Does supply chain visibility enhance agility? ☆

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ABSTRACT

Agility is a major preoccupation for both supply chain managers and academic researchers in supply chain management. Yet, many questions remain unanswered about how best to achieve this operational capability. We study supply chain agility using the dynamic capabilities approach within the resource based-view of the firm, positioning ourselves from the vantage point of the supply chain manager. A survey of 171 French supply chain managers is undertaken and the results are analysed using factor analysis and a structural equation model. We provide insights by mapping the relationships between different managerial resources and processes and agility. These processes are grouped into three lower order capabilities: external, visibility, and internal processes. We show that external and internal managerial processes enhance agility. However, supply chain agility is not enhanced when managerial processes related to visibility are applied. Processes enhancing visibility across the chain, reliant on integrating Enterprise Resource planning and other software, tracking and tracing, reporting tools and web collaborative platforms, which other research pointed out as supporting agility, are found to be without influence on agility. On the other hand, external and internal capabilities are shown to enhance agility. We contend that some higher level processes and routines not included in the survey may explain the difference. Managerial insights and further avenues of research are presented.

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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 1990s 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 understanding and improving the relationships between chain members (Jacoby, 2009). At the same time, markets have become ever more fickle and competition both in home markets and abroad has grown increasingly strong. Zara's performance in this environment springs to mind: its ability to overcome vagaries of the fast fashion industry by its agility is legendary (Zhelyazkov, 2011). Pressure from e-commerce, e-tailers and now m-commerce increases the need for speed and quick inventory turnover. Supply chain managers are under continual pressure to maximise service while containing costs. Companies also need the abilities to adapt the services and goods on offer to follow consumers' changing tastes and behaviours (Stank et al., 2013; KPMG, 2012).

Supply chain managers are under pressure to instil agility in supply chains to match the speed of change and the accelerating competition in markets (Hummels and Schaur, 2012). Consulting companies, software providers and professional organisations have taken an interest in providing the necessary managerial and technological tools to enhance supply chain agility (Baird and Kilcourse, 2011; CapGemini Consulting, 2012). Agility has also become a mainstream topic for academic research as the increasing flow of articles in recent years can attest (e.g., Swafford et al., 2008; Bottani, 2010; Ngai et al., 2011; Richey et al., 2012; Malhotra and Mackelprang, 2012; Liu et al., 2013; Blome and Schoenherr, 2013).

The management practices required to achieve the operational capabilities to enhance agility are treated in the literature from different managerial viewpoints (e.g., operations, strategy, information systems, marketing, human resources) as exemplified in Li et al. (2008, 2009b). The focus of the present study is on supply chain practitioners. The study considers the supply chain manager as being at the centre of the decision-making and management of the supply chain. As such, s/he has at her/his disposal a range of managerial practices which s/he deploys to achieve the strategic goals of the organisation among which agility features so highly. These include routines, processes, systems, human resources, and

assets, which, when combined, enable the flow of goods, information, and cash throughout the supply chain to be agile.

This study addresses the following question. To obtain agility, what practices and processes does a supply chain manager deploy? We develop a series of hypotheses which we test through an empirical study. In particular, we ask whether or not visibility provided by control tower type of practices enhances agility. We find that the practices most associated with visibility and information gathering of the partners in a supply chain do not provide additional agility as has been reported in other works. On the other hand, both internal capabilities (forecasting and Sales & Operations Planning) and external capabilities (Efficient Customer Response) contribute significantly to agility. We control for effects from two variables: firm size and economic sector. The results do appear to vary according with respect to the economic sector of the focal firm but these differences are not statistically significant, probably due to an insufficient sample size. No differences were observed which could be attributed to firm size. The results may require some revision of previous works and they open up new avenues for research.

We describe our conceptual framework in the next section before presenting the research methodology and sample characteristics in Section 3. The analysis of the data is reported in Section 3.5. We analyse the relationships between lower order capabilities and operational capability in Section 4 before discussing their implications and concluding in Section 5.

2. Conceptual framework

When reviewing the literatures relative to agility in manufacturing or in supply chain management, it is important to recognise 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 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 approach through Dynamic Capabilities introduced in Teece and Pisano (1994). 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). This theoretical perspective argues that superior firm performance comes from two types of organisational capabilities, namely, *dynamic* capability and *operational* capability (Cepeda and Vera, 2007; Zahra et al., 2006; Helfat and Peteraf, 2003).

The literature formulated the basic difference between *dynamic* capability and *operational* capability (Teece, 2007; 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 markets change. Dynamic Capabilities are a learned pattern of collective activity and strategic routines through which an organisation can generate and modify operating practices to achieve new resource configuration, and so obtain or sustain a competitive advantage (Teece et al., 1997; Zollo and Winter, 2002; Teece, 2007). Barreto (2010) concluded that research in this field should focus on the internal and external factors that may enable (or inhibit) firms to realize the potential represented by their dynamic capabilities.

Rather than seeking formulas for generalised effectiveness, it is important to recognise that the value of *dynamic* capabilities is context dependent (Wilden et al., 2013). They improve the effectiveness, speed, and efficiency of organisational responses to environmental turbulence (Chmielewski and Paladino, 2007; Hitt et al., 2001) which ultimately enhance performance. Attaining competitive advantages requires efficient, effective sharing, and deployment of resources between partnering organisations and supply chain partners (Rajaguru and Matanda, 2013). By contrast, an *operational* capability provides 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, their role is very different in contributing to higher relative firm performance (Drnevich and Kriauciunas, 2011).

An operational capability refers to a firm's ability to execute and coordinate the various tasks required to perform operational activities; e.g., 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 (called oragnisational routines or competences in Teece et al., 1997) 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). An operational capability like agility is founded upon both internal processes and those relative to the coordination, integration, information and control of suppliers and downstream partners; ie, the whole supply chain as viewed from the focal firm's standpoint.

To build and operate a supply chain that is agile, it is helpful to have an in-depth understanding of the lower-order capabilities (or microfoundations,as described in Teece, 2007) that are required. Within the boundary-spanning networks that supply chains have become, effective integration requires business partners to be highly embedded operationally, technically, and strategically (Hult et al., 2004).

Lower-order capabilities include managerial processes, procedures, systems, and structures that undergird each class of capability, as distinct to the capability itself (Teece, 2007). Together, they provide the coordination and collaboration processes and tools among the different chain members which enable the supply chain to be responsive to market changes (described as the oragnisational practice of external integration in Braunscheidel and Suresh, 2009).

