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# Which tools enhance agility, flexibility or resilience in supply chains? An empirical study

**Working Paper**

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**Abstract**

Agility, flexibility and even resilience have become mainstream preoccupations both of supply chain managers and academic researchers in the last few years. Yet, many questions remain unanswered about how best to achieve such operational capabilities. Using the resource based-view of the firm and the dynamic capabilities theory, we attempt to improve the existing knowledge on how to achieve agility, flexibility and resilience in supply chains by mapping the relationships between some lower-order capabilities and operational ones. Three lower order capabilities have been identified and characterized: Collaboration tools, Information technology tools, and Reactivity tools. Based upon a survey of 170 French supply chain managers, we provide insights on their application and which operational capability they enhance. Even though relationships exist on a general view, through a post hoc analysis, we show that these relationships no longer hold when the economic sector is taken into consideration. We present evidence that the food and beverage sector, the general retail sector and industry will choose different tool-sets providing for different operational capabilities. These results confirm earlier research: firms in a supply chain have different views on how to develop dynamic capabilities.

Keywords : Supply Chain, agility, resilience, flexibility, empirical research.

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# 1 Introduction

Over the past two decades, there has been a marked shift in the focus of supply chain management. If the nineties were about aligning the actors in a supply chain in terms of objectives and collaboration, practitioners and researchers in the twenty-first century are focusing on improving the relations between the chain members (Jacoby, 2009). At the same time, the markets have become ever more fickle, competition both in home markets and abroad has grown increasingly ferocious. Zara's example springs to mind: its ability to overcome vagaries of the fast fashion industry is legendary. Pressure from e-commerce, e-tailers and now m-commerce increases the need for speed and quick inventory turnover[1]. Supply chain managers have been under increasing pressure to maximize returns and service while containing costs. They are also forever adapting the services and goods on offer to a consumer that not only has changing tastes but also changing behavior about where and how his favorite products should be delivered. The crisis in 2008 has abruptly put them in the limelight (Hindle, 2008, The Economist, 2009). Their orders are to instil agility, flexibility and resilience in supply chains to match the speed of change and the accelerating competition in their markets. All consulting companies, software editors and professional organizations have suddenly taken an interest in how best provide the managerial and technological tools to enhance those qualities[2]. Agility, flexibility and resilience have also become mainstream in the academic world as the increasing flow of articles in recent years can attest (eg, Swafford et al., 2008, Bottani, 2010, Ngai et al., 2011, Bhamra et al., 2011, Blackhurst et al., 2011, Richey et al., 2012, Mandal, 2012, Malhotra and Mackelprang, 2012, Liu et al., 2013, Blome and Schoenherr, 2013).

Given the extant literature and interest in these operational capabilities, it is surprising that the management tools required to achieve them are treated from so many different managerial viewpoints (eg, operations, strategy, information systems, marketing, human resources, ...). The present study considers the supply chain manager as being at the center of the decision-making and management processes of the supply chain.

This work concerns itself with the following question. To obtain such agility, flexibility or resilience, what capabilities does a supply chain manager deploy? We enunciate a series of hypotheses which we test through an empirical study. Because some of the results are surprising, we formulate a post hoc analysis which extracts some further results by separating the data according to the respondent's economic sector. As shall be seen, results vary according to the economic sector of the respondent's firm. It appears that particular capabilities are valued differently according to the economic sector.

These results should entail some revision of previous works and open new avenues of research.

We describe our conceptual framework in the next section before presenting the

[1] Supply chain agility in an 'M-com' world, scemagazine.com

[2] A report on volatility and uncertainty and their impact on supply chains by Capgemini is available from their site

research methodology and sample characteristics in §3. The analysis of the data is reported in §4. We analyze the relationships between lower order capabilities and operational capabilities in §5 and renew the analysis for three economic sectors in §5.2 before concluding in §6. Some tables are relegated to the appendix (§7).

## 2 Conceptual framework

When reviewing the literatures relative to agility, flexibility or resilience in manufacturing or in supply chain management, it is important to recognize that approaches can be discussed as manufacturing paradigms as well as performance capabilities. When discussed as paradigms, the authors tend to treat them as systems of practices, also containing philosophical, value, and cultural elements (Narasimhan et al., 2006). At such level of aggregation, attributes tend to lose their distinctive qualities. Further, it becomes difficult to distinguish between *what* and *how*: agility tends to become both a desirable trait and a managerial practice.

There is a much more powerful theoretical framework which can be brought to bear in the present setting: the resource based view (RBV)(Wernerfelt, 1984) and an extension in the form of the concept of Dynamic Capabilities Theory introduced in Teece et al. (1997). The latter defines it as the ability to integrate, build, and reconfigure competences to achieve congruence with the changing business environments. Today, the Dynamic Capabilities perspective is a widely applied paradigm to explain variance in performance across competing firms (Barreto, 2010, Teece et al., 1997, Wu, 2010, Zaheer et al., 1998, Zhou and Li, 2010). With its roots in RBV, this theoretical perspective argues that superior firm performance comes from two types of organizational capabilities, namely, *dynamic* capability and *operational* capability (Cepeda and Vera, 2007, Zahra et al., 2006, Eisenhardt and Martin, 2000, Helfat and Peteraf, 2003).

Dynamic Capabilities are a learned pattern of collective activity and strategic routines through which an organization can generate and modify operating practices to achieve new resource configuration (Eisenhardt and Martin, 2000, Teece, 2007, Zollo and Winter, 2002). Dynamic Capabilities include such factors as strategic decision-making and alliance management that ensure that substantive capabilities can change to provide sustainable competitive advantage. The literature formulated the basic difference between *dynamic* capability and *operational* capability (Eisenhardt and Martin, 2000, Kabadayi, 2011, Winter, 2003, Wu et al., 2010). Scholars refer to the former as the means by which a firm achieves new resource conditions as market changes; by contrast, the latter is the means by which a firm functions or operates to make a living in the present (Winter, 2003). Dynamic Capabilities are considered to be of a higher order than operational capabilities.

An operational capability refers to a firm's ability to execute and coordinate the various tasks required to perform operational activities; eg, distribution logistics, operations planning, which are processes and routines rooted in knowledge (Cepeda and Vera, 2007). Scholars consider this capability as reflecting a high-level routine or a collection of routines that can be used to respond to market changes (Barreto, 2010, Eisenhardt and Martin, 2000, Pavlou and Sawy, 2006). For example, given the increasing importance of timely and cost-effective product delivery, supply chain agility is considered a critical type of operational capability required to obtain a competitive advantage (Ngai et al., 2011, Overby et al., 2006). It also reflects the coordination and collaboration efforts among the different chain members which enable the supply chain to be responsive to market changes (Braunscheidel and Suresh, 2009, Swafford et al., 2006, 2008).

These operational capabilities include all of internal operations plus the coordination, collaboration, information and control of suppliers and downstream partners; ie, the whole supply chain as viewed from the focal firm. In their turn, these operational capabilities are composed of lower-order capabilities such as IT capabilities (Liu et al., 2013). IT capabilities are antecedents of higher-order operational capabilities such as agility (Sambamurthy et al., 2003). For the purpose of a supply chain, the IT capabilities must be comprised of all the boundary-spanning technologies and value-added networks that link suppliers and buyers (Craighead et al., 2006).

We conceptualize supply chain *agility*, *resilience*, and *flexibility* as different operational capabilities. To build and operate a supply chain that is agile, resilient or flexible, it is helpful to have an in-depth understanding of the lower-order capabilities that are required. Within these boundary-spanning networks, effective integration requires business partners to be highly embedded operationally, technically, and strategically (Hult et al., 2004).

With this vision, the supply chain manager can describe from his vantage point the operational capabilities applied at his firm and within his supply chain (see Figure 1).

In the next three sub-sections we describe in detail the operational capabilities which this manager will want to develop so as to contribute to the Dynamic Capabil-

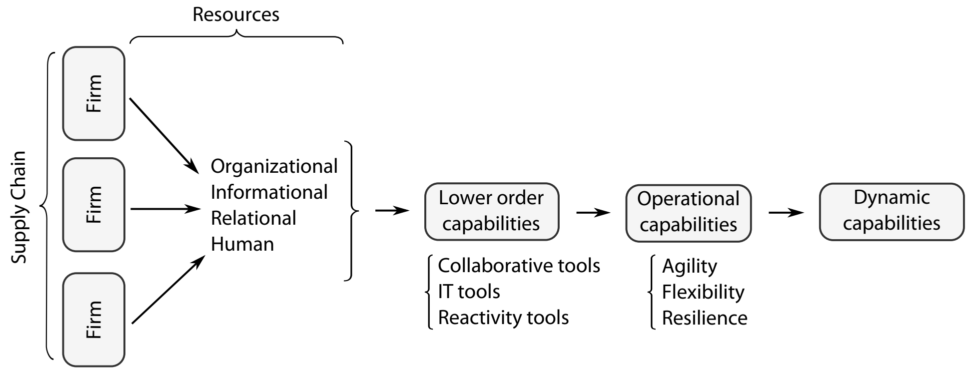


Figure 1: Theoretical model of a Resource-Based-View of a supply chain

ities of his supply chain. In the following three ones, we characterize the lower-order capabilities which he must develop to achieve the operational ones.

## 2.1 Agility in supply chains

Agility has been approached either from a theoretical perspective or by means of empirically-based research.

