



# The organizational antecedents of a firm's supply chain agility for risk mitigation and response

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## ARTICLE INFO

### Article history:

Received 19 January 2007

Received in revised form 4 July 2008

Accepted 19 September 2008

Available online 8 October 2008

### Keywords:

Supply chain management

Agility

Flexibility

Supply chain integration

Disruption risk mitigation and response

## ABSTRACT

Today's marketplace is characterized by intense competitive pressures as well as high levels of turbulence and uncertainty. Organizations require agility in their supply chains to provide superior value as well as to manage disruption risks and ensure uninterrupted service to customers. Thus the cultivation of agility is approached as a risk management initiative that enables a firm to respond rapidly to marketplace changes, as well as anticipated and actual disruptions in the supply chain. Agility is of value for both risk mitigation and response.

This research investigates the impact of two cultural antecedents, market orientation and learning orientation, and three organizational practices, all aimed at augmenting the supply chain agility of a firm. A firm's supply chain agility (FSCA) is defined as the capability of the firm, both internally and in conjunction with its key suppliers and customers, to adapt or respond in a speedy manner to marketplace changes as well as to potential and actual disruptions, contributing to the agility of the extended supply chain.

The two cultural antecedents of market and learning orientations are posited to affect the organizational practices of internal integration, external integration with key suppliers and customers, and external flexibility, and eventually impact the firm's supply chain agility. The external flexibility elements considered are volume and mix flexibility. In addition, the specific organizational characteristics and practices exhibited by firms with high levels of supply chain agility are also investigated.

Through the use of the structural equation modeling technique, partial least squares (PLS), it is shown that strong linkages exist among the cultural antecedents, the three organizational practices considered, and the firm's supply chain agility. All three organizational practices, internal integration, external integration with key suppliers and customers, and external flexibility are shown to have significant positive impact on the firm's supply chain agility.

Market orientation is shown to significantly impact both internal and external supply chain integration, along with the two elements of external flexibility. Learning orientation, on the other hand, is shown to have a strong and direct influence only on the level of internal integration. Firms with high levels of external integration are also shown to have high levels of internal integration, consistent with past research. Internal and external integration efforts are also seen to be unrelated to the levels of external flexibility present. The results serve to establish a set of key drivers for augmenting supply chain agility as a risk management initiative.

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## 1. Introduction

An emerging body of research in supply chain management pertains to the development of flexibility and agility, in order to cope with the challenges of more dynamic market places. In recent years, in addition to increasing levels of competitive pressure, business environments have also been characterized by growing levels of turbulence and unpredictability. Thus it has been stressed that organizations must consciously develop agility to provide superior value as well as to manage disruption risks and ensure uninterrupted service to customers (Christopher, 2000; Christopher and Towill, 2001; Zhang et al., 2002, 2003; Chopra and Sodhi, 2004; Kleindorfer and Saad, 2005; Swafford et al., 2006).

The management of supply chain disruption risk is beginning to receive attention among researchers. Chopra and Sodhi (2004) classified supply chain risks into different categories, along with the drivers of these risks. They also identified several risk mitigation strategies, such as adoption of flexibility and responsiveness, some of which may work at cross purposes. Kleindorfer and Saad (2005) categorized these risks into two types: (1) risks related to supply and demand coordination and uncertainty, and (2) disruption risks that are caused by such events as natural disasters, terrorism and labor strikes. They developed a conceptual framework consisting of 10 principles for supply chain risk assessment and mitigation. Faisal et al. (2006) list several enablers for supply chain risk mitigation. These include information sharing, supply chain agility, trust, collaborative relationships, etc. Likewise, Tomlin (2006) makes the distinction between mitigation tactics (which are taken in advance of a disruption) and “contingency tactics” (response tactics which are adopted only if a disruption occurs). The adoption of volume flexibility, for instance, is viewed as a mitigation tactic that provides for the possibility of rerouting of supplies after a disruption has occurred, or has become imminent. The cultivation of flexibility, agility and responsiveness has been frequently mentioned in this emerging stream of literature as a key component in management of disruption risks. The three terms have been mentioned somewhat interchangeably.

However, an independent stream of research in recent years has led to the view that agility is conceptually distinct and different from flexibility; but flexibility is a key characteristic of agility (Christopher, 2000). While both concepts refer to the ability to change, Swafford et al. (2006) characterize flexibility-agility association as a *competence–capability* relationship. As emphasized in strategy literature, capabilities are externally focused, while competencies are internally focused, and, capabilities are derived from competencies (Prahalad and Hamel, 1990; Teece et al., 1997; Zhang et al., 2002, 2003). In this light, supply chain agility may be viewed as an externally focused capability, while flexibility is an internally focused competency that is its antecedent. As Swafford et al. (2006) point out, a system can be flexible without being agile, but an agile system is also flexible.

Over the years, many dimensions of organizational flexibility have been identified and researched (e.g.,

Gerwin, 1987; Sethi and Sethi, 1990; Upton, 1994; Koste and Malhotra, 1999; Vokurka and O’Leary-Kelly, 2000; Slack, 2005). Zhang et al. (2002, 2003) categorize various types of flexibility within a competence–capability framework, for realizing “value chain flexibility”. They categorize flexibilities such as machine, labor, material handling and routing flexibilities as internal competencies, and flexibilities such as mix and volume flexibility as external, customer-facing capabilities. The key distinguishing point is that, flexibilities regarded as competencies are internally focused, providing the processes and infrastructure that enable firms to achieve other types of flexibility that are characterized as capabilities. Flexibilities that are regarded as capabilities are externally focused, and they provide a linkage among corporate, marketing, and manufacturing strategy (Watts et al., 1993). Agility has also been defined, in the context of disentangling leanness and agility, as “the ability to efficiently change operating states in response to uncertain and changing market conditions. Agility involves many types of flexibility, and it includes the capability to do unplanned new activities in response to unforeseen shifts in market demands or unique customer request” (Narasimhan et al., 2006).

This research stream on supply chain agility is also in an incipient stage. In this paper, supply chain agility, being external facing, is regarded as a capability. The cultivation of agility is viewed as a risk management initiative that enables the firm to respond rapidly to market place changes, as well as to potential and actual disruptions in the supply chain. Thus, agility is of value for both risk mitigation and response.

Building on the useful foundations of Zhang et al. (2002, 2003) and Swafford et al. (2006), this research stream on agility is extended further in several ways. First, besides flexibility, other possible antecedents of agility are investigated, in particular, the role of internal integration, involving cross-functional alignment, and external integration with key customers and suppliers. These aspects have not been studied before. The studies of Zhang et al. (2002) and Swafford et al. (2006) investigated flexibility aspects and did not consider internal and external integration elements. As shown below, flexibility alone is not enough for agility in the supply chain. Internal and external integration are also necessary to ensure connected and coordinated response to meet unforeseen changes. Secondly, these past works did not consider processes external to the focal firm. In this study, the scope of the analysis is extended more to the supply chain level, by considering integration processes with key suppliers and customers. In addition, the impact of supply chain integration, internal and external, on supply chain *performance* (such as cost and service levels) has been investigated in the past, but the impact of integration on supply chain *agility* is yet to be investigated.

Thirdly, the impact of two organizational characteristics, market and learning orientation that stem from organizational culture is also explored in this research. There has been a relative dearth of research on the impact of organizational culture in operations management literature (Nahm et al., 2004; McDermott and Stock, 1999). A few past studies have shown that organizational

culture has a significant impact on operational decisions such as the adoption of advanced manufacturing technology (Zammuto and O'Connor, 1992; McDermott and Stock, 1999), cellular manufacturing in small businesses (Yauch and Steudel, 2002) and time-based manufacturing practices (Nahm et al., 2004).

It is well known that supply chain efforts involve major cultural changes such as establishment of trust, a shift from adversarial relationships to collaboration and partnership among buyers and sellers in the supply chain, etc. These aspects have begun to be researched extensively. In this research, the impact of two cultural dispositions not considered before, namely market and learning orientation is investigated, in addition to direct initiatives leading to agility. Recent research in marketing, strategy and organizational culture has shown that cultural antecedents such as market and learning orientation may be important determinants of competitive advantage for the firm (e.g., Cohen and Levinthal, 1990; Slater and Narver, 1995; Baker and Sinkula, 1999).

Fourthly, another contribution made relates to the supply chain agility construct, which is explicitly referred to as a *firm's* supply chain agility (FSCA). As explained in Section 2.3 below, there has been a general ambivalence in past research relating to the unit of analysis. While the construct has been referred to as “supply chain performance”, “supply chain agility” etc., past research has been based almost entirely on the characteristics of a single, focal firm within the supply chain and, in addition, based on responses from a single key informant within the focal firm. Thus, this construct has been defined more precisely below as: the capability of the *firm*, internally, and in conjunction with its key suppliers and customers, to adapt or respond in a speedy manner to marketplace changes as well as to potential and actual disruptions, contributing to agility of the extended supply chain.

Thus, an enhanced agility framework is developed and investigated in this study. In the next section, the theoretical background and linkages within the framework are provided, along with the various constructs and hypotheses developed. This is followed by a description of the research methods in Section 3. A description of the results is provided in Section 4, which is followed by a discussion of the results and managerial implications in Section 5, and the conclusions in Section 6.

## 2. Theoretical development

Focusing on enhancement of agility as a risk management initiative, the antecedents of agility form the central elements of interest. The theoretical model postulated is shown in Fig. 1. First, it is hypothesized that a firm's supply chain agility is impacted, as direct antecedents, by the three organizational practices of: (1) internal integration, (2) external integration with key suppliers and key customers, and (3) external flexibility. The two cultural elements, market and learning orientation are posited to give rise to the three organizational practices. The rationale for the hypothesized model structure, definitions for various constructs, rationale for relating them and the resulting hypotheses are outlined below, starting with the two cultural dimensions.

### 2.1. Organizational orientation

Market orientation and learning orientation have been studied widely in marketing and strategy literature as key cultural antecedents that affect organizational performance, sustainable competitive advantage, innovation performance, etc. (e.g., Cohen and Levinthal, 1990; Deshpande et al., 1993; Slater and Narver, 1995; Hurley and Hult, 1998; Baker and Sinkula, 1999). Along the lines of this body of work, both these organizational orientations are considered as cultural variables and posited to influence the organizational practices of internal integration, external integration, and external flexibility.

This research does not involve discussion of organizational culture at the underlying level of values and beliefs. Organizational culture pertains to widely shared, and strongly held values in an organization (Chatman and Jehn, 1994; O'Reilly et al., 1991). Four types of organizational cultures are generally identified: *clan*, *adhocracy*, *market* and *hierarchy*, based on two dimensions: *focus* (internal or external) and *processes* (organic or mechanistic). The clan culture, for instance, has an internal focus, with organic processes, characterized by high levels of flexibility and discretion. This scheme for organizational culture is based on the *competing values model*, as described by Quinn and Rohrbaugh (1983) and Quinn and Kimberly (1984).