Under this conceptual framework, it becomes easy for the supply chain manager to describe from her/his vantage point the operational capabilities s/he wishes to enhance as well as the practices, procedures, and processes applied at her/his firm and within her/his supply chain (see Fig. 1). In the following, we shall
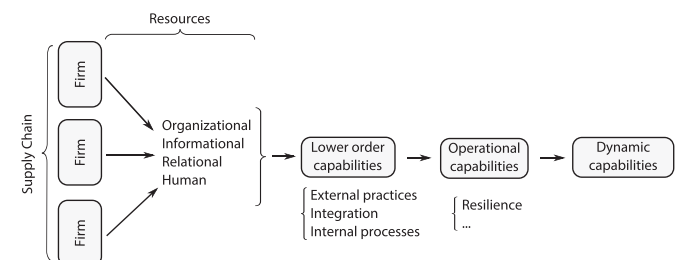

Fig. 1. Theoretical model of a Resource-Based-View of a supply chain.

interest ourselves in the relationship between lower order capabilities and operational capabilities.

In the next two sub-sections we describe in detail the *Operational Capabilities* as secondary latent variables which the supply chain manager will want to develop so as to contribute to the Dynamic Capabilities of his supply chain. We present the observable dimensions which characterise each capability. In the following one, we characterise the lower-order capabilities which constitute the micro-foundations to the operational ones and formulate hypotheses which we want to test.

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 recognised to play a major role for survival in turbulent and volatile markets (Gunasekaran, 1999; Yusuf et al., 1999; Christopher, 2000; Christopher and Towill, 2001; Agarwal et al., 2006). Christopher (2000) has identified a number of characteristics that a supply chain must have in order to be "truly agile":

- Market sensitive – it is closely connected to end-user trends.
- Virtual – it relies on shared information across all supply chain partners.
- Network-based – it gains flexibility by using the strengths of specialist players.
- Process integration – it has a high degree of process interconnectivity between the network members.

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 vantage point from which practice is observed in the present study is through the eyes of the supply chain manager. Her/His post within an organisation is best suited to organise, stimulate and otherwise coordinate both internal and across-network resources. She/He is in the unique position to make a difference in terms of routines and practices upon the agility of a supply chain. In the following, we compare our framework to those of the major empirical studies on agility in the recent past.

Swafford et al. (2008) look into agility attributes and enablers which can be found in individual European manufacturers. However, the supply chain agility described relates to dynamic capability characteristics rather than operational capability ones and have to do with duties that may not be relevant to a supply chain manager: reducing product development cycle time, reducing manufacturing lead times, increasing the level of customisation, reduce setup/changeover time,…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. Braunscheidel and Suresh (2009) view organisational practice, internal integration, and industrial flexibility as antecedents to agility. In all the above, the operational and even strategic tools that supply chain managers use in practice are not contemplated. These authors do not look at lower order operational capabilities which constitute the operational ones as required by the Dynamic Capabilities approach. Bottani (2010) presents tools which may be employed by a firm internally (computer aided control or design, automated assembly, intranet connection, etc.), but do not use externally oriented ones. Moreover, most of the tools presented do not relate to the supply chain manager's remit. Braunscheidel and Suresh (2009) look at generic *qualities* applicable to internal processes and flexibilities without describing them at process, system or practice level. Blome and Schoenherr (2013) look at *competences* on each side of a firm: demand and supply as well as process compliance, but again without enumerating lower order capabilities as the Dynamic Capabilities approach would.

As Agarwal et al. (2006) point out, agile supply chains are inherently more market oriented because they are better able to synchronise supply with demand. Achieving synchronisation requires integration across a firm's internal functions as well as its suppliers and supplier's suppliers, and customers and customers' customers (Narasimhan et al., 1997; Frohlich, 2002).

In the present study, agility in a supply chain is viewed as an operational capability stemming from the ability to manage across networks demand-side, supply-side processes, systems, and routines. Agility *per se*, because it is based upon static capabilities, does not provide the *dynamic* capabilities which are required if a supply chain is to maintain or increase its overall position in satisfying the customer as well as its ability to continuously generate profits. If it did, Dell, the personal computer and information systems manufacturer, would still be considered a parangon of agility as in Lee (2004).

Having described the operational capability, we now characterise the lower order capabilities available to the supply chain manager which, if deployed in full and used by all members of the supply chain, might generate this operational capability and spell out the corresponding hypotheses.

2.2. Lower order capabilities and hypothesis development

We define lower order capabilities as the set of physical, financial, human, technological, and organisational resources (Grant, 1991) coordinated by organisational routines (Nelson and Winter, 1982) and deployed in an organisation and across organisations.

The literature describes abundantly a large number of supply chain managers' practical managerial routines and processes. Given the focus of this study, we concentrated on those which (a) are applied by supply chain managers; (b) have been identified as combining resources of organisational, informational, relational and human origins, and encompassing both local as well as other partners in a supply chain. Even though authors describing the practices do not refer to the RBV of the firm, the characteristics, purpose, and resources required to set them up, apply them and obtain tangible results clearly mark them as pertaining to the class of lower capability capabilities which we identified earlier. A managerial tool such as an Enterprise Resource Planning (ERP) system, for example, is composed of tangible assets (computers, servers and wide area networks), intangible assets (software), human resources, processes and routines rooted in knowledge. This ERP system will be connected through specialised software to other firms in the supply chain to exchange forecasts, delivery schedules, etc. (Akkermans et al., 2003). When combined with other tools and routines, the ERP system contributes to an operational capability (Su and Yang, 2010).

In the following, we describe the three groups of practices which we deem to have influence on the operational capabilities.

External collaboration capabilities: These are the tools of the Collaborative Planning, Forecasting and Replenishment (CPFR) variety (Skjoett-Larsen et al., 2003) where partners have to collaborate through, among others, Vendor Managed Inventory (VMI) and Efficient Customer Response (ECR) routines 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). As a corollary, inventories are streamlined along the supply chain. Flows of goods in and from the warehouse are monitored through the use of warehouse and transport management systems. The collaborative routines stem from the retailer's perspective and apply along the lines of the conceptual framework presented in Richey et al. (2012). When ECR is effectively applied by manufacturers and retailers, demand and supply information as well as physical flows are jointly managed to enhance the customer's satisfaction by meeting his demands in terms of price, choice, location and time (Kotzab, 1999).

As said in Skjoett-Larsen et al. (2003), "CPFR-collaboration also includes a wish to develop qualifications to continue improvement of the company's processes. Such a learning process leads to a more agile and changeable supply chain". We purport that

Hypothesis 1. Supply chains who exhibit a high implementation rate for *external collaborative capabilities* will display high levels of *Agility*.

Visibility capability: This capability groups the tools of Information Technology (IT) which enhance inter-organisational integration and coordination through information systems (Patterson et al., 2003; White et al., 2005; Lin et al., 2006; Agarwal et al., 2007; Faisal et al., 2007; 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, sales reports, and inventories (see Qrunfleh and Tarafdar, 2012, for an appreciation of the impact of Information Systems on supply chain performance). A collaborative platform provides a real-time information exchange (Benjamin et al., 1990; Boyson et al., 2003). Tracking and tracing of goods allows for greater control over operations within the chain. The performance of suppliers is monitored (García-Dastugue and Lambert, 2003). We built upon the IT systems described in the survey presented in Li et al. (2009a) as 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).

