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Formalized problem-solving practices and the effects of collaboration with suppliers on a firm's innovative performance

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Abstract

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INTRODUCTION

Innovation is an iterative search and problem-solving process that is characterized by uncertainty, particularly when industry-level knowledge is not available to map and guide a firm's innovation activity (Katila and Chen, 2008). To deal with uncertainty, and to reduce the costs and time to new product development, firms increasingly are adopting both inter-organizational practices, such as collaboration with external actors (Ahuja, 2000; Cassiman and Veugelers, 2002; Powell, Koput, and Smith-Doerr, , 1996) and knowledge management practices (e.g. organized brain storming and problem-solving; reliance upon decision-aiding tools and practices; team work; training and personnel mobility) to foster intra-organizational knowledge creation and transfer (Huber, 1990; Levine, Higgins, and Choi, 2000; Paulus and Yang, 2000).

While extensive literature suggests that inter-organizational and intra-organizational practices may independently lead to remarkable performance gains (Argote and Ingram, 2000; Nonaka and Takeuchi, 1995; Powell et al., 1996), prior research does not provide many insights into how practices that foster *intra-* and *inter-organizational* knowledge creation and transfer, and knowledge recombination, interact and affect performance (van Wijk, Jansen and Lyles, 2008).¹ This is particularly important as firms increasingly rely on external knowledge sources for innovation, and the effect of these practices on the firm innovative and economic performance may also depend on the form in which knowledge development and transfer is organized within the focal firm (Berdrow and Lane, 2003).

Foss, Laursen, and Pedersen (2011) examine how practices aimed at improving employee participation and commitment (notably, intensive vertical and lateral communication, rewarding employees for sharing and acquiring knowledge, and high levels of delegation of decision rights), mediate the contribution of customer collaboration to innovation. While this study extends analyses of inter-organizational knowledge transfer to include the moderating role of organizational practices, it is restricted to a subset of

¹ Van Wijk, et al. (2008) perform a multi-level analysis of 75 studies that examine either inter or intra knowledge transfer processes. They argue that there are no contributions focusing at the interplay between intra and inter organizational practices. They find that not only the antecedents of intra and inter organizational knowledge transfer are different but also the relationship between knowledge transfer and performance is higher at intra-organizational level.

general management practices and does not consider specific practices targeted at innovation development and problem solving, which might directly affect the firm's use of knowledge developed in the collaboration. In addition to this, this study does not analyse the specific contexts (in terms of uncertainty) in which the interaction between inter-organizational and intra-organizational practices is likely to produce the most effective outcomes in terms of innovative performance. This paper addresses both these issues by looking at how Formalized Problem Solving (FPS) practices for product development act as moderators in the relationship between external collaborations and a firm's innovative performance.

We focus on collaboration with suppliers, as an example of inter-organizational practice, because this type of collaboration is considered to be a source of variety of technological solutions to specific problems linked to new products development rather than a source of new ideas, technological options and designs, which may have very long lags to the market (Wagner, 2012). We focus on FPS, as an example of intra-organizational practice, because we understand innovation as a problem solving process entailing the creation, selection and retention of knowledge (Dosi and Grazzi, 2006; Huber, 1991; Levitt and March, 1988; March, 1991). New solutions to specific problems developed in collaborations need to be communicated, transferred and recombined by the firm through its routines and practices - a process called retention, which is moderated by the presence of organizational practices (Hansen, 1999; Mors, 2010; Szulanski, 1996).

As retained solutions developed in collaboration are likely to need some adaptations to the focal firm's context, we contend that the moderating effect of FPS practices varies depending on whether the firm's innovation development process occurs in the presence or in the absence of industry-level knowledge. Specifically, we argue that collaboration with suppliers for new product development provides a firm with an opportunity to increase the variety of solutions that can be considered and tested, and reduces the uncertainty and costs related to innovation (Clark, 1989; Uzzi, 1996; 1997; Wagner, 2012). The marginal benefits of collaboration in terms of reducing uncertainty should be the higher the lower the amount of relevant information already available in the industry (Szulanski, 1996; Uzzi, 1996; 1997; van de Vrande,

Vanhaverbeke, and Duysters, 2009). FPS practices help a firm to search and select among a variety of potential solutions. However, depending on the context, FPS practices unevenly moderate the relationship between collaboration and the benefits from innovation. In the presence of industry level information, existing FPS practices help in the search for and selection among the variety of possible alternatives, in a context that is similar to the one in which the solutions were originally developed. FPS can accelerate the achievement of solutions compatible with those already tried and tested by the focal firm or its competitors. Retention is likely to be smooth (Leonard-Barton, 1992; Tripsas and Gavetti, 2000). In the absence of industry level information, difficulties arise due to the modifications and adaptations needed which require the firm to engage in new learning (Sorenson Rivkin, and Fleming, 2006; Szulanski, 1996). At the same time, FPS practices may prematurely halt the search for alternatives and restrict the use of unconventional knowledge. In this case retention is problematic. FPS practices hinder the ability effectively to use the knowledge gained from collaboration.

Our empirical investigation is based on a sample of 1,596 French manufacturing firms with 10 or more employees that innovated in the three-year period 2004-2006. Our findings suggest: first, that collaboration with suppliers generally improves the innovation performance of firms, though the effect is stronger when there is no available industry-level knowledge; second, that adoption of FPS practices in the presence of industry-level knowledge does not increase the benefits from collaboration; third, that adoption of FPS practices reduces the benefits from collaboration in a context of no available industry-level knowledge.

This study makes several contributions. First, in the context of distributed innovation, it considers the relationships between intra and inter-organizational practices for new product development and their benefits from innovation. Second, it extends recent work (Foss et al., 2011), which has examined the moderating role of practices targeting mostly employee commitment in the benefits from interaction with external actors for innovation, by focusing on the case of formalized practices associated with the specific activities and process of innovation development. Third, by arguing that the performance effect of collaboration with suppliers, as well as the moderating effect of practices fostering intra-organizational

knowledge development and transfer varies depending on the context of the collaboration, we contribute to recent work that argues that the degree of novelty of innovation depends also on whether the innovation development process occurs in a context of presence or absence of industry-level knowledge (Katila and Chen, 2008).

The rest of the paper is organized as follows. We situate our study in the prior literature and develop hypotheses about the effect of collaboration with suppliers on the innovative performance of buyers and on the moderating role of buyers' organizational practices. We describe the data, method and results and offer some conclusions.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Collaboration with suppliers and firms' innovative performance

Prior evidence on inter-firm collaboration has found that a firm's decision to organize its sourcing activities within a shared-governance organization improves a firm's innovative performance. Specifically, collaboration with suppliers has been found to increase product quality and market responsiveness, and to reduce new product development lead times (Chung and Kim, 2003; Clark, 1989; Clark and Fujimoto, 1991; Petersen, Handfield, and Ragatz, 2005). In contexts characterized by increasing competition in global markets, collaboration with suppliers reduces uncertainty and the costs of innovation and consequently increases a firm's innovative performance (Ahuja, 2000; Corsten and Felde, 2005; Dyer, 1996, 1997; Powell et al., 1996). Collaboration with suppliers is especially useful for increasing the pool of resources available to firms, to search for and identify potential solutions, to select the most appropriate solutions, and consequently to reduce the uncertainty in the process of new product development and the time to market (Clark, 1989; Clark and Fujimoto, 1991; Hoegl and Wagner, 2005; Wagner, 2012). Close collaboration with suppliers for the development of innovation allows buyers to acquire technological inputs that are tailored to their technology profile, production, and market context, which consequently reduces the time required for technology integration (Uzzi, 1996, 1997).

