The path of innovation: purchasing and supplier involvement into new product development

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Abstract

In many industries innovation has become the most important critical success factor to compete: the rapid change of technology, shortened product lifecycles, and the market globalization renewed executives' focus on new product development (NPD) processes.

In this scenario, suppliers and – later – purchasing department involvement into innovation processes has been recognized as a potential source of sustainable competitive advantage, as innovation requires to manage external as well as internal knowledge. However, the literature is not fully consistent.

This paper aims to investigate the effects of supplier collaboration as well as the enabling characteristics that the purchasing function might have (i.e. purchasing knowledge and strategic sourcing) on the firm innovation performance. Two important aspects are also considered: first, the level of technological uncertainty related to the purchase is explored as an important contingent factor that might influence the firm's innovation objectives as well as the emphasis on supplier collaboration or strategic sourcing; secondly, companies adopt different buying behaviors according to the type of purchasing category considered, therefore this is the unit of analysis for this research.

Towards this end, we develop a theoretical framework and test it through a survey conducted on a sample of 498 companies worldwide. Results show that innovation, as a category priority, does lead to emphasize supplier collaboration and strategic sourcing which, in turn, ensure better innovation performance. Empirical evidence also shows that, on the one hand, adequate purchasing (managers) knowledge enables greater supplier collaboration and strategic sourcing; on the other hand, category technological uncertainty put greater emphasis on category innovation's objectives as well as on supplier collaboration.

Keywords: innovation; supplier collaboration; strategic sourcing; purchasing knowledge; technological uncertainty.

1 Introduction

"Not to innovate is to die", says a famous quote by Freeman & Soete (1997), who clearly emphasized the pivotal role innovation plays in determining the survival and success of modern organizations. Starting from the 1990s, market globalization, faster technology evolution, shortened product lifecycles, and aggressive competition renewed executives' focus on innovation as one of main sources of sustainable competitive advantage. However, "companies rarely innovate by themselves" (Edquist, 1997): innovation is the product of a network rather than of a single person or firm. This idea paved the way to the open innovation paradigm (Chesbrough & Crowther, 2006) and to collaborative innovation as a way to support the innovation effort by accessing external resources (e.g., knowledge, technology, human workforce) that the focal firm might lack (Verganti, 2008). This study focuses on new product development (NPD) capabilities, which is one of the facets of innovation[1].

In this scenario, supplier and – later – purchasing department involvement into innovation processes has been recognized as a potential source of sustainable competitive advantage, even though the literature is not fully consistent. Among external sources of innovation, suppliers have a crucial role in improving firms' innovation performance (e.g., Clark, 1989; Handfield et al., 1999): they know their customers' business and mechanisms for knowledge transfer from supplier to customer are typically in place (Yu, 2008). Suppliers' contribution assumes various forms, such as supply of innovative components and product/process technologies (Walter et al., 2003), or joint product development projects (Bonaccorsi & Lipparini, 1994). Indeed, earlier and more extensive supplier involvement emerged as one of the most effective ways to improve NPD process performance (Clark, 1989; Ragatz et al., 2002). However, engaging suppliers into collaborative innovation is not so easy to achieve (Krause, 1999; Smals & Smits, 2012). Firstly, the availability of highly-skilled suppliers is not sufficient per se: both buyer and supplier must be willing to participate into shared NPD projects and possess the necessary experience and capabilities to do so (Monczka et al., 2000; Schiele, 2006). Secondly, the interest in the subject by an increasing number of firms, the concentration of supply markets, the increasing outsourcing/offshoring rate are shifting the bargaining power from buyers to suppliers, who becomes highly selective and resistant to adapt to customers' requests (Christiansen & Maltz, 2002). In order to have access to the best resources, such as brainpower, the customer must increase its level of attractiveness (Schiele et al., 2011). Firms' top management is therefore dedicating more resources to engage suppliers beyond traditional power-dominated relations (Cox, 1999) and to enhance their knowledge of supply markets as well as capabilities of scouting appropriate suppliers, i.e., suppliers with the right skills (Modi & Mabert, 2007).

All in all, we might recognize a (chrono)logical trend in the literature (see Table 1): as innovation literature emphasized the diffusion of collaborative innovation, this inspired operations management literature to look at inter-firm collaborations as a potential source of innovation, paving the way to a broad stream of studies dedicated to supplier involvement (Dowlatshahi, 1998), development (Anderson & Weitz, 1992), and integration (Das et al., 2006). A naturally consequent stage of research investigates what role the purchasing department plays in innovation, as it has become the common interface with the supply base (Ellram & Pearson, 1993; Araujo et al. 1999).

Although the literature recognizes that the purchasing department might represent a critical cornerstone for adapting innovation from suppliers and stewarding it through the product

[1]For an exhaustive review of different meanings of innovation and innovativeness the reader might refer to Garcia & Calantone (2002).

lifecycle, a broad empirical analysis of the effect of supplier and purchasing involvement on the innovation performance is still missing.

Innovation sourcing is also a relevant topic for managers, as testified by a recent report from CAPS research (2011) as well as popular reports published by The Boston Consulting Group (Arndt & Einhorn, 2010) and the Harvard Business Review (Prahalad & Mashelkar, 2010), which recognize innovation is making a comeback as a high-priority corporate strategy, after the great recession.

The aim of this article is to increase our understanding of the specific processes that are necessary to effectively manage the collaboration with suppliers, constantly monitor supply markets, and leverage purchasing knowledge in order to increase innovation outcomes. This is original in two respects: first of all, extant literature does not test the simultaneous and reciprocal effect of supplier and purchasing involvement in improving NPD. Instead, we argue that – in order to innovate – the firm must manage knowledge that is inside and outside its boundaries (Lichtenthaler, 2009; Chen et al., 2009). Secondly, research so far is largely based on case studies rather than on large-scale surveys, thus limiting generalizability.

Complementary to the majority of existing research, this study investigates several antecedents of product innovation (including both supplier and purchasing related factors) and their mutual relations. In particular, we theorize that *purchasing knowledge* is key to make the most of the firm's supply base as it allows greater *supplier collaboration* as well as *strategic sourcing* effort. This assumption is consistent with several studies linking the firm's innovation capability to the knowledge it possesses (Grant, 1996; Subramaniam & Youndt, 2005). Moreover, such antecedents are linked to two main driving factors: the level of *technological uncertainty* related to the product/service exchanged between buyer and supplier and the firm's *innovation objectives*.

The article is organised as follows. Table 1 summarizes previous literature according to the three main streams of interest for the study. Next, the theoretical background and research hypotheses are explained, followed by the research method (i.e., the survey and measures used). The last three sections present data analysis, discuss results, and summarise main conclusions respectively.