The concept of agility was introduced by researchers of the Iacocca Institute (Iacocca Institute, 1991) and later refined in Yusuf et al. (1999). Agile strategies are recognized to play a major role for survival in turbulent and volatile markets (Gunasekaran, 1998, Yusuf et al., 1999, Agarwal et al., 2006). These help companies to follow customers' tastes in providing the right product at the right time and price. Examples of industries where agility has become a required trait for survival include the garment industry (Bruce et al., 2004) (of which the fast fashion segment is a particularly exaggerated example, see Sull and Turconi, 2008, Lemieux et al., 2012), the electronic component industry which provides to the consumer industry (Estrada Guzmán, 2011). Other notable examples include Dell, Wal-Mart and Amazon (Lee, 2004).

The recent study Bottani (2010) looks into agility attributes and enablers which can be found in individual European manufacturers. Li et al. (2008, 2009b) propose a scale to measure agility as two dimensions viewed from three time horizons. The dimensions are alertness and response capability and they are combined with a strategic, operational and episodic vision of management. Blome and Schoenherr (2013) view each member of a supply chain as a link between the supply side and the demand side. In this study, agility is viewed as an operational capability stemming from the ability to manage demand-side, supply-side as well as production management.

Though originally conceived as being a firm's attribute, agility has been extended to the whole supply chain as a firm cannot be truly agile by itself in these days of extended organizations (Christopher, 2000). Agility is closely tied to the effectiveness of strategic supply chain management (Lee, 2004, Ketchen and Hult, 2007). Moreover, agile supply chains are inherently more market oriented because they are better able to synchronize supply with demand (Agarwal et al., 2006). Achieving synchronization requires integration across a firm's internal functions as well as its suppliers and customers (Narasimhan et al., 1997, Frohlich, 2002).

Agility includes both notions of volatile markets and competition as well as the capabilities to adapt to such conditions. The accent is not on the passive type of adaptability but on the proactive one: the most important item refers to the review of information systems parameters. This definition is consonant with the ones seen in Lee (2004), Gunasekaran (1999), Ismail and Sharifi (2006), Bruce et al. (2004), Swafford et al. (2008), Bottani (2010).

## 2.2 Flexibility in supply chains

Supply chains must also be flexible (Christopher and Holweg, 2011, Stevenson and Spring, 2007, Gunasekaran et al., 2004). A flexible supply chain is one which, in particular, has short lead times to satisfy its customers. An example is the Italian firm Luxottica which has reduced time to market for new products by 44% and reorder lead time and back orders by 43% between 2009 and 2012 while also reducing inventory[3] Vickery et al. (1999) say that "flexibility reflects and organization's ability to effectively adapt or respond to change[..]. Flexibility should be viewed from the perspective of the entire value-adding system." It should be examined from a customer-oriented perspective as a component of the quality management that supply chains wishing to satisfy customers wish to enhance (Rosenzweig et al., 2003, Robinson and Malhotra, 2005).

A flexible supply chains is able to match evolutions in final demand, however large. It can absorb demand peaks and troughs (separating "*base*" from "*surge*" demand as argued in Christopher and Holweg, 2011), but also distribution channel evolutions: from brick to click, from peri-urban malls to proximity shops, from mom-and-pop shops to franchises, etc. This definition can be compared with the

[3] Luxottica web site: press release January 2012.

ones in Vickery et al. (1999), Johnson et al. (2003), Stevenson and Spring (2007), Christopher and Holweg (2011), Malhotra and Mackelprang (2012). In particular, this definition is almost a mirror of the one characterized in Vickery et al. (1999): "flexibility should be viewed from the perspective of the entire value-adding system, ie, *total system flexibility*[4] [...] from an integrative, customer-oriented perspective". This definition is somewhat more explicit and arguably more complete than the one for external flexibility used by Braunscheidel and Suresh (2009).

Examples of firms which have deployed highly flexible supply chains include DELL and ZARA (Ferdows et al., 2004, Fugate and Mentzer, 2004, Kapuscinski et al., 2004). It is distinct from the definition of resilience as the latter characteristic "invariably causes additional cost, in the form of slack resources (eg, inventory and capacity) as well as higher coordination cost (eg, due to multiple sourcing)." (Christopher and Holweg, 2011). It is built from "the flexibility of its inbound and outbound supply chain partners" (Malhotra and Mackelprang, 2012). Toni and Tonchia (2005) define flexibility as the ability of a supply chain to change or react with little penalty in time, effort, cost or performance. The definition of flexibility in supply chains draws heavily from the flexibility in operations as seen in Vickery et al. (1997) and references therein.

## 2.3 Resilience in supply chains

Another important aspect to all supply chain managers is the capacity of their supply chain to withstand upheavals, disruptions and unforeseen events (Cf Bhamra et al., 2011, Sheffi and Rice, 2005, and references therein). A supply chain able to still perform and deliver products and services under such circumstances is called a *resilient* or robust one (Blackhurst et al., 2011). It is defined in Fiksel (2006) and in Pettit et al. (2010) as "the capacity for an enterprise to survive, adapt, and grow in the face of turbulent change". Resilience has a wider remit than just supply chain risk control. Since supply chains have increased in both length and complexity (Blackhurst et al., 2005), natural catastrophes, wars, strikes and economic upheavals severely impact performance (Chopra and Sodhi, 2004, Zsidisin et al., 2005, Wagner and Bode, 2008). Hendricks (2005) state that it is critical for firms to enhance the resiliency (sic) in their supply chains and call for research into specific tactics that help firms develop such capabilities.

[4] In italics in the source.

Resilience is often used as an alternative to robustness to specify the ability of a supply chain "to continue to function well in the event of a disruption" (Dong, 2006, Tang, 2006, Water, 2007, Vlajic et al., 2012). As demonstrated for the German automotive supply chain in Thun and Hoenig (2011), supply chain risk and vulnerability to disturbances can be overcome through implementation of preventive and reactive instruments. Studies are concerned with the ability of the same to return to its original state of operation after being disturbed (Pettit et al., 2010, Wagner and Neshat, 2010). Today's supply chains are more prone to disruptions due to natural and man-made causes (Wagner and Bode, 2008). Hence, the ability to recover quickly has become a topic of concern for practitioners and academics. Risk prevention and resilience hold important promises in enabling such recovery (Lavastre et al., 2012). The model proposed in Ponomarov and Holcomb (2009) linked several important concepts like connected, control, improved coherence and integration of logistical capabilities. Mandal (2012) identifies the dimensions or antecedents that IT professionals perceive as important for achieving resilience in the Indian context. Peck (2007) presented results of an investigation into the food chain in the UK.

To be able to face such risks requires first to be aware of them or at least evaluate their potential levels; deploy contingency planning; set up a sourcing policy for critical inputs and finally to have a good enough visibility of the activities of the other links in the supply chain. Lavastre et al. (2012) describe the case of a large medical equipment production global company in France which has chosen to plan for any and all situations. Managers run their entire supply chain by planning and predicting the activities of all the players and by attempting to anticipate all possible contingencies. Other references on resilience include Christopher and Peck (2004), Klibi et al. (2010). Fernie et al. (2000) reported that large retailers in the UK applied collaborative efforts and managed to "save millions of dollars in the late 1990s" by increasing efficiency and decreasing supply chain disruptions.

The definition and corresponding references in literature have been summarized in Table 1. An extensive table presenting all the references related to the identified concepts is included in appendix as Table 14 on page 35.

Having described the operational capabilities, we now want to characterize the lower order capabilities which, if deployed in full and used by all members of the supply chain, might generate those capabilities.

Table 1: Operational capabilities, definitions and literature base

| Constructs | Definitions | Literature |
|---|---|---|
| Agility | Quality which enables a supply chain to respond quickly and effectively to (unexpected) changes in market demands, with the aim to meet varied customer requirements in terms of price, specifications, quality, quantity and delivery. | Gunasekaran (1999), Christopher (2000), Christopher and Towill (2001), Lee (2004), Bruce et al. (2004), Gunasekaran et al. (2004), Ismail and Sharifi (2006), Agarwal et al. (2006), Zhang and Sharifi (2007), Swafford et al. (2008), Bottani (2010), Zhang (2011), Tseng and Lin (2011), Blome and Schoenherr (2013) |
| Flexibility | The qualities of a flexible supply chains include the built-in capabilities to match evolutions in final demand, however large. It includes the ability to absorb demand peaks and troughs, but also distribution channel evolutions. | Vickery et al. (1997), Ferdows et al. (2004), Fugate and Mentzer (2004), Kapuscinski et al. (2004), Christopher and Holweg (2011), Malhotra and Mackelprang (2012), Richey et al. (2012), Vlajic et al. (2012) |
| Resilience | Quality which enables a supply chain to withstand upheavals, disruptions and unforeseen events and still be able to deliver products and services with the desired quality, price, place and time. | Christopher and Peck (2004), Chopra and Sodhi (2004), Zsidisin et al. (2005), Dong (2006), Tang (2006), Blackhurst et al. (2005, 2011), Pettit et al. (2010), Wagner and Neshat (2010), Klibi et al. (2010), Thun and Hoenig (2011), Lavastre et al. (2012), Bhamra et al. (2011), Mandal (2012) |

## 2.4 Lower order capabilities

**Collaborative tools**: these are the tools of the Collaborative Planning, Forecasting and Replenishment variety where partners have to collaborate through VMI and ECR tools with retailers to enhance close cooperation among autonomous partners engaged in joint efforts to effectively meet end-customer needs (Faisal et al., 2007, Derrouiche et al., 2008, and references therein). A collaborative platform provides end-to-end real-time information exchange (Benjamin et al., 1990, Boyson et al., 2003) to communicate sales and forecast data (see Table 6). The collaborative tools stem from the retailer perspective and apply along the lines of the conceptual framework presented in Richey et al. (2012).