Collaborating with suppliers also allows firms to access context specific (i.e. sticky) knowledge (Jensen and Szulanski, 2004; von Hippel, 1994) and to develop technological options. Suppliers' knowledge on the components/inputs they develop is sticky, and buyers' knowledge about how to use those inputs and technologies in their final products is similarly sticky. Also, buyers have specific expectations about the functionalities and interfaces of new inputs. By pooling their know-how with that of their suppliers, buyers can access a variety of technological and market knowledge and information allocated to a technological objective and, at the same time, can increase their capacity for monitoring and selecting among available technology alternatives (Cassiman and Veugelers, 2002, Katila and Chen, 2008; Powell et al., 1996). Hence, especially in technologically turbulent environments, collaboration with suppliers creates a space where sticky information can be managed, and problem-solving activities can be undertaken more efficiently (Gulati and Singh, 1998; Jensen and Szulanski, 2004; von Hippel, 1986; 1994).

Setting up formal collaborations for innovation also has advantages over other types of relationships with suppliers (Uzzi, 1996). Compared to arms-length contracts with suppliers, for instance, collaboration allows buyers to acquire knowledge on the characteristics of specific inputs that enhances their technological competences to integrate inputs developed by several different actors. Compared to internalization, collaborating with suppliers for innovation provides greater flexibility and lower risks of technological lock-in especially in contexts of rapid technological development (Gulati and Singh, 1998; van de Vrande et al., 2009; von Hippel, 1986; 1994). Hence, collaboration with suppliers reduces the risk of loss of capabilities to suppliers, in value-added activities and components (Christensen, Verlinden and Westerman, 2002). Finally, collaboration rather than contracts permits to build trust, foster communication and interaction, which in turn allows the parties to mitigate agency costs and opportunism resulting from incomplete contracts (Gulati and Nickerson 2008; Hoetker and Mellewigt, 2009), and to build mechanisms to "coordinate functions and work out problems" (Uzzi, 1997, p.47). On the basis of the above discussion we hypothesize that:

H1: Ceteris paribus, collaboration with suppliers improves the firm's innovative performance.

Collaboration with suppliers and firms' innovation performance in the presence or absence of industry related knowledge

Previous studies have found that the extent of the benefits from collaboration with suppliers depends on the technological and relational characteristics of the parties involved in the collaboration, and on the content and intensity of their relationship (Corsten and Felde, 2005; Croom, 2001; Hoegl and Wagner, 2005; Petersen et al., 2005). Here, we argue that these benefits may also depend on the type of innovation (i.e. exploratory or exploitative) (Anderson and Tushman, 1990; Tushman and Anderson, 1986).

Exploratory innovation results from the search in the technology space for new and more productive techniques and products whose demand is unknown. It often involves discontinuity with existing technological and organizational capabilities and problem-solving practices (Christensen and Bower, 1996; Greve, 2007; Gupta, Smith, Shalley, 2006; March, 1991; Tushman and Anderson, 1986). It may entail the development of new product designs and use of different knowledge bases, and often target new market needs. Exploratory innovations usually require greater investment in the search for new knowledge, and identification and selection among alternatives (Gupta et al., 2006; Jansen, van den Bosch, and Volberda, 2006). Exploitative innovation tends to build on accumulation of and refinements to existing technological, organizational and market knowledge of the firm (Christensen and Bower, 1996; Greve, 2007; Gupta et al., 2006; March, 1991; Tushman and Anderson, 1986). It includes incremental improvements to increase the efficiency of existing products, and minor changes to the firm's product portfolio. Exploitative innovations tend to be less costly and less risky since they focus on improving the performance and efficiency of established technologies, product designs, organizational structures and market strategies (Greve, 2007; Jansen et al., 2006).

Most of the literature on organization has distinguished between exploratory and exploitative innovation, understood as distance from, or proximity to, existing technological and organizational capabilities and product portfolios. One important aspect that the literature has neglected is the industry context in which the innovation is developed. Firms can undertake exploratory search for technologies and products that are not new to the market. Hence, an innovation can be new to only the focal firm or to *both* the focal firm

and the market. In searching for solutions that are not new to the market the firm relies on industry-level knowledge resulting in lower market and technology uncertainty. The presence of industry-level knowledge reduces uncertainty by directing the innovative search and reducing the available variety of solutions to identify and select from.

Very few studies have examined the likelihood and performance of exploratory and exploitative innovations taking into consideration the presence or absence of industry-level knowledge. Katila and Chen (2008) examine the frequency and novelty of the firm's innovations in relation to its market competitors. They show that exploratory innovations by the focal firm are more frequent if the focal firm searches exclusively, while exploitative innovations are more frequent if competitors started searching ahead. In 'synchronized search races' the innovative performance of firms is relatively lower. Jansen et al. (2006) examine the moderating role of a dynamic and competitive environment on the performance of exploratory and exploitative innovation. They find that exploratory innovation is more likely to improve firms' performance in dynamic environments while exploitative innovation is more beneficial in more competitive environments.

We classify firm innovations in relation to the firms' and the industry's available knowledge. *New-to-the-market innovations* are new to both the firm and the industry. They are akin to 'market-exploratory innovations' since they are developed without prior industry-level knowledge. *New-to-the-firm innovations* are new to the firm but not to the industry. They are similar to 'market-exploitative innovations' because their development occurs in the presence of industry knowledge. We argue that the effect of collaboration with suppliers on the benefits from innovation varies depending on the type of innovation.

When engaging in the development of *new-to-the-market innovations*, the firm faces higher uncertainty because it cannot rely on prior experience, existing knowledge or the experience of competitors to map/direct and evaluate the problem-solving activity linked to innovating. Within this context of problems that cannot be handled routinely, collaboration can help to reduce this high level of uncertainty (Gulati and Singh, 1998; van de Vrande et al., 2009). Causal ambiguity about how factors interact and

lead to success in new product development increases the stickiness and tacitness of the knowledge required to solve specific technological problems and, hence, requires close interaction, informal communication and knowledge exchange with partners (Szulanski, 1996). Expectation of reciprocity and pool of resources as a backup behaviour in a collaboration allows actors to increase the availability of different resources for the development of complex technologies (Uzzi, 1997) and, consequently, to increase the potential number of new solutions, as well as testing a greater number of possible knowledge recombinations.

In the case of *new-to-the-firm innovation* the firm faces lower levels of market and technology uncertainty because the firm's innovation objectives are more focused, and the main bottlenecks relate to the development and integration of incremental changes to existing components rather than the need to investigate a larger variety of possible solutions. Within this context of low causal ambiguity and knowledge stickiness (Jensen and Szulanski, 2004; Szulanski, 1996), the benefits from collaboration with suppliers are mostly associated with "economies of time" (Uzzi, 1997, p.49), i.e. reductions in the time required for innovation development, and speedier launch of new products onto the market. In a collaboration, contracting costs and time may be minimized, and information transfer and decision-making can be quickened as both parts as the transaction details may be negotiated on the fly, and mechanisms for data exchange and problem-solving may be already developed (Uzzi, 1997).

Also, in the presence of industry knowledge, it is more likely that the supplier partner is a direct or indirect competitor for the final product or is a competitor in the market for strategic resources. In such situations, the focal firm might reduce the scope of the collaboration to achieve balanced knowledge exchange in the development of the innovation, and to control knowledge flows to avoid unintended knowledge leakages (Oxley and Sampson, 2004). Thus, we hypothesize that:

H2: Ceteris paribus, the positive effect of collaboration with suppliers on the firm's innovative performance is stronger in the case of new-to-the market innovation than in the case of new-to-the-firm innovation.

