Small and medium enterprises' collaborations with universities for new product development

An analysis of the different phases

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1. Introduction

Understanding how to foster innovation in small and medium-sized enterprises (SMEs) is a priority in many countries, and is of particular importance to European policy-makers (Jones and Tilley, 2003) due to the relevance of SMEs for economic growth, innovation, employment and social integration.

It is widely acknowledged that SMEs have difficulty innovating without leveraging external sources of knowledge, particularly technical ones (Rothwell, 1983). Thus, universities can play a major role in strengthening the innovation performance of SMEs. Via collaboration with universities, SMEs can compensate for their limited in-house technical capabilities, share the cost and risk related to research activity, and speed up their innovation processes, leveraging external, flexible and capable resources (Macpherson and Ziolkowski, 2005; Rothwell, 1992).

However, this potential is far from being fully exploited because there are obstacles to university-industry collaborations (Schartinger *et al.*, 2002; Kruecken, 2003; Van Looy *et al.*, 2011). Scholars have identified some mechanisms that should increase the

likelihood of achieving the expected outcomes of collaborations with universities (Balconi *et al.*, 2004; Schartinger *et al.*, 2002; Harryson *et al.*, 2008), but such mechanisms are defined mainly with reference to large firms and do not take into account the specificities of SMEs, such as a lack of financial and labor resources (Buijs, 1987) as well as managerial capabilities (Rothwell, 1994). Hence, SMEs are required to develop specific approaches to engage in successful collaborations with universities (Motohashi, 2005).

Based on these considerations, we aim to understand how SMEs can improve their ability to manage collaborations with universities, with a specific focus on collaborations devoted to develop new products, since this specific type of collaboration is the most common among SMEs (Motohashi, 2005).

Starting from a review of the existing literature regarding university-industry collaborations, we highlight the importance of two distinctive capabilities for managing such collaborations:

(1) technology management capability; and

(2) project management capability.

The former is related to the SMEs ability to identify and integrate relevant technologies within their processes, while the latter refers to the SME's ability to adequately manage innovation projects in terms of quality, cost and time. Furthermore, combining both qualitative and quantitative evidence from the Italian context, we show that the relevance of such capabilities increases moving from the easiest collaborations (e.g. during the testing phase of the new product development process) to more complex collaborations (e.g. during the research phase).

This paper is organized as follows. In the next section, the relevant literature is introduced, and the specific research questions are described, after which the theoretical framework and the methodology are presented. In the Results section, the results are described and discussed. Finally, the last section highlights managerial implications, the limits of the study and the ideas for further research.

2. Literature review

University-industry collaborations (UICs) have been studied from different perspectives (see Perkmann and Walsh, 2007; Agrawal, 2001). One of the main topics addressed by the literature is how large, established firms can overcome the barriers that hamper the establishment of successful UICs. On the one hand, some authors focus their attention on firm characteristics. An adequate level of absorptive capacity (Cohen and Levinthal, 1989, 1990) is deemed fundamental to exploit university knowledge fruitfully. Furthermore, firm flexibility and adaptation are crucial for aligning cultural aspects of firms and universities (Santoro and Chakrabarti, 1999). Finally, organizational features impact the outcome of collaborations. In this vein, both firm and university champions play an important role (Santoro and Chakrabarti, 1999, 2002), as do *ad hoc* organizational units for managing collaborations (Buganza and Verganti, 2009).

On the other hand, other authors focus on the collaboration process between firms and universities. The collaboration process can be supported by adopting different organizational forms (Perkmann and Walsh, 2007; Schartinger *et al.*, 2002), varying in terms of intensity of personal relations and in terms of types of knowledge exchanged (Schartinger *et al.*, 2002). In particular, Sherwood and Covin (2008) show the impact of some factors (trust, partner familiarity, technology familiarity, alliance experience,

formal collaboration team and technology experts' communications) on tacit and explicit knowledge transfer. Trust predicts the successful acquisition of tacit knowledge but not explicit knowledge. Moreover, both forms of knowledge are predicted by partner familiarity and communication between partners' technology experts.