Table 2: Lower order capabilities, definitions and literature base

| Constructs | Definitions | Literature |
|---|---|---|
| Collaborative tools | Tools which enable communication and collaboration between the members of the supply chain to effectively meet end-customer needs with lower costs. | Benjamin et al. (1990), Boyson et al. (2003), Faisal et al. (2007), Derrouiche et al. (2008), Richey et al. (2012) |
| IT tools | tools enabling the different members to be integrated in terms of information for continuous adjustments | Themistocleous et al. (2004), Lin et al. (2006), White et al. (2005), García-Dastugue and Lambert (2003), Gruen and Shah (2000), Patterson et al. (2003), Liu et al. (2013), Rajaguru and Matanda (2013) |
| Reactivity tools | tools which enable shorter time lag when responding to customer changing requirements: forecasting, planning, decoupling point | Sauvage (2003), Charles et al. (2011), Lemieux et al. (2012), Duclos et al. (2003), Faisal et al. (2006) |

**IT tools**: this capability groups the tools of Information Technology which enhance inter-organizational integration and coordination through information systems (White et al., 2005, Lin et al., 2006, Patterson et al., 2003, Liu et al., 2013, Rajaguru and Matanda, 2013). It promotes the practice of a collaborative supply chain through information systems and continuous adjustments to the product lineup and inventories (See Qrunfleh and Tarafdar, 2012, for an appreciation of the impact of Information Systems on supply chain performance). Tracking and tracing of goods allows for better control over operations within the chain. The performance of suppliers is monitored (García-Dastugue and Lambert, 2003). The IT tools described in the survey presented in Li et al. (2009a) are applicable to a supply chain: enlarging upon the internal logistics and tracking capabilities such as Electronic Data Interchange, barcodes, usage of computers in operations, and decision-making systems. The enterprise information systems (among others the ERP) are integrated into other supply chain management tools (Themistocleous et al., 2004).

**Reactivity tools**: This last set of tools increases the responsiveness of a supply chain to stimuli from the end-consumers. It is the ability to evaluate and take needs into account quickly (Charles et al., 2011). The forecasting and planning processes within the supply chain are enhanced. These supply chains which require reactivity will move the decoupling point between industrial push and final demand pull downstream. The effect is to enhance the reactive capabilities of the supply chain by enabling it to predict final demand changes and adapt to it both in upstream and downstream operations. Those tools provide a vital link between lean manufacturing operations within the supply chain and the responsive distribution and differentiation ones (Sauvage, 2003). Because supply chains these days depend increasingly on the demands and decisions of large accounts, safety stocks can cater less and less for very large orders. The ability to react faster to both these changing demands as well as to competitive actions becomes an essential capability[5]. In the fashion industry customers are increasingly demanding more variety, better quality, and service, including both reliability and faster delivery (eg, the fashion industry Lemieux et al., 2012, Duclos et al., 2003, Faisal et al., 2006).

The definitions and corresponding literature are presented in a single table in Table 2.

In the following section (§3) the hypotheses that we wish to test and the method are presented, followed by the results in §3.1.

### 2.5 Hypotheses development

We recall the question we wish to answer: to obtain an agile, resilient or flexible supply chain, what lower order capabilities do the supply chains deploy? The following hypotheses are tested through a structural equation model (see Figure 2). As reactivity tools were deemed to be of less pertinence when resilience is desirable, we do not propose to test the influence of reactivity tools on resilience.

**Hypothesis 1** *Implementation of* Collaborative tools *influences positively* resilience *in a supply chain;*

the link between both has been studied in Faisal et al. (2007) and in French companies in Lavastre et al. (2012).

**Hypothesis 2** *Implementation of* Collaborative tools *influences positively* agility *in a supply chain;*

this hypothesis stems from the works of Lin et al. (2006), Derrouiche et al. (2008), Swafford et al. (2008), Tseng and Lin (2011), Bottani (2010), Ngai et al. (2011) among others.

[5]Based upon an internal document from a large Swiss food company.

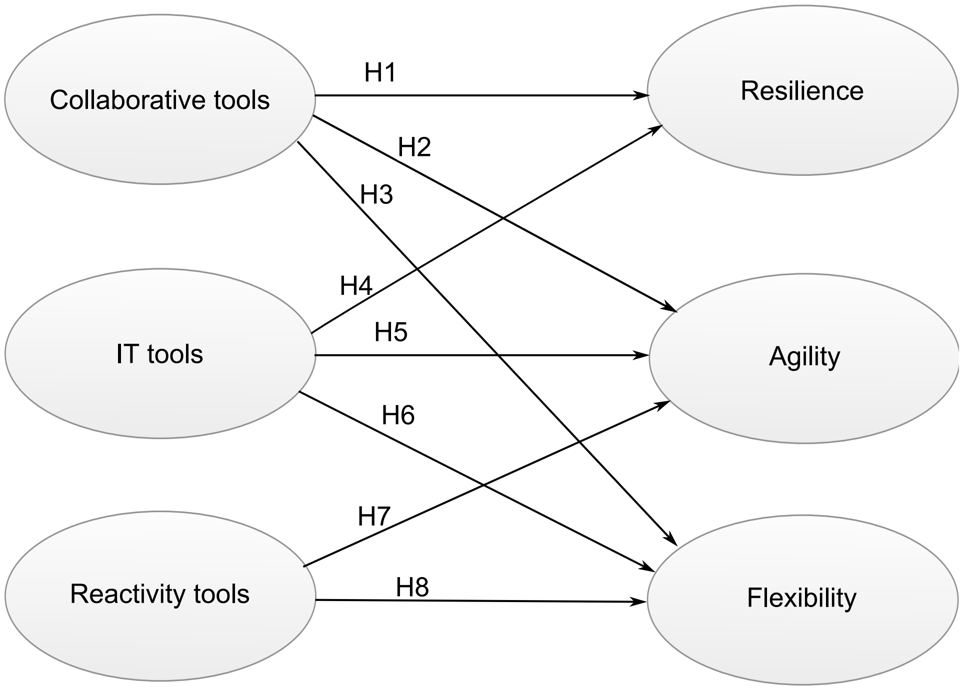


Figure 2: Research model.

**Hypothesis 3** *Implementation of* Collaborative tools *influences positively* flexibility *in a supply chain;*

the tools we describe here are taken to enhance "the capability to provide products/services that meet the individual demands of customers" (Gunasekaran et al., 2004, Swafford et al., 2008, Richey et al., 2012).

**Hypothesis 4** *Implementation of* IT tools *influences positively* resilience *in a supply chain;*

this hypothesis stems from the observations in Patterson et al. (2003): Dröge and Germain (1998) posit environmental uncertainty may be characterized by unpredictable changes in customer demand, unreliability of supplier quantities and quality, volatile price fluctuations, unpredictable competitor actions, rapid shifts in production processes, and/or brief product life cycles. Regardless of the source, "uncertainty exists because organizations do not have perfect information to make decisions"(Walton and Miller, 1995, p. 121). In order to overcome imperfect information and uncertainty, organizations may institute a variety of mechanisms to fhfhpromote, advance, and strengthen coordinationfhfh between organizational subunits and partners (Truman, 2000, p. 213) or innovate in order to survive and flourish. Robertson and Gatignon (1986) suggest demand uncertainty fhfhheightens perceived competitive vulnerability and makes a firm more susceptible to innovation in its quest for competitive advantage.fhfh Ahmad and Schroeder (2001) argue that an uncertain environment requires more frequent exchange of information between business partners so that activities can be prioritized as changes occur and delivery expectations met.

**Hypothesis 5** *Implementation of* IT tools *influences positively* agility *in a supply chain;*

this hypothesis stems from the case study in White et al. (2005) and the survey in Bottani (2010). The following one is supported by an extensive literature which has already been presented in Table 1, and, in particular, Lin et al. (2006), Qrunfleh and Tarafdar (2012), Sambamurthy et al. (2003) or Rajaguru and Matanda (2013).

**Hypothesis 6** *Implementation of* IT tools *influences positively* flexibility *in a supply chain;*

**Hypothesis 7** *Implementation of* Reactivity tools *influences positively* agility *in a supply chain;*

these tools and the link with agility has been investigated in Christopher (2000), Sauvage (2003), Charles et al. (2011), Lin et al. (2006).

**Hypothesis 8** *Implementation of* Reactivity tools *influences positively* flexibility *in a supply chain.*

Flexibility – as defined by Toni and Tonchia (2005) and applied by Charles et al. (2011)– can be obtained through the deployment of the Reactivity tools since they enhance velocity, visibility and responsiveness (Lemieux et al., 2012, Duclos et al., 2003, Faisal et al., 2006, Christopher and Holweg, 2011).

We thus have 8 separate hypotheses to evaluate, as represented in the model in Figure 2.

# 3 Research methodology

## 3.1 Data collection procedure

So as to achieve dependable results, we used a survey approach to gather data. The survey was developed for a single respondent with the organization serving as the unit of analysis. As such, our research uses an embedded design in which the organization is viewed as "embedded in a network of relationships that impact its performance" (Saraf et al., 2007, p. 327). Although a multiple-respondent, dyadic or even triadic survey design would have been preferable, a single-respondent design was selected to improve acceptable response rate (Saraf et al., 2007). This is consistent with recent approaches for studying inter-organizational phenomena (Tang and Tang, 2010, Flynn et al., 2010). Although the subjective nature of the data gathered is a limitation of the current study, subjective data are frequently used in this type of research and their use is considered acceptable (Chan et al., 1997).