The effects of collaboration with suppliers on the innovation performance of buyers depend on the parties' joint efforts and on the opportunity to pool different types of knowledge. Buyer and supplier are likely to have different technological backgrounds and experience, and employ different routines for identifying, evaluating and selecting among alternative solutions. Buyer and the supplier might be experienced in specific forms of learning, patterns of solutions to technological problems, and specific forms of communication and knowledge transfer. Thus, the collaboration for innovation development could involve the creation, recombination, transfer and exchange of a great variety of knowledge and information. Within this context, the presence of FPS practices targeting intra-organizational knowledge development and transfer can influence how buyers use the new knowledge created in the collaboration and, therefore, may affect the performance of the collaboration. Again, we argue that the moderating effect of FPS practices varies depending on the type of innovation.

The moderating role of FPS practices on the effectiveness of collaboration with suppliers for innovation performance

In line with the literature, we understand problem-solving as a process of searching for and selecting solutions to organizational and technological problems in the design, development and bringing to market of new products (Dosi and Grazzi, 2006; Marengo, Dosi, Legrenzi, and Pasquali, 2000; Marengo and Dosi, 2005). Problem solving involves the development and acquisition of new knowledge, its distribution, interpretation, selection and codification into new products, practices or processes (Argote and Ingram, 2000; Huber, 1991). Thus, problem-solving activities are mechanisms for learning and for changing the range of possible behaviours by promoting individual and organizational understanding of the environment, and its challenges and opportunities (Huber, 1991; Nonaka and Takeuchi, 1995).

As searching for and selecting among solutions may entail a lengthy iterative analytical process involving a large number of interdependent components and tasks, firms try to identify and codify best practice in problem-solving in order to reduce the uncertainty associated to new product development, to save time and improve efficiency of problem-solving activities and foster 'collective creativity' (Hargadon and

Bechky, 2006; Zollo and Winter, 2002). Formalizing practices involves codifying the knowledge resulting from learning through experience and/or trial-and-error into new practices, and stabilizing routines around best practice.

Similar to other types of process management practices, FPS are characterized by a focus on process improvement, team work, employee empowerment, efficient use of information, and co-ordination and communication within work groups (Benner and Tushman, 2003; Ittner and Larcker, 1997). FPS practices are then expected to increase the number of relevant informed people participating in the problem-solving process, in order to foster communication and shorten decision-making (Huber, 1990). Some FPS practices such as '*organized group brainstorming*' and '*problem-solving*' facilitate intra-organizational communication and knowledge transfer by providing space to seek help, to give help, and for reflective reframing (Hargadon and Bechky, 2006; Paulus and Yang, 2000). Other FPS practices, such as '*formalized value analysis*' or '*value engineering analysis*', are instead used to structure the problem solving processes around key required functions, and to test and evaluate alternative modes to meet those requirements (Huber, 1990; 1991; Lindgreen and Wynstra, 2005; Sobek, Ward, and Liker, 1999; Tidd, Bessant, and Pavitt, 2005).

Overall, FPS practices formalize the ways that search for solutions to a specific problem is undertaken, and the heuristics for assessing the costs and benefits of undertaking this search and selecting options. In this way, FPS practices codify the processes of identification and perception of problems and, consequently, the process of search, construction, and selection of possible solutions. In addition, FPS practices help to define the content and nature of communication events occurring during the problem solving process, and to manage the process of combination, selection and storage of relevant information.

The benefits of FPS practices have been identified by organization scholars. Use of FPS practices can reduce problems of information overload and improve the efficiency of the overall process of search and selection of alternatives for the innovation development process (Jansen et al., 2006; Levitt and March, 1988; Zollo and Winter, 2002). By setting the heuristics for problem recognition, search and selection, FPS practices can help to define problems proximate to past similar problems and, consequently, can help

to narrow the search for options and their selection (Huber, 1991; Kiesler and Sproull, 1982). Hence, these practices can contribute to faster knowledge creation and dissemination within the firm, accelerate convergence towards specific technological and market solutions, and consequently improve firm performance (Dosi and Grazzi, 2006; Hargadon and Bechky, 2006; Jansen et al., 2006; Zollo and Winter, 2002). The faster the firm is able to identify, evaluate and select among different development paths to follow, different knowledge combinations to try, and solutions to be brought to the market, the faster it will be able to innovate, increasing the possibility to appropriate value from innovation (Lazer and Friedman, 2007).

FPS practices can also create a space for mindfulness by ‘forcing’ individuals to allocate effort and attention to specific problems. They can stimulate collective innovation effort by leveraging the processes of ‘help seeking’, ‘help giving’, and ‘reflective framing’ (Hargadon and Bechky, 2006; Paulus and Yang, 2000). Hence, FPS practices provide a framework for generation and selection of quick and efficient responses to specific problems thereby preventing the build up of large internal repositories of alternative solutions.

These advantages are particularly relevant for firms engaged in innovative activities under relatively low technology and market uncertainty (Benner and Tushman, 2002; Jansen et al., 2006, Katila and Chen, 2008). FPS practices developed to improve efficiency within an existing knowledge context or a well specified product architecture help to accelerate the process of knowledge creation and communication and the selection among alternatives. Hence, in the presence of industry level knowledge, FPS practices may increase the ability of buyers to improve the performance of collaboration with suppliers which this creates opportunities to improve products that are similar to those already existing in the market. We thus hypothesize that:

H3a: In the case of new-to-the-firm innovation, formalization of problem-solving practices positively moderates the relationship between collaboration with suppliers and the firm’s innovative performance.

Organization scholars have emphasized the drawbacks of adoption of formalized practices.

Organizational structures that are efficient at codifying and distributing information internally tend to have better short-term, but worse long-term performance. Long-term performance is rooted in the ability to manage the tensions among efficient levels of variety and selection (Andriopoulos and Lewis, 2009; Benner and Tushman, 2003; Brown and Eisenhardt, 1997; Raisch et al., 2009). It requires possession of sufficient variety to nurture the development of novel innovations and sufficient practices to develop incremental innovations. By setting the heuristics for problem recognition, search and selection, FPS practices may lead to the definition of problems in the proximity of past similar problems, and consequently narrow the search and selection of options (Huber, 1991; Kiesler and Sproull, 1982). Loss of variety is the price paid for rapid knowledge creation and dissemination.

In addition, especially when FPS practices follow a ‘coercive logic’ (Adler and Borys, 1996), these rules and procedures may limit the possibility for experimenting and disrupting the firm’s existing technological, organizational and market bases. However, developing novel products may require organizations to engage in processes of ‘unlearning’, that is, discarding knowledge that has become misleading or obsolete in the search for and selection of solutions to new technological problems (Hedberg 1981; Huber, 1991; Leonard-Barton, 1992; Tripsas and Gavetti, 2000).

Excess focus on improving the efficiency of the knowledge development and transfer processes may reduce the organizational incentives for new learning (Benner and Tushman, 2002, 2003; Cowan, David, and Foray, 2000; Jansen et al. 2006) and may lead to premature rejection of radically different solutions (Lazer and Friedman, 2007). Stabilization of knowledge flows, limiting the learning focus, and reducing learning incentives could result in diverting organizational learning towards specific internal learning patterns and predictable outcomes, and ignoring other knowledge bases, the long run perspective and the ‘broad picture’ (Henderson and Clark, 1990; Levitt and March, 1988; Tushman and Anderson, 1986). Thus, firms that rely on formalized organizational structures are likely to become myopic to new external and internal knowledge that does not fit with formalized practices. These limitations of FPS practices

seem associated with the early objective of stabilizing practices, which makes it problematic to constantly challenge formalized procedures (Cowan et al., 2000).