Insert Table1 here

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2 Theoretical background

Compared to the widespread literature on supplier involvement and its potential benefit on the NPD process, relatively smaller and more recent attention has been paid to the role of the purchasing department, which is increasingly taking the lead in the management of supply relationship. It is still not clear whether or not the purchasing department significantly contributes to the innovation outcomes (Mendez & Pearson, 1994); more specifically, we wonder whether or not purchasing professionals' knowledge facilitate the process of supplier involvement and therefore the firm capability to innovate.

In this context, several studies emphasize the role technological uncertainty plays in stressing innovation as a critical success factor to compete, as well as the need to access other partners' know–how and complementary technologies (e.g. Lancioni & Chandran, 2009; Martín-de Castro et al., 2011).

These arguments are in line with the managerial literature: in order to foster innovation sourcing, CAPS research (2011) recommends establishing supply network relationships as well as systems, processes and capabilities to speed up innovation ideas to commercialization. The proposed set of main supply strategies contains the crucial aspects addressed by the

research framework of this study: robust category strategy development and execution; early supply/supplier engagement in new product development; supplier relationship management with a focus on trust building and communication to develop preferred customer status and first access to supplier innovations; supply base management to assure access to a "bookshelf" of key suppliers with leading innovation capabilities; equitable contracting and risk/reward approaches; systems and processes to acquire, evaluate and implement supplier innovations.

Our theoretical framework grounds on the Resource Based View of the firm (RBV). The theory suggests that possessing the appropriate resources can lead to competitive advantage and better performance (Barney, 1986, 1991). According to Day and Wensley (1988), not only does a firm need to attain superior resources (i.e., "do more or do better, or both, than its competitors") but it also needs to convert those resources into positional advantages, which can then lead to higher performance. Examples of positional advantages are the execution of activities at a lower cost than competitors, the offering of a product with innovative features, and the delivery of such with superior execution. These activities offer value added benefits that customers would pay a price premium to obtain, and thus enable a firm to achieve superior performance.

Drawing on this conception, which is one of the most cited in the literature (Song et al., 2011), we see innovation as a positional advantage. The study is not meant to show that innovation positional advantage is precursor of success, as this is already debated in the literature (Chen et al., 2010; Henard & Szymanski, 2001; Song and Parry, 1999; Swink & Song, 2007; Song et al., 2011). Instead, we examine a set of antecedents (i.e., sources of advantage) by considering the tasks the firm must accomplish in order to achieve success with NPD: define appropriate procedures for *supplier collaboration*, master the *strategic sourcing* process, and possess compelling *purchasing knowledge*. Following Day & Wensley (1988), we argue that internal (i.e., purchasing) and external resources (i.e., suppliers) allow the firm to build the positional advantage. Furthermore, we introduce two drivers (i.e., *innovation objectives* and *technological uncertainty*) leading to look for specific sources of advantage. The resulting theoretical model is shown in Figure 1.

These research issues are further complicated by the fact that companies frequently buy differently by category (i.e., a specific group of items, also known as a "purchasing group" or "commodity"). For instance, differences are noted between direct and indirect goods and among categories that are positioned differently within the Kraljic matrix (Kraljic, 1983). The focus of NPD literature on single projects, related to specific products or services is consistent with the idea that different categories should be studied separately: as different purchasing group requires different strategic management approaches, different collaboration mechanisms will be implemented. This consideration introduces a challenge in terms of the unit of analysis in the sense that it requires a focus on the category level rather than on the overall company portfolio of expenditures or different transactions with the same supplier. Therefore, in this study we are adopting a category perspective.

2.1 Effect of technological uncertainty on innovation objectives

Technological uncertainty can be defined as the frequency of expected changes in specifications of purchased components (Walker, 1987). Most scholars recognize technological uncertainty as one of the main variables affecting the firm innovation strategy (Petersen et al., 2003; Oh, 2008; Robertson et al., 1986; Cassiman et al., 2002). For example, innovation emphasizes the need for supplier integration: involving key suppliers early in NPD allows organizations to hedge its exposure against technological risk by improving the integration capability of new technologies into final products (Ettlie & Pavlou, 2006; Bozdogan et al., 1998), and creating a bookshelf of embryonic technological innovations

which may result useful in the future (Schilling, 2008). Ragatz et al. (2002) along with Powell et al. (1996) specifically face this issue in proposing a supplier involvement framework: both studies conclude that NPD collaboration is particularly important in a context characterized by rapid technological change as it allows leveraging on suppliers knowledge and expertise.

The literature does not deliver one clear and shared definition of innovation or innovativeness. However, authors like Ward et al. (1990) or Krause (2001) clarify that innovation must be added to the list of operational competitive priorities originally defined by Hayes & Wheelwright (1984) (i.e., cost, time, quality, and flexibility). Garcia & Calantone (2002) account for more than fifteen different constructs (and fifty-one scale items) used to model product innovativeness. For this study, we share the OECD (1991) definition of innovation pointed out by the authors: "innovation is an iterative process initiated by the perception of a new market and/or new service opportunity for a technology-based invention which leads to development, production, and marketing tasks striving for the commercial success of the invention". We also share the common view in the literature that associates innovation to the NPD effort. As a result, we deal with the firm's innovation objectives and – correspondingly – with innovation performance in terms of the NPD process speed (i.e. time to market) and frequency (i.e. rate of new products introduction). Our conclusions will be therefore limited to this context.

A variety of strategic perspectives, such as time-based competition, first-mover advantage, fast-follower strategy, and fast product development cycle time, have emphasized the importance of NPD speed (Kessler & Chakrabarti, 1996; Menon et al., 2002; Stalk & Hout, 1990). This argument raises some questions regarding drivers as well as enablers of NPD process speed. As a matter of fact, Chen et al. (2004) argue that "an understanding of the salient and cross-situationally consistent antecedents of NPD speed is necessary and will have important research and practical implications".

From a purchasing category perspective, we expect that different levels of technological uncertainty (meant as novelty and rate of change of the technology involved in the category for the buying firm) influence the category strategy: when uncertainty is high, purchasing activities might be affected in different ways as firms need to become more flexible and proactive to cope with such uncertainty (Pope & Prasad, 1998; Han et al., 1993; McIvor & Humphreys, 2004).

We therefore assume the following:

H1. A higher level of technological uncertainty determines a greater emphasis on innovation objectives.

2.2 Effect of innovation objectives on supplier collaboration and strategic sourcing

When innovation is considered a competitive priority, it is expected to be transferred from business to purchasing and ultimately to the category level, leading to emphasize supply management in order to improve component innovation rate and time–to–market (Teece, 2010; Bidault et al., 1998).