Based upon the theoretical model described in section 2, and the literature presented above, we drew up a list of tools used by supply chain managers. This list was presented to the consultants within the supply chain practice at CapGemini for comment. Given the numerous definitions of agility, flexibility, and resilience available in literature and confusion in the minds of practitioners (Kidd, 2000), it was expected that a particularly wide cross-section would emerge. A broad consensus was achieved through a general discussion in which each participant described what effect each enabler had on the overall supply chain and how this effect could be achieved and measured. A first version of the survey questionnaire was pretested among experts and journalists from supplychainmagazine.fr. As a result of this pre-test, some inconsistencies and unclear formulations were cleared. In a second test, the questionnaire was presented to five supply chain managers. Their remarks were incorporated. The result is a list of 13 affirmations about capabilities that their supply chains possess and of 27 tools. When replying about the capabilities, the respondents were asked to rate their agreement: from totally disagree rated 1 to fully agree (rated 5). For the tools, managers were asked to specify if it was not applicable to their particular case (rated 1), under consideration (rated 2) to fully deployed and in use (rated 5).

Owing to the target population size, the number of questions and the cost involved in contacting respondents, we opted for an e-mail survey. Respondents' concerns obliged us to render the answers confidential and confine ourselves to general descriptive affirmations.

A link to the web-based questionnaire was sent to some 8 000 tested e-mail addresses of the subscribers in France to the newsletter of the web magazine supplychainmagazine.fr[6]. The newsletter subscribers are exclusively opt-in readers who declared their interest in supply chain management general news. Only those that were strictly speaking involved in managing supply chain positions were extracted (other subscribers include software editors, consultants and other suppliers of handling and information tools for example). These were identified by their company names, job title and industrial sector. The questionnaire link was sent on April 13$^{th}$, 2011. Two reminders were sent in the following 3 weeks. A total of 366 replies were recorded, ie, an access rate[7] of 4.6%, before the close of the survey on May 5$^{th}$, 2011. 170 were completed, a retention rate[8] of 1.9% of the identified population but 46% of the respondents (Yu and Cooper, 1983). The analysis of unfinished or otherwise unusable questionnaires showed a high number of lurkers and lurking drop-outs (Bosnjak and Tuten, 2001)[9]. Melnyk et al. (2012) have evaluated the erosion of the response rate in supply chain management research surveys over the last twenty years and note an acceleration since 2004. The rate observed for this survey is concordant with the extrapolation that can be made from their figure 3 on page 39. The length of the questionnaire (there were 73 questions in ours) is also a common cause of drop-out rate as cited in Melnyk et al. (2012).

### 3.2 Sample characteristics

The responses excluded were due to incomplete answers. Respondents were given the choice between 16 possible economic sectors, increasing the generality of the results (Malhotra and Grover, 1998). Among others, the usable subset of the sample included firms operating in the food and beverage (17.6%), retail (25.9%), and general industrial (24.1%) sectors as can be seen in Table 7 in appendix. In terms of size of payroll, the sample reflected an interesting proportion of small to medium sized firms (Table 8 in appendix). Due to the restricted time-window to gather answers from potential respondents (three weeks), no test was done between early or late ones

[6]URL : http://www.supplychainmagazine.fr

[7]Access rate refers to those members of the sample that decided to start the survey (Heerwegh and Loosveldt, 2009)

[8]Retention rate or percentage of participants reaching the last section of the survey.

[9]Lurkers are persons who are in the target, look at all the questions but do not answer. Lurking drop-outs start answering but drop out before finishing.

to assess non-response bias. Respondents were told apart by the internet address indicating that the computers used for answering were different.

# 4 Data analysis and results

## 4.1 Partial Least Squares (PLS)

This study uses Partial Least Squares (PLS) path modeling (two main references are Wold, 1982, 1985), a component based structural estimation modeling technique. PLS has its distinctive features compared to other structural equation modeling techniques such as LISREL/AMOS, covariance-based structural equation modeling techniques. PLS does not have minimal requirements of the restrictive assumptions such as measurement scales, sample size, and distributional assumptions imposed by the AMOS-like models (Chin, 1998b, Tenenhaus et al., 2005). Finally, Chin and Newsted (1999) observe that PLS path modeling is generally more suitable for studies in which the objective is prediction or the phenomenon under study is new or changing. 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, 1998a). As a result, instead of relying on the overall fit of the proposed model by goodness-of-fit tests, PLS tests the strength and direction of individual paths by statistical significance (Calantone et al., 1998). PLS is also most useful for exploratory studies where theory is still being developed while Maximum Likelihood modeling techniques (eg, AMOS) are most suitable for confirmatory studies (Lee et al., 2006). 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 with the largest number of independent variables impacting it (Chin, 1998b).

## 4.2 Testing common method bias

Since there was a single informant per organization, the potential for common method bias was assessed. Analysis of Harman (1967)'s single-factor test of common method bias (Podsakoff and Organ, 1986, Podsakoff et al., 2003) revealed twelve distinct factors with eigenvalues above or near one which explained cumulatively 87.6% of total variance. According to this test, if common method bias exists, (1) a single factor will emerge from a factor analysis of all survey items (Podsakoff and Organ, 1986), or (2) one general factor accounting for most of the common variance existing in the data will emerge. The first factor explained 24.32% of the variance, which was not the majority of total variance and is considered to be low enough not to be of concern.

### 4.3 Measurement validation (reliability and validity)

This study follows Anderson and Gerbing (1988) recommended two-step approach to interpret the PLS results: (1) measurement model and (2) structural model. In the first step, this study tests the measurement model and establishes the validity (ie, convergent and discriminant validity) and reliability of the items. Convergent validity may be assessed by (a) the significance of the loading factors for each item on the constructs, (b) the average variance extracted (AVE) which is greater than 0.50, and (c) composite reliability (Fornell and Larcker, 1981, Anderson and Gerbing, 1988). 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 (Cf. Table 6 on page 31 for the loading factors and Cronbach $\alpha$ readings). On this indicator, *flexibility* does not reach the mark. A lower bound of 0.7 is recommended for composite reliability (Chin, 1998a, Gefen et al., 2000). Average variance extracted (AVE), the other utilized measure, 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 (Fornell and Larcker, 1981, Chin, 1998b).

In Table 3 on page 19, we present in bold in the column labeled "All" the numbers for which the minimum acceptable values for each construct on each of the measures. In the case of the *agility*, *Collaborative tools* and *IT tools* latent variables, whereas the composite reliability and Cronbach's $\alpha$ are above the threshold, the AVE is not. We have chosen to keep these variables for the remaining analyses, disregarding the AVE.

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 shared variance to the square of the correlation between the constructs. If the square root of AVE is greater than the correlation

Table 3: Reliability analysis of latent variables for the whole sample and for three economic sectors (in bold the numbers where both composite reliability is greater than 0.7 and Average Variance Explained (AVE) is greater than 0.5).

| | | All | Industry | Retail | Food |
|---|---|---|---|---|---|
| Agility | C.R. | .789 | **.797** | .696 | .754 |
| | AVE | .488 | **.537** | .395 | .442 |
| Collaborative tools | C.R. | .734 | .737 | .706 | **.797** |
| | AVE | .419 | .415 | .391 | **.509** |
| Flexibility | C.R. | **.818** | **.854** | **.783** | **.756** |
| | AVE | **.692** | **.864** | **.644** | **.607** |
| IT tools | C.R. | .789 | .808 | .744 | .809 |
| | AVE | .352 | .384 | .325 | .392 |
| Reactivity tools | C.R. | **.879** | **.847** | **.888** | **.885** |
| | AVE | **.712** | **.660** | **.727** | **.726** |
| Resilience | C.R. | **.875** | **.877** | .640 | **.915** |
| | AVE | **.702** | **.705** | .493 | **.782** |

coefficients between constructs, then discriminant validity is said to exist (Fornell and Larcker, 1981, Chin, 1998a, Koufteros, 1999, Koufteros et al., 2001). The correlation factors between the latent variables and the square root of the average variance extracted (on the diagonal) are provided in Table 10 on page 33. Reactivity tools is more highly correlated to IT tools than the square root of IT tools' AVE.

Divergent or discriminatory validity was also tested by analyzing bivariate correlations between the six latent variables and other potentially confounding demographic variables included in the study : economic sector and size of the respondent's firm. There were no significant correlations between the latent variables and sector or size of the firm, thus the variables were not measuring other unintended constructs (see Table 9 on page 32 in appendix). There was also no correlation between the lower order capabilities and the size of firms. This is noteworthy as it could intuitively be supposed that the larger firms might also be further advanced in deploying the tools and enablers under consideration here.

# 5 Analysis of connection between lower order and operational capabilities

We first present the results when the full sample is used before renewing the analysis for three sectors in particular.

The research hypotheses are tested by assessing the direction, strength and level of significance of the path coefficients. In particular, the t-values were evaluated through a bootstrap resampling method with 5000 samples of 169 cases.

## 5.1 Model results for all economic sectors

From Figure 3, all hypotheses save H6 and H7 are supported at the $p < 0.05$ level. For H6, and H7, $t < 1.96$ and the path estimates $\beta$ are very low. This means that, surprisingly, IT tools may have no influence on flexibility and that reactivity tools may not enhance agility. This is, overall, a conclusion which is at variance with the results from several reported results, among which Lin et al. (2006) or Sauvage (2003), Charles et al. (2011).