Incentives for local search, reduced variety and reduced options for communication and transfer of knowledge, translate into reduced transfer and assimilation of external knowledge (Sorenson, 2003) and/or lock-in to inefficient suppliers or partners (Handfield et al., 1999; Szulanski, 1996). These shortcomings become amplified if there is no available industry-level knowledge because firms face higher uncertainty, increased problems of coordination and complexity of information processing, and high demand for innovative approaches (Das, Narasimhan, and Talluri, 2006). In uncertain environments, further difficulties arise as the context is different from the one in which the solutions were originally developed (Sorenson et al., 2006; Szulanski, 1996). Hence, firms may need to generate and test a greater variety of technical solutions before making a final selection. If knowledge developed within the collaboration leads to drastic changes in product characteristics or the buyer's product portfolio, or if the knowledge developed in the collaboration requires modification and adaptation, the firm cannot rely on industry or market feedbacks. In these cases, existing FPS practices could lead firms to replicate the behaviours and patterns of technological choice that, in the past, led to higher performance, and are likely to prematurely select out of alternatives (Leonard-Barton, 1992; Tripsas and Gavetti, 2000). In this case the presence of FPS practices, reduces the number of alternatives and restricts the use of unconventional knowledge, and hinders the ability of buyers to effectively use the knowledge gained from the collaboration. We thus hypothesize that:

H3b: In the case of new-to-the-market innovation, formalization of problem-solving practices negatively moderates the relationship between collaboration with suppliers and the firm's innovative performance.

METHOD AND DATA

We test our hypotheses combining data from the 6th wave of the French Community Innovation Survey (CIS) carried out in 2007, and the French organizational survey Changements Organisationnels et Informatisation (COI) carried in 2006. Both surveys target companies with 10 or more employees, and the two datasets can be merged with the help of the firm identifying number. The CIS mainly investigates the process of innovation development by firms in the three years preceding the survey, in our case 2004-2006, and focuses only on manufacturing firms.² The COI investigates the organizational structure and routines of both manufacturing and service firms in two periods: the year of the survey (in our case 2006) and three years before the survey year (in our case 2003).³ For the purpose of our analysis, we focus on the sample of 1,596 manufacturing firms that responded to both the COI and CIS surveys.

From the CIS survey we extract information on collaboration with suppliers, and innovation performance. From the COI survey we collect information on firms' FPS practices in place before collaboration with suppliers. We use these measures to analyse the relationship between collaboration with suppliers and the innovative performance of firms.

Dependent Variable. We measure innovation performance by considering the proportion of turnover in 2006 from product innovations developed and introduced in the 2004-2006 period. Since the CIS survey asks firms to distinguish between the introduction of *new-to-the-firm* and *new-to-the-market* product innovation, we can identify innovation performance in the presence and absence of industry-knowledge.⁴

New-to-the-market innovation provides information on the innovation performance of the firm in the absence of industry knowledge. It is measured as the share of turnover that firms declared was due to

² Firms are asked about the type of innovation introduced in the three years preceding the survey, the sources of information and collaboration used in the process, investments in several types of innovation activities, and the mechanisms used to protect innovations. The survey also asks firms about the effects of innovation on turnover, and the achievement of objectives related to products and market, processes and standards. The survey questionnaire is available from the French Ministry of Economy and Industry at <http://www.industrie.gouv.fr/seSSI/enquetes/innov/cis2006/cis.htm>.

³ COI focuses on how the company uses different management tools, including information technology (IT) in the production, conception and marketing, and in their relationships with clients and suppliers. <http://www.enquetecoi.net/>.

⁴ Respondents declaring that the firm had developed a product innovation in the period 2004-2006 were asked to qualify the nature of the product innovation(s) based on the following questions: "Did your company launch new or significantly improved product innovations in the market before their competitors (*new to the market innovation*)?"; "Did your company launch new or significantly improved products that already existed in the market, provided by your competitors (*new to the firm innovation*)?" Respondents were then asked to estimate the share of turnover due to new to the market or new to the firm product(s) launched in the period 2004-2006.

new-to-the-market products. *New-to-the-firm innovation* provides information on the innovation performance of the firm in the presence of industry knowledge. It is measured as the share of turnover that firms declared was due to new-to-the-firm products. Both these measures of innovation performance have been used in previous studies using CIS data (Grimpe and Kaiser, 2010; Laursen and Salter, 2006) and are well established in the literature.

Independent Variables. The variable *collaboration with suppliers* is equal to 1 if the firm has collaborated with suppliers for innovation development and equal to zero otherwise.

To measure the use of FPS practices we include the variable, *formalization of problem-solving activities*. This is a count variable which reports the number of practices aimed at formalization of problem-solving activities, which were in place in the period prior to collaboration with suppliers. The variable takes values between zero and 2 depending on the number of problem solving practices reported. The following FPS practices were identified: use of formalized methods for problem-solving, engineering and value analyses; use of formalized methods for changing product characteristics. To assess the moderating role of FPS practices targeting intra-organizational knowledge development and transfer, we created linear interactions between this variable and the variable *collaboration with suppliers*.

Control Variables. We include variables that control for firm size, belonging to a group, intensity of R&D investment, whether product design is done internally, and industry fixed effects. The variable *firm size* is the logarithm of the number of the firm's employees. Existing evidence suggest that large firms are more likely to perform exploitative rather than exploratory innovation (Tripsas and Gavetti, 2000). We also include a dichotomous variable to capture information on whether the firm is part of a group rather than being an independent firm. Firms that are part of a group seem to have a higher propensity for incremental innovation (Cassiman and Veugelers, 2006). The variable, *part of a group*, is equal to 1 if the focal firm is part of a group and zero otherwise.⁵ We control for level of firm's investment in R&D using the variable *R&D Intensity* which is the ratio of the firm's R&D expenditure (intramural R&D activities,

⁵ The Oslo manual (OECD, 2005), defines firms that are part of a group as an 'association of enterprises bound together by legal or financial links'.

extramural R&D activities, and acquisition of other external knowledge) to total sales (Rothaermel and Alexandre, 2009). *R&D Intensity* is log transformed to reduce the skewness and kurtosis of its distribution. Prior evidence suggests that firms that invest heavily in R&D are more capable of developing new technologies and using external knowledge (Cohen and Levinthal, 1990). The dichotomous variable, *internal design* is a dummy. It provides information on whether the firm performs product conception and design in-house. Previous research has shown that the ability of firms to reap benefits from collaboration with suppliers is associated with the existence of internal design capabilities (Brusoni, Prencipe and, Pavitt, 2001). Finally, we control for industry specific effects by including an industry dummy for each NACE 2-digit industry. *Other manufacturing activities* is the reference category. This allows us to control for the presence of cross industry differences in terms of speed and patterns of market and technology evolution (Abernathy and Utterback, 1978; McGahan and Silverman, 2001).

Estimation Method. The variables *new-to-the-market innovation* and *new-to-the-firm innovation* are proportions that range between 0 and 1. In these circumstances, ordinary least square (OLS) estimates would produce inconsistent estimates. Therefore, we use Tobit regression models with robust errors to analyse our data (Laursen and Salter, 2006; Raymond et al., 2010) In these estimates, the dependent variables can be treated as censored continuous variables bounded by zero from below and by 1 from above.