In contrast, literature addressing the issues surrounding UICs from the perspective of SMEs is still limited. Some authors have investigated the impact of SME-university collaborations on localized industrial regions, showing a positive effect on the local economy (Keeble *et al.*, 1999; Jones-Evans *et al.*, 1999). Other authors focus the attention on the typologies of collaborative projects between SMEs and universities. Santoro and Chakrabarti (2002) affirm that SMEs usually engage in collaborations with universities to solve specific problems regarding their core technologies. Motohashi (2005), examining the role of new technology-based firms in UICs in Japan, shows that small firms approach UICs with practical goals, such as the development of new products or new processes. In this vein, Macpherson and Ziolkowski (2005) demonstrate that SMEs that have collaborated in the development of new products have experienced higher investment returns than their counterparts that have focused on process development. Tavares (2000) suggests that SMEs should engage in collaborations with academia to support small-risk applied research projects, with results that can be exploited in the immediate future. Finally, Macpherson and Ziolkowski (2005) affirm that SMEs can engage in collaborations with universities related to incremental innovation projects. In this particular kind of project the main benefit for SMEs is the acquisition of well-established procedures.

However, how SMEs can manage these kinds of collaborative projects with universities successfully is a topic that deserves further investigation. Among the interesting contributions, Demain (2001) suggests that university must have an interpersonal approach rather than a formal one to involve SMEs in innovation projects. In the same vein, Santoro and Chakrabarti (2002) show that SMEs usually prefer to manage projects with universities through the use of arrangements specifically designed to address immediate problems, such as contract research and faculty consulting, while Motohashi (2005) claims that SMEs need to develop specific innovation capabilities in order to manage collaborations with universities. Still, further research is needed in this area. In particular, focusing on collaborations between SMEs and universities devoted to developing new products, we claim that such collaborations are not static along the different stages of the new product development process. For example, the scope of the collaboration itself can be very different according to the phase of the innovation process during which the collaboration takes place. It can go from the exploration of possible new ideas to the final test of existing products (Cooper and Kleinschmidt, 1986). Consequently, collaborating with universities in different phases of the innovation process entails specific challenges for SMEs (Schartinger *et al.*, 2002). Furthermore, it is reasonable to suppose that, although the capabilities of an SME are important throughout the entire process, they play different roles in the different phases of the collaboration process itself.

Starting from these considerations, we want to answer two research questions:

(1) How can SMEs sustain their collaborations with universities in the different phases of the new product development process?

(2) What capabilities do SMEs need to leverage the collaboration in the different phases of the new product development process?

3. Research framework

Based on the objectives of the paper, two aspects of UICs must be taken into account. The first is the potential for SMEs and firms in general to collaborate with universities during different phases of the NPD process, each of which may entail specific challenges (Schartinger *et al.*, 2002). The second is what capabilities a SME must develop to benefit from UICs. In the following pages, these two aspects will be briefly reviewed.

3.1 Phases

The literature has identified a set of steps that firms must follow to develop new products successfully. Cooper and Kleinschmidt (1986) argue that product development projects can be thought of as being made up by 13 different phases ranging from the initial screening of possible ideas to the market launch. However, SMEs rarely go through all these 13 phases (Huang *et al.*, 2002). Huang *et al.* (2002) note that SMEs are mainly focused on production or technical phases such as product development, preliminary production analysis, in-house product testing, and preliminary technical analysis. Hence, we focus our analysis on a simplified NPD process composed of three distinct phases:

(1) Applied research (hereafter "research") – The set of activities associated with accessing and using the knowledge, methods and techniques of the scientific community for a specific, commercial, or client-driven purpose.

(2) Development – The actual design and development of the product, resulting in the final design and prototype.

(3) Testing – The set of activities devoted to testing product performance and fine-tuning products before the market launch.

The literature has shown that collaborations with universities can be beneficial in all three phases (Lee, 2000; Santoro and Chakrabarti, 2002) but has not focused on how SMEs could establish collaborations with universities during the different phases.

3.2 Capabilities

The literature has frequently indicated the importance of developing specific capabilities that facilitate innovation (dynamic capabilities; Eisenhardt and Martin, 2000; Teece *et al.*, 1997). Motohashi (2005) underlines that to capture the potential benefits of collaborations with universities, SMEs must develop *ad hoc* capabilities. However, there is limited evidence about such capabilities for SMEs, whereas a larger body of literature is available for large firms. The latter is briefly discussed here and represents the basis for understanding the capabilities necessary for SMEs to manage UICs successfully.

Cohen and Levinthal (1989) argue that to acquire and develop university knowledge and integrate it into firm processes, an adequate level of absorptive capacity is required (Cohen and Levinthal, 1989, 1990). This capacity can be developed through R&D investment (Cohen and Levinthal, 1989, 1990) and through connections with the science community more generally (Cockburn and Henderson, 1998).