However, rather than assess these underlying dimensions of culture, in line with many past studies (such as the ones mentioned above), it is assumed that a firm's culture

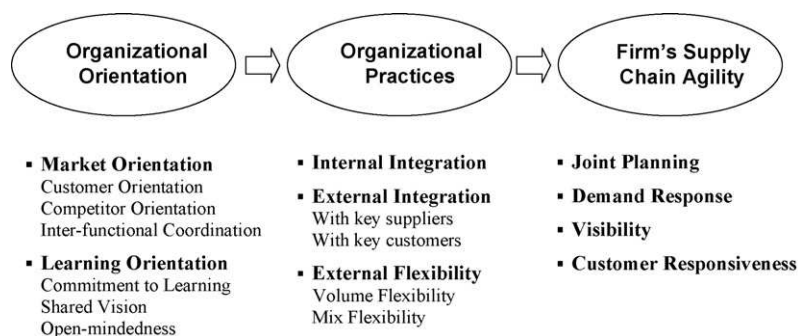


Fig. 1. Overall model structure.

is manifested in market and learning orientation, and these two orientations are investigated as cultural antecedents that give rise to various organizational practices. This is also in line with the assertion of Denison (1990, p. 2) that “culture refers to the underlying values, beliefs and principles that serve as a foundation for an organization’s management system as well as the set of management practices and behaviors that exemplify and reinforce those basic principles”.

#### 2.1.1. Market orientation

Market orientation has been defined as (Narver and Slater, 1990): “the organizational culture that creates the behaviors necessary for creation of superior value for customers, and it can be conceptualized as the set of behaviors that exhibit: (1) customer orientation, (2) competitor orientation and (3) inter-functional coordination”. Customer orientation refers to sufficient understanding of one’s target buyers to create superior value for them continuously. Firms with customer orientation actively seek to add value to their offerings as required by customers. Second, competitor orientation is the understanding of short-term strengths and weaknesses as well as long-term strategies of current and potential competitors. Both customer and competitor orientations include activities associated with generation of information about buyers and competitors and its dissemination throughout the organization. Third, inter-functional coordination is the coordinated utilization of company resources in creating superior value for target customers. The organization responds to the generated and disseminated market intelligence through the collective efforts of design, production, distribution and promotion of the product offering.

A market-driven culture supports the value of market intelligence and the necessity of functionally coordinated action directed at gaining competitive advantage (Day, 1994, p. 43). Slater and Narver (1995, p. 67) define market orientation as “the culture that (1) places the highest priority on profitable creation and maintenance of superior customer value, while considering the interests of other stakeholders; (2) provides norms for behavior regarding the organizational development and responsiveness to market information”.

In accordance with Narver and Slater (1990), market orientation is viewed as a continuum, with firms exhibiting varying degrees of this propensity. It is conceptualized as a second-order construct that reflects the three organizational behaviors of customer orientation, competitor orientation and inter-functional coordination. As shown in Appendix A, the scales for market orientation were based primarily on the work of Narver and Slater (1990).

#### 2.1.2. Learning orientation

Learning orientation has been investigated as another important cultural driver in recent years. In order to survive in dynamic and turbulent markets, firms must continue to seek the processes of learning, behavior change and performance improvements (Slater and Narver, 1995). Like market orientation, learning orientation has also been identified as a key cultural element that acts synergisti-

cally with market orientation (e.g., Sinkula et al., 1997; Slater and Narver, 1994).

Sinkula et al. (1997) conceptualized learning orientation as an organizational value that influences the tendency of an organization to create and use knowledge, and hence, to learn and adapt. Organizational learning refers to, essentially, experience-based improvements in task performance (Argyris and Schon, 1978). It may also be viewed as a process by which firms learn through interaction with their environment (Sinkula, 1994). In this vein, Nevis et al. (1995) argued that production systems should also be considered as learning systems. A learning organization is skilled at challenging the underlying assumptions that its business is based upon (Baker and Sinkula, 1999). Additionally, it is adept at modifying its behavior in response to the creation, acquisition and transfer of knowledge (Garvin, 1993). Organizations continually create new knowledge by reconstructing existing perspectives, frameworks, or premises on a day-to-day basis (Nonaka, 1994, p. 19).

In this study, the propensity of an organization to learn and adapt is investigated by assessing its learning orientation as an organizational value, and its influence on the adoption of the selected organizational practices. A firm with a learning orientation is characterized by (1) a commitment to learning, (2) open-mindedness and (3) shared vision (Sinkula et al., 1997). Commitment to learning refers to the relative value that a firm places on learning. Open mindedness relates to the concept of unlearning and to the emphasis that firms place on questioning the assumptions that govern. Shared vision relates to the direction of learning and provides a focus for organizational members with respect to energy, commitment and purpose. Thus, learning orientation is modeled as a second-order construct that is reflected by the above three underlying behaviors. As indicated in Appendix A, the scales developed and employed by Sinkula et al. (1997) and Baker and Sinkula (1999) were used to measure learning orientation. Several of these items were reverse coded to help attenuate response bias.

Slater and Narver (1995) theorized that the synergies of market and learning orientation have a positive influence on competitive advantage. Baker and Sinkula (1999) investigated the impact of the synergies between these two orientations on firm performance. Independently, market orientation and learning orientation were found to have a significant impact on changes in relative market share, new product success and overall performance. Synergistically, these two orientations had a significant influence on changes in relative market share and new product success, but not on overall performance. In addition, in their work on absorptive capacity, Cohen and Levinthal (1990) argued that a critical ingredient to a firm’s innovative capabilities is the ability to recognize, assimilate and apply new, external information. Such studies, emphasizing the importance of being able to learn and adapt in dynamic markets, led us to consider learning orientation as the second major cultural element in the context of supply chain agility.

While market and learning orientations have been shown to be synergistic, these two constructs have been

recognized to be separate and distinct. As Baker and Sinkula (1999) stated, learning is not a necessary outcome of firms that exhibit a market orientation; and learning orientation goes beyond a marketplace focus (Baker and Sinkula, 1999, p. 413). Firms may exhibit many combinations of market and learning orientation levels. In other words, a firm may have a high market orientation and a medium learning orientation. It may also be added that a market orientation is often associated with adaptive (or “single-loop learning”) whereas a learning orientation is associated with generative (or “double-loop learning”) (Baker and Sinkula, 1999). From the point of view of organizational knowledge creation, however, double loop learning is considered to be a daily activity for the organization (Nonaka, 1994).

## 2.2. Organizational practices

Next, we relate market and learning orientation with the three organizational practices of internal integration, external integration, and external flexibility. We hypothesize, as shown in Fig. 2, that the cultural antecedents of market and learning orientation affect internal and external integration, and the external flexibility elements of volume and mix flexibility. We also propose possible inter-relationships among all these constructs. Specific definitions for these constructs, supporting rationale, and the resulting hypotheses are provided below.

### 2.2.1. Internal and external integration practices

Several studies in the past have investigated internal and external integration as major factors affecting a supply chain's performance, by way of reduced costs and improved service levels (e.g., Frohlich and Westbrook, 2001). In this study, it is hypothesized that, in addition to performance of a supply chain, the agility of the supply chain is also improved by higher levels of supply chain integration, due to possibly more coordinated and connected response on the part of firms in a supply chain. Likewise, internal integration, which refers to inter-functional and inter-departmental integration, may also lead to a connected and more coordinated response to marketplaces changes and disruptions. In addition, it may be hypothesized that the level of agility in a supply chain may also be affected by the extent of flexibility present, especially externally focused flexibility. Thus, in this research, internal and external supply chain integration are investigated as antecedents of agility (as opposed to performance), alongside external flexibility, as possible levers for a firm's supply chain agility.

We first relate market orientation with internal and external integration efforts, as shown in Fig. 2. Market orientation, as stated earlier, consists of the two externally oriented elements of customer orientation and competitor orientation, and the internally oriented element of inter-functional coordination. Firms that demonstrate a high level of market orientation may thus exhibit both

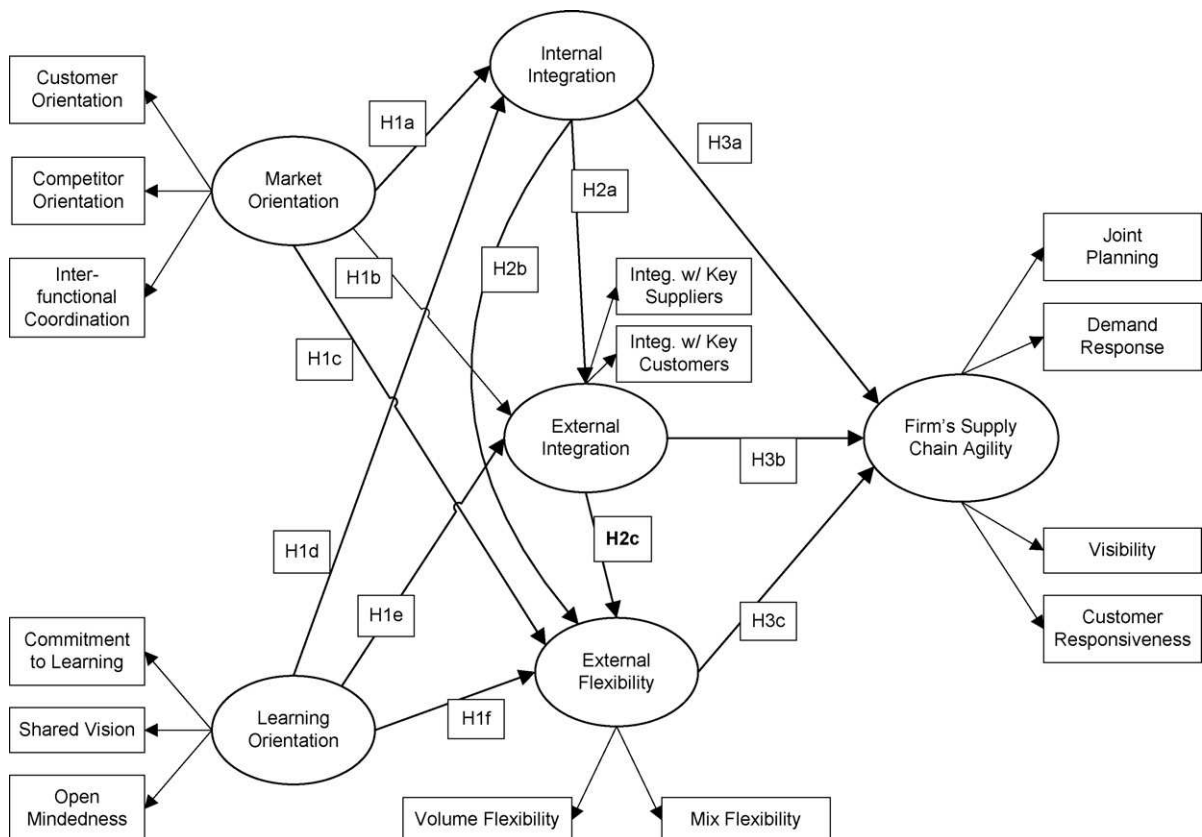


Fig. 2. Hypothesized relationships.



externally and internally focused behaviors. Through sensitivity to the marketplace, firms that possess high market orientation may be more knowledgeable about competitors' actions, and what customers demand and desire. In order to be better aligned with customer needs, better inter-departmental alignment and coordination could be effected within the firm. Externally, one of the ways that a firm can stay aligned with its customers is forward integration. Additionally, another means for being more responsive to customer demands is to integrate with its suppliers so that suppliers can be more responsive to the demands of the marketplace (Frohlich and Westbrook, 2001; Rosenzweig et al., 2003; Stevens, 1989). Thus we hypothesize a positive effect of market orientation on both internal and external integration practices:

**H1a.** Firms which exhibit high levels of market orientation will have high levels of internal integration.

**H1b.** Firms which exhibit high levels of market orientation will have high levels of external integration.

Likewise, learning orientation is explored as an antecedent to integration efforts. Firms with a learning orientation may actively question how well their organizational processes work, how well they are internally organized, and how well they are externally connected to serve the customers. It may be surmised that firms with high learning orientation may actively question their current processes, and seek better ways to be organized such as using cross-functional teams, and adopting a process orientation. There is practically no past research results on these aspects. Based on the above reasoning, we propose the following twin hypotheses:

**H1d.** Firms which exhibit high levels of learning orientation will have high levels of internal integration.

**H1e.** Firms which exhibit high levels of learning orientation will have high levels of external integration.

Internal integration has often been mentioned as a necessary step in supply chain integration process (Stevens, 1989; Rosenzweig et al., 2003; Vickery et al., 2003). Stevens (1989) identified four stages that a firm must go through to achieve supply chain integration. The first stage refers to a firm that is characterized by separate departments, with little synchronization. Stage two is functional integration with an emphasis on inbound flow of goods. Stage-three integration is called internal integration where an organization recognizes that it must effectively and efficiently manage the flow of goods into and out of the organization. The fourth stage is external integration with suppliers and customers.