In the cases of the supported hypotheses (H1 through H5 and H8), the standardized path coefficients should be greater than 0.20 and, ideally, higher than 0.3 Chin (1998a). In this respect, we have to ask ourselves, whether the *Collaborative tools* have a real influence on resilience (H1, $\beta$ = .193) and *agility* (H2, $\beta$ = .183)

## 5.2 Model results for industry, food and retail sectors

We now present the results of the analysis of the data according to the economic sector of the respondent's firm. From the 16 economic sectors (Table 7), we have chosen to concentrate our analysis on the 3 sectors for which most responses have been registered: food and beverages, retail, and industry. Note that industry here excludes firms in the aeronautical, automotive, chemicals, energy, high technology, life sciences, and telecommunications sectors.

Reading from Table 3, it appears that data provided by respondents can be considered valid if one considers the composite reliability but the AVE over most latent variables would tend to indicate a lack of validity for a PLS analysis.

As seen in Table 6, the constructs are indeed unidimensional when all sectors are considered together. This is no longer the case when we open the results by sector. This increases the evidence that, for future research, sectors should be taken separately

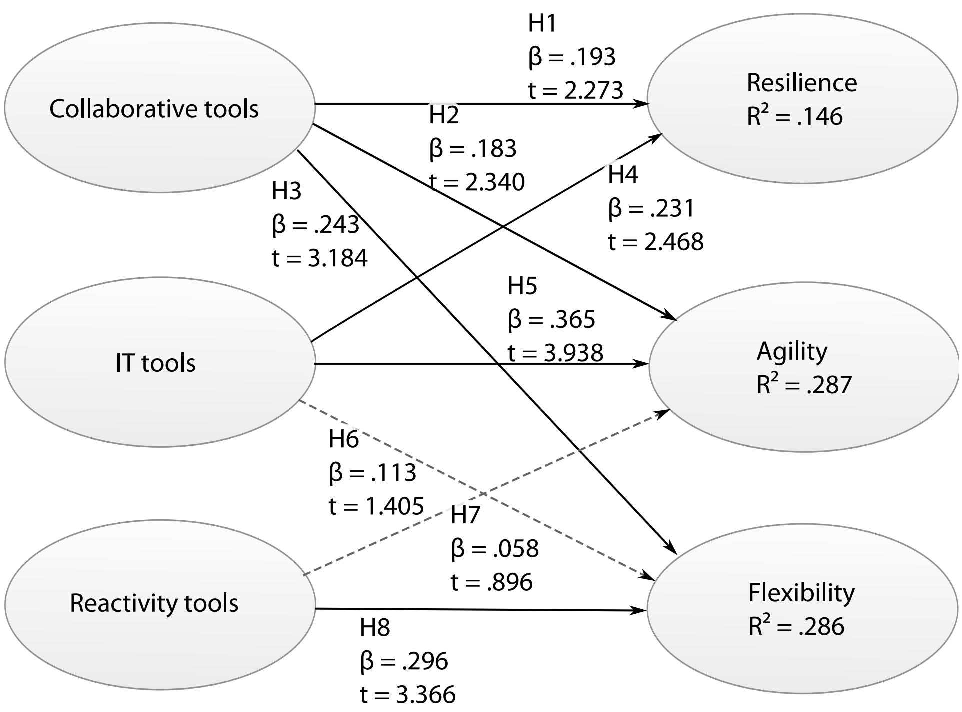


Figure 3: PLS path model coefficients and t-values for the full sample

when looking for the adequate tools to foster a particular dynamic capability in their supply chain.

The correlation factors for the 3 sectors are listed in Table 11 to Table 13 in appendix with the square root of AVE being indicated on the diagonal. The square root of AVE is not always greater than the correlation among the latent variable scores (eg, agility in the retail sector, or in the food sector) with respect to its corresponding row and column values. These observations further indicate that different sectors deploy different tools to obtain some particular trait for their supply chain.

In the second step of our analysis, we evaluate the structural model presented in Figure 2 by sector. Even though some latent variables ought not to be included as seen above, we tested again for all 8 hypotheses. Some of those were not supported even at the $p < 0.05$ level, so we considered that they were not acceptable. We have pared the corresponding connectors to obtain the results presented in Figure 4 to

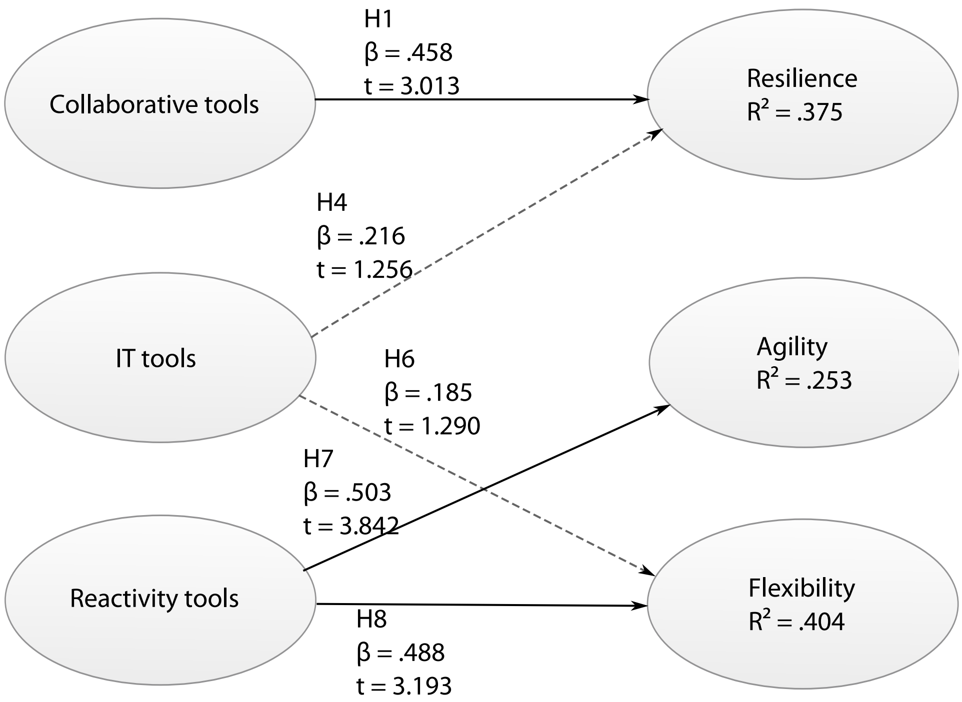


Figure 4: PLS result for the industry sector

Figure 6, providing increased significance and strength.

To make the results comparable between the three analyzes, we have re-evaluated the path results in the case of the whole sample by paring the connectors corresponding to H6 and H7 (as has been done in the models per sector). We present the results in Table 4. The relationships linking the lower order capabilities to the operational ones differ according to the economic sector. Those that exist are stronger (ie, $\beta$ is higher and $p$ is lower, represented by the stars after each coefficient) when looked at by sector and explain more of the variance of the operational capabilities when the whole population is taken into consideration. For each sector, the strength and existence of the relationships clearly differ.

Even though PLS path modeling does not optimize any global scalar function so that it lacks an index that can provide the user with a global validation, the Goodness-of-Fit (GoF) represents an operational solution so as to compare the different models

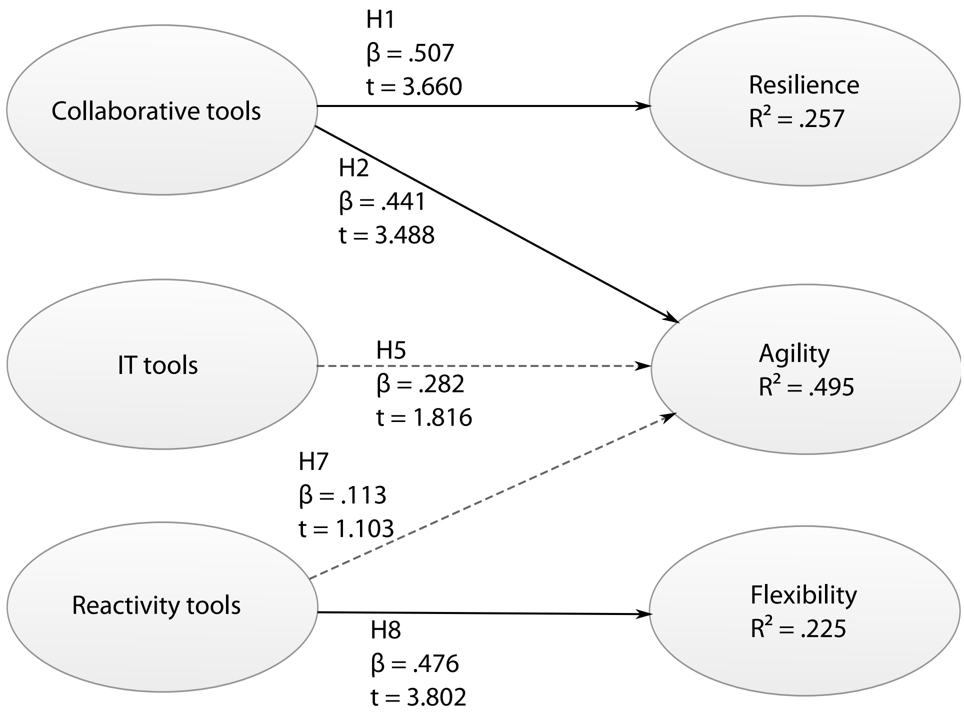


Figure 5: PLS result for the retail sector

presented here (Tenenhaus et al., 2005). The computed values according to Tenenhaus et al. (2005) are presented in the last line of Table 4. As can be seen the all-sector model has the lowest reading on that criterion.

On a more fundamental level, all the latent variables identified will have to be reconsidered when investigating the supply chains of a particular economic sector (Cf. Table 3).