Organizational routines also play an important role in the management of UICs. Santoro and Chakrabarti (1999) point out that the organizational structure, planning/controlling processes and co-ordination systems have a deep impact on the

outcome of collaborations. In this vein, the presence of both university and firm champions plays an important role in establishing fruitful collaborations (Santoro and Chakrabarti, 2002). Champions promote new product ideas (Schon, 1963) and create a link between people and organizations (Hauschildt, 1999). Moreover, university-industry collaborations are projects, and hence the maturity of project management practices within a firm can influence the results of the collaborative NPD process. The literature has identified a set of factors that can lead to project failure, such as the absence of a project manager and wrong resource allocation or task schedules (Pinto and Slevin, 1988; Milosevic and Patanakul, 2005).

Based on this brief analysis, we see the importance of two distinctive set of capabilities for managing UICs. On the one hand, firms must be able to identify relevant technologies and integrate university knowledge within their processes; i.e. they must develop technology management capabilities. On the other hand, firms must be able to manage collaboration projects with universities and thus must develop project management capabilities.

This framework based on the three NPD phases (research, development and testing), and two enabling capabilities (technology management and project management) was used as a guide for collecting and analyzing the data.

4. Research methodology

To answer the research questions, both qualitative and quantitative evidence was collected.

4.1 Qualitative research

Due to the lack of previous contributions about the collaboration process and the capabilities required for SMEs to collaborate fruitfully with universities, it was deemed appropriate to conduct an exploratory study based on case studies. Indeed, the case study methodology is particularly suitable to answer how and why questions and to build a rich understanding of complex phenomena where the context is not easily isolable from the subject of investigation (Eisenhardt and Graebner, 2007).

Hence, five in-depth cases studies were conducted. The aim of this preliminary analysis was two-fold. The case studies enabled us to select the most important variables to investigate within the companies (Eisenhardt, 1989). At the same time, because the case study methodology can be used to answer "how" questions (Yin, 2003) and takes into account the context in which the observed phenomenon is embedded (Yin, 2003), case studies were used here to develop a preliminary model of how SMEs can engage in successful collaborations with universities.

The cases were selected from a database developed by the Chamber of Commerce of Milan, investigating the innovative activities of SMEs operating in the Lombardia region. The Lombardia region indeed accounts for almost 25 percent of Italian GDP and it is characterized by a strong presence of innovative SMEs. In this vein, the Lombardia region is characterized by an economic tissue that is similar to other European countries, increasing the external validity of the research. Among the 1,000 SMEs listed, 28 indicated at least one previous collaboration with a university or a research center. After a phone interview of about half an hour with the CEO of each SME, five SMEs were selected for the qualitative analysis based on the following criteria:

- including cases from different industries to increase external validity;
- including the most interesting collaboration projects; and
- including collaboration with universities in different phases of the new product development process.

Table I reports basic information about the case studies and gives a brief description of the most significant collaborative project for each firm. For confidentiality reasons, the names of the firms and universities are not revealed.

The analysis was performed at the firm level, considering the SMEs involved in UIC. However, to understand in greater detail what capabilities positively impact the establishment of fruitful collaborations, project-level data were also collected. In particular, the SMEs were asked to describe in detail the most significant project they had ever undertaken in collaboration with a university. We conducted retrospective case studies, interviewing both the people in charge of innovation tasks, mainly R&D responsible or CEO, at the firm and the researchers at the university with which the SME had collaborated. The data from the interviews were triangularized with data from secondary sources (Eisenhardt, 1989).

In order to improve the reliability of the empirical research, we applied structured procedures for data manipulation and analysis (Yin, 2003). In particular, we went through the following steps, recommended by Miles and Huberman (1994):

- data categorization, i.e. a breakdown followed by an aggregation of raw data carried out with the aim to unearth important characteristics and to streamline comparisons;
- data contextualization, i.e. a systematic analysis of contextual factors not included in the theoretical framework;
- within-case analysis through explanation building procedures – this was necessary to identify the reasons underlying the relationships between the identified variables; and
- cross-case analysis, carried out to compare the patterns emerged in each case study.

4.2 Quantitative research

To support the preliminary results obtained, all 28 SMEs were surveyed. The final questionnaire was developed from the qualitative evidence collected during the case studies and focused on two main areas related to the two main research questions:

(1) phases of collaboration; and

(2) technology and project management capabilities.

In particular, regarding the complex issue of assessing capabilities, we investigated technology management capabilities by asking companies the following:

- whether they had devoted human resources to research activities (at least part time);
- whether if they had graduates among their employees;
- whether they had hired individuals with technical/scientific degrees during the previous two years; and
- whether they designated an individual to be officially in charge of relationships with universities and research centers.