Frohlich and Westbrook (2002) found, in the context of web-based integration in supply chains, that reduction of internal barriers is a required first step before removal of supplier and customer barriers to achieve supply chain integration. Vickery et al. (2003), in a study of the automotive supply industry, found that there is a positive, causal relationship between integrative information technologies and supply chain integration, which comprised both horizontal integration (within a firm) and vertical

integration (with suppliers and customers). Frohlich and Westbrook (2001) empirically demonstrated a strong association between performance and the greatest level ("arc") of internal and external integration. However, they did not hypothesize a causal relationship, nor did they explore possible antecedents of integration practices.

It has also been shown that the joint application of external and internal integration practices has a synergistic effect on firm performance (Droge et al., 2004). Rosenzweig et al. (2003) employed the use of an integration intensity measure (consisting of both internal and external measures of integration) to demonstrate its impact on competitive capabilities and business performance. This integration intensity is a combined measure of both internal and external integration components. In this research, we attempt to distinguish between internal and external integration practices and, in addition, seek to empirically validate the assertions of Stevens (1989) and others that internal integration is an antecedent to external integration:

**H2a.** Firms which exhibit a high level of external integration will tend to have high levels of internal integration.

For internal integration, a new scale was proposed and developed. Two of the items were reverse coded to alleviate response bias. Individual items were developed from the work of Pagell (2004) and Jaworski and Kohli (1993), as shown in Appendix A. External integration was modeled as a second-order construct reflecting integration with key customers, and integration with key suppliers. For integration with key customers, individual scale items from several sources were identified and deemed suitable for this study. These items were gleaned from the research of Frohlich and Westbrook (2001), Narasimhan and Das (2001) and Shah (2002). For integration with key suppliers, a valid and reliable scale was developed based on a literature review. The works of Frohlich and Westbrook (2001), Christopher (2000), van Hoek et al. (2001) and Shah (2002) were used as sources of scale items.

### 2.2.2. External flexibility

The third organizational practice considered is the augmentation of flexibility, as a major means for enhancing agility in the supply chain, as shown in the recent study of Swafford et al. (2006). Manufacturers adopt flexible practices in response to the uncertainty and turbulence in the marketplace and to meet customer expectations without excessive cost, time or disruption (D'Souza and Williams, 2000; Koste and Malhotra, 1999; Sethi and Sethi, 1990; Zhang et al., 2003). Flexibility has been researched extensively over the years, and many dimensions of flexibility have been identified (e.g., Gerwin, 1987; Sethi and Sethi, 1990; Upton, 1994; Koste and Malhotra, 1999; Vokurka and O'Leary-Kelly, 2000; Slack, 2005).

The role of various types of flexibility as antecedents for "value chain flexibility" was explored in the studies of Zhang et al. (2002, 2003). Zhang et al. (2003) develop a hierarchy of flexibility types in a competence-capability framework, as stated earlier. The flexibility types of machine, labor, routing and material handling are characterized as competencies,

which give rise to, or influence external flexibility, consisting of mix and volume flexibility, which are regarded as capabilities. It is empirically demonstrated that the four flexible competencies have significant positive impacts on the external facing, volume and mix flexibilities. Likewise, in Swafford et al. (2006), procurement flexibility, manufacturing flexibility and distribution flexibility have been considered as competencies and are shown to contribute to supply chain agility, which is viewed as the capability.

In this research, external flexibility, comprising mix and volume flexibility, as defined by Zhang et al. (2003), is considered as one of the three direct antecedents of a firm's supply chain agility. The firm's supply chain agility is viewed as the capability, since it is more external than mix and volume flexibilities which, along with internal and external integration, are viewed as being more akin to competencies. We do consider mix and volume flexibilities as the most external facing among various flexibility elements, consistent with Zhang et al. (2003), and propose that they have positive impact on a firm's supply chain agility. We do not consider the internal flexibility elements of machine, labor, material handling and routing flexibilities in this research, since the relationships between them and external flexibility types have been established in Zhang et al. (2003).

The construct of external flexibility is modeled as a second-order construct reflective of volume and mix flexibility measures. In accordance with Zhang et al. (2003), mix flexibility is defined as the ability of an organization to produce different combinations of products economically and effectively given certain capacity. Volume flexibility is defined as the ability of an organization to operate at a variety of different output levels without compromising the performance of the system from either a cost, quality or service perspective. This supports agility by being responsive to changing market needs and demands. If a firm exhibits volume flexibility, it can vary the output of its production process without negatively impacting the cost or capability of the process. In a similar vein, Tomlin (2006) defines volume flexibility as the amount of extra capacity that becomes available, and the speed with which it becomes available when faced with supply disruptions. Mix flexibility is concerned with product variety and the ability of a firm to produce a wide range of products effectively and efficiently in response to changing market requirements. The scale items provided by Zhang et al. (2003) were also utilized to measure volume and mix flexibility, as shown in Appendix A.

Given the above definitions for external flexibility, the cultural antecedent of market orientation may be posited to have a positive impact on the level of external flexibility present in a firm. Market orientation consists of the two externally oriented elements of customer orientation and competitor orientation, and the internally oriented element of inter-functional coordination, as stated earlier. It may be argued that both types of external flexibility, mix and volume, may stem from not only from various types of internal flexibility, as Zhang et al. (2003) have shown, but also on the cultural antecedent of market orientation. This leads to us to investigate the following hypothesis:

**H1c.** Firms which exhibit a high level of market orientation will have high levels of external flexibility.

Likewise, learning orientation requires active examination of current processing methods and the willingness to learn new methods and processes. As a propensity to learn and be adaptive to the needs of the marketplace, learning orientation may be viewed as another cultural driver for external flexibility:

**H1f.** Firms which exhibit high levels of learning orientation will have high levels of external flexibility.

Both internal and external supply chain integration emphasize the value chain, and being flexible in delivering value to the customer rather than being constrained by internal organizational compulsions, and the needs of various functional units and departments. Thus, we hypothesize a positive, causal/associative relationship between both types of integration with external flexibility:

**H2b.** Firms which exhibit high levels of internal integration will have high levels of external flexibility.

**H2c.** Firms which exhibit high levels of external integration will have high levels of external flexibility.

### 2.3. Firm's supply chain agility (FSCA)

Supply chain agility is a relatively new construct in operations and supply chain management literature. In the study by Swafford et al. (2006, p. 172), this construct is defined as follows (italics introduced): "we define supply chain agility as the *supply chain's capability* to respond in a speedy manner to a changing marketplace environment". Elsewhere in this study (p. 176), it is defined as "supply chain agility addresses the *supply chain's capability* to respond in a timely manner to a changing marketplace environment. It represents an outcome or externally focused concept, and this is regarded as a capability rather than a competency. Therefore, a *firm's supply chain agility* deals with the capability of the firm to respond or react rapidly to key supply chain outcome measures, not how effectively the outcome measures are achieved (which would be measuring 'performance' rather than 'agility')".

In the above definitions, it is seen that this construct is referred to both as the "supply chain's capability", and also as "a firm's supply chain agility". Thus a key question, relating to the unit of analysis, arises as to whether this construct refers to the agility of the focal firm or the entire supply chain. This general ambivalence relating to the unit of analysis has been a common feature in many past studies in the area of supply chain management.

A second issue relates to the scope of the analysis. It is mentioned in Swafford et al. (2006, p. 172) that "we hypothesize that the key antecedents of a firm's supply chain agility are the inherent flexibility dimensions within each of the three supply chain processes. We choose to address an organization's internal supply chain, rather than its extended supply chain, which includes the firm's suppliers' and customers' supply chain processes. While possessing agility over a firm's extended supply chain is

desirable, a firm has less control over its external processes compared to its own. Also, from a practical viewpoint, it would be difficult, if not impossible to investigate the agility of every process in an organization's extended supply chain. By focusing on the key processes in a firm's internal supply chain, we have sought to keep this study more tractable, while gaining an understanding of the antecedents of a firm's supply chain agility that are within the firm's domain of control".

We concur with the above statements of Swafford et al. (2006) that it would indeed be meaningful, and practical to focus on the immediate supply chain neighborhood of the firm. However, in order to contribute towards refinement of this measure, other performance-related measures utilized in past research, we refer to this construct explicitly as the "firm's supply chain agility" in this study. A firm's supply chain agility (FSCA) is defined as: the capability of the firm, internally, and in conjunction with its key suppliers and customers, to adapt or respond in a speedy manner to a changing marketplace, contributing to agility of the extended supply chain.

In Swafford et al. (2006), all the scale items utilized to measure the "supply chain agility construct" elicited responses from "the business unit" (p. 186). Their study was also confined to internal processes and flexibilities within the focal firm, without involving the firms' suppliers and immediate customers. In this study, we include integration aspects with the firm's key suppliers and key customers, thereby extending the scope of the analysis more towards the supply chain level. Thus, this research considers a firm's supply chain agility, and higher-level supply chain professionals in the focal firm were requested to consider and provide responses, especially for the construct of external integration, as they relate to key customers and key suppliers. In this way, the research team was able to extend the investigation to include the firm's external integration efforts and the firm's supply chain agility.

In order to operationalize the new FSCA construct, several scale items were drawn from the works of van Hoek et al. (2001), Christopher (2000) and Swafford et al. (2006). Since this is a new scale, appropriate steps to demonstrate validity and reliability were undertaken. As shown in Appendix A, these scale items were grouped under the categories of demand response, joint planning, customer responsiveness, and visibility. A factor analysis was conducted on the individual scale items for the firm's supply chain agility construct. As a result, four factors emerged and these factors were named according to the prevailing theme that they represented. These four factors bear a marked resemblance to the work of Christopher (2000) and van Hoek et al. (2001). As shown in Fig. 2 and Fig. 5, the firm's supply chain agility was theorized to be a second-order construct that is formed by the first-order constructs of demand response, joint planning, customer responsiveness and visibility.

Finally, relating the three organizational practices of internal integration, external integration, and external flexibility to firm's supply chain agility results in the following three hypotheses:

**H3a.** Organizations which exhibit high levels of internal integration will tend to exhibit high levels of the firm's supply chain agility.

**H3b.** Organizations which exhibit high levels of external integration will tend to exhibit high levels of the firm's supply chain agility.

**H3c.** Organizations which exhibit high levels of external flexibility will tend to have high levels of the firm's supply chain agility.