When examining the *Industry* sector, we note the fact the the *Collaborative tools* strongly influence *resilience* but neither *agility* nor *flexibility*. The influencers are the *Reactivity tools*. Note the absence of influence of *IT tools*, a very surprising result contradicting some of the latest research in this respect (eg, Bottani, 2010).

There are indications that the *retail* sector applies *Collaborative tools* for substantial effect to achieve *agility* (explaining almost half of its variance). They also have a strong link to *resilience* ($\beta$ = .507), even though some other lower capabilities are

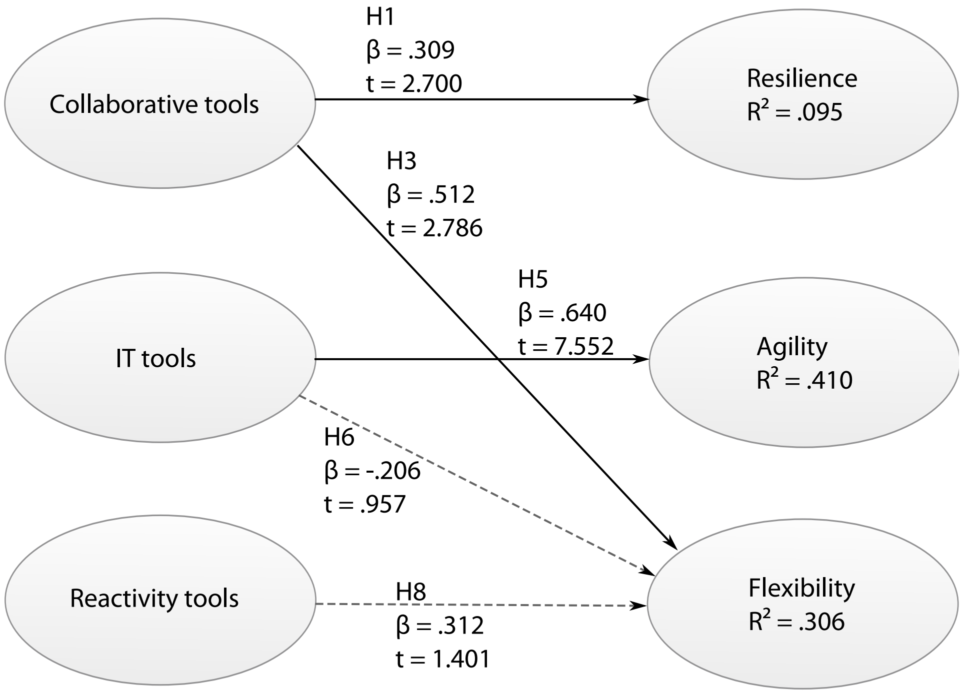


Figure 6: PLS result for the food sector

Table 4: Results of hypotheses tests for all respondents and for three economic sectors: industry, retail, and food and beverages. (n=170,41, 44, 30 respectively)

| Relationships | Hyp | All | Industry | Retail | Food |
|---|---|---|---|---|---|
| Collab. – Resilience | H1 | .193* | .458** | .507** | .309* |
| Collab. – Agility | H2 | .183* | | .441** | |
| Collab. – Flexibility | H3 | .243** | | | .512** |
| IT tools – Resilience | H4 | .231* | .216 | | |
| IT tools – Agility | H5 | .365** | | .282 | .640** |
| IT tools – Flexibility | H6 | | .185 | | -.206 |
| Reactiv. – Agility | H7 | | .503** | .113 | |
| Reactiv. – Flexibility | H8 | .296** | .488** | .476** | .312 |
| Goodness of Fit | | .352 | .428 | .385 | .374 |

* : $p < .05$; ** : $p < .01$

Table 5: $R^2$ of dependent variables for each of the 4 models: all sectors, industry, retail, food

| | All | Industry | Retail | Food |
|---|---|---|---|---|
| Resilience | .146 | .375 | .257 | .095 |
| Agility | .287 | .253 | .495 | .410 |
| Flexibility | .286 | .404 | .225 | 306 |

required since only a quarter of resilience's variance is explained by it. *Reactivity tools* also have a strong link to *flexibility* ($\beta$ = .476). However, all the above must be qualified in view f the low C.R. and AVE as noted in Table 3.

The *food* sector has deployed *Collaborative tools* to achieve *flexibility* to good effect. The positive relationship between *IT tools* and *agility* has to be taken with caution as both latent variables have low AVE. further investigation using a bigger sample is warranted to consolidate these results.

As Table 5 shows, the R square explained by the influence of the independant variables are lower for the overall sample than those per industry further indicating a need to study those influence mechanisms per industry rather than taking the relationships between lower order and operational capabilities as general for all supply chains.

## 6 Discussion and concluding remarks

In this paper, three constructs were identified which represent lower order capabilities. They affect positively another three identified constructs which are operational capabilities in supply chains given the end-consumer's requirements and competition's abilities. A conceptual model, embedded in dynamic capability theory, was developed and tested using data from French supply chain managers. Overall, the model can be said to validate previous results reported in literature. However, we find some strong indications that these results differ substantially according to the standpoint of the focal firm. The results show that relationships envisaged in literature may not be as powerful as previously reported. We show that the relationships between lower order capabilities and operational ones they enhance can be better explained and evaluated by segmenting the supply chain managers according to the economic sector they belong to.

The interpretation of the results should be handled with due care. The data are based on a single method (survey) and a single informant from each firm which may result in common method and informant bias. The responses are perceptual in nature. This may lead to three possible biases. First, respondents may be unwilling or unable to recognize poor abilities in their supply chains, leading to exaggerated evaluations. Second, respondents may have a limited or localized vision of the lower order capabilities deployed through their supply chain. Third, their opinions about the operational capabilities that their supply chain enjoys result from confronting their firm's performance and their perception of what it should be, given the market's requirements. In spite of these inherent limitations of survey methods, this study provides valuable insights on how a supply chain may enhance some quality traits by using some sets of managerial tools.

As noted in extant literature, there is sometimes a gap between management research and practice (Markides, 2007, Shapiro et al., 2007). Here the gap is between, on one side, the commonly held view that a supply chain, being composed of different firms in various economic sectors, should still be integrated in its capabilities, aims and purposes – whether agility, flexibility or resilience – and implement the corresponding best practice; and on the other the practice of supply chain management. This article wishes both to provide evidence of this gap and to close some of it by providing "workable answers for managers" (Ackoff, 1979) and open avenues for future research.

The *food and beverage industry* clearly wishes to enhance *flexibility* by applying *Collaborative* tool-sets. This means that they use Efficient Customer Response (ECR) tools, practice Vendor Managed Inventory (VMI), have set up collaborative platforms with the other members of their supply chain, and, finally, have also set up set up alternative production contingency plans. When they also wish to enhance agility, they will do so through IT tools: adapting their product lineup, manage their suppliers, deploy Track & Trace as well as S&Op. They will integrate supply chain management software to their ERP. This brings to mind the fresh dairy producers like Danone which must be able to serve their market through very tight communication of their distribution and retail channel partners. They wish to ensure a wide choice of channels, to ensure absolute control over quality and traceability, including over suppliers. Another example is given by the practice of source-water bottling companies which do not want to repeat the Perrier water benzene contamination in 1990 (Kurtzbard and Siomkos, 1992).

The major focus of the *retail* sector is to enhance *agility* through the deployment of all three tool sets: *Collaborative*, *IT* and *Reactivity*. Together, they explain 42% of the variance of agility. They also use ECR, VMI, collaborative platforms with their suppliers (coherently with the results presented above for the food industry) but also the tools related to Information Technology like Sales and Operation Planning (S&Op), Track & Trace and integrate their ERP with other supply chain management software. They reevaluate their inventory and lineup needs throughout their network. This behavior is consonant with what has been amply reported in retail chains like Casino and Carrefour[10]. Even so, consultants in France and the Supply Chain director of Carrefour France point to the backwardness of French retailers in applying ECR, VMI and collaborative platforms as compared to Tesco or Wal-Mart[11].

*Industry*, as distinct from the food, consumer goods, life science, luxury, chemicals and automotive sectors, wishes to enhance *flexibility* and *agility*. To do so, it shares across the chain forecasting and planning processes and fine-tunes the position of the decoupling point. Industry also deploys *Collaborative tools*, but it is to achieve *resilience*: they deploy alternative contingency production plans, position stock on their customers' premises and focus on efficiently responding to those customers' requirements so as to achieve better visibility over the whole chain, evaluate potential risks and plan for contingencies.

On the basis of the above results, one can draw some general conclusions. We detail them below.

First, starting from the classic view that in the same food supply chain, we should find a manufacturer (eg, for packaging or other inputs), an agrifood producer and a retailer as partners, it is interesting to note that each partner will deploy different tools. In the *Retail* industry, *Agility* is obtained through the deployment of *Collaborative* and *IT tools*, whereas the manufacturer and the agrifood producer will wish to enhance *flexibility*. The *Food* sector, on their part, will prefer to deploy *IT tools*. In terms of theory, we argue that it is no longer enough to consider that supply chains deploy in a monolithic way some managerial practice to achieve a particular quality such as agility, flexibility or resilience. The economic sector of the focal firm in which the analysis is being conducted must be taken into account and the scientific corpus of literature which refers to these operational capabilities revisited.

Second, on the basis of our empirical investigation, results indicate that sup-

[10] See the press release by ECR France about the zero stock-out competition in 2012 in which Carrefour and Coca-Cola won first prize.