Table I. Most significant projects developed in collaboration with universities

SMEs	Firm description	Most significant collaborative project
Firm A	Firm A operates in the biotechnology sector, producing biological promoters based on selected enzymes and microorganisms for the treatment of organic substances, soil, water and air	Firm A had developed a product to reduce the smell related to the intensive breeding of pigs. During the collaboration process, the professor and the CTO of Firm A started to discuss the possibility of modifying the product to change how it was administered to the animals. Firm A declared itself to be satisfied with the collaboration. The CTO's decision to continue the project (even in absence of public funding) is also a testament to the firm's positive impression of the endeavor
Firm B	Founded in 1988, Firm B specializes in the design of equipment and systems in microelectronics and industrial areas	Firm B developed a wireless system based on an intelligent sensor in collaboration with an engineering university. After one year, Firm B was able to sell its system
Firm C	Firm C's core business it is to buy flour from other mills, mixing different types of flour and additives to satisfy customer needs	The principal innovation developed with the university was a new disinfestation process for Firm C's mill. This new process enabled the firm not to completely stop the mill. The new process, which helped the mill to avoid completely stopping work, allowed consistent cost savings
Firm D	Firm D researches, develops and produces a broad range of chemical products, including organic esters, industrial lubricants, ceramic additives, metalworking and detergents	Firm D collaborated with universities just to test already developed products. All of these collaborative efforts were very similar. Firm D is satisfied with these collaborations. The university personnel were competent and able to respect deadlines
Firm E	Begun in 1988, Firm E specializes in the design and manufacture of industrial furnaces for melting and heat-treating light alloys	Firm E collaborated with the university to develop a particular type of furnace for melting and heat-treating light alloy. Firm E was unsatisfied with the outcome of the collaboration efforts. The new product was supposed to provide up to 30 percent cost savings yet did not

Simultaneously, we measured project management capabilities, asking whether they:

- formally launched a project to pursue an innovation;
- named a project manager for every innovation process;
- formally planed and controlled the time and costs associated with the innovation process; and
- used formalized project management practices and tools (i.e. software).

All the questions were based on a binary scale. The collected data were used to define whether each company had (or lacked) technology management capabilities and project management capabilities. The eight questions were binary. An aggregate measure was created for both constructs (i.e. technology management capabilities and project management capabilities) by taking the average of the four respective answers. Companies were determined to have a capability if the value of the construct was above the mean for the whole sample (Griffin, 1997).

Due to the limited number of firms, the questionnaire was administered by phone by one of the authors. Thus, we had the option of adding any qualitative comment that might be made during the call. All of the firms contacted answered the questionnaire.

The sample of 28 SMEs includes 20 small enterprises with less than 50 employees and eight medium-sized enterprises with less than 250 employees. Table II indicates the industry distribution of the SMEs in the sample.

The overall sample of 28 SMEs is too limited for theory testing. Hence, this paper is explorative in nature, and we rely on quantitative data simply to support the evidence that arises from the qualitative analysis. In particular, we show that the findings of the case studies are not specific to the cases selected but represent a more general trend within the overall sample. Furthermore, we increase the robustness of the results by controlling for size and industry variables. Such variables could have a significant impact on the behavior of SMEs in their collaboration with universities (Santoro and Chakrabarti, 2002).

5. Results and discussion

To answer our research questions, we analyzed how SMEs sustain university collaboration during different phases of the NPD process (section 5.1) and the role of the capabilities in supporting such collaborations (section 5.2).

5.1 Collaboration phases

Table III reports evidence regarding the phases (research, development and testing) during which the five SMEs interviewed had collaborated with universities, and takes into account all UIC projects they had undertaken.

Table II.
SME distribution within industries

Industry	Textile and fashion	Machinery and materials	ICT	Non-food biotechnology	Food biotechnology
Number of SMEs	7	4	3	5	9

Table III.
Summary of the collaboration efforts involving universities during the different phases of the NPD process

SMEs	Phase in which SMEs engage in collaboration with universities: Applied research	Development	Test
Firm A	We, at the moment, are involved in two research projects with universities. The research activities are not jointly developed. Each actor is focused on the aspects of the research to which it can make the highest contribution	We collaborate with universities to develop and improve our existing products	We collaborate with universities mainly to validate existing products. The aim of these collaborations is two-fold: to improve product image, and to identify areas for further improvement
Firm B		In a few cases, we have engaged in collaboration with universities to develop the components of a new product for which we did not have the appropriate competences	Usually, we collaborate with universities to test our existing products through the supervision of a thesis
Firm C		We collaborated with the university to develop a new disinfestation process for the mill. The project involved a student who worked three days per week at the firm and a full-time researcher at the university	Usually, we collaborate with universities to test our existing products through the supervision of a thesis
Firm D			Usually, we collaborate with universities to test products that have already been developed. However, there are some cases in which the university contacted us to conduct some research using the firm's machinery
Firm E		We collaborated with one technical university in Lombardia to develop a particular type of furnace for melting and heat-treating light alloys	

A preliminary analysis of Table III reveals a common pattern, a progressive behavioral model of the phases of the NPD process in which SMEs collaborate with universities. More specifically, firms that collaborate during the research phase have normally already collaborated during the development and testing phases on other previous projects. In the same way, SMEs collaborating with universities during the development phase tended to collaborate with them also during the testing phase. The only exception is Firm E. But it is important to underline that in this case the collaboration was a failure.