#### 2.4. Relationship to emerging studies on disruption management

In the emerging literature on management of disruption risk in supply chains, the attributes of flexibility, agility, responsiveness, etc. have been recognized as key elements for dealing with potential and actual disruptions. However, flexibility and agility have been mentioned somewhat interchangeably in these early studies.

In the recent study of Craighead et al. (2007), two mitigation capabilities are defined, which, alongside supply chain design characteristics like density and complexity, moderate or reduce the severity of disruptions. The first mitigation capability is referred to as *recovery capability* which is defined as interactions of supply chain entities and corresponding coordination of supply chain resources to return the supply chain to a normal and planned level of product flow. In this definition, the connections to FSCA and the role of internal and external integration constructs may be seen. They also mentioned that this recovery capability should be proactive in nature, i.e., mitigation-oriented as opposed to being reactive, after occurrence of disruptions. The second mitigation capability refers to *warning capability* which refers to interactions and coordination of supply chain resources to detect a pending or realized disruption and to subsequently disseminate pertinent information about the disruption to relevant entities within the supply chain. This again can be related to the integration and FSCA constructs in the model proposed above.

Likewise, the elements of agility, flexibility, responsiveness, mix and volume flexibility, etc. may all be clearly seen in the emerging literature on disruption management such as Chopra and Sodhi (2004), Kleindorfer and Saad (2005), and Faisal et al. (2006), even as theoretical and causal frameworks are being developed, and empirical research beginning to be conducted.

### 3. Research methodology

In order to design and validate an appropriate survey instrument, a thorough review of the literature was undertaken to identify scales used in past research for some of the constructs identified earlier. Newly created scales were based upon the literature review and associated theoretical foundation presented earlier, following the paradigm of Churchill (1979).



The initial survey instrument was reviewed, for content validity, by a panel of academic and practitioner experts in supply chain management for content, clarity and understanding. The review was conducted by 4 academics familiar with the constructs employed in this research. The 6 practitioners who reviewed the instrument held such titles as general manager, VP-operations and operations manager. After all the comments were reviewed, the survey instrument was modified accordingly. Multiple items were used for evidence of internal consistency, and so that discriminant and convergent validity could be determined.

All the scales used in the study employed a 7-point Likert scale. The end points were labeled 'Strongly Disagree' (1) to 'Strongly Agree' (7). The mid-point (4) was labeled 'Neither Agree nor Disagree'. The survey items and related literature are shown in [Appendix A](#). After finalizing the main survey instrument, a data base of 4000 names was obtained from the Institute of Supply Management (ISM). As shown in [Table 1](#), a wide variety of manufacturing organizations, spanning SIC codes to 20–39 was sampled. The following supply chain professional

titles were deemed appropriate to be considered as part of the sample: purchasing: VP, director, manager; manufacturing/operations: VP, director, plant manager; logistics: VP, director, manager, supply chain manager, material manager; and general managers, presidents and other titles similar to the above. For the types of questions covered in this survey, high-ranking respondents, with sufficient level of seniority tend to be more reliable sources of information than their subordinate rank, in accordance with [Phillips \(1981\)](#). As in studies such as [Frohlich and Westbrook \(2002\)](#), it was felt that these were managers with enough seniority to know about their companies' upstream and downstream integration and performance. This is also consistent with many past survey-based research studies in supply chain management.

In order to contact the respondents in an efficient and cost-effective manner, a web-based survey was employed, based on the methods of [Dillman \(2000\)](#). The survey was hosted on a university website to add legitimacy, as a survey request from a research institution, and to allay fears of accessing a website that may pose potential harm in the way of computer viruses. Following the methods

**Table 1**  
Profile of survey respondents ( $n = 218$ ).

		No. of firms	%
SIC code	20: Food and kindred products	11	5.0
	23: Apparel and other textile products	1	0.5
	25: Furniture and fixtures	7	3.2
	28: Chemicals and allied products	19	8.7
	30: Rubber/miscellaneous plastic products	12	5.5
	34: Fabricated metal products	19	8.7
	35: Industrial and Commercial Machinery and Computer Equipment	15	6.9
	36: Electrical equipment and components	48	22.0
	37: Transportation equipment	11	5.0
	38: Measurement and Instrumentation	10	4.6
	39: Miscellaneous manufacturing industries	57	26.2
Annual sales	Missing data	8	3.7
	<\$10 million	20	9.2
	\$10 to \$50 million	48	22.0
	\$51 to \$100 million	29	13.3
	\$101 to \$250 million	23	10.5
	\$251 to \$500 million	19	8.7
	\$501 million to \$1 billion	20	9.2
	>\$1 billion	54	24.8
Manufacturing process	Missing data	5	2.3
	Job shop	51	23.4
	Batch	46	21.1
	Repetitive assembly	43	19.7
	Continuous flow	73	33.5
Manufacturing type	Missing data	5	2.3
	Make-to-stock	57	26.1
	Make-to-order	117	53.7
	Engineer-to-order	20	9.2
	Assemble-to-order	18	8.3
Title	Missing data	6	2.8
	VP/director purchasing	36	16.5
	Purchasing manager	109	50.0
	VP/director manufacturing	10	4.6
	Plant manager	2	0.9
	VP/director logistics	3	1.4
	Logistics manager	8	3.7
	Other	50	22.9

suggested by Dillman (2000), five separate e-mails for introducing the research, for thanking respondents, follow-up e-mail, etc. were sent. Only non-respondents received the follow-up e-mails.

Of the 4000 names provided by ISM, 3489 had valid e-mail addresses. Of the 3489 e-mails sent, 354 stated being out of the office, 161 requested to be removed from the distribution list and another 19 were undeliverable or were rejected by SPAM or other types of protective software. Potential sample size was thus reduced to 2955 respondents, and 303 responses were received. A total of 218 usable responses were analyzed, after deleting multiple responses from organizations, deleting inappropriate titles and deleting surveys with missing data. Company information was requested and collected from the survey respondents. The response from the highest ranking respondent from individual organizations was retained for analysis, provided the survey information was complete. This represented a 7.4% response rate. While this response rate is not as high as desired, a sufficient sample size was received in order to perform the required data analysis. The survey was conducted in the spring of 2005.

To check for differences between early and late responders, a  $\chi^2$  test was performed on four demographic variables, and no significant differences were found among them. The results were (1) title:  $\chi^2 = 2.344$ ,  $p = 0.886$ ; (2) annual sales:  $\chi^2 = 1.978$ ,  $p = 0.992$ ; (3) product line:  $\chi^2 = 6.165$ ,  $p = 0.104$ ; and (4) manufacturing process:  $\chi^2 = 1.346$ ,  $p = 0.718$ .

Likewise, a  $\chi^2$  test was performed to check for differences between respondents and non-respondents. No allowances were made for those who opted out of the survey (e.g., who were out of the office). These potential respondents were coded as being non-responders. The SIC

code was used to determine if there were differences between those who responded and those who did not. In order to support generalizability of the study, it was desired to understand if there was a response bias or if this was due to the sampling frame. For the SIC code, no significant difference was found between responders and non-responders ( $\chi^2 = 14.87$ ,  $p = 0.189$ ). Thus it is believed that no bias existed between respondents and non-respondents.

## 4. Analysis of the model

### 4.1. Measurement model

The structural equation modeling (SEM) technique employing Partial Least Squares (PLS–Graph version 03.00) was utilized in this research. PLS is a components-based approach to structural modeling (Chin et al., 2003). The structural and measurement models under PLS consist of three sets of relations: (a) the inner (structural) model which specifies the relationships between latent variables; (b) the outer (measurement) model which specifies the relationships between the latent variables and their associated observed variables; and (c) the weight relations upon which the case values for the latent variables can be estimated (Chin, 1998b). For PLS, a good model fit is established with significant path coefficients, acceptably high  $R^2$  values and internal consistency (construct reliability) being above 0.7 for each construct (Gefen et al., 2000). Unlike covariance-based structural equation modeling, PLS does not use fit indices. Sample size requirements for PLS are ten times the larger value of the following: (a) the block with the largest number of formative indicators or (b) the dependent latent variable

**Table 2**  
Reliability analysis ( $n = 218$ ).

Scale	Cronbach's $\alpha$ , min $\geq 0.70$	Composite reliability, min $\geq 0.70$	Average variance extracted (AVE), min $\geq 0.50$
Organizational orientation			
Market orientation	0.9237		
Customer orientation	0.8968	0.923	0.668
Competitor orientation	0.8418	0.904	0.758
Inter-functional coordination	0.8507	0.899	0.692
Learning orientation	0.9055		
Commitment to learning	0.9042	0.939	0.838
Shared vision	0.7927	0.883	0.717
Open-mindedness	0.7901	0.875	0.700
Organizational practices			
Internal integration	0.7921	0.858	0.551
External integration	0.8153		
With key customers	0.7405	0.833	0.502
With key suppliers	0.8180	0.862	0.473
External flexibility	0.8954		
Volume flexibility	0.8248	0.884	0.657
Mix flexibility	0.8302	0.887	0.662
Firm's supply chain agility	0.8847		
Joint planning	0.8771	0.904	0.612
Demand response	0.8058	0.877	0.642
Visibility	0.8518	0.929	0.867
Customer responsiveness	0.8758	0.921	0.794

**Table 3**  
Convergent validity.

		Factor loading (range)
Organizational orientation		
Market orientation	Customer orientation	0.7169–0.8628
	Competitor orientation	0.8576–0.8945
	Inter-functional coordination	0.6985–0.8905
Learning orientation	Commitment to learning	0.8741–0.9373
	Shared vision	0.7095–0.9112
	Open-mindedness	0.8117–0.8834
Organizational practices		
Internal integration		0.6319 <sup>a</sup> –0.8512
External integration	with key customers	0.5877 <sup>a</sup> –0.7781
	with key suppliers	0.6162 <sup>a</sup> –0.7577
External flexibility	Volume flexibility	0.7765–0.8448
	Mix flexibility	0.7941–0.8240
Firm's supply chain agility		
Joint planning		0.7531–0.8531
Demand response	0.7468–0.8597	
Visibility		0.9264–0.9358
Customer responsiveness		0.8784–0.9011

<sup>a</sup> New scale: 0.50 acceptable.

with the largest number of independent latent variables impacting it (Chin, 1998a).

Table 2 provides a summary of reliability analysis for all the constructs. Three measures of reliability or internal consistency were used: Cronbach's  $\alpha$ , composite reliability and average variance extracted. For Cronbach's  $\alpha$ , a minimum value of 0.70 is considered acceptable for existing scales and a value of 0.60 is deemed appropriate for newly developed scales (Nunnally, 1978).

Composite reliability, unlike Cronbach's  $\alpha$ , does not assume equally weighted measures, and therefore the alpha value tends to be a lower-bound estimate of reliability. A lower bound of 0.7 is recommended for composite reliability (Chin, 1998b; Gefen et al., 2000). Average variance extracted (AVE), the third measure utilized, tends to be more conservative than composite reliability. It is recommended that the AVE be at least 0.50, as this indicates that 50% or more of the variance is explained by the indicators of the latent variable (Chin, 1998b; Fornell and Larcker, 1981). In Table 2, it is seen that the minimum acceptable values for each construct on each of the measures were met, with the exception of AVE for integration with key suppliers. However, since Cronbach's  $\alpha$  and composite reliability were reasonably high, it was deemed that this scale showed sufficient reliability.