As for the practices that follow an innovation strategy, Van Echtelt et al. (2008) suggest that "the process of selecting the suppliers and determining their extent of involvement are critical in anticipating and addressing the technical and organizational risks associated with particular choices about suppliers and workload outsourcing". The authors propose to distinguish between an operational, project-related, short-term setting and a strategic, long-term-oriented setting. The former setting represents the engine to effectively set up and manage joint buyer-supplier development projects and include several processes, such as coordinating development activities with suppliers, feeding back supplier performance, or designing communication interface with suppliers. The latter setting reflects the planning,

execution, and evaluative stages in developing policies and the desired supplier base. Activities included are, for instance, monitoring supply markets, pre-selecting suppliers for NPD, and periodically evaluating guidelines and supply base performance. Both sets of processes, implemented as permanent activities, can contribute to improved collaboration results.

We might therefore link the company orientation to innovation to two main processes characterizing the purchasing activity (i.e, supplier collaboration and strategic sourcing) as they are determinants of NPD outcomes. *Supplier collaboration* reflects Van Echtelt's et al. operational setting, whereas *strategic sourcing* includes processes associated to the strategic setting. Therefore:

H2a. A higher emphasis on innovation objectives positively influences the effort on supplier collaboration.

H2b. A higher emphasis on innovation objectives positively influences the effort on strategic sourcing.

2.3 Effect of technological uncertainty on supplier collaboration and strategic sourcing

Several authors show that buyer-supplier interactions are essential in technology-based industrial markets (Athaide & Zhang, 2011; Huggins, 2010). Therefore we expect that supplier collaboration and strategic sourcing are particularly relevant when the complexity of the purchase, the degree of redesign since the last purchase, and the contribution of the subsystem to the functionality of the final product are high (Wynstra & Ten Pierick, 2000): in this case, firms will try to optimize their capability to involve suppliers into NPD and, consequently, innovate their final products by leveraging on suppliers specialized capabilities and know–how (Dowlatshahi, 1998; Schilling 2008; van Echtelt et al., 2008). In other words, the uncertainty related to the good/service exchanged also matters.

Uncertainty is defined as the lack of information necessary to perform a task (Galbraith, 1977; Premkumar et al., 2005). Resolving or at least minimizing the impact of such uncertainty calls for particular organizational arrangements. Literature has since long suggested that strong communication and coordination mechanisms are a critical instrument to effectively respond to uncertainty (Lawrence & Lorsch, 1967). Recent research looking at supply-chain relations in product development clearly shows the need for communication and tight coordination mechanisms in contexts of uncertainty (Lakemond et al., 2006; Petersen et al., 2003; Sobrero & Roberts, 2001, 2002). For example, Wasti & Liker (1999) show that task uncertainty is a strong predictor for supplier involvement in product design. Song & Thieme (2009) show that, when facing task uncertainty, firms adjust their knowledge boundary by increasing the knowledge overlap with their supply-chain collaborators.

In the context of buyer-supplier relationships, technological uncertainty requires knowledge that might not be available within company boundaries. Therefore, it may result into an active supplier participation in NPD (Handfield et al., 2002; Ragatz et al., 2003). Several authors confirm the importance of exploiting specific partners' knowledge to mitigate the risk associated with applying a technology to a new product (Chakrabarti et al., 1989; Lawless, 1974, Johnston, 2004; Knudsen, 2007). Others emphasize that, under technological uncertainty, companies need to accelerate their know-how acquisition process through collaborations with other parties, in order to enable an effective NPD (Stock et al., 2000; Littler et al., 1998).

Thus, we expect that increasing uncertainty forces companies to leverage supply management capabilities by focusing on core knowledge and competencies (Wernerfelt et al., 1984) and acquiring complementary competencies through suppliers (Wasti & Liker, 1999; Wynstra & Ten Pierich, 2000).

In order to effectively involve suppliers into firm processes, some guidelines deserve to be carefully followed (Henke & Zhang, 2010), such as: involve suppliers in the company's processes, especially product development; demonstrate openness and share information with suppliers in a timely manner; work with suppliers to help them improve their competitiveness in both cost and quality. By following this kind of recommendations, a company can maximize its opportunities to gain innovations from its suppliers' knowledge, skills and capabilities, thereby increasing its competitive advantages in the marketplace while strengthening its supplier working relations and strengthening the suppliers as well.

Naturally, evidence also shows contradictory examples: the need to collaborate emphasized by technological turbulence is not always perceived by managers, who obviously must be aware of environmental uncertainty in first place (Holcomb & Hitt, 2007), and capable to overcome inertia and barriers to collaboration (Calantone et al., 2003). Assuming that these conditions hold, we expect the following:

H3a. A higher level of technological uncertainty positively influences the effort on supplier collaboration.

H3b. A higher level of technological uncertainty positively influences the effort on strategic sourcing.

2.4 Effect of purchasing knowledge on supplier collaboration and strategic sourcing

Some authors suggest that external integration requires specific internal capabilities (Koufteros et al., 2005). In particular, some studies shed light on the role of the purchasing department in managing supplier involvement and the conditions enabling its effective involvement in product development (Anklesaria & Burt, 1987; Atuahene-Gima, 1995; Dowlatshahi, 1992; van Echtelt et al., 2008).

Indeed, the literature about supplier involvement considers different players within the buyer and supplier firm. Among other organizational units, the purchasing department recently received relevant scholars' attention, as it often takes the role of relationship manager (Dowlatshahi, 1992), and its contribution to supplier involvement in NPD is examined by some seminal studies (Bonaccorsi, 1992; Hakansson & Eriksson, 1993; Wognum et al., 2002). Lakemond et al. (2001) define different configurations – and corresponding enabling factors – allowing purchasing integration into NPD. Other authors investigate the role of purchasing for effective supplier integration (Wynstra et al., 2003; Wagner, 2003; McGinnis &Vallopra, 2001; Schiele, 2010).

Few authors (e.g., Atuahene-Gima, 1995; Nijssen et al., 2002) studies driving factors such as the skills of buyers and top management commitment. As suppliers are increasing their importance for manufacturers due to the increasing incidence of purchases (Roberts 2001), purchasing capabilities become crucial (Gadde, 1994; Macbeth, 1994). This is particularly true in the context of NPD collaborations, which increase the dependency on supplier's performance (Anderson & Dekker, 2005). According to Wynstra et al. (1999, 2001), successful supplier integration is ensured by the organization of the purchasing department and adequately skilled human resources. Similarly, other authors and conclude that the likelihood of supplier involved at early stages of NPD increases when purchasing professionals have a good recognition by top management (Hillebrand & Biemans, 2004), are part of the development team (Tracey, 2006), and participate to strategic planning processes (Schiele, 2010). However, a function's role is strictly connected to the level of knowledge and skills owned by its human resources (Jackson et al., 2003; Youndt et al., 1996).