Visibility capabilities are antecedents of higher-order operational capabilities such as agility (Agarwal et al., 2007; Swafford et al., 2008; Sambamurthy et al., 2003). For the purpose of a supply chain, the Visibility capabilities must be comprised of boundary-spanning technologies and value-added networks that link suppliers and buyers (Craighead et al., 2006) as well as other procedures, processes and routines which enable distinct firms to work together towards a common goal (Christopher, 2000). Visibility capabilities of firms in processing information inputs can advance know-how and create intellectual capital, which enables firms to make informed decisions and take effective actions (Yang, 2014; Lai et al., 2008). In light of the above, we argue that the implementation and use of web collaborative platforms, reporting tools, track and trace as well as integration of supply chain management software with the ERP by the focal firm within a supply chain will provide it with the agility required to overcome the challenges posed by competition and customers. We formulate the following hypothesis:

Hypothesis 2. Supply chains who exhibit a high implementation rate for *Visibility capabilities* will display high levels of *Agility*.

Internal capabilities: This last set of processes increases the responsiveness of a supply chain to stimuli from the end-consumers. It is a firm's ability to evaluate and take needs into account quickly (Charles et al., 2011). Those processes and routines, also named Sales and Operations Planning (S&Op), provide a vital link between lean manufacturing operations 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 satisfy less and less very large orders. "The ability to react faster to both these changing demands and to competitive actions becomes an essential capability".[1] Hence, forecasting takes a vital role in ensuring that a supply chain works in lockstep (Christopher, 2000; Collin and Lorenzin, 2006). In the fashion industry, customers are increasingly demanding more variety, higher quality, and better service. The latter include both reliability and faster delivery (e.g., Lemieux et al., 2012; Duclos et al., 2003; Faisal et al., 2006). Sen (2008) adds that further manufacturing responsiveness may be achieved by establishing or improving internal processes at the manufacturing level such as forecasting and planning future production needs. This leads to the following hypothesis.

Hypothesis 3. Supply chains who exhibit a high implementation rate for *Internal capabilities* will display high levels of *Agility*.

Having now described the hypotheses that we wish to test, we present the protocol we followed to establish the construct measures (Section 3.1). The data collection is described in Section 3.2, the analysis in Section 3.5, the results of the model in Section 4; a discussion of these results in Section 5 concludes.

3. Research methodology

3.1. Construct measures

The four theoretical constructs of our research model (Fig. 2) constitute latent variables requiring indirect measurement. As such, following the paradigm for creating effective measures forwarded by Churchill (1979), we commenced by the domain specification of each construct and by the collection of relevant measurement items from related literature.

The resulting list of capabilities and processes appears in Table 1.

3.2. Sampling method

So as to achieve dependable results, we used a survey approach to gather data. The survey was developed for a single respondent with the organisation serving as the unit of analysis. As such, our research uses an embedded design in which the organisation 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-organisational 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). Respondents'

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[1] Quote based upon an internal document from a large Swiss food company.

Table 1
Measurement items and descriptive statistics ($n=171$).

Construct	Item		Mean	St.D.
Agility	Q Innov	The rate of innovation forces us to make our supply chain evolve constantly	3.509	1.113
	Q Chan	The complementarities of our sales channels allow us to meet our customers' requirements	3.485	1.280
	Q Prev	Our sales forecasts allow us to anticipate the major market changes	3.421	0.987
	Q Param IS	We review the parameters of our Information Systems regularly so as to adapt to market conditions	3.398	0.878
Internal cap	IT Fore Plan	Deploy S&Op	4.860	1.124
	T Forecast	Set up/ameliorate the forecasting process	4.953	1.142
	T Plan	Set up/ameliorate the planning process	4.971	1.098
External cap	T Inventory	Streamline/resize inventory in your distribution network	4.737	1.304
	T IT WMS	Deploy WMS and TMS	4.977	1.292
	T VMI	Deploy a Vendor Managed Inventory policy (VMI)	3.596	1.295
	T ECR	Deploy an Efficient Customer Response policy	3.842	1.224
Visib. cap	T IT ERP	Integrate your ERP with other SCM tools	4.497	1.303
	T IT Trace	Deploy Track & Trace IT tools	4.433	1.311
	T IT Report	Deploy reporting tools (IT)	5.211	0.953
	T Collab Plan	Develop web collaborative platforms	4.193	1.382

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

A link to the web-based questionnaire was sent to the 8000 tested e-mail addresses of the subscribers in France to the newsletter of the web magazine supplychainmagazine.fr[2]. The newsletter subscribers are exclusively opt-in readers who declared their interest in supply chain management general news. Only those that were strictly speaking in managing supply chain positions were extracted. These were identified by their company names, job title and industrial sector. A total of 366 replies were recorded with 171 valid for statistical analysis, a response rate of 2.1% of the identified population but 47% of the sample usable (Yu and Cooper, 1983). This response rate is comparable to other research within the field of supply chain management (e.g., Van der Vaart and Van Donk, 2008; Wagner, 2010).

The subset of responses excluded in this study was due to incomplete answers in most or all of the questions. Sixteen industries are represented by the sample, which is expected to increase the generality of the survey results (Malhotra and Grover, 1998). In terms of size of payroll, the sample reflected an interesting proportion of small to medium sized firms.

3.3. Testing common method bias

Since there was a single informant per organisation, 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 12 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.

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

3.4. Non-response and late-response bias

The threat of non-response bias exists whenever significant numbers of the targeted population fail to respond. Given a relatively low response rate, we checked for possible non-response bias using a "time trend extrapolation test" in which "late" versus "early" respondents are compared along key study variables (first suggested by Oppenheim, 1966). The assumption behind this test is that "late" respondents are very similar to non-respondents, given that they would have fallen into that category without the follow-up efforts (Armstrong and Overton, 1977). T-tests conducted showed no significant differences between "early" and "late" respondents along any of the key study variables. While this analysis suggests sample representativeness, we cannot ascertain whether respondents and non-respondents differ on unmeasured variables that also correlate with our independent and dependent variables.

3.5. Analysis and results

Content validity represents the sufficiency with which a specific domain of control (ie, construct) was sampled (Nunnally, 1978). As Flynn et al. (1995) highlighted, content validity is subjective and judgmental but is often based on two standards put forward by Nunnally: does the instrument contain a representative set of measures, and were sensible methods of scale construction used? The positive answer stems from the way the questionnaire was built, ie, by soliciting the advice from practitioners and integrating all their suggestions both for qualities as well as managerial practice. Construct validity represents how well the item measures relate to each other with respect to a common concept, and is exhibited by the existence of significant factor loadings of measures on hypothesised constructs (Anderson and Gerbing, 1988).