Construct validity examines the degree to which a scale measures what it intends to measure. This includes the three sub-dimensions of content validity, convergent validity and discriminant validity. Content validity does not have a formal statistical test. However, content validity in this research is augmented by a thorough literature review, linkage to theory, and review of the initial survey instrument by a panel of experts comprising both academics and practitioners.

Convergent validity, the ability of items in a scale to converge or load together as a single construct, is measured by examining individual loadings for each block of indicators. Each indicator should share more variance with the component score than with the error variance. It

was assessed by examining the individual loadings of each scale item onto its latent variable. The standardized loadings should be greater than 0.707, implying that the indicators share more variance with their respective latent variable than with error variance. A lower bound of 0.50 or 0.60 may be sufficient for newly developed scales (Chin, 1998b). Table 3 provides a list of standardized loadings for each construct, and it is seen that they are above the acceptable minimum values.

Discriminant validity is the extent to which items from one construct discriminate from items representing another construct. One measure of discriminant validity is to compare the average variance extracted (AVE) to the square of the correlation between the constructs. If AVE is greater than the square of the correlations, then discriminant validity is said to exist. Alternatively, the square root of AVE should be larger than the correlations between constructs (Chin, 1998b; Fornell and Larcker, 1981; Koufteros, 1999; Koufteros et al., 2001).

Table 4 indicates the correlations between the latent variables. The square root of AVE is indicated on the diagonal. It is seen that the square root of AVE is greater than the correlation among the latent variable scores, with respect to its corresponding row and column values. This indicates that none of the constructs shares more variance with another construct than with its own indicators, thus exhibiting sufficient levels of discriminant validity. Figs. 3 and 4 provide details for the measurement models, including the survey items used. These figures also display the path coefficients between the first and second-order constructs.

#### 4.2. Structural model

The results from evaluation of the structural model are reported in Fig. 5 and Table 5. First, from the PLS model in Fig. 5, it can be seen that the standardized path coefficient from market orientation to internal integration is significant (0.364;  $p < 0.001$ ). Thus organizations with strong

Table 4

Discriminant (square root of AVE on diagonal in boldface).

	Internal integration	Customer orientation	Competitor orientation	Inter-functional coordination	Commitment	Shared vision	Out of box	Volume flexibility
Internal integration	<b>0.742</b>							
Customer orientation	0.585	<b>0.817</b>						
Competitor orientation	0.501	0.634	<b>0.871</b>					
Inter-functional coordination	0.647	0.631	0.609	<b>0.832</b>				
Commitment	0.563	0.522	0.468	0.622	<b>0.915</b>			
Shared vision	0.632	0.553	0.508	0.671	0.658	<b>0.847</b>		
Out of box	0.630	0.484	0.474	0.649	0.628	0.707	<b>0.837</b>	
Volume flexibility	0.312	0.388	0.205	0.297	0.340	0.282	0.253	<b>0.811</b>
Mix flexibility	0.293	0.266	0.213	0.273	0.211	0.214	0.202	0.548
Integration with key suppliers	0.531	0.428	0.399	0.457	0.462	0.440	0.433	0.298
Integration with key customers	0.374	0.481	0.308	0.371	0.300	0.293	0.319	0.272
Joint planning	0.387	0.417	0.373	0.338	0.327	0.357	0.284	0.173
Customer responsiveness	0.400	0.524	0.292	0.320	0.410	0.351	0.252	0.321
Demand response	0.404	0.353	0.298	0.450	0.388	0.364	0.349	0.394
Visibility	0.398	0.407	0.349	0.454	0.443	0.435	0.414	0.255
	Mix flexibility	Integration with key suppliers	Integration with key customers	Joint planning	Customer responsiveness	Demand response	Visibility	
Internal integration								
Customer orientation								
Competitor orientation								
Inter-functional coordination								
Commitment								
Shared vision								
Out of box								
Volume flexibility								
Mix flexibility	<b>0.814</b>							
Integration with key suppliers	0.228	<b>0.688</b>						
Integration with key customers	0.083	0.417	<b>0.709</b>					
Joint planning	0.221	0.581	0.438	<b>0.782</b>				
Customer responsiveness	0.387	0.351	0.338	0.527	<b>0.891</b>			
Demand response	0.335	0.521	0.268	0.346	0.213	<b>0.801</b>		
Visibility	0.325	0.563	0.285	0.449	0.353	0.485	<b>0.931</b>	

market orientation are found to exhibit high level of internal integration, lending support to H1a. Likewise, the path coefficient from market orientation to external integration is also significant (0.277;  $p < 0.001$  level), supporting the notion that market orientation has a positive impact on the level of external integration exhibited by a firm. Hence we find support for H1b. The standardized path from market orientation to external flexibility is also statistically significant, but less strong ( $p < 0.1$ ), with a path coefficient of 0.202. This lends marginal support to hypothesis H1c that a strong market orientation can significantly contribute towards external flexibility. Thus, it can be stated that a firm's market orientation level has a positive influence on all three organizational practices investigated.

The standardized path coefficient from learning orientation to internal integration is seen to be strongly significant (0.428;  $p < 0.001$ ), lending support for H1d. But the standardized path from learning orientation to external integration is not found to be significant. Thus no support for H1e was found. However, given the strong influence of learning orientation on internal integration, and the significant relationship between internal and external integration (H2a), it is apparent that learning orientation affects external integration indirectly, via internal integration.

The standardized path from learning orientation to external flexibility is also not statistically significant, and

thus no support for H1f is demonstrated. Thus, unlike market orientation, which had significant impact on all three organizational practices, learning orientation is seen to affect only internal integration directly.

Among the three organizational practices studied, internal integration was found to have strong, significant and direct influence on external integration (0.300,  $p < 0.001$ ). Thus hypothesis H2a is strongly supported, consistent with the assertions of Stevens (1989) and others that internal integration is a necessary step prior to external integration with suppliers and customers.

The standardized path coefficient from external integration to external flexibility was not found to be statistically significant. Therefore support for hypothesis H2c was not found. Similarly, the link from internal integration to flexible practices was also not statistically significant and there is no evidence to support hypothesis H2b. From these results, it is apparent that internal and external integration efforts, and external flexibility, are unrelated.

Turning to the firm's supply chain agility, we find that the variance explained in FSCA construct is 0.538, indicating good model fit. The path from external integration to a firm's supply chain agility is seen to be strong at 0.541 ( $p < 0.001$ ), in support of hypothesis H3b. Likewise, the path from external flexibility to a firm's supply chain agility is seen to be strong and statistically significant (0.213;  $p < 0.001$  level), providing ample



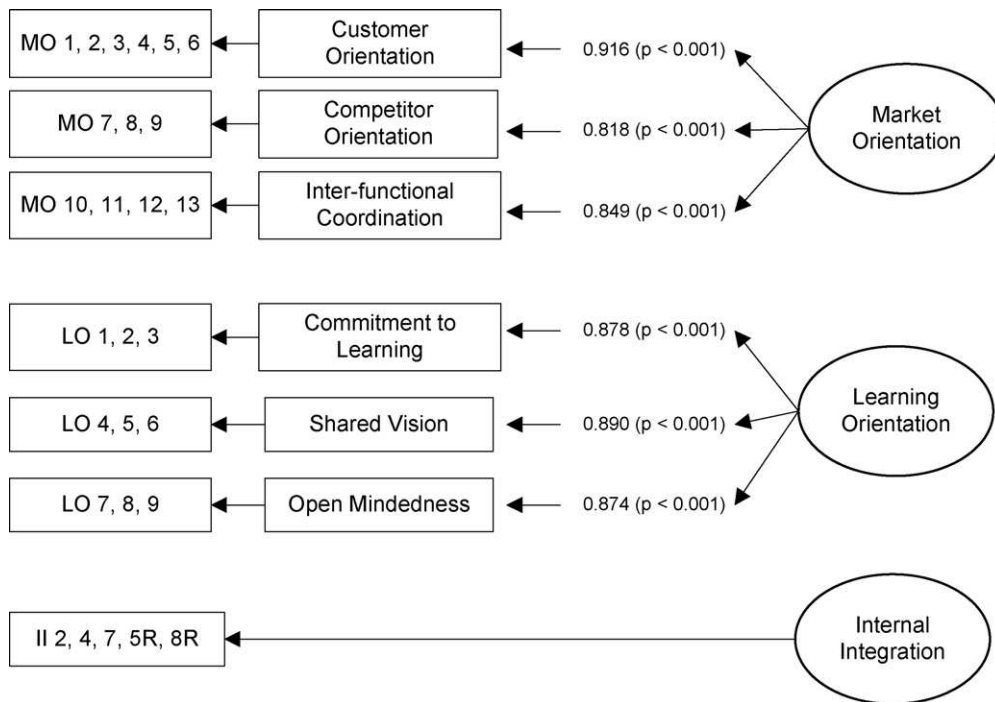


Fig. 3. Measurement model: market & learning orientation and internal integration.

evidence in support of hypothesis H3c. However, the path from internal integration to a firm's supply chain agility is seen to be less strong (0.141), but still significant at 0.05 level. Thus we have support for hypothesis H3a.

Overall, the hypothesized model provides evidence that market orientation and learning orientation do affect the organizational practices of internal integration, external

integration and external flexibility significantly. Market orientation shows an effect on all three organizational practices of internal integration, external integration and flexible practices, while learning orientation only has a strong impact on internal integration. All three organizational practices investigated are found to have direct and significant impact on a firm's supply chain agility.

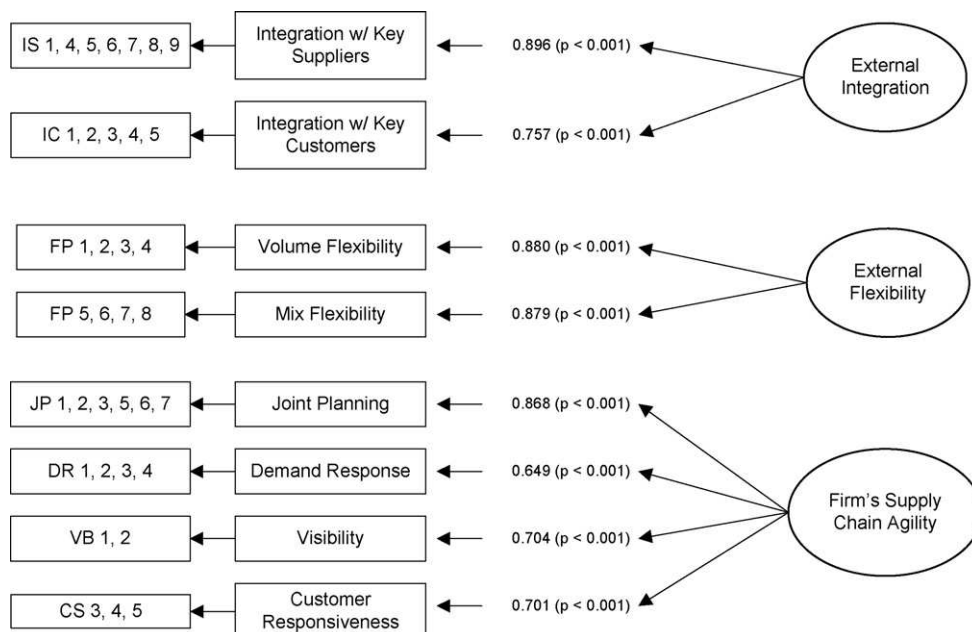


Fig. 4. Measurement model: external integration, external flexibility and firm's SC agility.