[11] Supplychainmagazine.fr April, 2010: Grande Distribution: quel modèle pour demain?

ply chain managers distinguish between *three* different types of capabilities and, to achieve a set of capabilities, they will choose between *three* different tool sets according to their economic sector. This result has some consonance with those observed in Narasimhan et al. (2006) or in Zhang (2011). This result does not appear in Bottani (2010) because of their focus on agility as an operational capability. However, that study does show that the degree of implementation of the enablers and ensuing attributes of agility differ according to the economic sector, confirming our results. A second consequence is the perspective in which one may put the scale for agility devised in Li et al. (2008, 2009b): instead of one dimension, agility should in fact be decomposed into three different ones.

Third, the study also reveals important consequences for managers. First, they must clearly identify the supply chain traits that they wish to enhance before turning to the tools to do so. These tools, in turn, will be different according to the supply chain or sector they are in. Second, they will need to group the management and information technology tools in terms of families: mixing tools from different families do not provide evidence of a benefit.

Fourth, using the Dynamic Capabilities Theory, this empirical survey has highlighted the critical linkage value between specific managerial tools and supply chain capabilities according to the industrial sector. The results call for additional research in three directions. (a) Understanding how specific capabilities can be enhanced in other economic sectors. (b) Understanding the link between those qualities and competitive advantage which was initially presented in the conceptual framework. (c) More cross-cultural empirical research with relatively large samples is called for to establish if the results found for France can be extended to other countries.

Finally, it appears that the population of French supply chain managers is not a homogeneous one, more research is required to verify which real criteria should be used to segment them and if their counterparts in other countries follow the same typology.

## List of Tables

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# 7 Appendix

Table 6: Capabilities for supply chains: Cronbach $\alpha$ and factor loadings

| | $\alpha$ | Load. |
|---|---|---|
| **Resilience** | 0.783 | |
| My firm is able to evaluate the levels of risk facing our SC | | .909 |
| We deploy alternative plans associated with identified risks | | .882 |
| The organization of our SC allows us to increase visibility over all our chain | | .708 |
| **Agility** | 0.655 | |
| The innovation rate in our industry forces us to make our supply chain evolve constantly | | .640 |
| We react very quickly both to changes in our customers' requirements and to offers from our competitors | | .589 |
| We review the parameters of our Information Systems regularly so as to adapt to market conditions | | .845 |
| The organization of our SC allows us to adapt well to market requirements | | .693 |
| **Flexibility** | 0.558 | |
| Our sales forecasts allow us to anticipate the major market changes | | .863 |
| The complementarities of our sales channels allow us to meet our customers' requirements | | .800 |
| **Collaborative** | 0.734 | |
| Set up alternative production contingency plans | | .455 |
| Deploy an Efficient Customer Response policy | | .804 |
| Deploy a Vendor Managed Inventory (VMI) policy | | .714 |
| Develop web collaborative platforms | | .558 |
| **IT tools** | 0.789 | |
| Better manage the offer of products and services | | .558 |
| Manage in a collaborative way performance of suppliers | | .665 |
| Streamline inventory in your distribution network | | .589 |
| Deploy S&Op tools (IT) | | .715 |
| Deploy Track & Trace IT tools | | .507 |
| Integrate your ERP with other SCM tools | | .618 |
| **Reactivity** | 0.879 | |
| Set up / ameliorate the forecasting process | | .921 |
| Set up / ameliorate the planification process | | .913 |
| Shift / adapt the decoupling point | | .674 |

Table 7: Sample by industrial sector

| Sector | Subset used | | Total sample | |
|---|---|---|---|---|
| | Count | % | Count | % |
| Aeronautical | 6 | 3.5 | 20 | 6.4 |
| Food and beverages | 30 | 17.6 | 56 | 12.8 |
| Automotive | 9 | 5.3 | 23 | 7.8 |
| Others | 8 | 4.7 | 25 | 8.5 |
| Chemicals | 2 | 1.2 | 6 | 2.1 |
| Retail | 44 | 25.9 | 79 | 17.0 |
| Energy | 3 | 1.8 | 9 | 3.5 |
| Government, public admin | 0 | 0.0 | 2.0 | 1.4 |
| High technology | 3 | 1.8 | 6.0 | 2.1 |
| Industry | 41 | 24.1 | 69 | 14.2 |
| Luxury | 3 | 1.8 | 11 | 3.5 |
| Consumer goods | 8 | 4.7 | 16.0 | 4.3 |
| Life sciences | 2 | 1.2 | 6.0 | 1.4 |
| Services | 4 | 2.4 | 14 | 5.0 |
| Telecommunications | 2 | 1.2 | 6 | 2.8 |
| Transport | 5 | 2.9 | 18 | 7.1 |
| Total | 170 | 100 | 366 | 100 |

Table 8: Payroll size

| Payroll | Subset used | | Total sample | |
|---|---|---|---|---|
| | Count | % | Count | % |
| Less than 500 | 71 | 41.9 | 170 | 46.4 |
| Between 500 and 2 000 | 43 | 25.6 | 82 | 22.4 |
| Between 2 000 and 10 000 | 28 | 16.3 | 60 | 16.4 |
| More than 10 000 | 28 | 16.3 | 54 | 14.8 |
| Total | 170 | 100.0 | 366 | 100.0 |

Table 9: Pearson's pairwise correlation coefficients between latent variables and demographic variables

| | | Payroll | Econ. sector |
|---|---|---|---|
| Agility | | .064 | -.039 |
| | Sig. (2-tailed) | .409 | .616 |
| Resilience | | -.117 | -.073 |
| | Sig. (2-tailed) | .127 | .344 |
| Flexibility | | -.070 | -.079 |
| | Sig. (2-tailed) | .363 | .306 |
| Collab. tools | | .197** | -.062 |
| | Sig. (2-tailed) | .010 | .424 |
| IT tools | | .158* | .062 |
| | Sig. (2-tailed) | .040 | .418 |
| Reactivity | | .115 | -.002 |
| tools | Sig. (2-tailed) | .136 | .977 |

*: $p < .05$, **: $p < .01$

Table 10: Discriminant validity for the whole sample (square root of AVE on diagonal, the cases where this root is less than the correlation coefficients between latent variables are marked in bold)

| | | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| Agility | 1 | 0.698 | | | | | |
| Collaborative tools | 2 | 0.431 | 0.647 | | | | |
| Flexibility | 3 | 0.527 | 0.417 | 0.832 | | | |
| IT tools | 4 | 0.516 | 0.625 | 0.449 | **0.594** | | |
| Reactivity tools | 5 | 0.348 | 0.348 | 0.451 | **0.622** | 0.844 | |
| Resilience | 6 | 0.419 | 0.337 | 0.312 | 0.351 | 0.173 | 0.838 |

Table 11: Discriminant validity for the *industry* sector (square root of AVE on diagonal, the cases where this root is less than the correlation coefficients between latent variables are marked in bold)

| | | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| Agility | 1 | 0.733 | | | | | |
| Collaborative tools | 2 | 0.161 | 0.644 | | | | |
| Flexibility | 3 | 0.564 | 0.253 | 0.864 | | | |
| IT tools | 4 | 0.343 | 0.604 | 0.541 | **0.620** | | |
| Reactivity tools | 5 | 0.503 | 0.457 | 0.623 | **0.730** | 0.812 | |
| Resilience | 6 | 0.382 | 0.588 | 0.39 | 0.492 | 0.389 | 0.84 |

Table 12: Discriminant validity for the *retail* sector (square root of AVE on diagonal, the cases where this root is less than the correlation coefficients between latent variables are marked in bold)

| | | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| Agility | 1 | **0.629** | | | | | |
| Collaborative tools | 2 | **0.644** | 0.625 | | | | |
| Flexibility | 3 | 0.360 | 0.218 | 0.802 | | | |
| IT tools | 4 | 0.606 | 0.618 | 0.317 | 0.570 | | |
| Reactivity tools | 5 | 0.354 | 0.252 | 0.475 | 0.457 | 0.853 | |
| Resilience | 6 | 0.459 | 0.507 | 0.038 | 0.406 | 0.066 | 0.702 |

Table 13: Discriminant validity for the *food* sector (square root of AVE on diagonal, the cases where this root is less than the correlation coefficients between latent variables are marked in bold)

| | | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| Agility | 1 | 0.665 | | | | | |
| Collaborative tools | 2 | 0.397 | 0.714 | | | | |
| Flexibility | 3 | 0.276 | 0.496 | 0.779 | | | |
| IT tools | 4 | 0.640 | 0.513 | 0.251 | 0.626 | | |
| Reactivity tools | 5 | 0.411 | 0.285 | 0.33 | 0.621 | 0.852 | |
| Resilience | 6 | 0.285 | 0.309 | 0.043 | 0.18 | 0.042 | 0.884 |