RESULTS

Table 1 reports the means, standard deviations and zero-order pairwise correlations among the study variables.

[Insert Table 1 about here]

To test our hypotheses we proceed as follows. We start with a model that includes only the controls (model 1) and we add the remaining variables in sequence starting with the simple effect of collaboration with suppliers (model 2), adoption of FPS practices (model 3), and ending with their linear interaction

(model 4). Results are summarized in Table 2 which reports the coefficients of performance of *new-to-the-market* and *new-to-the-firm* innovation separately. Table 3 reports the marginal effects computed at the mean values for the full model (model 4) (Greene, 1999, 2004; Wiersema and Bowen, 2009).

[Insert Table 2 about here]

[Insert Table 3 about here]

Results provide support for Hypothesis 1. The coefficient of *collaboration with suppliers* is always positive and significant across specifications for both *new-to-the-market* and *new-to-the-firm* innovations. Also, the marginal effects calculated at the mean for the full model and reported in Table 3 provide support for Hypothesis 2 that the positive effect of collaboration with suppliers on the firm's innovative performance is stronger in the case of *new-to-the market* than *new-to-the-firm* innovations. All else being equal at the mean, a change from non-collaboration to collaboration provides an increase of 6.5 per cent of the share of turnover from *new-to-the-market* innovations compared to an increase of 4 per cent in the case of *new-to-the-firm* innovations.

We find support also for Hypothesis 3b that, in the case of *new-to-the-market* innovation, FPS practices negatively moderate the relationship between collaboration with suppliers and the firm's innovative performance. The coefficient of the interaction variable between collaboration with suppliers and the number of FPS practices is negative and significant for explaining innovative performance in Model 4 (Table 2 column 7). We do not find support for Hypothesis 3a that, in the case of *new-to-the-firm* innovation, FPS practices positively moderate the relationship between collaboration with suppliers and the firm's innovative performance. In this case, the coefficient of the interaction variable between collaboration with suppliers and FPS practices is not significant in Model 4 (Table 2 column 8).

To better understand the moderating role of FPS practices, we plot their effect on the innovative performance, following a procedure common in the literature (Aiken and West, 1991; Jansen et al., 2006). Figures 1 and 2 show the predicted innovative performance of firms when the effect of the interaction is computed at the mean for all the control variables.

[Insert Figure 1 and 2 about here]

Figure 1 shows that in the presence of industry-level knowledge (i.e. in the case of innovation new to the firm) collaboration with suppliers has a positive effect on the returns from innovation. Also, the higher the number of FPS practices implemented, the higher the returns. However, the slope is almost identical in all three cases suggesting that there is not significant statistical difference in the performance of firms that make different use of FPS practices. Figure 2 shows that, in the absence of industry-level knowledge (i.e. in the case of innovation new to the market), collaboration with suppliers also has a positive effect on the returns from innovation. However, the higher the number of FPS practices implemented, the lower the returns from collaboration.

Our controls behave as follows. Firms size, presence of internal design labs, and R&D intensity are positively associated with the returns from both new-to-the-market and new-to-the-firm innovations with the effect of Size curvilinear. Belonging to a group does not have any significant effect on the returns from innovation.

Sensitivity analysis

To check the robustness of our results we perform four types of sensitivity analysis. Results for the robustness check are summarized in Table 4.

[Insert Table 4 about here]

We start by employing alternative estimation techniques. The Multinomial Fractional Logit model, an extension of the General Linear Model binomial family with a logit link, is an estimation method that is appropriate when the dependent variable is a proportion (Hardin and Hilbe, 2007; Papke and Wooldridge, 1996). Model (5) reports the results for the Multinomial Fractional Logit. The results are qualitatively similar to those obtained from the Tobit regression reported in Model (4). *Collaboration with suppliers* improves the returns from *new-to-the-market* and *new-to-the-firm* innovations, the effect being stronger for the performance of the former. In line with the results of Model 4, we find that *formalization of problem-solving practices* negatively moderates the relationship between *collaboration with suppliers*

and the firm's innovative performance in the case of *new-to-the-market* innovation performance, but has no effect in the case of *new-to-the-firm* innovation.

We address some potential problems in our methodology related to the potential endogeneity of our explanatory variable *collaboration with suppliers*. In our setting, endogeneity can arise from two sources. On the one hand, the observed collaboration with suppliers is likely to be influenced by past level of innovative performance. Indeed, while collaborating with suppliers is likely to improve the innovative performance, innovative firms may also be more likely to be chosen as collaboration partners. This introduces an issue of reverse causality. On the other hand, there might be unobserved determinants that might influence both collaboration with suppliers and the firm's innovative performance.

We tackle these issues in two ways. First, we lag our explanatory variable capturing collaboration with suppliers by relying on information from the previous wave of the CIS, CIS4, carried out in 2004. CIS 4 investigated the process of innovation development by firms in the three years preceding the survey year - 2002-2004. From this survey we extracted information on whether the firms in our sample collaborated with suppliers for innovation. This ensures that information on the independent and the moderator variables refers to a period prior to the dependent variable in relation to innovation performance, partly reducing the issue of reverse causality. As the sets of firms surveyed in CIS 2006, COI, and CIS 4 overlap only partially, the size of our sample drops to 823 observations. Model (6) addresses the issue of potential endogeneity by employing a lagged variable for collaboration with suppliers. Again, the results do not change with respect to our baseline model although in the case of *new-to-the-firm* innovation performance the coefficient is only weakly significant.

Second, we use an instrumental variable approach to control for endogeneity. Traditional approaches, such as the instrumental variable Tobit model proposed by Smith and Blundell (1986), are not straightforwardly applicable to our case since they do not allow for discrete endogenous regressors. To overcome this shortcoming, we use the 'treatment-effect model' presented in Cameron and Trivedi (2010: 192). According to this approach the dichotomous endogenous variable (*collaboration with suppliers*) is

considered as a ‘treatment indicator’, estimated as an unobserved latent variable first, and then ‘plugged’ into the structural equation. The estimation is carried out using the maximum likelihood method.

Our choice of instruments is motivated by recent evidence on the determinants of collaboration with suppliers for product innovation. The evidence highlights that firms that collaborate with suppliers tend to protect their innovation rents through design and technological complexity, and to entail a change in the practices to deal with those firms (Oxley, 1997; Oxley and Sampson, 2004) Therefore, we use the following two dichotomous variables as exogenous instruments: *complexity* which equals 1 if the firm employs design and technological complexity as an appropriation method and zero otherwise; and *external practices* which is a dummy equal to 1 if the firm has revised its practices to relate to external actors and zero otherwise.⁶ Model (7) reports the results of our ‘treatment effect model’. Compared with Model (4), the coefficient of *Collaboration with suppliers* decreases in the case of *new-to-the-market* innovation and increases in the case of *new-to-the-firm* innovation; however, the sign and significance remain the same. For both estimates we report the value and standard error of *rho*, which is the error correlation term between our structural equation and the equation for the latent binary response variable. If rho is equal to zero the errors are independent and there is no endogeneity of collaboration with suppliers. A Wald Chi-square test rejects the null hypothesis of exogeneity in the case of performance from *new-to-the-firm* innovation. In the case of *new-to-the-market* innovation, the null hypothesis cannot be rejected; thus, the results from Model (4) are preferred.

As a further check, we transform our measure for *FPS practices* into a dichotomous variable. Model (8) reports the estimated coefficients when we include the dichotomous variable *FPS practices*, instead of a count as in Model (4). Again, the results are similar to those for our baseline regression.