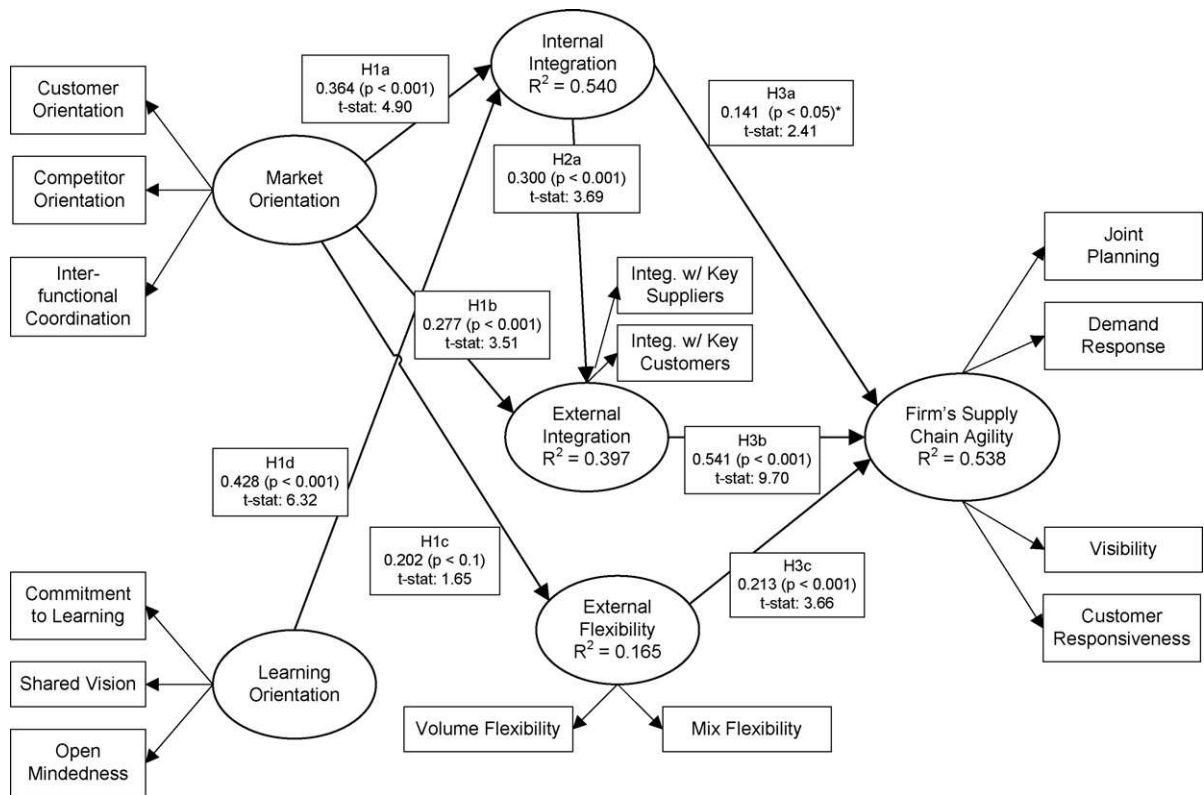


Fig. 5. Estimates of structural model.

#### 4.3. Characteristics of firms with high and low FSCA

Another objective of this study was to determine if there are specific differences between firms with high and low levels of firm's supply chain agility. Thus more analysis was carried out for additional insights, as well as to seek further validation for the above results. Differences between firms that exhibited high FSCA, and those that showed low FSCA, were assessed in terms of the five sub-elements of the three organizational practices.

The organizations in the data set were accordingly divided into three equal groups based on the weighed average value for FSCA construct. This was computed by using factor loadings from the outer model of the PLS

output. Employing a factor score in this manner creates a more accurate measure than computing the simple mean, which assigns equal weights (Lastovicka and Thamodaram, 1991). The middle third of the data set was discarded for this analysis, and the two remaining groups represented firms with high and low levels of FSCA.

The next step was to conduct a multiple analysis of variance (MANOVA) to determine if there were significant differences between firms with high and low FSCA on each of the 5 sub-elements of organizational practices: internal integration, external integration with key suppliers, external integration with key customers, volume flexibility and mix flexibility. In employing MANOVA, one needs to ensure that the following three assumptions are not violated: (1) the observations must be independent, (2) the observations on the dependent variables must follow a multivariate normal distribution in each group, and (3) the population covariance matrices for the dependent variables are equal (Stevens, 2002). The observations in this study are clearly independent since they represent responses from supply chain professionals from different organizations. In order to assess the second assumption, relating to multivariate normality, the Kolmogorov–Smirnov test was conducted as the sample size was greater than 50 (George and Mallery, 2001). The results of this test are shown in Table 6 and they indicate that four of the dependent variables (shown in *italics* in the table) do not exhibit multivariate normality based on the Kolmogorov–Smirnov test. However, Stevens (2002) maintains

**Table 5**  
Summary of hypotheses.

H1a	Market orientation	→ Internal integration	Supported
H1b	Market orientation	→ External integration	Supported
H1c	Market orientation	→ External flexibility	Supported
H1d	Learning orientation	→ Internal integration	Supported
H1e	Learning orientation	→ External integration	No support
H1f	Learning orientation	→ External flexibility	No support
H2a	Internal integration	→ External integration	Supported
H2b	Internal integration	→ External flexibility	No support
H2c	External integration	→ External flexibility	No support
H3a	Internal integration	→ Firm's SC agility	Supported
H3b	External integration	→ Firm's SC agility	Supported
H3c	External flexibility	→ Firm's SC agility	Supported

**Table 6**

Tests of multivariate normality and equality of covariance matrices.

Multivariate normality				
Construct		Kolmogorov–Smirnov statistic		Significance
Internal integration	<i>High FSCA (df = 64)</i>	.116		.033
	<i>Low FSCA (df = 66)</i>	.138		.002
External integration with key suppliers	<i>High FSCA (df = 64)</i>	.125		.015
	<i>Low FSCA (df = 66)</i>	.057		.200*
External integration with key customers	<i>High FSCA (df = 64)</i>	.072		.200*
	<i>Low FSCA (df = 66)</i>	.082		.200*
Volume flexibility	<i>High FSCA (df = 64)</i>	.098		.200*
	<i>Low FSCA (df = 66)</i>	.085		.200*
Mix flexibility	<i>High FSCA (df = 64)</i>	.135		.005
	<i>Low FSCA (df = 66)</i>	.106		.062
Box's M	F	Df 1	Df 2	Significance
Equality of covariance matrices				
40.013	2.556	15	65829.506	0.001

Entries in italics violate assumption of multivariate normality.

\* This is a lower bound of the true significance.

that deviations from multivariate normality have only a small effect on Type I error. Therefore, violations of this assumption are robust with respect to Type I error. For the third assumption, Box's Test of Equality of Covariance Matrices was performed. The results in Table 6 show that this assumption has been violated because the test results are significant ( $p < 0.001$ ), indicating that the covariance matrices for dependent variables are different. However, the results that violate this assumption are relatively robust if the ratio of the largest group size to smallest group size is less than 1.5 (Stevens, 2002). In this study, this ratio amounts to 1.03 (66/64); hence it was determined that this data is suitable for a MANOVA analysis.

A one-factor MANOVA was then conducted with FSCA as the fixed factor, binary coded for high and low FSCA groups. Internal integration, external integration with key suppliers, external integration with key customers, volume flexibility and mix flexibility were treated as the dependent variables. Each of these constructs was represented by creating a factor score, using the outer model weights from the PLS analysis. MANOVA results and descriptive statistics are shown in Table 7 and Table 8 respectively.

**Table 7**  
MANOVA results.

Effect	Value	F	Significance
Multivariate tests			
Pillai's trace	.540	29.082	.000
Wilks' lambda	.460	29.082	.000
Hotelling's trace	1.173	29.082	.000
Roy's largest root	1.173	29.082	.000
Dependent variable		F	Significance
Tests of between-subjects effect			
Internal integration		49.811	.000
External integration with key suppliers		84.898	.000
External integration with key customers		29.016	.000
Volume flexibility		19.252	.000
Mix flexibility		44.515	.000

From these tables, it can be established that organizations with high levels of FSCA are significantly different than firms that have low levels of FSCA. In addition, an inspection of the between-subjects effects output from SPSS indicated that there are significant differences between high FSCA and low FSCA firms on all 5 sub-elements of the organizational practices considered. This can be seen in Fig. 6: all five variables considered are higher for firms with high FSCA than for firms with low FSCA values. These results provide additional support for the results obtained from the PLS model discussed above.

## 5. Discussion of results

The research results are discussed below in the following order. The drivers for the enhancement of supply chain agility, approached as a risk management initiative, are discussed first. The impact of the three organizational practices on FSCA and risk management is summarized in Section 5.1. This is followed by the effects of cultural antecedents, market and learning orientation, and their role in augmenting FSCA and disruption risk management in Section 5.2. In Section 5.3, the research results are related to past assertions and findings made so far in the emerging body of work on disruption risk management.

### 5.1. Impact of organizational practices on FSCA and risk management

All three organizational practices of internal integration, external integration and adoption of external flexible practices were found to be direct antecedents of a firm's supply chain agility, explaining a significant portion of the variance in the FSCA construct. Among these three antecedents, external integration with key suppliers and customers was seen to be the strongest predictor of a firm's supply chain agility. These results empirically validate the assertions of Christopher (2000) and van Hoek et al. (2001)

**Table 8**  
Descriptive statistics for MANOVA analysis.

Construct		Mean	S.D.
Internal integration	High FSCA (N = 64)	5.9783	.7642
	Low FSCA (N = 66)	4.7401	1.1962
External integration with key suppliers	High FSCA (N = 64)	5.7002	.7576
	Low FSCA (N = 66)	4.0838	.9953
External integration with key customers	High FSCA (N = 64)	5.2969	.9992
	Low FSCA (N = 66)	4.3519	.9721
Volume flexibility	High FSCA (N = 64)	5.0842	.9216
	Low FSCA (N = 66)	4.3145	1.3468
Mix flexibility	High FSCA (N = 64)	5.5573	1.1112
	Low FSCA (N = 66)	4.3868	1.4022

who pointed out that external integration may be a contributing factor for supply chain agility. The results support the notion that external integration, involving greater connectedness among key firms in the chain, may enable more coordinated mitigation tactics as well as superior, joint response tactics to foreseen and unforeseen disruptions.

Many past studies have shown that that external integration contributes towards cost and service-level performance in a supply chain. For instance, [Frohlich and Westbrook \(2001\)](#) demonstrated that firms with the widest “arc of integration”, i.e., strong integration with both customers and suppliers, had superior performance compared to firms with lower levels of integration, with either customers or suppliers. However, in addition to *performance*, the notion that *agility* and thereby risk mitigation and response in the supply chain are also improved through external integration is demonstrated in the results of our study.

The level of agility was also found to be affected by the extent of externally focused flexibility. External flexibility, comprising mix and volume flexibility was found to be the second major antecedent of FSCA. This is in line with the assertion that external flexibility elements of mix and volume are intended to improve responsiveness in an organization ([Gupta and Somers, 1996](#); [Womack and Jones, 1996](#); [Zhang et al., 2003](#)). These results also add to the findings of [Swofford et al. \(2006\)](#), which demonstrated

that flexibility in manufacturing, logistics and procurement are antecedents of agility in the supply chain. The external flexibility orientation of the firm can be added to this collection of flexibility elements to provide agility in the supply chain. However, and perhaps more importantly, the results of the current study show that flexibility alone is not enough for agility. As stated above, external integration was found to be the strongest among the three predictors for FSCA. Thus, in addition to creating requisite competencies of flexibility, it is also necessary for the firms in a supply chain to be sufficiently integrated to ensure agility and contribute towards risk mitigation and response tactics.

