p 546.

Lee, H.L. "The Triple-A Supply Chain," *Harvard Business Review* (82:10) 2004, pp 102-114.

Lee, H.L., and Whang, S. "Winning the Last Mile of E-commerce," *MIT Sloan Management Review* (42:4) 2001, pp 54-62.

Levina, N., and Ross, J.W. "From the vendor's perspective: exploring the value proposition in information technology outsourcing," *MIS Quarterly* (27:3) 2003, pp 331-364.

Levinthal, D.A. "Adaptation on Rugged Landscapes," *Management Science* (43:7) 1997, pp 934-950.

Li, S., Rao, S.S., Ragu-Nathan, T.S., and Ragu-Nathan, B. "Development and Validation of a Measurement Instrument for Studying Supply Chain Management Practices," *Journal of Operations Management* (23:6) 2005, pp 618-641.

Lindsey, D., Cheney, P., Kasper, G., and Ives, B. "TELCOT: An Application of Information Technology for Competitive Advantage in the Cotton Industry," *MIS Quarterly* (14:4) 1990, pp 346-357.

Makadok, R. "Toward a Synthesis of the Resource-Based and Dynamic-Capability Views of Rent Creation," *Strategic Management Journal* (22) 2001, pp 387-401.

Malhotra, A., S. Gosain, et al. "Absorptive Capacity Configurations In Supply Chains: Gearing For Partner- Enabled Market Knowledge Creation," *MIS Quarterly* (29:1) 2005.

Markus, M.L., and Robey, D. "Information Technology and Organizational-Change - Causal- Structure in Theory and Research," *Management Science* (34:5) 1988, pp 583-598.

Mayer, K., Nickerson, J.A., and Owan, H. "Are Supply and Plant Inspections Complements or Substitutes? A Strategic and Operational Assessment of Inspection Practices in Biotechnology," *Management Science* (50:8-August) 2004, pp 1064-1081.

McCullen, P., and Towill, D.R. "The bullwhip in the supply chain problem: a case of old wine in new bottles," Proceedings of the European Operations Management Association 8th International Conference, , Bath, 2001, pp. 516-527.

McFarlan, W.E. "Portfolio approach to information systems," *Harvard Business Review*:September- October) 1981, pp 142-150. .

McGahan, A.M., and Porter, M.E. "How much does industry matter, really?," *Strategic Management Journal* (18 Special Issue Supplement) 1997, pp 15-30.

Melnyk, S.A., Stank, T.P., and Closs, D.J. "Supply Chain Management at Michigan State University: The Journey and the Lessons Learned," *Production and Inventory Management Journal* (41:3) 2000, pp 13-18.

Mendelson, H., and Pillai, R.R. "Clockspeed and informational response: evidence from the information technology industry," *Information Systems Research* (9:4) 1998, pp 415-433.

Mendelson, H., and Pillai, R.R. "Industry clockspeed: measurement and operational implications," *Manufacturing & Service Operations Management* (1:1) 1999, pp 1-20.

Milgrom, P., Roberts, J. "The Economics of Modern Manufacturing: Technology, Strategy, and Organization," *American Economic Review* (80:3) 1990, pp 511-528.

Milgrom, P., Roberts, J. "Complementarities and fit strategy, structure, and organizational change in manufacturing," *Journal of Accounting and Economics* (2:3) 1995, pp 179-208.

Milgrom, P., Qian, Y., and Roberts, J. "Complementarities, Momentum, and the Evolution of Modern," *American Economic Review* (81:2 - MAY) 1991, pp 84-88.

Monczka, R.M., Trent, R.J., and Handfield, R.B. *Purchasing and Supply Chain Management* South-Western College Publishing, Cincinnati, OH, 1998.

Monteiro, L., and Macdonald, S. "From efficiency to flexibility: the strategic use of information in the airline industry," *Journal of Strategic Information Systems* (5:3) 1996, pp 169–188.

Nagel, R.N., and Bhargava, P. "Agility: the ultimate requirement for world-class manufacturing performance," *National Productivity Review* (13:3) 1994, pp 331-340.

Nambisan, S. "Designing virtual customer environments for new product development: Toward a theory," *Academy of Management Review* (27:3) 2002, pp 392-413.

Narasimhan, R., Swink, M., and Kim, S.W. "Disentangling leanness and agility: An empirical investigation," *Journal of Operations Management* (24:5-1 September) 2006, pp 440-457.