Finally, we check whether our results might depend on the type of knowledge involved in the collaboration. As discussed above, collaboration with suppliers mainly involves the transfer of applied

⁶ The Sargan-Hansen test where the null hypothesis is that the chosen instruments are valid, could not be rejected. The estimated probability value of the test is 0.10 in the case of returns from *new-to-the-market* innovation, and 0.52 in the case of returns from *new-to-the-firm* innovation. We also performed a Wu-Hausman endogeneity test in which the null hypothesis is the exogeneity of the variable collaboration with suppliers. The estimated probability value of the test is 0.10 for *new-to-the-market* innovation, and 0.002 for *new-to-the-firm* innovation. Thus, endogeneity appears to be an issue only in the case of *new-to-the-firm* innovation.

knowledge targeted towards development and/or assembly of components in the process of development and introduction of new products. In this context we expect FPS practices to play a crucial role in influencing how flows of information are communicated, transferred and evaluated between firm and suppliers. Collaboration with other external actors, such as universities, is much more likely to involve the transfer of basic knowledge to generate new ideas (Cohen et al., 2002). In this context, we expect FPS practices to be less relevant or not at all relevant for moderating the effects of collaborations on the firm's innovation performance because it can take a long time to translate into products the more general knowledge related to the generation of new technological options and new designs.

Model (9) reports the estimated coefficients when we include in the original model (4) the variable *collaboration with universities* and its linear interaction with the variable *No. FPS practices*. The baseline regression results do not change. In addition, the simple effect of *collaboration with universities* is positive and significant only for *new-to-the-market*, but not *new-to-the-firm* innovations while the linear interaction with *No. of FPS practices* is never significant, suggesting that the moderating role of FPS practices may indeed depend on the type of knowledge involved in the collaboration. In other words, not all intra-organizational practices may influence the use of every different type of knowledge developed in collaborations.

DISCUSSION AND CONCLUSIONS

The literature generally suggested the presence of a positive association between collaboration with external partners and firm's innovative performance, but has not explored whether and how intra-organizational practices moderate this effect, or how the context in which the innovation activities are performed influences the effect of intra and inter-organizational practices on innovative performance. Understanding how intra and inter-organizational practices interact to influence innovative performance under uncertainty is particularly relevant as firms increasingly innovate in collaboration with external actors and set up internal routines aimed at fostering innovation, creativity and problem-solving. This paper addresses and provides new evidence on these issues.

We argued that if we understand innovation as a problem solving process that entails search, selection, and retention of possible solutions to a specific problem, then the benefits from collaboration for innovation development and the moderating effect of FPS practices will depend on the context of the inter-organizational collaboration for innovation.

Within this framework, we hypothesized in Hypothesis 1 that collaboration with suppliers is generally beneficial for innovation because it allows the firm to explore a wider set of possible solutions to specific problems and because it allows the transfer of knowledge tailored to specific needs, technological profiles, and application contexts. In developing Hypothesis 2 we considered that the context in which the collaboration occurs might affect the extent of the benefits from collaboration with suppliers. Firms collaborate with suppliers to access extraordinary resources, to search and test alternative solutions, and to reduce the uncertainty and costs of developing innovations. In other words, collaboration with suppliers provides a space to increase the variety of solutions considered and tested by the firm. Hence, we argued that the magnitude of the benefits will be the higher the lower the availability of knowledge and/or the possibility to access it from other alternative sources. Collaboration with suppliers in the presence of industry related knowledge is thus associated with relatively lower benefits than in the absence of industry related knowledge.

We then considered whether the firm's internal routines specific to the innovation and problem-solving process, namely the presence of FPS practices, acts to moderate the returns from collaboration in the presence or in the absence of industry-related knowledge. In developing our hypotheses we argued that for the knowledge created through collaboration to be valuable requires adaptation and adjustments are required, especially when there are no similar products in the market, and FPS practices are used mainly to streamline and optimize this process of selection and retention of alternative solutions to a specific problem. Hypothesis 3a proposed that, in the presence of industry level knowledge, FPS practices are beneficial because, in a relative stable environment, they speed up adjustment and adaptation by fostering knowledge creation and communication and the selection among alternatives. Hypothesis 3b proposed that FPS practices would hamper the benefits from collaboration because an excessive focus on

improving the efficiency of the processes of knowledge development and transfer could reduce the incentives for new learning required in the absence of industry-related knowledge.

We tested these theoretical arguments empirically using survey data for a large sample of French manufacturing firms, distinguishing between *new-to-the-market* and *new-to-the-firm* product innovations according to whether the innovation occurred in the absence or presence of industry-level knowledge. We found that collaboration with suppliers generally improves the firm's innovative performance, but the benefits are higher for *new-to-the-market* innovation than *new-to-the-firm* innovation. We found also that FPS practices unevenly moderate the relationship between collaboration with suppliers and firm's innovative performance; they do not improve the benefits from collaboration in the case of *new-to-the-firm* innovation and reduce the benefits in the case of *new-to-the-market* innovation. In sum, results support H1, H2 and H3a, but not H3b.

In the presence of industry level knowledge, collaboration with suppliers decreases time and costs of innovation (Uzzi, 1997), and FPS practices enhance innovative performance by fostering rapid ideas selection and targeted problem-solving. However, FPS practices do not moderate significantly the ability to use knowledge developed in inter-organizational collaborations. This seems related to the fact that in presence of industry-related knowledge, the knowledge developed under the collaboration is mostly compatible with the knowledge and organization prevalent in the focal firm. The instrument variable analysis, which shows that the effect of collaboration with suppliers on the development of products new to the firm is endogenous to innovation performance while it is exogenous in the case of collaboration in the absence of industry related knowledge, seems to support this explanation.

Limitations and future research

Our study has some limitations.

The first limitation is related to the nature of the intra and inter-organizational practices examined. In this paper we considered the case of collaboration with suppliers and FPS practices. Our results cannot be generalized to other intra and inter-organizational practices interactions.

Second, we focused on the moderating role of FPS practices specific to the innovation development process, but we do not know how the organizational structure of the focal firm might facilitate knowledge

sharing within the organization. Some studies suggest that, by influencing individual motivations, different types of organizational structures (i.e. hierarchical vs flat) also affect the role of organizational practices (Carzo and Yanouzas, 1969; Gavetti, 2005; Osterloh and Frey, 2000). Further work should explore this issue.

Third, there is the issue of the logic underlying the implementation of FPS practices. As in the case of any internal formalized procedure, the design and implementation of FPS practices may be aimed at streamlining the duties of employees by functions or providing employees with an understanding of the rationale underlying a specific process. To the extent that these aims correspond to different logics, coercive vs enabling (Adler and Borys, 1996), we might expect the negative moderating effect to decrease in the case of the enabling logic. Further research that includes a finer distinction among FPS practices could explore this issue.

Fourth, since the analysis is based on survey data, we do not have detailed information on the characteristics of collaboration with suppliers. In particular, we lack information on whether or not the firms had previous collaboration experience with suppliers. Zollo, Reuer, and Singh (2002) show that only partner specific experience has a positive effect on collaboration performance. Similarly, we could expect that long term collaborations and first time collaborations might have different effects on innovation performance related to new-to-the-market and new-to-the-firm innovation. Also, the moderating effect of FPS practices might differ for long and short term collaborations. It might be that, within long term collaborations, the codification of best practice related to FPS which was successful in previous collaborations might bring increased benefits for new-to-the-firm innovations and not reduce the benefits related to new-to-the-market innovations. Further in depth research using empirical and analytical tools could consider these characteristics of collaboration.