Internal integration was seen to be the third major antecedent for agility. This was found to be significant at a slightly lower level ( $p < 0.05$ ). However, it was seen that internal integration contributes more significantly ( $p < 0.001$ ) towards achieving external integration. This lends support to the assertions of [Stevens \(1989\)](#) and others that internal integration may be a necessary first step prior to external integration. The need for prior internal integration is also consistent with the first of ten principles outlined by [Kleindorfer and Saad \(2005\)](#): “putting one’s own house in the supply chain in order first”. Thus, in order for a firm to be agile in a supply chain and to be both proactive as well as responsive to supply chain disruptions, efforts must be undertaken to eliminate functional barriers within the organization. The benefits of organizing along cross-functional business processes, or value chains have been emphasized frequently in recent years. The research results also serve to extend the findings of [Pagell \(2004\)](#), which demonstrated the positive impact of internal integration on performance. But, in addition to performance, the current study shows that internal integration contributes to agility and risk mitigation and response.

These results also extend the work of [Rosenzweig et al. \(2003\)](#) who demonstrated the importance of ‘integration intensity’ on competitive capabilities, with the measure for integration intensity being a combination of internal and external integration. Separating the two types of integration, our study shows that both have a significant impact on the firm’s supply chain agility. The results also support the findings of [Vickery et al. \(2003\)](#), who considered supply chain integration to consist of both vertical linkages

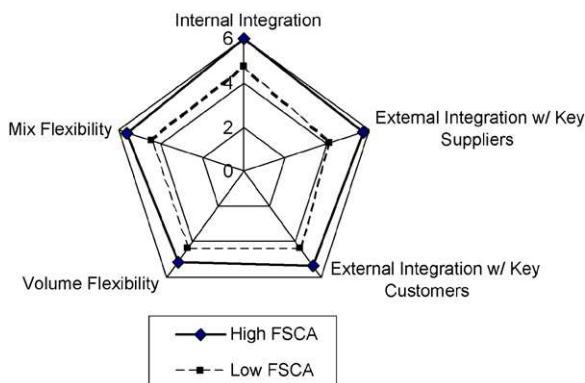


Fig. 6. Comparison between high and low FSCA organizations.



(between firms in different positions in the chain) and horizontal linkages (between various functions within a firm). It was shown that both vertical and horizontal linkages contribute towards performance. Our study results complement these by showing that internal and external integration also contribute towards agility.

The research results also suggest that there is a separation between the organizational practices of external flexibility, and internal and external integration. Among the three antecedents of FSCA, it was noted that no significant relationship existed between the two integration constructs and external flexibility (i.e., no support found for H2b and H2c). This suggests that organizations may pursue flexibility as a separate initiative, unrelated to internal and external integration efforts, and related only in terms of end outcomes. The results suggest that external flexibility is impacted by the level of market orientation of the firm. In addition, it can be augmented through other, antecedent flexibility elements such as machine, labor, routing and material handling flexibility, as established by Zhang et al. (2002, 2003).

MANOVA analysis, at the level of the first-order constructs behind the three organizational practices, showed that firms that exhibited high levels of FSCA had significantly higher levels of internal integration, external integration with key suppliers, external integration with key customers, as well as higher levels of volume flexibility and mix flexibility. This additional analysis corroborated the results from the PLS analysis at a more elemental level.

Thus this study adds to the emerging body of literature on supply chain agility, and disruption risk management, by examining and validating the joint effects of internal and external integration, along with external flexibility. A major implication is that, from the standpoint of enhancing agility, and risk mitigation and response, all three organizational practices contribute significantly. In addition, internal and external integration may be as important as enhancement of external flexibility.

## 5.2. Impact of cultural antecedents

It is well known that supply chain initiatives involve major cultural transformations among constituent firms such as establishing trust, a shift from adversarial relationships to collaboration and partnership, optimizing behavior at the supply chain level, instead of at the firm level, etc. In this research, the impact of two cultural dispositions not considered before, namely market and learning orientation was investigated, in addition to more direct initiatives leading to agility.

Of the two cultural drivers, market orientation was seen to directly affect both types of integration (both at  $p < 0.001$ ), as well as external flexibility ( $p < 0.1$ ). Market orientation, as stated earlier, consists of two externally oriented behaviors (customer and competitor orientation) and one internally oriented behavior relating to inter-functional coordination. Firms with high levels of market orientation have a propensity to actively scan the competitive landscape, and give due attention to customers. Internally, market information is actively shared within the organization in order to effectively respond to

this information. The research results add to the findings of culture-driven studies such as Slater and Narver (1995), Hurley and Hult (1998) and Baker and Sinkula (1999). Specifically, it was shown that in the context of supply chain-related efforts, firms with high levels of market orientation are likely to have higher levels of internal integration as well as external integration with key suppliers and customers. Likewise, firms with high levels of market orientation were shown to have high levels of external flexibility, though this was at a lower level of significance ( $p < 0.1$ ).

Learning orientation was shown to have a strong and significant influence on internal integration ( $p < 0.001$ ). Learning orientation, which is essentially a predisposition to learn and adapt, leads to firms actively questioning current ways of conducting business and seeking new ways to succeed in the marketplace. This includes re-examining current, functional modes of operation and accomplishing faster, cross-functional processes which internal integration requires. Learning orientation was not found to have a direct and significant influence on external integration and external flexibility. But, given its strong effect on internal integration, which in turn had a strong and direct effect on external integration, it may be stated that learning orientation had an indirect effect on external integration.

A somewhat counter-intuitive finding was the fact that learning orientation had no significant effect on external flexibility. These findings may seem to differ from studies such as Cohen and Levinthal (1990), which have suggested a strong relationship between a firm's learning orientation and the adoption of new organizational practices. However, external flexibility results from other, more fundamental elements of flexibility such as machine, labor, material handling and routing flexibility, as Zhang et al. (2002, 2003) showed. It is conceivable that learning orientation may have a more pronounced effect on these internally oriented flexibility elements. This aspect needs to be investigated further.

Thus, this set of results adds to our understanding of cultural drivers for internal and external coordination in the supply chain, and for adopting externally oriented flexibility. Both market and learning orientation have been studied, and established as cultural antecedents of firm-level competitive advantage before, and this study establishes their importance in the context of supply chain initiatives that are aimed at enhancing agility, risk preparedness and better response to foreseen and unforeseen disruptions.

## 5.3. Relationship with past studies on disruption risk management

The research results serve to establish a set of key drivers for augmenting supply chain agility as part of a risk management initiative. In addition, the results add to the research literature on disruption risk management in many ways. Risks within the supply chain are often interconnected and alleviating one type of risk might aggravate another type of risk (Chopra and Sodhi, 2004). Therefore mitigation strategies should be employed with

minimal contradiction. Chopra and Sodhi (2004) identified several categories of risk including disruption, delay, forecast, procurement, risk, capacity and inventory risks, along with their interconnections. Two of the mitigation strategies listed are enhancing responsiveness and increasing flexibility levels. Both these risk mitigation strategies are stated to reduce a variety of risks including delays, forecast risk, capacity risk and inventory risk. However, adopting a more elaborate causal framework, in the research results presented above, responsiveness was shown to be a key component of agility, and external flexibility shown to be a key antecedent of FSCA.

Kleindorfer and Saad (2005) outlined a list of 10 principles developed from the industrial risk management and supply chain literatures. Again, these principles are subsumed within the network of constructs considered in this research, and several of them validated by the findings. For instance, the first principle (“put one’s own house in order”) can be related to the construct of internal integration. The research finding that internal integration is an important precursor to both external integration with key customers and key suppliers, and FSCA tends to validate this principle. The third principle advocated by Kleindorfer and Saad (2005) refers to the need for early warning systems. In this research study, one of the first-order constructs employed in FSCA is visibility (of demand and inventory levels) across the supply chain with key customers and key suppliers. The presence of early warning systems can be related to active environmental scanning emphasized by the market orientation construct. Likewise, the seventh principle (“the collaborative sharing of information is essential to identifying vulnerabilities and preparing for and executing effective crisis management”) is clearly part of internal and external integrations constructs considered.

Faisal et al. (2006) listed several enablers of risk mitigation, including information sharing, agility in the supply chain and collaborative relationships, all of which form part of the network of constructs considered in this study. Their assertion that collaborative relationships, information sharing and trust among supply chain partners are major drivers of risk mitigation has been generally validated, even though trust among supply chain partners was not explicitly studied in this research. Likewise, Tomlin (2006) stated that volume flexibility can be a large factor in the determination of a firm’s disruption management strategy. Volume flexibility, along with mix flexibility, was one of the two external flexibility constructs considered in this research. In line with the assertion of Tomlin (2006), flexibility can be of value for both mitigation and for speedy and efficient response following a disruption.

Similarly, the research results pertaining to the cultural antecedents again add to the literature on disruption risk management. For instance, Ritchie and Brindley (2007) provided examples of risk management to include information sharing, relationship development and joint reviews. These elements form part of the constructs of internal integration, external integration with key customers and key suppliers, and first-order constructs (demand response, joint planning and visibility) consid-

ered within this research. Likewise, they also stated that market scanning activities may reduce the risk of systematic risk exposure and make the company more aware of, and be responsive to its environment. The market and learning orientation constructs discussed above included these aspects, and were shown to have an impact on the three organizational practices affecting agility. Cultural factors clearly have a role in flexibility, responsiveness, agility, etc. all of which impact supply chain risk mitigation and response to disruptions.

In the research model proposed in Craighead et al. (2007), starting with supply chain design characteristics like density and complexity, two mitigation capabilities are defined, which moderate or reduce the severity of disruptions. The first mitigation capability, *recovery capability*, is defined as interactions of supply chain entities and corresponding coordination of supply chain resources to return the supply chain to a normal and planned level of product flow. In this definition, the connections to FSCA and the role of internal and external integration constructs may be seen. They also mentioned that this recovery capability should be proactive in nature, i.e., mitigation-oriented as opposed to being reactive, after occurrence of disruptions. The second mitigation capability refers to *warning capability* which refers to interactions and coordination of supply chain resources to detect a pending or realized disruption and to subsequently disseminate pertinent information about the disruption to relevant entities within the supply chain. This again can be related to the integration and FSCA constructs in the model proposed above. Additionally, market orientation places emphasis on active environmental scanning through its first-order constructs.

Thus the research results add to the emerging body of research knowledge in disruption risk management, by way of identifying a set of key drivers for cultivating flexibility, responsiveness, agility, etc., and by developing a causal structure for variables affecting risk mitigation and response tactics.

## 6. Conclusions

In this study, the cultivation of agility and its antecedents is viewed as a disruption risk management tactic that enables the firm and its partners to respond rapidly to market place changes, and to respond rapidly to both potential and actual disruptions in the supply chain. Agility and its antecedents are of value for both mitigation and response tactics, emphasizing fast, proactive measures when faced with potential disruptions, and also for rapid response measures following the occurrence of expected or unforeseen disruptions.