Nelson, R., and Winter, S. *An Evolutionary Theory of Economic Change.* Harvard University Press, Cambridge, MA, 1982.

Oh, W., and Pinsonneault, A. "On the Assessment of the Strategic Value of Information Systems: Conceptual and Analytical Approaches," *MIS Quarterly* (31:2) 2007, pp 239-265

Orlikowski, W.J. "The duality of technology: Rethinking the concept of technology in organizations," *Organization Science* (3:398-427) 1992.

Orlikowski, W.J. "Using technology and constituting structures: A practice lens for studying technology in organizations," *Organization Science* (11) 2000, pp 404-428.

Overby, E., Bharadwaj, A., and Sambamurthy, V. "Enterprise Agility and the Enabling Role of Information Technology," *European journal of Information Systems* (15:2) 2006, pp 120-132.

Parthasarthy, R., Sethi, S.P. "The Impact of Flexible Automation on Business Strategy and Organizational Structure," *Academy of Management Review* (17:1) 1992, pp 86-111.

Parthasarthy, R., Sethi, S.P. "Relating strategy and structure to flexible automation: A test of fit and performance implications," *Strategic Management Journal* (14:7) 1993, pp 529-549.

Pavlou, P.A., and El Sawy, O.A. "From IT Leveraging Competence to Competitive Advantage in Turbulent Environments: The Case of New Product Development " *Infomration Systems Research* (17) 2006 pp 198-227.

Penrose, E. *The Theory of the Growth of the Firm* (3rd ed.) Oxford University Press, Oxford, UK, 1959.

Peteraf, M.A. "The Cornerstones of Competitive Advantage: A Resource-Based View," *Strategic Management Journal* (14) 1993, pp 179-191.

Pfeffer, J. *Organizations and Organization Theory.* Pitman Publishers, Boston, MA, 1982.

Piccoli, G., Ives, B. "IT-Dependent Strategic Initiatives and Sustained Competitive Advantage: A Review and Synthesis of the Literature," *MIS Quarterly* (29:4) 2005.

Pine, B.J. *Mass Customization: The New Frontier in Business Competition* Harvard Business School Press, Boston., 1993.

Porter, M.E. *Competitive Strategy* The Free Press, New York, 1980.

Porter, M.E. "What is Strategy?," *Harvard Business Review*) 1996, pp 61-78.

Porter, M.E., and Miller, V.E. "How information gives you competitive advantage," *Harvard Business Review* (63:4) 1985, pp 149-160.

Prahalad, C.K., and Hamel, G. "The Core Competence of the Corporation," *Harvard Business Review* (68:3) 1990, pp 79-87.

Priem, R.L., and Butler, J.E. "Is the "Resource-Based View" a Useful Perspective for Strategic Management Research? ," *Academy of Management Review* (26:1) 2001, pp 22-41.

Prince, J., and Kay, J.M. "Combining lean and agile characteristics: Creation of virtual groups by enhanced production flow analysis," *International Journal of Production Economics* (85:3) 2003, pp 305-318.

Rai, A., Patnayakuni, R., and Patnayakuni, N. "Firm Performance Impacts of Digitally Enabled Supply Chain Integration Capabilities," *MIS Quarterly(forthcoming)*) 2006.

Ray, G., Waleed, A.M., and Barney, J.B. "Information Technology and the Performance of the Customer Service Process: A Resource-Based Analysis," *MIS Quarterly* (29:4), December 2005, pp 625-652.

Rice, R.E., and Blair, J.H. "New organizational media and productivity.," in: *Th...e New Media,* R.E.A. Rice (ed.), Sage, Beverly Hills, CA, 1984.

Roberts, M., and Wood, M. "The strategic use of computerised information systems by a micro enterprise," *Logistics Information Management* (15:2) 2002, pp 115-125.

Rockart, J., Earl, M., and Ross, J. "Eight Imperatives for the New IT Organization," *Sloan Management Review*:Fall) 1996, pp 43-55.

Rogers, D.S., Lambert, D.M., Croxton, K.L., and García-Dastugue, S.J. "The Returns Management Process," *The International Journal of Logistics Management* (13:2) 2002, pp 1-18.

Rogers, D.S., Lambert, D.M., and Knemeyer, A.M. "The Product Development and Commercialization Process," *The International Journal of Logistics Management* (15:2) 2004, pp 43-56.

Ross, J.W. "Creating a strategic IT architecture competency : learning in stages," *MIS Quarterly Executive* (2:1) 2003, pp 31-44.