We performed an exploratory factor analysis (Kim and Mueller, 1978) on both lower order capabilities and operational ones as observed variables to detect unidimensional indicators and help ensure reliable scales (Flynn et al., 1990; O'Leary and Vokurka, 1998).

We first describe the results of the analysis for operational capabilities before doing the same for the lower order ones.

A principal component analysis (PCA) with rotation based on Varimax with Kaiser's normalisation was performed on the items composing the *Agility* operational capability. For this analysis, the sample size is more than the heuristic recommended value of five times the number of variables examined (Hair et al., 1992). The

4 items characterising the operational capability did load onto one single axis. This axis represented a cumulative 61.8% of the total variance of the respondents' answers on these items. The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy stands at 0.693. A minimum KMO score of 0.70 is considered necessary to reliably use factor analysis for data analysis, but the value obtained is near enough. Similarly, Bartlett's test of sphericity (the higher the better) was 239.3 with significance level of $p < 0.000$.

Factor scores using the regression method, normalised and standardised were saved. Factor scores are the weighted averages of the values on all the original variables using factor loadings as weights. Using factor scores in this manner creates a more accurate measure than simply computing a mean, which assigns equal weights to items (Lastovicka and Thamodaram, 1991).

A within-scale factor analysis was done (Saraph et al., 1989). *Construct unidimensionality* is supported if the items tentatively related to a variable all load on this specific latent variable when within-scale factor analysis is run (see Table 2). All four items projected on a single axis, confirming their unidimensionality (Gerbing and Anderson, 1988; O'Leary and Vokurka, 1998).

We proceeded to perform an exploratory factor analysis on the lower order capabilities.

3.6. Validity of latent variables

A within-scale factor analysis was performed to confirm the strength of the constructs and their items, the results are presented in Table 2. Validity was also tested by analysing bivariate correlations and correlations with demographic characteristics (economic sector and payroll size). The results are presented in Table 3. The correlations between *Visibility* and both *External* (47.2%) and *Internal capabilities* (37.9%) as well as *Internal* with *External capabilities* (38.0%) are the highest. These percentages are still significantly lower than the ones between these constructs and the corresponding items (see Table 3). These correlations can be interpreted as meaning that the supply chains involved simultaneously deploy both sets of tools or have not started at all.

Table 2
Agility scale for supply chains: results from within-scale factor analysis.

Construct and item	Cronbach's alpha	Factor scores
Agility	0.673	
We review the parameters of our Information Systems regularly so as to adapt to market conditions		0.723
Our sales forecasts allow us to anticipate the major market changes		0.698
The complementarities of our sales channels allow us to meet our customers' requirements		0.670
The rate of innovation forces us to make our supply chain evolve constantly		0.659
Internal process capability	0.879	
Set up/ameliorate the planning process		0.917
Set up/ameliorate the forecasting process		0.936
Deploy S&Op tools (IT)		0.839
Visibility capability	0.696	
Develop web collaborative platforms		0.807
Deploy reporting tools (IT)		0.721
Deploy Track & Trace IT tools		0.721
Integrate your ERP with other SCM tools		0.654
External capability	0.683	
Deploy an Efficient Customer Response policy		0.808
Deploy Vendor Managed Inventory policy (VMI)		0.722
Deploy WMS and TMS		0.638
Streamline/resize inventory in your distribution network		0.693

Table 3
Pearson's pairwise correlation coefficients between enablers and demographic variables ($n = 171$).

Construct/control variables	Correlation coefficient	Visib	Intern	Extern	Payroll	Econ. sector
Visibility	Pearson	1	0.379**	0.472**	0.197**	0.135
	Sig.		0.000	0.000	0.010	0.078
Internal	Pearson	0.379**	1	0.380**	0.157*	−0 0.085
	Sig.	0.000		0.000	0.040	0.270
External	Pearson	0.472**	0.380**	1	0.199**	−0.107
	Sig.	0.000	0.000		0.009	0.164
Payroll	Pearson	0.197**	0.157*	0.199**	1	0.153*
	Sig.	0.010	0.040	0.009		0.045
Economic Sector	Pearson	0.135	−0.085	−0.107	0.153*	1
	Sig.	0.078	0.270	0.164	0.045	

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table 4
Descriptive statistics, correlations, composite reliabilities, average variance extracted and discriminant validity tests.

Construct/control variables		Mean	St. dev.	1	2	3	4
1	Agility 4 items	3.45	0.76	0.504[a]			
2	External 4 items	4.29	0.91	0.511	0.514		
3	Visibility 4 items	4.58	0.90	0.245	0.417	0.528	
4	Internal 3 items	4.93	1.01	0.388	0.189	0.177	0.806

[a] Average variance extracted are on the diagonal.

There is no relevant correlation between constructs and demographic parameters. We conclude that they do not measure unintended constructs.

3.7. Reliability

The *reliability* of each construct was further analysed following Flynn et al. (1995)'s example. Descriptive statistics, correlations, composite reliabilities, average variance extracted, and the discriminant validity test results are given in Table 4. The reliability of the scale for agility, Cronbach's alpha is only 0.673, warranting further investigation. We looked at the average variance extracted (AVE) (Fornell and Larcker, 1981). The AVE measures the amount of variance for the specified indicators (items) that is accounted for by the latent construct. The AVE is a complementary measure to the construct reliability value. Bagozzi and Yi (1988) suggest that the average variance extracted for a construct should exceed 0.50. This is the case for agility which has an AVE of 0.504, as can be seen in Table 4. As discussed in Koufteros (1999), depending on the measure of alpha for unidimensionality would be deceiving: scales exhibiting high measures of alpha do not necessarily conform to the conditions of unidimensional measurement. Composite reliability, which is a more accurate method of measuring measurement reliability than Cronbach's alpha (Raykov, 1998) ranged for all constructs from 0.8021 to 0.9258, indicating sufficient level of reliability (Hair et al., 2006).

3.8. Discriminant validity

Discriminant validity was assessed in two ways: (1) structural equation modelling methodology (i.e., Bagozzi and Phillips, 1982),

in which χ^2 differences were examined between models where correlation between two latent variables is fixed at 1 and with the other correlations between latent variables free to assume any value (Kourfteros et al., 1998; Koufteros, 1999); and (2) by comparing the average variance extracted with the squared correlation between constructs (Fornell and Larcker, 1981). The χ^2 value for the difference must be greater or equal to 9.1 for 10 comparisons for significance at $p < 0.05$ (Cohen and Cohen, 1983). In all cases, the χ^2 differences are greater than the critical value which implies that they are significant (see Table 4).