This study developed an enhanced theoretical framework for agility in supply chains, and investigated the impact of three major organizational practices and two cultural antecedents. Building on the foundations of Zhang et al. (2002, 2003) and Swafford et al. (2006), this research stream was extended further in several ways.

First, besides flexibility, other possible antecedents of agility were investigated, in particular, the role of internal, cross-functional integration, and external integration with

key customers and suppliers. These aspects have not been studied before. The studies of Zhang et al. (2002, 2003) and Swafford et al. (2006) investigated flexibility aspects, and did not consider internal and external integration elements. In Swafford et al. (2006), it was established that flexibility in sourcing, manufacturing, distribution and logistics contribute directly to the creation of agility. Likewise, Zhang et al. (2002, 2003) investigated the relationships among various types of flexibility in terms of achieving value chain flexibility. In our study, we considered the external flexibility elements of mix and volume, and it was shown that, in addition to enhancement of flexibility, internal and external supply chain integration practices are also important antecedents of a firm's supply chain agility. The impact of supply chain integration, internal and external, on supply chain *performance* (such as cost and service levels) has been investigated in past research, but not on supply chain *agility*. It was shown that integration efforts have a strong bearing on enhanced agility in the supply chain. Secondly, the past studies of Zhang et al. (2002, 2003) and Swafford et al. (2006) did not consider processes external to the focal firm. In this study, the scope of the analysis was extended more to the supply chain level, by considering external integration processes with key suppliers and customers.

Thirdly, besides contributing to the incipient body of knowledge pertaining to supply chain agility, this study also adds to an emerging body of research investigating cultural antecedents in operations management research. Supply chain efforts involve major cultural changes such as the establishment of trust, a shift from adversarial relationships to collaboration and partnership among firms in the supply chain, etc. These aspects have begun to receive attention. In this research, the impact of two cultural dispositions not considered before, namely market and learning orientation was investigated, and shown to affect the impact of other direct initiatives leading to agility.

Fourthly, this study has also contributed to the refinement of the supply chain agility construct, which was explicitly referred to as a *firm's* supply chain agility (FSCA). As explained in Section 2.3 above, there has been a general ambivalence in past research relating to the unit of analysis. While the construct has been referred to as “supply chain performance”, “supply chain agility” etc., past research has been based almost entirely on the characteristics of a single, focal firm within the supply chain and, in addition, based on responses from a single key informant within the focal firm. Thus, this construct has been refined, and redefined below as: the capability of the *firm*, internally, and in conjunction with its key suppliers and customers, to adapt or respond in a speedy manner to a changing marketplace, contributing to

agility of the extended supply chain. This naturally points towards similar improvements needed in the definitions for other performance measures adopted in supply chain research.

The limitations due to perceptual nature of the data used to assess the various constructs, reliance on key informants, and the possibility of mono-respondent bias and common methods variance that are common to many empirical research studies of the past do apply to this study as well. Like most studies in the past, this study surveyed high-level supply chain professionals from individual firms, who are generally capable of internal and external assessments involving key suppliers and customers. While this is a potential limitation, it is also an opportunity for future research. Ideally, a broader respondent base within the supply chain may enable researchers to observe and analyze the interactions and interdependencies between firms that are organized into a supply chain.

This research has also contributed towards a better understanding of agility and related concepts in the context of managing disruption risks in supply chains. The findings are also of relevance to supply chain agility in service operations management contexts. Given calamitous events of the 21st century, characterized by increasing levels of unpredictability (events such as hurricane Katrina), limitations in inter-agency coordination and inadequacies in emergency response systems have been highlighted in recent years. In these service logistics management processes, proactive measures to anticipate extreme events and, after the event, to provide fast response, based on greater inter-agency integration and agility have become major concerns. This necessitates new lines of inquiry in the agility of service supply chains. Likewise, much work remains to be done to develop methods for proactively avoiding disruptions and providing fast response in globally dispersed manufacturing and service supply chains.

## Acknowledgments

The authors thank the referees and editors of the special issue for insightful comments on earlier versions of the manuscript. Support received from Institute for Supply Management (ISM) is gratefully acknowledged.

## Appendix A

The table lists the constructs, item measures and the literature related to this work (Table A.1).

**Table A.1**  
Constructs, item measures and related literature (dropped items in *italics*).

Construct/item measure		Source/construct
Market orientation		Narver and Slater, 1990
MO1	Our business objectives are driven by customer satisfaction	Customer orientation
MO2	We monitor our level of commitment and orientation to serving customers' needs	Customer orientation
MO3	Our strategy for competitive advantage is based on our understanding of customer needs	Customer orientation

Table A.1 (Continued)

Construct/item measure		Source/construct
MO4	Our business strategies are driven by our beliefs about how we can create greater value for customers	Customer orientation
MO5	We measure customer satisfaction systematically and frequently	Customer orientation
MO6	We give close attention to after-sales service	Customer orientation
MO7	Our salespeople share information within our business concerning competitors' strategies	Competitor orientation
MO8	We respond to competitive actions that threaten us	Competitor orientation
MO9	The top management team regularly discusses competitors' strengths and strategies	Competitor orientation
MO10	Our top managers from every function visit our current and prospective customers	Inter-functional coordination
MO11	We communicate information about our successful and unsuccessful customer experiences across all business functions	Inter-functional coordination
MO12	All of our business functions (e.g., marketing, manufacturing, R&D, finance) are integrated in serving the needs of our target markets	Inter-functional Coordination
MO13	All of our managers understand how everyone in our company can contribute to creating customer value	Inter-functional coordination
Learning orientation		Sinkula et al., 1997
LO1	Managers agree that our organization's ability to learn is the key to our competitive advantage	Commitment to learning
LO2	The sense around here is that employee learning is an investment, not an expense	Commitment to learning
LO3	The collective wisdom in this organization is that once we quit learning, we endanger our future	Commitment to learning
LO4	There is total agreement on our organizational vision across all levels, functions and divisions	Shared vision
LO5	All employees are committed to the goals of this organization	Shared vision
LO6	We do not have a well-defined vision for the organization	Shared vision
LO7	We are not afraid to reflect critically on the shared assumptions we have about the way we conduct business	Open-mindedness
LO8	Managers encourage employees to "think outside of the box"	Open-mindedness
LO9	Managers in this organization do not want their "view of the world" to be questioned	Open-mindedness
Internal integration		
	The following set of questions concerns integration practices that are followed by your firm. They relate to integration with key customers, integration with key suppliers and internal integration. Please circle the number that best represents your agreement or disagreement with the statement.	
II1	<i>All departments within our firm are connected by a single central information system [(e.g., enterprise resource planning)]</i>	
II2	We use cross functional teams to solve problems	Pagell, 2004
II3	<i>Communications from one department to another are expected to be routed through "proper channels"</i>	Jaworski and Kohli, 1993
II4	Internal management communicates frequently about goals and priorities	Pagell, 2004
II5	Our firm does not encourage openness and teamwork	Pagell, 2004
II6	<i>When problems occur in our firm, finding someone to blame is more important than finding a solution</i>	Pagell, 2004
II7	Formal meetings are routinely scheduled among various departments	Pagell, 2004
II8	When problems or opportunities arise, informal, face-to-face meetings never occur	Pagell, 2004
IC1	Integration with key customers	
IC2	Our customers give us feedback on quality and delivery performance	Shah, 2002
IC3	Customers are actively involved in our new product development process	Shah, 2002
IC4	Customers frequently share demand information with our firm	Shah, 2002
IC5	Our production plans are shared with our customers	Frohlich and Westbrook, 2001
IC6	Our inventory levels are shared with our customers	Frohlich and Westbrook, 2001
Integration with key suppliers		
IS1	Our inventory levels are shared with our suppliers	Frohlich and Westbrook, 2001
IS2	We give our suppliers feedback on quality and delivery performance	Shah, 2002
IS3	We strive to establish long term relationships with our suppliers	Shah, 2002
IS4	Our key suppliers deliver to our plant in a JIT basis	Shah, 2002
IS5	We have high corporate level communication on important issues with key suppliers	Shah, 2002
IS6	Sharing of information via the internet is important to our supply chain.	Christopher, 2000;
		van Hoek et al., 2001
IS7	We work with our suppliers to seamlessly integrate our inter-firm processes (e.g., order placement)	Christopher, 2000
IS8	Our supply chain employs rapid response initiatives (e.g., continuous replenishment (CR) or vendor managed inventory (VMI))	van Hoek et al., 2001
IS9	We jointly develop new products/services with our suppliers	van Hoek et al., 2001
External flexibility		Zhang et al., 2003;
FP1	We can operate efficiently at different levels of output	Volume flexibility
FP2	We can operate profitably at different production volumes	Volume flexibility
FP3	We can quickly change the quantities for our products produced	Volume flexibility
FP4	We can easily change the production volume of a manufacturing process	Volume flexibility
FP5	We can produce a wide variety of products in our plant(s)	Mix flexibility



Table A.1 (Continued)

Construct/item measure		Source/construct
FP6	We can produce different product types without major changeover	Mix flexibility
FP7	We can build different products in the same plants at the same time	Mix flexibility
FP8	We can changeover quickly from one product to another	Mix flexibility
Supply chain agility		
Firms often participate in many supply chains. For the following questions please answer them with respect to key supply chains that your firm participates in. Please circle the number that best represents your agreement or disagreement with the statement.		
Demand response		
DR1	Our supply chain is able to respond to changes in demand without overstocks or lost sales	van Hoek, 2001
DR2	Our supply chain is able to leverage the competencies of our partners to respond to market demands	Christopher, 2000; van Hoek et al., 2001
DR3	Our supply chain is capable of forecasting market demand	Christopher, 2000; van Hoek et al., 2001
DR4	Our supply chain is capable of responding to real market demand	Christopher, 2000; van Hoek et al., 2001
DR5	<i>Our supply chain is order-driven rather than forecast-driven</i>	Christopher, 2000; van Hoek et al., 2001
Joint planning		
JP1	Joint planning with suppliers is important in purchasing	Christopher, 2000 van Hoek et al., 2001
JP2	Information integration with suppliers in the supply chain is important.	Christopher, 2000; van Hoek et al., 2001
JP3	Joint planning with suppliers is important in production	van Hoek, 2001
JP4	<i>We work with our customers to seamlessly integrate our inter-firm processes (e.g., order entry)</i>	Christopher, 2000 van Hoek et al., 2001
JP5	Joint planning with customers is important in logistics	van Hoek, 2001
JP6	Information integration with customers in the supply chain is important	van Hoek, 2001
JP7	Information integration with logistics service providers is important	van Hoek, 2001
Customer responsiveness		
CS1	<i>Products are customized rather than standardized</i>	van Hoek, 2001
CS2	<i>Our supply chain utilizes postponement strategies to enable customization of products/services</i>	Christopher, 2000 van Hoek et al., 2001
CS3	Improving our level of customer service is a high priority	Swafford, 2003
CS4	Improving delivery reliability is a high priority	Swafford, 2003
CS5	Improving responsiveness to changing market needs is a high priority	Swafford, 2003
CS6	<i>Products are easy to adjust to demand</i>	Swafford, 2003
CS7	<i>We strive to increase the level of customization</i>	Swafford, 2003
Visibility		
VB1	Inventory levels are visible throughout the supply chain	Christopher, 2000 van Hoek et al., 2001
VB2	Demand levels are visible throughout the supply chain	Christopher, 2000; van Hoek et al., 2001

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