In summary, we expect that the more buyers are competent, specialized, and skilful, the more they will contribute to the NPD process by helping firms to successfully involve suppliers (Wynstra et al., 2001; Wynstra et al., 1999; Schiele, 2006). In particular, a

connection between supplier involvement and purchasing human resource's skills and know–how should be plausible: skilled purchasing professionals are more likely to be involved in the development team and to support coordination with other partners. Furthermore, knowledgeable and mature purchasing professionals are likely to invest a greater portion of their time in strategic activities (such as market scouting and contracting) rather than operational and administrative ones (such as order emission and payment) (Chen et al., 2004). Monitoring the supply market and constantly scouting for new sources of innovation is strictly dependent upon the availability of suitable knowledge and skills within the purchasing department. As a matter of fact, inexperienced and unskilled buyers are expected to take care of clerical rather than highly value adding activities (Cousins & Spekman, 2003). We are therefore expecting that:

H4a. A higher level of purchasing knowledge positively influences the effort on supplier collaboration.

H4b. A higher level of purchasing knowledge positively influences the effort on strategic sourcing.

2.5 Effect of supplier collaboration, strategic sourcing, and purchasing knowledge on innovation performance

The literature largely confirms that companies increasingly rely on their supply base to achieve innovation (Inemek & Matthyssens, 2012; Chen et al., 2010; Koufteros & Marcoulides, 2006; Petersen et al., 2005; Primo & Amundson, 2002). These studies, however, mainly regard large firms and provide mixed results. It is known, for instance, that failure rates in NPD might even approach 80 percent (Cooper 1999). This is worrisome, given that a large share of firm value comes from newly developed products or services (Mahajan & Wind, 1991; Dowlatshahi, 1998; Birou & Fawcett, 1994). Considering the increasing outsourcing rate (Quinn & Hilmer, 1994), it is not surprising that research on supplier collaboration has greatly expanded during the last 30 years. In particular, scholars have been focusing on different facets of collaborations, including supplier involvement in NPD, supplier development, and supplier integration.

Supplier involvement in NPD concerns the integration of suppliers' capabilities into NPD projects (Dowlatshahi, 1998), the tasks they are able to carry out on behalf of the customer, and the responsibilities they assume for the development of a part, process or service (van Echtelt et al., 2008). On the one hand, supplier involvement potentially results in lower costs, higher quality, faster NPD time, and so on (see for instance Clark, 1989; Ragatz et al., 2002; Petersen et al., 2003; Wagner &Hoegl, 2006). On the other hand, longer development times and increased costs (Ragatz et al., 1997) as well as dissatisfaction with NPD outcomes (Handfield et al., 1999) might occur.

Supplier development involves a short-term sacrifice by the buying firm and the supplier; both firms must allocate resources and personnel time to the effort. Supplier development is defined as the set of activities undertaken by the buying firms in their efforts to measure and improve the products or services they receive from their suppliers and is associated to supplier performance improvement (Prahinski & Benton, 2004).

Finally, we know that the NPD process can benefit from supply chain integration, that is the extent to which a firm is strategically interconnected and aligned with its supply chain partners (Das et al., 2006; Jayaram et al., 2010). Multiple studies associate the supply chain integration with increased performance (e.g., Frohlich & Westbrook, 2001; Ragatz et al., 2002; Braunscheidel & Suresh, 2009; Flynn et al., 2010; Wong et al., 2011; Zhao et al., 2011). In general, scholars argue that benefits of integration outweigh its associated costs, leading to greater operational performance (Primo & Amundson, 2002; Koufteros et al., 2007,

Song & Di Benedetto, 2008).

All in all, we assume that supplier collaboration enhances the firm's innovation performance. Indeed, the literature reports several potential advantages related to supplier collaboration, including: improved efficiency and effectiveness of future project collaboration (Dyer & Ouchi, 1993), alignment of technological strategies with suppliers (Bonaccorsi, 1992), better and faster access to technological resources and knowledge (Ragatz et al., 1997; Bonaccorsi, 1997), lead time reduction (Clark, 1989; Wasti & Liker, 1997; Ragatz et al. 1997), reduced development costs and time (Clark, 1989; Hartley et al., 1997), better product performance and design (Bonaccorsi & Lipparini, 1994; Kamath & Liker, 1994; Ragatz et al., 1997), better product quality (Dowlatshahi, 1992). In particular, we ground on studies showing that supplier collaboration could shorten development cycle time (Chen et al., 2010; Millson et al., 1992; Song & Parry, 1999). Failure to involve supplier in production decisions may lead to high costs and low production capacity (Chen et al., 2010). Further, supplier collaboration enables product differentiation by obtaining information and expertise regarding new ideas and technologies that can help developing a highly innovative product (Song & Di Benedetto, 2008). In other words:

H5a. *A greater effort on supplier collaboration positively influences innovation performance*.

As noted previously, van Echtelt et al. (2008) distinguish between operational and strategic processes for supplier involvement: not only NPD requires to jointly perform operational activities with suppliers; some strategic antecedents of NPD performance should also be considered, such as strategic sourcing and purchasing knowledge. The former refers to activities like reverse marketing and supplier selection: Petersen et al. (2005) noted that selecting the "right" supplier (good match of capabilities and culture) leads to improved performance. The latter refers to skills and competences of purchasing managers, who are often in charge of strategic tasks related to NPD. As a matter of fact, Johnsen (2009) shows that the latest research on the collaborative NPD process emphasizes the need for supplier selection (e.g., Song & Benedetto, 2008; Schiele, 2006), relationship development and adaptation (e.g., Petersen et al., 2003; Ragatz et al., 2002; Primo & Amundson, 2002), and internal customer capabilities (e.g., Ragatz et al., 1997; Takeishi, 2001; Hillebrand & Biemans, 2004). We therefore expect that:

H5b. *A greater effort on strategic sourcing positively influences innovation performance*.

H5c. *A higher level of purchasing knowledge positively influences innovation performance*.

2.6 A final note on the model

Aggregating several empirical studies, Chen et al. (2010) provide theoretical support to prominent models of new product performance. The model we propose (see Figure 1) is consistent with the strategic orientation and organizational capability model drawn by Kessler & Chakrabarti (1996) as well as the centrifugal and centripetal model by Sheremata (2000). Moreover, the study shows that NPD speed is a primary indicator of firm innovation performance, and is essential for the success, survival, and renewal of firms in turbulent and uncertain environments (Eisenhardt & Tabrizi, 1995; Kessler & Chakrabarti, 1996). Therefore, it is important to identify salient and cross-situational factors that facilitate or hinder fast development of new products. To this end, Chen et al. (2010) identify 17 most frequently examined antecedents of NPD speed and cluster them into four groups of

characteristics: *project* (i.e. attributes of the NPD projects, such as newness and complexity), *process* (i.e. process formalization and concurrency, iteration and learning), *strategy* (i.e. emphasis on speed, top management support, and goal clarity), and *team* (i.e. staff and structure, reflecting people expertise and team organization). These groups are fully consistent with the antecedents we are addressing in this study: as for the *project* group we consider the technological uncertainty of the purchase; whereas supplier collaboration and strategic sourcing can be associated to the *process* group; innovation objectives to the *strategy* group, and, finally, purchasing knowledge to the *team* group. Furthermore, we argue that a path can be identified among these antecedents, as shown in Figure 1.