Divergent or discriminatory validity was also tested by analysing bivariate correlations between the scales and the size and other potentially confounding demographic variables included in the study such as industrial sector and size of the respondent's firm. There were no significant correlations between the scales and sector or size of the firm, thus the scales were not measuring other unintended constructs (see Table 5).

3.9. Variance based SEM

This study uses variance based structural equation modelling (SEM) (two main references are Wold, 1982, 1985), a component based structural estimation modelling technique. Variance based SEM has its distinctive features compared to other structural equation modelling techniques such as LISREL/AMOS, covariance-based structural equation modelling techniques. Variance based SEM 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). "The identification of reflective hierarchical models using covariance-based SEM is not an easy task. Even if the model *per se* is theoretically identified, it might still suffer from empirical under-identification, which may cause non-convergence and/or improper solutions" (Wetzels et al., 2009). Moreover, Chin and Newsted (1999) observe that variance based SEM path modelling is generally more suitable for studies in which the objective is prediction or the phenomenon under study is new or changing as is the case here.

The structural and measurement models under variance based SEM 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, variance based SEM tests the strength and direction of individual paths by statistical significance (Calantone et al., 1998). Variance based SEM does not use fit indices. Sample size requirements for variance based SEM are 10 times the larger value of the following: (a) the block with the largest number of indicators, or (b) the dependent latent variable with the largest number of independent variables impacting it (Chin, 1998b).

Table 5
Pearson's pairwise correlation coefficients between scales for characteristics and demographic variables ($n = 171$).

Construct/ control variables	Correlation coefficient	Agility	Payroll	Econ sector
Agility	Pearson	1	−0.069	−0.076
	Sig.		0.369	0.326
Payroll	Pearson	−0.069	1	0.153*
	Sig.	0.369		0.045
Econ sector	Pearson	−0.076	0.153*	1
	Sig.	0.326	0.045	

* Correlation significant to $p < 0.01$ (2-tailed).

Tenenhaus et al. (2005), as a complementary more theory-oriented paper than Chin (1998b), have compared both SEM-ML (Joreskog and Sorbom, 1986) and variance based SEM. Even though it is recognised that those methods give different results, for our purpose variance based SEM is most useful where theory is still being developed while Maximum Likelihood modelling techniques (e.g., AMOS) are most suitable for confirmatory studies (Lee et al., 2006). Variance based SEM allows for more exploratory investigations into the links between certain enablers and the traits of supply chains due to its less rigorous requirement of restrictive assumptions.

4. Model results

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.

4.1. Model results for all economic sectors

From Fig. 3, we observe that only H1 and H3 are supported at least at the $p < 0.05$ level. As an added sign of confirmation, we observe that the standardised path coefficients are greater than 0.3, indicative of a strong influence Chin (1998a). To enunciate the result, *External capabilities* and *Internal capabilities* do enhance *Agility* in a supply chain according to the supply chain managers.
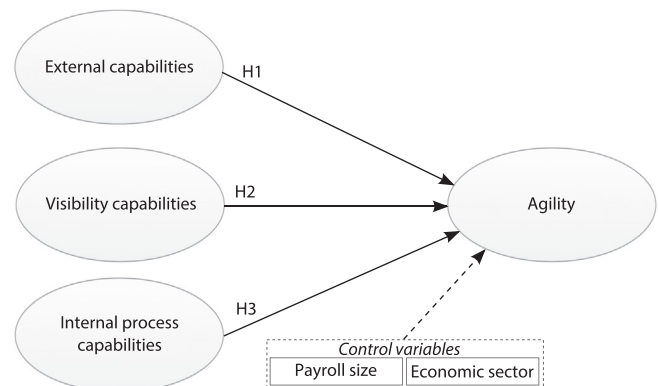
Fig. 2. Research model.
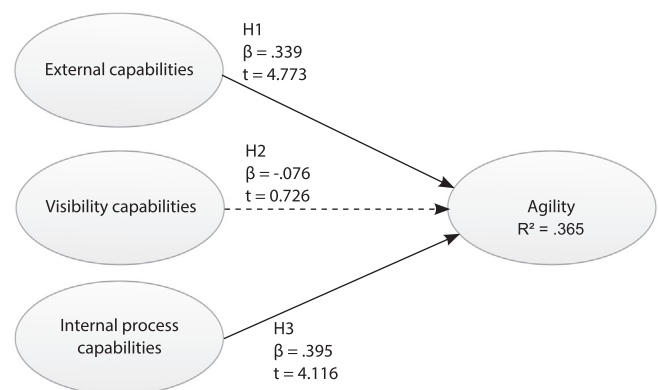
Fig. 3. PLS path model coefficients and t-values for the full sample.

For H2, $t < 1.96$ and the path estimate β is practically nil. To confirm the absence of influence of these lower order capabilities, we did a post hoc power analysis taking into account that we have three predictors for Agility and a sample size of 171 records. For *Agility*, given that $R^2 = 0.365$, the observed statistical power is 99.55% at $p \leq 0.01$, more than the minimum 80% required for this test to be valid. Hence the score achieved for *Visibility capabilities* about their relationship with *Agility* are valid statistically: we are not in a Type II error (a Type II error is when a true connection is not correctly detected). This means that not only is H2 not validated, but that *Visibility capabilities do not* influence in any way *Agility*. The corresponding processes are well deployed and used as evidenced by the means of the items of Visibility shown in Table 1.

Even though variance based SEM path modelling does not optimise any global scalar function so that it lacks an index that can provide the user with a global model validation, the Goodness-of-Fit (GoF) represents an operational solution so as to compare the different models presented here (Tenenhaus et al., 2005). The levels of Goodness of Fit as computed according to Tenenhaus et al. (2005) and presented in the last lines of Table 7 confirm that the model fittingly describes the data since it has Goodness of Fit index greater than 0.4, considered to be, as a rule of thumb, the cutting-off value (Latan and Ghozali, 2013). This confirms the readings on CR and AVE in Table 6.

This lack of influence of the lower-order capabilities associated with *Visibility* on *Agility* is at variance with the results from several studies, among which Yang (2014), Bottani (2010), Lin et al. (2006), Agarwal et al. (2007), DeGroote and Marx (2013), and White et al. (2005). Let us look at the differences in detail.

In the case of Yang (2014), the survey was conducted in Shanghai, receiving 137 valid answers from CEOs as well as logistics managers. The metric used for the firm's IT capability is composed of four items which reflect a comparison between the respondent's firm IT capability (without any further detail) and (a) industry standard, (b) competitors, (c) customers, and a final item which asks about the use of information networks with key suppliers. Sharing information is a separate construct based upon items related to trust, formal information sharing, and informal information sharing (without any description as to the information being shared). In the ensuing model, IT capability has a positive and valid influence on agility, but information sharing does not. A third construct, labelled operational collaboration, and composed of items related to the sharing of operations planning, forecasts, linking order management systems and joint capacity management systems, has positive and valid contribution to agility. Even though the first two barely have any relationship with our Visibility capability, Operational capability closely resembles our *Internal capability* and our *External capability*. Hence, we do concur

with the results in Yang (2014), but their IT capability construct has no relationship with our Visibility one, hence the results are not comparable.