Finally, our hypothesis about the positive moderating effect of FPS practices for innovations new to the firm was not confirmed. Conditional on collaboration taking place, increasing the number of FPS practices has no statistically significant effect on the returns from collaboration with suppliers, in the presence of industry related knowledge. This result points to the limited additional efficacy of FPS practices in the creation, selection and retention of knowledge within a collaboration, in contexts where

uncertainty is not a major issue. Whether this result depends on the number of FPS practices considered, and their related costs, or on the relatively 'coarse' definition adopted in the paper should be investigated in future research.

Contributions

Despite the limitations described above, our study makes several contributions. To the extent that suppliers can be considered one of several external sources for innovation, this study contributes to the literature on open innovation (Chesbrough, 2003; Laursen and Salter, 2006) by highlighting how inter-organizational practices targeted at innovation development and problem solving can be leveraged by the effect of intra-organizational arrangements. Our results suggest that, in the context of open innovation, the processes of search, recombination and problem-solving may require less formalized practices.

Our paper adds to the empirical literature on the effects of organizational practices on innovation. Prior contributions have looked at the effect of organizational practices (Jansen et al. 2006) or environmental conditions (Katila and Chen, 2008) in isolation. An innovation can be a product or process that is new only to the focal firm or to both the focal firm and the market. This distinction is important because in the exploration of technologies and products that are not new to the market, a firm can rely on industry-level knowledge. In this case, the firm faces lower market and technology uncertainties than when innovation cannot rely on industry-level knowledge. In other words, by directing the innovation search and reducing the variety of available solutions to identify and select, the presence of industry-level knowledge reduces uncertainty. By looking at firms engaged in collaboration with suppliers in the presence and in the absence of industry-related knowledge, we take account of the role of both organizational antecedents and environmental conditions.

In term of knowledge transfer, the prior literature has shown that knowledge-related factors, such as lack of absorptive capacity, causal ambiguity, and a difficult relationship between the partners, constitute major barriers to knowledge transfer (Argote and Darr, 2000; Szulanski, 1996; Szulanski and Jensen, 2006; Winter and Szulanski, 2001). Our analysis and evidence is consistent with the idea that FPS practices can become barriers to knowledge transfer, although limited to specific contexts.

Finally, we provide an empirical contribution to the literature on supplier integration, understood as the combination of external initiative and internal oriented practices aimed at improving performance returns. Contributions in this field have suggested the importance of the firm striking the right balance between level of external initiative and internal oriented practices to get the most advantage from collaboration with suppliers (Das et al., 2006). Our evidence supports and qualifies these results by suggesting that the balance should also include sets of FPS practices, which optimize internal information processes in different contexts (i.e. when innovation development occurs in the absence of industry-level knowledge, and when innovation development occurs with participation of external actors).

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Table 1: Summary statistics and correlations

	Min	Max	Mean	Std. Dev.	1	2	3	4	5	6	7	8	9	10
(1)	0.00	1.00	0.07	0.16	1									
(2)	0.00	1.00	0.07	0.15	0.091**	1								
(3)	0.00	1.00	0.25	0.44	0.189**	0.172**	1							
(4)	0.00	2.00	0.89	0.76	0.058*	0.124**	0.160**	1						
(5)	0.00	2.00	0.28	0.60	0.108**	0.163**	0.797**	0.416**	1					
(6)	1.79	11.34	5.71	1.24	0.153**	0.140**	0.309**	0.389**	0.351**	1				
(7)	3.21	128.55	34.16	14.32	0.159**	0.140**	0.312**	0.385**	0.363**	0.988**	1			
(8)	0.00	1.00	0.79	0.41	0.072**	0.073**	0.157**	0.243**	0.175**	0.456**	0.418**	1		
(9)	0.00	0.08	0.00	0.01	0.112**	0.062*	0.048	-0.113**	-0.043	-0.327**	-0.300**	-0.228**	1	
(10)	0.00	1.00	0.73	0.44	0.049	0.063*	0.054*	0.059*	0.052*	0.042	0.033	-0.076**	0.068**	1

Note: ** significance at 0.01 level, * significance at 0.05 level. (1) %turnover from New to the market Innovation; (2) %turnover from New to the firm Innovation; (3) Collaboration with suppliers; (4) No FPS practices; (5) Collab. X No FPS practices; (6) Size; (7) Size²; (7) Part of a group; (8) R&D intensity; (9) Internal Design Lab

Table 2: Main results

	(1)		(2)		(3)		(4)	
	New to market	New to firm	New to market	New to firm	New to market	New to firm	New to market	New to firm
Collab. with suppliers			0.134*** [0.021]	0.117*** [0.020]	0.134*** [0.021]	0.117*** [0.020]	0.230*** [0.037]	0.142*** [0.036]
No. FPS practices					-0.005 [0.012]	0.044*** [0.013]	0.023 [0.015]	0.051** [0.016]
Collab. x No. FPS practices							-0.092*** [0.025]	-0.024 [0.026]
Size	0.216*** [0.050]	0.243*** [0.055]	0.191*** [0.049]	0.225*** [0.054]	0.192*** [0.049]	0.217*** [0.054]	0.166*** [0.049]	0.210*** [0.055]
Size ²	-0.009* [0.004]	-0.013** [0.004]	-0.009* [0.004]	-0.013** [0.004]	-0.009* [0.004]	-0.013** [0.004]	-0.007+ [0.004]	-0.013** [0.004]
Part of a group	0.035 [0.030]	0.038 [0.027]	0.026 [0.029]	0.030 [0.027]	0.027 [0.029]	0.023 [0.027]	0.026 [0.029]	0.023 [0.027]
R&D intensity	13.432** * [1.850]	11.015** * [1.837]	12.122** * [1.802]	9.858*** * [1.823]	12.130*** * [1.803]	9.809*** * [1.836]	11.656*** * [1.786]	9.701*** * [1.851]
Internal Design lab	0.059** [0.021]	0.072*** [0.022]	0.054* [0.021]	0.067** [0.022]	0.055* [0.021]	0.062** [0.021]	0.054* [0.021]	0.062** [0.021]
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	- 1.167*** [0.165]	- 1.164*** [0.177]	- 1.067*** [0.160]	-1.085*** [0.174]	-1.069*** [0.160]	- 1.062*** [0.173]	-1.016*** [0.159]	- 1.048*** [0.174]
sigma	0.289*** [0.018]	0.288*** [0.018]	0.286*** [0.018]	0.285*** [0.018]	0.286*** [0.018]	0.284*** [0.018]	0.284*** [0.018]	0.284*** [0.018]
Observations	1,596	1,596	1,596	1,596	1,596	1,596	1,596	1,596
Degrees of Freedom	15	15	16	16	17	17	18	18
F Statistic	12.03	9.839	13.21	11.13	12.46	10.79	12.00	10.16
log Likelihood	-593.8	-611.4	-569.8	-593.3	-569.7	-587.2	-563.0	-586.8
Pseudo R Squared	0.190	0.139	0.222	0.165	0.223	0.173	0.232	0.174

Robust standard errors in brackets, *** p<0.001, ** p<0.01, * p<0.05, + p<0.1

Table 3: Marginal effects for the full Model (model 4)