Insert Figure 1 here
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3 Methodology

3.1 Sample and data collection

The hypotheses were tested using data collected in winter 2009/2010 in ten countries in Europe and North America (Canada, Finland, France, Germany, Italy, the Netherlands, Spain, Sweden, United Kingdom, and the United States of America) through an online survey questionnaire about purchasing priorities, purchasing practices, and purchasing performance, using constructs derived from the literature.

The English version of the questionnaire was translated into different languages using the TRAPD (Translation, Review, Adjudication, Pre-testing and Documentation) procedure (Harkness et al., 2004) and subsequently tested by submitting it to a couple of purchasing executives in each country to check the clarity of the questions. The final version of the survey tool was uploaded onto the project web-site and made visible only to respondents selected in the sampling procedure. The Internet survey offers higher levels of accuracy and reduces missing values due to either the respondent or some data entry mistakes (Boyer et al., 2002). Firms were sampled from the membership lists of the corresponding national purchasing associations. Sampling criteria were pre-agreed among the participating researchers. 65.7% of the companies in the sample are from the manufacturing sector, even though other industries are represented (see the Appendix). The corresponding firms were first contacted and asked for participation. Reminder e-mails and telephone calls were conducted after four weeks to those who had not responded. Following other similar key informant-based research studies (Cini et al., 1993; Cousins, 2005), the goal was to find the right person within the organisation who was able to respond to all of the questions about the purchasing strategy, the buyer-supplier relation, purchasing practices and performance. For this reason, mostly CPOs, VPs of Purchasing, Purchasing Directors and Purchasing Managers were involved. The respondents consisted of highly qualified purchasing professionals who had played important roles in the purchasing functions of their firms. After the data collection process, each country cleaned its own data in accordance with a common agreement to build a shared international database. The overall sample is made of 681 usable responses corresponding to an average response rate of 10%, which is reasonable considering the length of the survey. However, only 498 companies provided sufficient information to test the hypotheses stated above (we excluded answers provided by companies that are not performing supplier collaboration and strategic sourcing processes as related to items in Table 3). The targeted companies are of various sizes and are mostly from the manufacturing sector, even if other industries are well represented. Non-respondent bias was tested by identifying

the differences between the first wave of respondents and later returns (Scott & Overton, 1997). The ANOVA shows no significant differences in terms of company size and sectors distribution). In addition, the ten country-specific subsamples were also proved to be appropriate in terms of pooling (Knoppen et al., 2010, 2011). See the Appendix for further details on the sample.

The core part of the survey focuses on a single purchasing category, autonomously selected by the respondent, therefore all the variables included in our analysis refer to this. This is a quite rare approach in Purchasing and Supply Management research, which generally refers to the overall activity of the function. However, since the seminal work of Kraljic (1983), the need for differentiated approach to different categories is clearly recognized, therefore this is the most suitable level of analysis for our research. In our sample, respondents mainly address direct expenditures (about 80% of cases), whereas indirect (15%) and capital (5%) expenditures are less represented. Moreover, categories are homogeneously spread across different types in terms of strategic importance and supply risk, with a prevalence of strategic items.

Given that we relied on a single respondent design, we controlled for common method bias in two ways: through the design of the study and through statistical control (Podsakoff et al., 2003). Regarding the survey, the research project was labelled as a broad overview of purchasing management and purchasing practices adoption. Therefore no explicit reference to the intention to test antecedents of innovation performance was evident. Thus, respondents' attention was not drawn to the relationships being targeted in this study. Questions including items and constructs related to each other in the general model were also separated in the questionnaire in order to prevent respondents from developing their own theories about possible cause-effect relationships. Furthermore, the questionnaire was carefully created and pretested and respondents were assured of strict confidentiality. Finally, we used different scales and formats for the independent and the criterion measures (Podsakoff et al., 2003). As a second mean to ensure against common method bias, we examined the unrotated factor solution (Podsakoff & Organ, 1986). We were able to determine four factors that account within a range of 6 to 28 percent for the variance in the measures. Consequently, neither a single nor a general factor is likely to account for the majority of the covariance among the measures.

3.2 Measures and their analysis

Hypotheses were tested using structural equation modelling (SEM) with the maximum likelihood (ML) estimation method. Most SEM applications described in the literature are analysed with this methodology. The hypothesised model was tested statistically in a simultaneous analysis of the entire system of variables to determine the extent to which it was consistent with the data. Where goodness-of-fit is adequate, the model can be seen as a plausible explanation of postulated interactions between constructs. The research model is analysed and interpreted sequentially: first the assessment of the reliability and validity of the measurement model and secondly the assessment of the structural model (Hulland et al., 1996). Amos version 18 was used to estimate both the measurement model and the structural model. The ML algorithm was used to obtain the paths, the loadings, the weights, and the quality criteria.

The operationalization of the constructs is based on existing measures of e.g. Chesbrough and Crowther (2006), Monczka et al. (2005), Tu et al. (2006) as well as Henke and Zhang (2010), using six and seven point semantic differential scales. Constructs validity and reliability are detailed in Table 3 and 4. In order to measure the category innovation objectives we followed the approach proposed by Hayes & Wheelwright (1984), who consider strategy as a mix of competitive priorities. Innovation as a category priority can

therefore be measured by looking at the rate of introduction of new product/services and time to market (Ward et al., 1990; Lagacé, 2003). Respondents were asked to provide answers on a Likert-like scale ranging from 1 ("Not at all") to 6 ("Completely") regarding to what extent the management had emphasized the need to "improve time-to-market with suppliers" and "improve introduction rates of new/improved products/services" during the previous two years for the chosen category.

The operationalization of category technological uncertainty is based on the approach of Ragatz et al. (2002) and Powel et al. (1996). According to this, each respondent had to rate "The extent to which technologies in this category are new" to his firm, "The extent to which technologies change in this category" and "The extent to which products/services are new" to his firm from 1 ("Extremely low") to 6 ("Extremely high").