The survey in Bottani (2010) was conducted in 2007 with 189 valid answers mainly from CEOs (only 15% from supply chain managers). Of these, from cluster analysis, 131 were classified as agile. Of the 18 enablers of agility which were identified, seven were related to manufacturing technology tools, five with engineering tools, only three with IT tools, and the last four are related with efficiency in manufacturing and production. Most of them are tools which are to be used by production managers and engineers; with a focus on internal operations, not boundary-spanning ones. Only the IT tools (Intranet connection, Enterprise Resource Planning and Extranet connection with networked companies) do seem to have some relation with our *Visibility capability*. This set of tools is reported in Bottani (2010) to be more highly implemented in the firms classified as agile. However, no comparison in deployment is made with those firms which were deemed not to be agile. But whereas Bottani (2010) reported that the components identified as enablers of Agility comprising computer aided systems, management information systems were still in limited use, we find that they are now deployed and used. Another factor rendering the comparison difficult is that Agility in Bottani (2010) covers a different semantic ground: focusing on employees' role and competency in the company, as well as a "Technology" decision domain seen as similar to the one defined in Yusuf et al. (1999). Under this conception, agility is basically a quality springing from purely internal factors of one firm and not of a whole supply chain. Moreover, the supply chain manager does not feature as having a role.

Based on a case study in Taiwan, Lin et al. (2006) show that through high top management involvement and the deployment of four types of routines and processes, a supply chain can become agile within a period of 2 years. From these four sets of routines, one (information integration through capture of demand information, transmission of information to the whole supply chain, and virtual connection) is the closest to our Visibility capability. Here again, there are sufficient grounds due to the differences to argue that the results presented in Lin et al. (2006) do not preclude the validity of our own.

In Agarwal et al. (2007), the authors with the help of "experts" build an interpretive structural model of tools up through processes to high level quality traits observed in agile supply chains. They find that the deployment of IT tools will help centralised and collaborative planning as well as process integration. Those in turn minimise uncertainty, resistance to change, and develop trust. Other variables build upon the latter to enhance agility. The model, based as it is on the opinion of 179 managers, states that the tools and processes associated with visibility and collaboration through IT are the basic tenets upon which other higher level sets of routines and processes have to be set up which *should enhance* agility in a supply chain. This model, as it is based upon expert opinion, cannot be construed to invalidate our results.

The invalidation of H2 also contradicts the results reported in the IBM case study (White et al. (2005)) where a web platform E2Open serves to "improve communications with both their customers and suppliers […] to connect to each other, allowing improved performance of the entire chain". There is no mention of actual practices or their implementation within the firm or across the chain which is what we have tried to measure.

We cannot close this discussion of our results compared with other studies without mentioning (DeGroote and Marx, 2013). This study clearly concludes that the deployment of "IT increases agility in supply chains". Several points merit discussion. The way the IT and Agility constructs are specified leaves ample room for interpretation by the respondents. The items are the following

Table 6

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).

Construct/ control variables	Correlation coefficient	All	Industry	Retail	Food
Agility	C.R.	**0.802**	**0.833**	0.779	0.734
	AVE	**0.504**	**0.558**	0.474	0.421
External capabilities	C.R.	**0.808**	0.746	0.702	**0.825**
	AVE	**0.514**	0.439	0.413	**0.542**
Visibility capabilities	C.R.	**0.817**	**0.801**	0.690	**0.847**
	AVE	**0.528**	**0.506**	0.442	**0.582**
Internal capabilities	C.R.	**0.926**	**0.927**	**0.874**	**0.971**
	AVE	**0.806**	**0.809**	**0.698**	**0.918**

sentences: "IT use to sense market changes in (a) customer demand, (b) technology trends", as well as "IT use to respond by developing coordinated plan with supply chain", "IT use to respond by executing coordinated plan with supply chain". The Agility construct is built using two items which start with the following sentence "Information quality in terms of" and end with one of the followings: adequacy, timeliness. Two more items are developing and executing coordinated plans within a supply chain. A number of questions which are listed as also belonging to agility are conveniently left out when reporting the multilinear regression analysis results. For example, for Agility, the item "execute coordinated plans with supply chain in terms of timeliness" is omitted. Another difference is that the sample comes only from manufacturing firms, with 19% in chemical and pharmaceutical, 15% in computer and electronic, and 11% in food and beverage sectors. In terms of size, the sample is heavily dominated by major international organisations with sales in excess of $2 billion (66% of the sample). No attempt has been made to control the correlations for size or economic sector. In conclusion, neither the routines, processes and other managerial tools nor the operational practices which we have identified and wished to measure appear in that research.

On the other hand, our result partially validates those of Rajaguru and Matanda (2013) which finds that strategic and cultural compatibility are antecedents to Inter-Organisation Information systems integration and both also contribute to supply chain capabilities. The lack of one of these antecedents will hamper supply chain ability to be responsive to customer requirements in a dynamic consumer market. The lack of influence of the routines and processes associated with *Visibility* on *Agility* also validates the result in Liu et al. (2013) where visibility provided by IT assimilation has no significant influence on agility.

In the same vein, Swafford et al. (2008) conduct a survey addressed to production and plant managers because they are "more likely to be knowledgeable about capabilities in the firm's internal supply chain functions". The IT integration construct which is described involves only activities related to design and development, procurement, manufacturing, logistics and distribution, and use of Enterprise Resource Planning or supply chain planning software. The model tested indicates a path coefficient between IT integration and agility of 0.11 with a *t*-value of 1.07, thus confirming that IT integration within the firm does not influence supply chain agility. This result and the items used do bear resemblance to the ones composing our own Visibility capability.

As mentioned when developing the basis for H2, the processes which the supply chain manager must have his organisation master are boundary-spanning and information sharing ones. They are routines and processes involving the coordination across the supply chain of several actors and systems. In terms of the four characteristics of agility identified in Christopher and Towill (2001) and cited earlier, these should strengthen the last two: the network based and process integration ones. The use of web collaborative platforms linking the supply chain partners, the reporting tools (which include both IT and manual variants), track & trace technology or IT integration involving the ERP and other supply chain software, all require the combination of both assets and operators as well as routines and processes. They constitute what Teece (2007) call microfoundations of a capability, but are not enough to constitute the capability itself. The procedures described produce information. This information has then to be filtered and built up using other processes to allow the supply chain manager to take the correct decisions in view of the risks and opportunities that emerge. They would appear to be a part of the extra mechanisms and procedures identified in David Teece's framework (Teece, 2007) to be performed by the higher

management ranks so that the corresponding insights can be acted upon, thus delivering the required agility. As mentioned in Teece (2007), "the identification of the microfoundations of dynamic capabilities must be necessarily incomplete, inchoate, and somewhat opaque and/or their implementation must be rather difficult. Otherwise sustainable competitive advantage would erode with the effective communication and application of dynamic capability concepts". Each organisation in each supply chain probably has its own idiosyncratic routines, making generalisation difficult. It may be the case that the managers have difficulty in articulating what this extra layer of routines consists in, because of the tacit knowledge involved, even if they wanted to. Further, as mentioned in Kim et al. (2011) implementation can be problematic, as it requires significant effort to redefine and extend the boundaries of the participating organisations as well as being compatible and operationally embedded.