Table 14: References citing one of the Latent Variables and type of research

Note: A: Agility, F: Flexibility, R: Resilience, C: Collaborative tools, IT: IT tools, R: Reactivity tools, C: Case study, S: Survey, F: Framework

| Authors | Study aim | A | F | R | C | IT | R | C | S | F |
|---|---|---|---|---|---|---|---|---|---|---|
| Agarwal et al. (2006) | Study of relationship between agility and some management tools in view of increasing performance | x | x | | | | | | | x |
| Ahmad and Schroeder (2001) | an uncertain environment requires more frequent exchange of information be- tween business partners so that activities can be prioritized as changes occur and delivery expectations met | | | x | | x | | | x | |
| Benjamin et al. (1990) | EDI to enhance collaboration | | | | x | | | | | |
| Bhamra et al. (2011) | Literature review on resilience | | | x | | | | | | |
| Blackhurst et al. (2005) | Framework for the study of risk in supply chains | | | x | | | | | | x |
| Blackhurst et al. (2011) | Study linking characteristics to supply chain resilience | | | x | | | | x | | |
| Blome and Schoenherr (2013) | Sources of agility in supply chains stemming from supply- and demand-side competencies | x | | | | | | | x | |
| Bottani (2010) | Understanding the link between agility and enablers for such agility | x | | | x | x | | | x | |
| Braunscheidel and Suresh (2009) | Influence of a firm's structure and organization on the supply chain's agility | x | x | | | | | | | |
| Bruce et al. (2004) | Case study approach to agility in textile supply chains | x | | | | | | x | | |
| Charles et al. (2011) | Agility and flexibility enablers through humanitarian supply chain study | x | x | | | | | x | | |
| Chopra and Sodhi (2004) | Identifies Risk sources and risk management to prevent disruptions in supply chains | | | x | x | | x | x | | |
| Christopher (2000) | Framework for studying agility in supply chains | x | | | | | x | | | x |
| Christopher and Holweg (2011) | Describes which tools can control supply chain turbulence and enhance flexibility | | x | x | | | x | | | |
| Christopher and Peck (2004) | Investigates links between management tools and resilience | | | x | | | | | | x |
| Christopher and Towill (2001) | Investigates the possibility of a lean and agile supply chain | x | | | | | | | | x |
| Craighead et al. (2006) | Study of the use of EDI in industry | | | | x | x | | | x | |
| Derrouiche et al. (2008) | Understanding which tools make for best-in-class collaborative strategies | | | | x | | | | | x |
| Dong (2006) | Characterization of management tools which enable resilience in supply chains | | | x | | | | | | x |
| Dröge and Germain (1998) | Uncertainty in the environment, in final demand can be overcome by the appropriate use of collaboration and information technology | | | x | x | x | | | x | |
| Duclos et al. (2003) | Investigating the ability of supply chains to react faster to changes in demand | | x | | | | x | | | x |
| Estrada Guzmán (2011) | Electronic industry as an example of a supply chain where agility is required for survival | x | | | | | | | x | |

| Authors | Study aim | A | F | R | C | IT | R | C | S | F |
|---|---|---|---|---|---|---|---|---|---|---|
| Faisal et al. (2006) | Understanding the influence of the choice of supply chain strategy on resilience and flexibility | | x | x | | | | | | x |
| Faisal et al. (2007) | identify various information risks that could impact a supply chain, and develop a conceptual framework to quantify and mitigate them. | | | x | x | x | | x | | |
| Ferdows et al. (2004) | Examples of flexible supply chains in textile industry | | x | | | | | x | | |
| Fiksel (2006) | Characterization of resilience in supply chains | | | x | | | | | | x |
| Frohlich (2002) | Survey of integration strategies up- and down-stream which foster operations performance | | | | x | x | | | x | |
| García-Dastugue and Lambert (2003) | IT tools which enhance coordination and performance in supply chains | | | | | x | | | | x |
| Gunasekaran (1998) | Framework to enable agile manufacturing through IT tools | x | | | | x | | | | x |
| Gunasekaran (1999) | Framework of tools enabling agility in manufacturing supply chains | x | x | | x | x | | | | x |
| Gunasekaran et al. (2004) | Framework to measure performance measurement metrics in Supply Chain Management | | x | | x | | | | x | |
| Hendricks (2005) | It is critical for firms to enhance the resiliency (sic) in their supply chains and call for research which investigates specific tactics that help firms develop such capabilities | | | x | | | | | | |
| Ismail and Sharifi (2006) | For each new product, a corresponding supply chain must be designed which must meet market and product requirements. Qualities such as flexibility, agility, robustness and innovativeness are identified. | x | x | x | | | | | | x |
| Johnson et al. (2003) | Achieving flexibility through supply chain integration | | x | | | | | | | x |
| Kapuscinski et al. (2004) | Achieving flexibility through inventory management, Dell's example. | | x | | | | | x | | |
| Ketchen and Hult (2007) | Effectiveness in supply chains stems from agility, adaptability and alignment. Speed, quality, cost and flexibility are key ingredients. | x | x | | | | | | | |
| Kidd (2000) | Practical definitions of agility for managers | x | | | | | | | | |
| Klibi et al. (2010) | A Supply Chain design method to foster robustness, responsiveness and resilience. | | | x | | | | | | |
| Lavastre et al. (2012) | Resilience in French supply chains | | | x | | | | | x | |
| Lee (2004) | Examples of agile supply chains | x | | | | | | x | | |
| Le Moigne (1990) | Agility in the fashion industry | x | | | | | | | | x |
| Li et al. (2009a) | Relationship between IT, integration and performance in supply chains | | | | | x | | | x | |
| Li et al. (2008) | Agility in Supply Chains through a work-design perspective | x | | | | | | | | x |
| Li et al. (2009b) | Scale to measure Supply Chain agility based on alertness and response, being both dynamic and operational capabilities. | x | | | | | | | x | |
| Lin et al. (2006) | Evaluating an agility index using fuzzy logic | x | x | | | | | x | | |

| Authors | Study aim | A | F | R | C | IT | R | C | S | F |
|---|---|---|---|---|---|---|---|---|---|---|
| Liu et al. (2013) | Flexible IT infrastructure, absorptive capacity provide agility in a Supply Chain | x | | | | x | | | x | |
| Malhotra and Mackelprang (2012) | Internal operational flexibility and that provided by suppliers enhance overall flexibility in a Supply Chain | | x | | | | | | x | |
| Mandal (2012) | Survey of resilience through IT tools in Indian Supply Chains | | | x | | x | | | x | |
| Narasimhan et al. (2006) | Distinguishing between leanness and agility in Supply Chains | x | | | | | | | x | |
| Ngai et al. (2011) | Contribution of IT tools to agility | x | | | | x | | x | | |
| Overby et al. (2006) | Enabling role of IT tools in Supply Chain agility | x | | | | x | | | | |
| Pavlou and Sawy (2006) | How IT competence provides dynamic capabilities in New Product Development | | | | | x | | | | |
| Peck (2007) | Achieving resilience in the food Supply Chain in the UK | | | x | | | | | x | |
| Pettit et al. (2010) | Characterization of Supply Chain resilience | | | x | | | | | | x |
| Ponomarov and Holcomb (2009) | Influence of integration of capabilities to achieve resilience | | | x | | | | | | |
| Qrunfleh and Tarafdar (2012) | Impact of several management tools on agility and flexibility | x | x | | | x | x | | x | |
| Rajaguru and Matanda (2013) | Usage of IT tools to enhance inter-organizational integration | | | | | x | | | x | |
| Richey et al. (2012) | Testing the relationship between flexibility and collaborative tools | | x | | x | | | | x | |
| Robinson and Malhotra (2005) | Influence of flexibility on quality in Supply Chains | | x | | | | | | | |
| Rosenzweig et al. (2003) | How an integration strategy enhances flexibility in Supply Chains | | x | | | | | | | |
| Sambamurthy et al. (2003) | Influence of IT tools on agility | x | | | | x | | | x | |
| Sauvage (2003) | Implementation of reactivity tools enhances agility in French Supply Chains | x | | | | | x | | x | |
| Sheffi and Rice (2005) | Resilience in a supply chain | | | x | | | | x | | |
| Stevenson and Spring (2007) | Literature review of Supply Chain flexibility | | x | | | | | | | |
| Sull and Turconi (2008) | Examples of agility in fast fashion | x | | | | | | x | | |
| Swafford et al. (2008) | Study of the influence of IT capabilities on agility and flexibility | x | x | | | x | | | x | |
| Swafford et al. (2006) | which tools enhance agility in Supply Chains | x | | | | | | | x | |
| Tang (2006) | Characterization of resilience in supply chains | | | x | | | | | | |
| Themistocleous et al. (2004) | Evaluating the impact of Information system integration in a Supply Chain | | | | x | x | | x | | |
| Thun and Hoenig (2011) | Resilience in the automotive Supply Chain | | | x | | | | x | | |
| Toni and Tonchia (2005) | Definition of flexibility in a Supply Chain as an operational capability | | x | | | | | | | |

| Authors | Study aim | A | F | R | C | IT | R | C | S | F |
|---|---|---|---|---|---|---|---|---|---|---|
| Truman (2000) | Collaboration among members in a Supply Chain | | | | x | | | | | |
| Tseng and Lin (2011) | Identifying enablers in Supply Chains which enhance agility through a fuzzy logic model | x | | | | | | x | | |
| Vickery et al. (1999) | External causes and components which require flexibility and influence performance | | x | | | | | | x | |
| Vickery et al. (1997) | Definition of flexibility in operations | | x | | | | | | | |
| Vlajic et al. (2012) | Framework on resilience in food supply chains | | | x | | | | | | x |
| Wagner and Neshat (2010) | Causes of vulnerabilities in supply chains | | | x | | | | | | |
| Walton and Miller (1995) | Assessing the way firms adopt technological tools to enhance integration | | | | x | x | | | | x |
| White et al. (2005) | Information technology to enhance agility | x | | | | x | | | | |
| Yusuf et al. (1999) | Definition of agility in manufacturing and its attributes | x | | | | | | | | x |
| Zhang (2011) | Taxonomy of agility components in manufacturing | x | | | | | | | | |
| Zhang and Sharifi (2007) | Taxonomy of agility components in manufacturing | x | | | | | | | | |
| Zsidisin et al. (2005) | Factors affecting supply chain efficiency and performance | | | x | | | | | | |

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