Supplier collaboration has been measured by asking respondents to use a Likert-like scale to rate from 1 ("Extremely low") to 6 ("Extremely high") the "level of proficiency of the process (i.e., the level of quality in executing the process)" for the following processes: "*Supplier development*: the process of selecting suppliers for the chosen category as candidates for supplier development, and assisting suppliers in quality and cost improvement projects", "*Supplier involvement into NPD*: the process of managing the involvement of suppliers in the development of (new) products / services / processes / technologies for the chosen category", "*Supplier integration in order fulfillment*: the process of integrating suppliers for the chosen category in operations (e.g. joint production or inventory planning) and/or in the order fulfillment process". This reflects the intention to assess the quality of the buyer-supplier relation in processes that can typically affect innovation performance (e.g. van Echtelt et al., 2008; Chen et al., 2010; Zhao et al. 2011). Similarly, strategic sourcing has been measured by asking the "level of formalization of the process (i.e., to what degree the process is guided by written rules and procedures) for the chosen category" for: "*Supply market analysis*: the process of analyzing the supply market for the chosen category (e.g. searching for new suppliers, supply market structure, technological developments, price developments)", "*Spend analysis*: the process of analyzing the purchasing spend of the chosen category (e.g., current spend, spend developments, contract compliance)", "*Sourcing strategy*: the process of formulating a sourcing strategy for the chosen category", "*Supplier selection and contracting*: the process of sending out request for quotations, tendering /negotiating, and selecting suppliers for the chosen category". This reflects how much is the firm serious about strategic sourcing, provided that the level of formalization is a good proxy of the firm's effort in these processes (Miller, 1982; McCabe, 1987; Kim, 2007; Juha & Pentii, 2008).

The measurement of purchasing professionals' knowledge is based on the approach of Tu et al. (2006), who understand manager knowledge as a vital element of absorptive capacity. According to this, respondents were asked to rank "The knowledge of purchasing manager(s) when making business decisions", "The knowledge of purchasing manager(s) when dealing with new technologies", "The knowledge of purchasing manager(s) when managing daily operations", and "The knowledge of purchasing manager(s) when dealing with human issues (e.g. human resource management, internal and external communications)" each from 1 ("Totally inadequate") to 6 ("Totally adequate").

Finally, in order to test the innovation outcomes of supplier involvement we referred to the established literature, which suggests that suppliers' contribution is expected to speed-up the development process and to improve products/services (either in term of costs or quality) (Clark, 1989; Koufteros et al., 2007; Primo & Amundson, 2002). In order to limit the number of items considered without neglecting constructs reliability we condensed some of the measures used by scholars: respondent have been asked to what extent category performance improved compared to management targets on a Likert-like scale form 1 ("Much worse than target") to 7 ("Much better than target").

After the data collection we verified the measures by assessing reliability and unidimensionality of each of the five constructs, i.e. item-to-total correlations within each construct were examined (Churchill, 1979). In terms of structural equation modelling we followed the two steps of Anderson and Gerbing (1988). Our measurement model was tested with AMOS 18.0 using the maximum likelihood method (Arbuckle, 2009) and is able to provide to a great extent discriminant validity as well as convergent validity (Bagozzi & Yi, 1988; Anderson & Gerbing, 1988; Fornell & Larcker, 1981). Only the composite reliability (CR) of one construct measured is slightly below.70, but still acceptable following Nunnally (1994). CR values of the remaining constructs attest to a great extent internal consistency of the measurement. The average variance extracted for innovation performance is below the threshold of .50 (Fornell & Larcker, 1981; Bagozzi & Yi, 1988), but none of the constructs violates the Fornell-Larcker criterion. Descriptive statistics and inter-correlations are shown in Table 2.

Insert Table 2 here

Following the recommendations of Bagozzi and Yi (1988) as well as Bagozzi and Baumgartner (1994) the quality of our model can be judged as sufficient. Table 3 comprises further results of the confirmatory factor analysis (CFA). All items were affirmed through confirmatory factor analysis (Table 3). The model consists of six multi-item constructs with a total of 18 indicators (see Figure 1). Two possible ways of evaluating model fit are the use of the chi-square goodness-of-fit statistic and the use of other absolute or relative fit indices (Hu & Bentler, 1999). It is quite common in management literature to avoid using the chi-square p-value as this measure is particularly sensitive to sample size and assumptions of normality (Hu & Bentler, 1995). As a consequence other fit indices are preferred to the p-value. Some authors suggest to check for the ratio between chi-square value and degrees of freedom in the model, where cutoffs values ranges from <2 to <5 depending on the investigator (e.g., Byrne, 1989; Kelloway, 1998). Another way to evaluate the fit of a model is to use fit indices that have been offered to supplement the chi-square. Fit indices range from 0 to 1, with values closer to 1 indicating good fit. Hu and Bentler (1999) recommend MLE-based fit indices and also suggest a two-index presentation strategy with, among others, the comparative fit index (CFI), and Gamma hat or root mean square error of approximation (RMSEA). An acceptable threshold for CFI is >0.95 whereas RMSEA is supposed to be lower than 0.05. The CFA reveals a sufficient model fit attested through such fit indices for the measurement model (Bollen, 1989; Shah & Goldstein, 2006): χ^2=146.1; χ^2/d.f.=1.27; RMSEA=.023; CFI=.992.

Insert Table 3 here
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4 Results

The postulated path model produced a sufficient fit to the data (χ^2 = 185.27; χ^2/d.f. = 1.557; RMSEA = .033; CFI =.982). Table 4 shows the results of the hypotheses testing.

Insert Table 4 here

Hypothesis 1 postulates that a higher level of technological uncertainty has a positive effect on the innovation objectives at the purchasing category level. Our results support H1 with a path coefficient of .435 ($p < .001$). According to hypothesis H2a, more emphasis on innovation objectives leads to a higher effort on supplier collaboration. H2a is supported through our results ($\beta = .321$, $p < .001$). Similarly, H2b assumes that a higher emphasis on innovation objectives has a positive impact on strategic sourcing. Our results also provide support for H2b ($\beta = .128$, $p < .05$). The hypotheses H3 refer to the positive influence of technological uncertainty on supplier collaboration (H3a) and on strategic sourcing (H3b). The findings reject H3a ($\beta = .044$, $p = .476$). The hypothesis H3b is supported through our results with a beta coefficient of .197 ($p < .01$).

In regard to the hypotheses H4 we postulate that a higher level purchasing knowledge has a positive effect on the supplier collaboration (H4a) and on strategic sourcing (H4b). Our findings indicate that H4a is supported with a parameter estimate of .340 ($p < .001$) as well as hypothesis H4b ($\beta = .296$, $p < .001$). Finally, the hypotheses H5 follow the argumentation that a higher level of innovation performance can be achieved through more emphasis on supplier collaboration (H5a) and strategic sourcing (H5b), and through a higher level of purchasing knowledge (H5c). Our findings support both H5a ($\beta = .336$, $p < .001$) and H5b ($\beta = .156$, $p < .014$). Surprisingly, H5c is rejected through the results of our analysis ($\beta = .087$, $p = .194$). All path significances and coefficients of determination are illustrated in Table 4.