These managerial routines are not investigated in our survey. We can only surmise that such procedures and mechanisms involved in building upon the *Visibility capability* were not well developed or do not provide the distinctive organisational routines in the respondents' supply chains. Beyond the collection and sharing of data provided by organised into operating routines, other relatively passive experiential processes of learning ("by doing'") as well as more deliberate cognitive and decisional processes which will articulate and codify the knowledge are required (Zollo and Winter, 2002).

On the contrary, the positive relationship of the *internal process* and *external* capabilities with *Agility* may stem, not directly from the microfoundations identified therein, but indirectly because the extra layer of operating routines is in place which builds upon them to achieve higher agility. Again, the survey provides no clue as to the existence of such layer of routines and processes. We posit that the microfoundations involved with *Visibility* have less historical usage and have evolved more recently than those for *Internal process* and *External capabilities*. All of the items which explain the two latter constructs have been in use in organisations involved in producing and transporting physical goods for the last 20 years, whereas, apart from reporting tools involving IT in *Visibility*, the others have been deployed much more recently and the corresponding usage by higher hierarchical rungs may yet be incipient.

A case study of an automotive parts supply chain in the United States supports this argument. Meixell et al. (2008) report that even though valuable information is provided to managers of different levels in the chain, this information is not acted upon leading to a quantifiable financial loss. The study reports that even though managers "typically know about promotions, but [they] may not attempt to reflect the knowledge in their inventory replenishment decisions". This means that the reporting tools implemented are not being correctly used by players along the supply chain. The study also mentions that warehouse managers routinely adjust manually the orders generated by the automated parts inventory system; i.e., the Supply Chain Management system may be in place and connected to the ERP, but other routines are needed to actually take advantage of it. A conclusion of Meixell et al. (2008) is that "managerial knowledge remains underutilised in operational business processes". One may wonder if these higher level routines are in place in that automotive parts supply chain. In any case, none of these manual processes or any others are covered in our survey as lower-order capabilities. They do appear in the *Agility* operational capability (see the description of the items in Table 2).

Having looked at the general picture, we now analyse the impact of two control variables, namely size and economic sector of the respondent's firm.

4.2. Size and economic sector control variables

We considered two control variables. The influence of payroll size (as a proxy for the size of a firm) was tested. The relationship between size and agility's t-value was highly significant at 2.728 and $\beta = -0.167$. The larger the firm, the lower the agility. The R-square increases from 0.365 to 0.392, thus explaining an added 0.026 of variance in agility. The relations hypothesised as H1 is stronger with $\beta = 0.354$ instead of 0.339, but weaker with $\beta = 0.358$ instead of 0.395 for H3. The t-values are also larger (5.254 and 4.442 for H1 and H3 respectively). However, H2 is still not validated as the t-value at 1.013 does not get large enough to make the influence of Visibility capabilities over agility relevant.

We venture an explanation for the surprising negative impact of the respondent's firm size on agility. A supply chain manager in the driving seat of a large firm, when considering this firm as the focal firm of a supply chain, may have powerful levers and resources to try and impose the best strategies on the other partners, but he also has to reach out to a much larger network involving several links upstream and downstream of the chain. There may be a perception, conveyed through the answers to the survey, that the supply chain does not rank well on the ensuing agility components. Remember that agility is the ability to (a) evolve constantly following the rate of innovation in the market; (b) enable the supply chain to address the customers' requirement through the complementarities of the sales channels; (c) anticipate major market changes with good sales forecasts; (d) review Information Systems parameters to adapt to market conditions (see Table 2). On the contrary, the supply chain manager of a small firm contends with a much smaller number of partners and is much nimbler in adapting to market fluctuations and customer demands. Further research is required to verify this insight.

We now present the results of the analysis of the data according to the economic sector of the respondent's firm. As several authors mention that comprehensive implementation and usage of sophisticated systems and processes increases with the size of the firm, we ran the model using the employee payroll number as a proxy for the size of the respondent's firm. We confirm that firm size has indeed a positive and relevant influence on all three lower order capabilities with β ranging between 0.162 and 0.198 and t-values between 2.66 and 3.03. 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 the composite reliabilities and average variance explained reported in Table 6, it appears that the model, based upon the data provided by respondents, can be considered valid except for the *Retail* sector.

To make the results comparable between the three analyses, we have re-evaluated the path results. The variance based SEM path model results are presented in Table 7.

The correlation factors for the whole sample is presented in Table 8. Those for the 3 sectors are listed in Tables 9–11 with the square root of AVE being indicated on the diagonal. The square root of AVE is always greater than the correlation among the latent variable scores with respect to its corresponding row and column values except for the food sector where External capabilities have a marginally higher correlation factor than the square root of the agility AVE (0.670 vs. 0.650).

The relationships linking the lower order capabilities to the operational ones differ according to the economic sector. Those that exist are mostly stronger when looked at by sector and generally *explain more of the variance* of the operational capabilities

Table 7
Path coefficients, results of hypotheses tests and Goodness of Fit (Tenenhaus et al., 2005) for all respondents using the economic sector as control variable.

Relationships			All 171	Indust. 41	Retail 44	Food 30
Extern.–agility	H1	β	**0.339**	0.256	**0.371****	**0.512****
		t	4.773	1.309	2.132	2.870
Visib.–agility	H2	β	−0.076	−0.061	−0.015	0.010
		t	0.726	0.929	0.304	0.084
Intern.–agility	H3	β	**0.395****	**0.434****	**0.405****	0.296
		t	4.116	2.921	2.608	1.096
Agility R^2			0.365	0.434	0.352	0.496
Goodness of Fit			**0.475**	**0.503**	**0.453**	**0.582**

*: $p < 0.05$.
**: $p < 0.01$.

Table 8
Discriminant validity for the whole sample (square root of AVE on diagonal, the case where this root is less than the correlation coefficients between latent variables the latter is marked in bold).

Construct/ control variables		1	2	3	4
Agility	1	0.698			
External	2	0.431	0.647		
Visibility	4	0.516	0.625	**0.594**	
Internal	5	0.348	0.348	**0.622**	0.844

Table 9
Discriminant validity for the *industry* sector (square root of AVE on diagonal).