	New to Market	New to firm
Collab. with suppliers	0.065*** [0.01]	0.04*** [0.01]
No. FPS practices	0.007 [0.004]	0.0145*** [0.004]
Collab. x No. FPS practices	-0.026*** [0.007]	-0.007 [0.007]
Size	0.045*** [0.014]	0.059*** [0.015]
Size ²	-0.002+ [0.001]	-0.004*** [0.001]
Part of a group	0.007 [0.008]	0.007 [0.008]
R&D intensity	3.285*** [0.497]	2.766*** [0.523]
Internal Design lab	0.015** [0.006]	0.018*** [0.006]
Observations	1,596	1,596
Degrees of Freedom	18	18
F Statistic	10.16	12.00
log Likelihood	-586.8	-563.0
Pseudo R Squared	0.174	0.232

Robust standard errors in brackets, *** p<0.001, ** p<0.01, * p<0.05, + p<0.1

Table 4: Robustness checks

	(5) Fractional Logit		(6) Tobit (Collab. suppliers Lagged)		(7) Tobit (Collab. suppliers Instrumented)		(8) Tobit (Practices dummy)		(9) Tobit (collab Univ)	
	New to market	New to firm	New to market	New to firm	New to market	New to firm	New to market	New to firm	New to market	New to firm
Collab. with suppliers	1.172*** [0.000]	0.780** [0.002]					0.205*** [0.000]	0.134*** [0.000]	0.209*** [0.042]	0.137*** [0.040]
Collab. with suppliers (lagged)			0.137** [0.005]	0.080+ [0.087]						
Collab. with suppliers (instrum.)					0.120** [0.032]	0.178*** [0.046]				
No. FPS practices	0.162 [0.179]	0.234* [0.048]	0.027 [0.154]	0.061** [0.005]	0.006 [0.006]	0.010+ [0.006]			0.020 [0.016]	0.050** [0.016]
FPS practices							0.011 [0.562]	0.067** [0.009]		
Collab. x No. FPS practices	-0.562** [0.002]	-0.184 [0.307]	-0.073* [0.026]	-0.026 [0.433]	-0.046** [0.015]	0.003 [0.015]			-0.112*** [0.031]	-0.028 [0.028]
Collab. x FPS practices							-0.092* [0.022]	-0.053 [0.167]		
Collab. with Universities									0.091* [0.043]	0.023 [0.042]
Collab. Univ x No. FPS practices									0.026 [0.030]	0.006 [0.029]
Size	0.472 [0.144]	0.806* [0.024]	0.244* [0.029]	0.148 [0.131]	-0.015 [0.019]	0.023 [0.019]	0.189*** [0.000]	0.221*** [0.000]	0.186*** [0.049]	0.215*** [0.055]
Size ²	-0.009 [0.697]	-0.044 [0.102]	-0.011 [0.140]	-0.007 [0.299]	0.003+ [0.002]	-0.001 [0.002]	-0.009* [0.019]	-0.013** [0.002]	-0.009* [0.004]	-0.013** [0.004]
Part of a group	0.217 [0.348]	0.153 [0.458]	0.106* [0.013]	0.045 [0.314]	0.011 [0.010]	0.005 [0.010]	0.028 [0.341]	0.027 [0.330]	0.023 [0.029]	0.023 [0.028]
R&D intensity	48.607*** [0.000]	42.876*** [0.000]	53.782** *	35.695*** [0.000]	3.301*** [1.025]	1.850* [0.727]	11.925*** [0.000]	9.716*** [0.000]	11.561*** [1.767]	9.697*** [1.848]
Internal Design lab	0.177 [0.275]	0.248+ [0.100]	0.039 [0.142]	0.063* [0.017]	0.009 [0.282]	0.010 [0.008]	0.054* [0.012]	0.063** [0.003]	0.045* [0.021]	0.059** [0.022]
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Constant	-6.163*** [0.000]	-6.647*** [0.000]	-1.402*** [0.001]	-0.892* [0.013]	-0.009 [0.050]	-0.094+ [0.050]	-1.066*** [0.000]	-1.066*** [0.000]	-1.036*** [0.159]	-1.055*** [0.174]
sigma			0.267*** [0.000]	0.274*** [0.000]			0.285*** [0.000]	0.284*** [0.000]	0.282***	0.284***
rho					-0.116 [0.127]	-0.553 [0.171]				
Wald test (rho ==0)					1.73	16.88***				

Observations	1,593	823	823	1,596	1,596	1,596	1,596	1,596	1,596
Degrees of Freedom	36	18	18	18	18	18	18	20	20
F Statistic		5.990	4.856			11.79	10.04	11.34	9.619
log Likelihood	-740.9	-281.0	-310.1	-88.701	-40.765	-566.7	-589.5	-549.6	-586.0
Pseudo R Squared		0.193	0.128			0.227	0.170	0.250	0.175

Robust standard errors in brackets, *** p<0.001, ** p<0.01, * p<0.05, + p<0.1

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Figure 1: Moderating effect of problem solving practices in the presence of industry-related knowledge

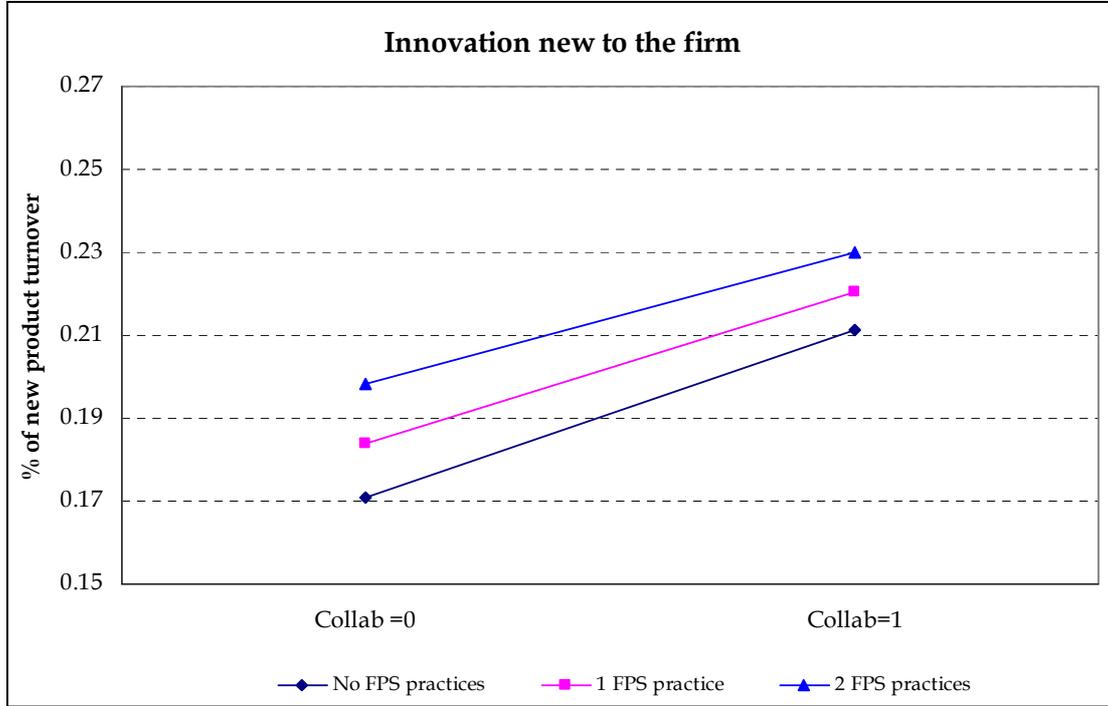


Figure 2: Moderating effect of problem solving practices in the absence of industry-related knowledge