5 Discussion

The study examines the innovation related processes that are necessary to effectively manage the collaboration with suppliers, monitor supply markets and leverage purchasing knowledge in order to increase innovation outcomes. According to this we are able to derive theoretical and managerial implications from our findings.

5.1 Theoretical implications

We find largely support for our postulated research model. Our analysis is able to identify a definite and positive relation between technological uncertainty and innovative objectives at the purchasing category level, thus confirming the argument claimed by several scholars at the business level: in the case of a high uncertainty the purchasing strategy emphasizes the importance of innovation, therefore the purchasing department must offer enough flexibility enabling the use of proactive purchasing instruments in order to cope with such uncertainty (McIvor & Humphreys, 2004). Additionally, more emphasis on innovation objectives has a positive effect on the dedication to supplier collaboration. At the category level different collaborations within a development project have to be set up and managed in order to achieve technical performance targets and the targeted costs (van Echtelt et al., 2008). Similarly, strengthening innovation objectives positively influences the dedication of strategic sourcing. Companies that concentrate on innovation goals increasingly have to look for help beyond their boundaries which strengthens the importance of strategic sourcing as the interface to the supply market (Lindner et al., 2003). In turn, the study also supports the existence of a substantial and positive link between a higher level of purchasing knowledge and a higher dedication to both supplier collaboration and strategic sourcing. Purchasing managers' knowledge represent an intangible asset which is growing in parallel with purchasing strategic importance within the firm, and which represents a prerequisite for an effective buyer-supplier interface. Competent and skilled buyers can significantly contribute to NPD by being capable to identify valuable supplier knowledge and consequently foster promising supplier collaboration (Johnston, 2004; Knudsen, 2007). Therefore, purchasing knowledge should not be considered as an asset directly affecting innovation performance per se, but rather as an important catalyst.

Interestingly, in the case of a high level of technological uncertainty our results do not support a direct impact on supplier collaboration, but only on strategic sourcing (although an indirect impact through innovation objectives exists). Firms perceiving high technological uncertainty seem to be affected in the quality of buyer-supplier relations, which represent a threat and require appropriate countermeasures. In general, sourcing has to consider different eventualities for reducing risk and ensuring the required knowledge base in dependence to the degree of technological uncertainty. For instance, under the condition of high technological uncertainty the early involvement of key suppliers allows the buying firm to hedge its exposures against technological risk and to accelerate the existing knowledge base for the development of new products (van der Valk & Wynstra, 2005).

We are able to show that a stronger dedication to supplier collaboration has a positive impact on innovation performance. Our findings comply in consequence with the literature on the effects of supplier collaboration which confirm e.g. better product quality and product performance (Bonaccorsi & Lipparini, 1994; Dowlatshahi, 1992; or Ragatz et al., 1997) or better and faster access to resources / knowledge (Bonaccorsi, 1997). Certainly, successful collaboration with vendors must take various factors into account, such as tier structure, inter-company communication, intellectual property agreements and degrees of responsibilities for specific tasks or the alignment of supplier's capabilities with regard to the degree of supplier involvement (Handfield et al., 1999). Further, innovation performance is influenced through a greater dedication to strategic sourcing. According to Petersen et al. (2005), selecting the right supplier and integrating the supplier early into NPD results in a better performance; our findings support this causality but they also fail to show the direct impact of purchasing knowledge on innovation performance. However, in the case of absorptive capacity Chen et al. (2009) identify a positive impact on innovation performance. As mentioned above, the approach of Tu et al. (2006) postulates (purchasing) manager knowledge as a vital element of absorptive capacity. Our results suggest however an indirect impact of purchasing knowledge on innovation, through supplier collaboration and strategic sourcing.

Finally and as a matter of fact, the importance of the purchasing function's role in detecting and promoting innovation potentials from the supply market and its influence on NPD outcomes becomes evident.

5.2 Managerial implications

From a managerial perspective our results have several implications for practitioners in industrial markets. To start with the innovation outcome, supplier collaboration and purchasing involvement in NPD actually leads to improved innovation performance. Previous research has already shown that companies can learn from their suppliers through close relationships (Chen et al., 2009; García-Morales et al., 2007). Our findings supplement this insight by identifying the purchasing department as the catalyst of collaborative innovation. Important success factors are the early involvement of representatives in NPD projects and an integrated evaluation of product design (van Echtelt et al., 2008). A high level of purchasing knowledge can be understood as a prerequisite for success in both supplier collaboration and strategic sourcing. Companies cannot identify capable suppliers or utilize sophisticated purchasing tools without having the corresponding knowledge to do so. Consequently, supply management can represent an innovation function within companies since it is able to take responsibility for the selection of promising suppliers and for the pursuance of new ideas in terms of NPD. Supply management as an innovation function is the impetus of modernization which continuously focuses on new business opportunities and communicates directly to members of the executive board of a company.

Further, key to successful strategic sourcing and supplier collaboration are innovation objectives that are focused, clearly articulated and integrated into strategy and daily processes.

In turn, innovation objectives have to cope with the supply market environment in terms of uncertainty. Innovation objectives that are fully integrated into the supply strategy on the functional level also have to consider the individual and sometimes conflictive objectives on the corresponding category level. To achieve this goal, innovation objectives of a category strategy should be properly communicated to the purchasing professionals. Trainings and incentive schemes in the purchasing function can facilitate to achieve the strategic fit. Supply managers should therefore be reassured regarding positive outcomes out of collaborations with vendors when innovation is a crucial competitive priority.

6 Conclusion and limitations

The study analyzes the effects of different impact factors on companies' innovation performance at the purchasing level. Using structural equation modeling we empirically investigate the impact of technological uncertainty on innovation objectives at the purchasing category level, as well as on supplier collaboration and strategic sourcing activities. Additionally, influences of purchasing (manager) knowledge and strategic sourcing at the category level are considered within our research propositions. Our findings largely suggest acceptance of the postulated model. Previous research (Wynstra et al., 2003; Wagner 2003; McGinnis & Vallopra, 2001) was clear about this possibility, yet largely case based. We instead provide empirical foundations to the positive effect of supplier collaboration, strategic sourcing and purchasing professional knowledge on innovation performance by analyzing a large data set of 498 entries. Based on our findings, purchasing senior managers are therefore advised to take several actions regarding – for instance – purchasing professionals training needs or adequate buyer-supplier collaboration configuration. Further we test the positive role suppliers could play in regard to innovation performance, but also demonstrated the enabling role entrusted to purchasing professionals. We also show that technological uncertainty calls for specific actions from managers in terms of strategic sourcing as well as for mechanisms to avoid negative effects on buyer-supplier relations.