Ross, J.W., Beath, C.M., and Goodhue, D.L. "Develop long-term competitiveness through IT assets," *Sloan Management Review* Fall) 1996, pp 31-42.

Sabherwal, R., and Kirs, P. "The Alignment Between Organizational Critical Success Factors and Information Technology Capability in Academic Institutions," *Decision Sciences* (25:2) 1994, pp 301-330.

Sambamurthy, V. *Business strategy in hypercompetitive environments: Re-thinking the role of IT differentiation* Pinnaflex Educational Resources, Inc., Cincinnati, OH, 2000.

Sambamurthy, V., Bharadwaj, A., and Grover., V. "Shaping Agility through Digital Options: Reconceptualizing the role of IT in Contemporary Firms," *MIS Quarterly* (27: 2), June 2003, pp 237-263.

Schönsleben, P. *Integral Logistics Management: Planning and Control of Comprehensive Supply Chains* St Lucie Press, Boca Raton, FL, 2004.

Schumpeter, J. *The Theory of Economic Development* Oxford University Press, Oxford, 1934.

Schumpeter, J.A. *Capitalism, Socialism and Democracy* Harper and Sons, New Yor, 1950.

Scott, W.R. *Institutions and Organizations* Sage, Thousand Oaks, CA 2001.

Selznick, P. *Leadership in Administration* Harper & Row, New York, 1957.

Selznick, P. "Institutionalism "Old" and "New"," *Administrative Science Quarterly* (41:2) 1996, pp 270-277.

Setia, P., Vickery, S., Sambamurthy, V., and Droge, C. "Higher order vs. lower order complementarities: Emprical test of agility in manufacturing firms," WISE Worskshop on Information System Economics, Northwestern University, Evanston Il., 2006.

Shapiro, B.P., Rangan, V.K., and Sviokla, J.J. "Staple Yourself to an Order," *Harvard Business Review* (70:4) 1992, pp 113-122.

Sharifi, H., and Zhang, Z. "A methodology for achieving agility in manufacturing organizations: An introduction. ," *International Journal of Production Economics* (62) 1999, pp 7-22.

Sheffi, Y. *The Resilient Enterprise* The MIT Press, Cambridge, MA., 2005.

Shepherd, C., and Günter, H. "Measuring supply chain performance: current research and future directions," *International Journal of Productivity and Performance Management* (55:3/4) 2006, pp 242-258.

Siggelkow, N. "Misperceiving Interactions among Complements and Substitutes: Organizational Consequences," *Management Science* (48) 2002, pp 900-916.

Simchi-Levi, D., Kaminsky, P., and Simchi-Levi, E. *Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies* Irwin/McGraw-Hill, Boston, MA, 2000.

Simon, H. *Models of My Life* Basic Books, New York, 1991.

Sinha, K.K., and Van de Ven, A.H. "Design of work within and between organizations," *Organization Science* (16:4) 2005, pp 398-408.

Slater, S.F., and Narver, J.C. "Market Orientation and the Learning Organization," *Journal of Marketing* (59:7) 1995, pp 63-74.

Sproull, L., and Kiesler, S. "Reducing social context cues: electronic mail in organizational communication," *Management Science* (32:11) 1986, pp 1492-1512.

Srivastava, R.K., Shervani, T.A., and Fahey, L. "Marketing, Business Processes, and Shareholder Value: An Organizationally Embedded View of Marketing Activities and the Discipline of Marketing," *Journal of Marketing* (63:4) 1999, pp 168-179.

Stalk, G., and Hout, T. "Redesign your organization for time-based management " *Planning Review* (18:1) 1990, pp 4-9.

Stank, T.P., and Lackey, C.W.J. "Enhancing performance through logistical capabilities in Mexican maquiladora firms," *Journal of Business Logistics* (18:1) 1997, pp 91-123.

Stenbacka, R., and Tombak, M.M. "Investment, Capital Structure and Complementarities between Debt and New Equity," *Management Science* (48:2, February) 2002, pp 257-272.

Swafford, P., Ghosh, S., and Murthy, N.N. "The Antecedents of Supply Chain Agility: Scale Development and Model Testing," *Journal of Operations Management* (24:2) 2006, pp 170-188.

Tallon, P., and Kraemer, K. "Using Flexibility to Enhance the Alignment between Information Systems and Business Strategy:Implications for IT Business Value, ,"April 20) 2003.