Construct	Agility	External	Visib	Internal
Agility	0.749			
External	0.453	0.662		
Visibility	0.352	0.558	0.707	
Internal	0.631	0.526	0.645	0.899

Table 10
Discriminant validity for the *retail* sector (square root of AVE on diagonal).

Construct	Agility	External	Visib	Internal
Agility	0.687			
External	0.523	0.643		
Visib	0.300	0.538	0.665	
Internal	0.552	0.468	0.394	0.836

Table 11
Discriminant validity for the *food* sector (square root of AVE on diagonal, the case where this root is less than the correlation coefficients between latent variables the latter is marked in bold).

Construct	Agility	External	Visib	Internal
Agility	0.650			
External	**0.670**	0.738		
Visib	0.401	0.567	0.766	
Internal	0.523	0.503	0.322	0.958

than when the whole population is taken into consideration (this can be seen from the R-square for the inner endogenous variable).

We note that H1 is not validated for Industry and H3 for the Food sector. H2 is invalidated in all three sectors.

Given this lack of support even at the $p < 0.05$ level, we did a post hoc *power analysis* using the sub-sample number of records (Baroudi and Orlikowski, 1989). This test is highly sensitive to the size of the sample so we expected it to cast more light on the absence of validation. For Industry, the absence of a relationship between *Visibility capabilities* and *Agility* can be accepted with a 96.99% certainty at $p \leq 0.01$. For the Retail sector, the lack of correlation of *Visibility capabilities* with *Agility* can be accepted at 96.91% with $p = 0.01$. Finally, in the case of the Food & beverages sector, given a sample size of 30, we cannot discard that *Visibility capabilities* has no influence on *Agility* (the difference is due to the R-square score: at 0.500 for *Agility*), with 3 predictors at $p \leq 0.01$).

When comparing the *Industry* sector with the whole sample we note that *Internal capabilities* provide a stronger contribution than for the whole sample to *Agility*, whereas *External capabilities* have a weaker impact on *Agility*. Again, in no industrial sector does *Visibility capabilities* influence *Agility*, confirming the full sample result.

The *Retail* sector applies *External capabilities* and *Internal capabilities* for substantial effect to achieve *Agility* (explaining 45.3% of its variance).

The *Food* sector also deploys *External capabilities* and *Internal capabilities* to achieve *Agility* to good effect (R-square = 0.582). Further investigation using bigger samples is needed to consolidate these results.

Are these differences between contributions of lower-order capabilities to agility according to the sector significant? Applying a two-tailed test, we found that none of the differences in path weights between sectors were statistically relevant. This indicates that either the samples were too small or that there was no actual difference in influence of the capabilities on agility.

5. Discussion and concluding remarks

In this paper, we have positioned ourselves from the point of view of the supply chain manager to understand how his actions, her/his decisions, the practices s/he applies, the routines s/he sets up, the collaborative and coordination effort and resources that s/he builds upon contribute to the agility of the supply chain to which her/his firm belongs. Three constructs were identified which represent lower order capabilities. These capabilities in turn enhance the agility of the whole supply chain (Yusuf et al., 1999; Lee, 2004; Swafford et al., 2006). In this way we substantiate the theory-driven conceptual model of supply chain agility regarded as a contributing factor of competitive advantage (Li et al., 2008; Chang and Grimm, 2006; Wisner, 2003).

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. The responses are perceptual in nature. This may lead to three possible biases. First, respondents may be unwilling or unable to recognise poor abilities in their supply chains, leading to exaggerated evaluations. Second, respondents may have a limited or localised 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 manager may enhance an operational capability by using particular sets of managerial routines and processes. We find strong indications that these results differ substantially from previous results. Our contributions are the following.

First, the models converge in validating H1 and H3. When controlling for the economic sector, results are more nuanced,

even if no statistical evidence was found for a real effect. Our results show that to enhance *Agility*, the best way is to deploy *External capabilities* and *Internal capabilities*. *External capabilities* are represented by the streamlining or resizing of inventories, deploying ECR and VMI together with logistics software bundles[3] thus corroborating the input provided by supply chain professionals of the supply chain case in Agarwal et al. (2006). This confirms also results reported in Agarwal et al. (2007) (interpretative structural modelling) where information drivers provided by EDI, "means of information" and data accuracy should enhance agility. This can be explained by the fact that their definition of IT is to consider that IT is a factor in (a) increasing the adequacy, accuracy, accessibility, timeliness of information; (b) improving the ability to develop and execute a coordinated plan throughout the supply chain. This set of processes must be combined with *Internal process capabilities*: Sales and Operations Planning and increased accuracy in both forecasting of demand and planning of all internal and external activities of the supply chain. These results support Sen (2008) and Gunasekaran (1998).

Second, *Visibility capabilities*, as described by the combination of an ERP system together with other supply chain management software, tracking and tracing of goods flows, reporting tools and web collaborative platforms apparently are not enough to enhance agility in a supply chain.

As Visibility represent managerial processes in supply chain, this result sheds also a different light on the *process compliance* as employed in Blome and Schoenherr (2013). In this paper, it is considered to be "the vehicle, foundation or infrastructure with which supply- and demand-side competence is most effectively developed and deployed into supply chain agility.[…] well-defined and controlled processes are considered essential for improving supply chain capabilities and performance of a firm".

We contend that these practices which generate *External* and *Internal capabilities* are the inputs upon which higher value routines generate *Agility*. On the contrary, the *Visibility capability*, even though deployed and in use, still lacks this added layer of routines with which Agility would be also generated. As suggested earlier, this may be due to the fact that the processes involved span organisation boundaries and the higher level processes involving upper management have had less time to use their output efficiently or completely. The output of the integration of the ERP with other SCM software, Track & Trace, reporting and web collaborative tools and processes all add substantially to the well identified "information overload". Additionally, as said in Teece (2007), "best practices that are already widely adopted cannot by themselves in a competitive market situation enable an enterprise to earn more than its cost of capital, or outperform its competitors".

Using the Dynamic Capabilities approach, this empirical survey has highlighted the critical linkage value between specific lower order capabilities and operational capabilities in a supply chain according to the industrial sector. The results call for additional research in three directions. (a) Understanding if agility can be enhanced differently according to the economic sector. (b) Understanding how those operational capabilities can be combined with dynamic ones and linked to competitive advantage. (c) More cross-cultural empirical research with large samples is called for to establish if the results found for France can be extended to other countries.

This paper provides a research framework and results that build upon earlier literature about agility in supply chains. It

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[3] See the example of Nordstrom and its improved multichannel capabilities which enable a customer to order an article on the web and pick it up at the store. This meant continuously monitoring inventories and updating forecasts to match fickle demand. Reported in the New York Times and Logistics Viewpoints in February 2011.

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