This study has its limitations, some of which will serve as the stimulus for future work. The contribution of purchasing knowledge towards category innovation performance is only indirectly considered within our analysis. Since it is common sense that the purchasing skills are able to provide access to supplier skills, it would be interesting to know to which degree the purchasing department is able to directly influence innovation outcomes at the category level. Similarly, different types of category clusters might be taken into account, in order to test how contingent factors influence the model significance.

Another open issue in the literature deals with possible drawbacks of supplier involvement in terms of development costs. Future research might contribute to answer this question by considering performance trade-offs in the context of collaborative NPD. Our study did not specifically look at small- and medium-sized enterprises (SMEs) and their specific innovation potential. Extending our work to examine SMEs' innovation potentials would shed further light on SME as innovation catalysts.

Finally, we only partially considered purchasing potential contribution to the firm innovation objectives by including purchasing professionals' knowledge as a construct in our model. More in-depth analysis might lead to isolate other factors explaining the buyer-supplier relationship and the purchasing role in it.

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8 Appendix: Sample statistics

Descriptive	Frequency	Percentage	Descriptive	Frequency	Percentage
Country			***Sector***		
Italy	46	9.2	Manufacturing	327	65.7
Netherlands	38	7.6	Transportation, storage and communication	29	5.8
United Kingdom	62	12.4	Wholesale and retail trade	24	4.8
Germany	47	9.4	Construction	23	4.6
Spain	41	8.2	Electricity, gas, and water supply	12	2.4
Sweden	108	21.7	Professional and administrative services	12	2.4
Finland	30	6.0	Human health and social work activities	10	2.0
United States	54	10.8	Financial services	9	1.8
Canada	38	7.6	Public administration and defense	7	1.4
France	34	6.8	Agriculture, forestry, fishing, and mining	6	1.2
			Hotels and restaurants	5	1.0
			Arts, entertainment and recreation	4	0.8
			Other	24	4.8
			Missing	6	1.2
Sales (mln €)			***Respondent position***		
< 50	148	29.7	CPO, VP of purchasing	66	13.3
51-250	138	27.7	Purchasing director	113	22.7
251-500	52	10.4	Purchasing manager	225	45.2
501-750	24	4.8	Senior, Project buyer	42	8.4
751-1000	16	3.2	Buyer, Purchasing agent	24	4.8
> 1000 M€	94	18.9	Other	27	5.4
Missing	26	5.2	Missing	1	0.2
Total	**498**	**100**		**498**	**100**

9 Tables

Table 1: Selected literature on collaborative NPD

Stream	Content	Authors
Open and collaborative innovation	Innovation is the outcome of a collective effort rather than the product of single person or firm.	Edquist 1997; Freeman and Soete 1997; Chesbrough and Crowther 2006; Parker 2000; Tether 2002
Role of suppliers in innovation	Among the possible sources of innovation outside the firm's boundaries, suppliers are one of the most valuable. Suppliers' engagement might have different forms, such as: • Supplier involvement into NPD; • Supplier development; • Supplier integration.	Anderson &Weitz 1992; Bozdogan et al. 1998; Clark 1989; Dowlatshahi 1998, 1999; Handfield et al. 1999; Frohlich& Westbrook 2001; Das et al. 2006; Henke & Zhang 2010; Johnsen 2009; Koufteros et al. 2007; Krause & Wagner 2008; Linder et al. 2003; Nellore 2001; Petersen et al. 2003; Ragatz et al. 1997; Wagner &Hoegl 2006; Wynstra 2003; Jayaram et al. 2010
Role of purchasing in innovation	The purchasing department is the natural interface/coordinator of the supply base, therefore it must be capable to take part into NPD activities.	Carr & Pearson 2002; van Echtelt et al. 2008; Lakemond et al., 2001; McGinnis & Vallopra 2001; Schiele 2010; Wagner 2003; Wynstra 1999, 2000, 2003; Wynstra et al., 2001

Table 2: Correlation matrix

Variables	1	2	3	4	5	6
1. Technological uncertainty	**.721**					
2. Innovation objectives	.424	**.854**				
3. Supplier collaboration	.174	.355	**.775**			
4. Strategic sourcing	.259	.226	.424	**.825**		
5. Purchasing knowledge	.047	.146	.362	.303	**.739**	
6. Innovation performance	.146	.225	.426	.303	.260	**.676**

The square root of the Average Variance Extracted (AVE) is shown in bold on the diagonal. Correlations are in the lower triangle of the matrix.

Table 3: Results of confirmatory factor analysis

First-order construct	Indicator	Loading	CR	AVE
Technological uncertainty	Technologies in this category are new to your firm	0.696	0.765	0.520
	Technologies change in this category	0.728		
	Products/services are new to your firm	0.739		
Innovation objectives	Time-to-market with suppliers	0.715	0.840	0.729
	Introduction rates of new/improved products/services	0.973		
Supplier collaboration	Supplier development	0.725	0.818	0.601
	Supplier involvement into NPD	0.851		
	Supplier integration in order fulfilment	0.744		
Strategic sourcing	Supply market analysis	0.863	0.894	0.681
	Spend analysis	0.861		
	Sourcing strategy	0.865		
	Supplier selection and contracting	0.699		
Purchasing knowledge	When making business decisions	0.721	0.823	0.547
	When dealing with new technologies	0.911		
	Wen managing daily operations	0.505		
	When dealing with human issues	0.763		
Innovation performance	Supplier time-to-market for new or improved prod./serv.	0.643	0.627	0.457
	Level of innovation in products/service from suppliers	0.708		

Fit indexes: *chi-square=146.1; p-value=0.027; chi/d.f.=1.27; CFI=.992; RMSEA=.023*

Table 4: Path analysis parameter estimates

Path			Standard Estimate	p-value	Conclusion
Innovation objectives	<---	Technological uncertainty	.435	***	Fail to reject H1
Supplier collaboration	<---	Innovation objectives	.321	***	Fail to reject H2a
Strategic sourcing	<---	Innovation objectives	.128	.021	Fail to reject H2b
Supplier collaboration	<---	Technological uncertainty	.044	.476	Reject H3a
Strategic sourcing	<---	Technological uncertainty	.197	.002	Fail to reject H3b
Supplier collaboration	<---	Purchasing knowledge	.340	***	Fail to reject H4a
Strategic sourcing	<---	Purchasing knowledge	.296	***	Fail to reject H4b
Innovation performance	<---	Supplier collaboration	.336	***	Fail to reject H5a
Innovation performance	<---	Strategic sourcing	.156	.014	Fail to reject H5b
Innovation performance	<---	Purchasing knowledge	.087	.194	Reject H5c

Fit indexes: *chi-square=185.27; p-value=0.000; chi/d.f.=1.557; CFI=.982; RMSEA=.033*

10 Figures

Figure 1: Theoretical model