Tanriverdi, H.S. "Information technology relatedness knowledge management capability and performance of multibusiness firms," *MIS Quarterly* (29:2) 2005, pp 311-334.

Tanriverdi, H.S. "Performance Effects of Information Technology Synergies in

Multibusiness Firms," *MIS Quarterly* (Forthcoming) 2006.

Teece, D.J. *The Multinational Corporation and the Resource Cost of International Technology Transfer* Ballinger Publishing Company, Cambridge, Mass, 1976.

Teece, D.J. "Economics of scope and the scope of the enterprise," *Journal of Economic Behavior and Organization* (1) 1980, pp 223-247.

Teece, D.J. "Profiting from technological innovations," *Research Policy* (15:6) 1986, pp 285-306.

Teece, D.J., Pisano, G., and Shuen, A. "Dynamic Capabilities and Strategic Management," *Strategic Management Journal* (18) 1997, pp 509-533.

Tidd, J., Bessant, J., and Pavitt, K. *Managing Innovation. Integrating technological, market and organizational change* John Wiley & Sons, England, 1997.

Venkataraman, N., V. Ramanujam. Measurement of business performance in the absence of objective measures. *Strategic Management Journal* (11: 4) 1986, pp 801-814.

Vickery, S.K., Jayaram, J., Dröge, C., and Calantone, R.J. "The Effects of an Integrated Supply Chain Strategy on Customer Service and Financial Performance: An Analysis of Direct Versus Indirect Effects," *Journal of Operations Management* (2:5 -December) 2003, pp 523-539.

Vitale, M.R. *American Hospital Supply Corporation: The ASAP system* Harvard Business School Press, Cambridge, Mass, 1990.

Wade, M., Hulland, J. "Review: The Resource-Based View and Information Systems Research: Review, Extension, and Suggestions for Future Research.," *MIS Quarterly* (28:1) 2004, pp 107-142.

Weick, K. *The Social Psychology of Organizing* (2nd ed.) Addison-Wesley., Reading, MA, 1979.

Weill, P., and Aral, S. "Generating Premium Returns on Your IT Investments," *MIT Sloan Management Review* (47:2, Winter) 2006.

Weill, P., Sibramani, M., and Broadbent, M. "Building it infrastructure for strategic agility," *Sloan Management Review* (44:1) 2002, pp 57–65.

Weill, P., and Vitale, M.R. *Place to Space: Migrating to eBusiness Models* Harvard Business School Press, Cambridge, MA, 2001.

Wheeler, C. "NEBIC: A Dynamic Capabilities Theory for Assessing Net-Enablement," *Information Systems Research* (13:2) 2002, pp 125-146.

Whittington, R., Pettigrew, A., et al. "Change and complementarities in the new competitive landscape: A European panel study, 1992-1996," *Organization Science* (10) 1999, pp 583-600.

Williamson, O.E. *Markets and hierarchies: Analysis and antitrust implications* Free Press. , New York, 1975.

Womack, K., Jones, D., and Roos, D. *The machine that changed the world* Maxwell Macmillan International, Oxford, 1990

Youssef, M.A. "Agile manufacturing: A necessary condition for competing on global markets," *Industrial Engineering*:December) 1992, pp 177-180

Zaheer, A., and Venkatraman, N. "Determinants of Electronic Integration in the Insurance Industry: An Empirical Test," *Management Science* (40:5 - May) 1994, pp 549-566.

Zaheer, A., and Zaheer, S. "Catching the Wave: Alertness, Responsiveness and Market Influence in Global Electronic Networks," *Management Science* (43:11) 1997, pp 1493-1509.

Zain, M., Rose, R.C., Abdullah, I., and Masrom, M. "The relationship between information technology acceptance and organizational agility in Malaysia," *Information & Management* (42:6) 2005, pp 829-839.

Zander, U., and Kogut, B. "Knowledge and the Speed of the Transfer and Imitation of Organizational Capabilities: An Empirical Test," *Organization Science* (6:1) 1995, pp 76-92.

Zmud, R.W. "Information Systems in Organizations," S.F.a. Company (ed.), Palo Alto, California, 1983.

Zmud, R.W. "An Examination of 'Push-Pull' Theory Applied to Process Innovation in Knowledge Work," *Management Science* (30:6) 1984, pp 727–738.

Zollo, M., and Winter, S.G. "Deliberate Learning and the Evolution of Dynamic Capabilities," *Organization Science* (13:3) 2002, pp 339-335.