This evidence suggests that at the beginning SMEs approach the collaborating universities with clear and easily definable tasks (such as testing) and only after positive experiences in these collaborations do they move towards more complicated, trust-based relationships such as development and research.

This qualitative evidence is consistent with the patterns visible for the sample of 28 SMEs (Table IV). Taking into account the characteristics of the sample as described in the "Research methodology" section, we ensured that the SMEs that follow the progressive behavioral model did not have similar characteristics in terms of size or industry, concluding that SMEs show a progressive pattern independent of their size or industry.

In particular, we observed that 24 companies out of 28 follow the progressive behavioral model previously identified, while only four companies (out of 28) do not use a progressive approach to UICs, collaborating during the development phase without having done so in the testing phase or during the research phase without having done so in the development phase. We also noticed that only two SMEs collaborated with universities during the testing and development phases. It seems that the SMEs are polarized in their approach to working with universities: either they only perform testing activities together or they collaborate throughout the entire NPD process.

This evidence can be interpreted through the lens of the transaction cost theory developed by Williamson (1998) and the "total cost" model for services proposed by Womack and Jones (2005). The total cost is defined as the sum of all costs that the client has to sustain to benefit from a service. It includes the cost of accessing the service (e.g. the costs sustained in identifying the best university and defining the transacted service), the costs of managing the relationship (interface), including those related to co-ordination meetings, and direct costs (e.g. the price paid to the university for the collaboration).

Working from these theories, we can state that the total cost a SME has to bear in order to collaborate with universities increases by moving from the testing phase to the research phase. Indeed, in discussing testing (e.g. wind tunnel tests), SMEs are able to define their needs clearly and precisely and to assess the quality of the services that are receiving. Hence, it is easy to define such contracts with universities, which are often standard. In other words, the access and interface costs are low because the service is

Table IV.
Progressive collaboration with universities

Testing	Testing and development	Testing and development and research	Companies not following the model
4	2	18	4

easily describable; buying a test service from a university is similar to outsourcing to any external company.

> It is easy for us to involve universities in testing our products. We simply call our contact within the university and deliver our products to him with information about the type of tests we want to perform. At that point, we only have to wait for the results (CEO of Firm D).

In contrast, collaborations in the research phase require SMEs to work on new technologies or new products that are very far from commercialization. At this stage, it is unclear how (or even if) the SME will be able to take advantage of this knowledge on the market. In such cases, it is very difficult to define requirements, deliverables and level of quality expected. The same can be said for intellectual property rights. Hence, the access costs are not only high but also mainly ineffective and the collaboration must be managed very closely by the company, which will considerably increase interface costs.

> I spent six months identifying the right professor and then, after the beginning of the collaboration, I had to control the advancement of the projects, trying to direct university effort toward what we really wanted (CEO of Firm E).

Based on the above considerations, we can say that both access costs and interface costs increase moving from the testing phase to the research one. Therefore, it is easier for SMEs begin collaborating with universities from the testing phase, as it was done by many companies in our sample.

Still, many of them also moved the collaboration towards more challenging phases such as development and research. In particular, as we noted previously, only two SMEs in our sample stopped collaborating once they had reached the development phase. This finding suggests that the main change in SME attitude regarding universities is the shift that occurs between collaborations during the testing and development phases. Once they have overcome the barriers of complex and challenging forms of collaboration, they tend to involve the universities throughout the whole NPD process.

The case of Firm A is emblematic in this respect. Firm A began collaborating with the department of animal health at the University of Milan after some bad experiences with other universities:

> We had some terrible experiences with universities before starting to collaborate with the Department of Animal Health at the University of Milan, and we were reluctant to engage a new collaboration with a university (CTO of Firm A).

However, the university professor was able to convince Firm A to begin the collaboration, proposing a very simple project: demonstrating the positive impact of Firm A's products on animal health, which meant collaborating during the testing phase:

> At the beginning, the collaboration process was very difficult for me. The CTO was skeptical about our competences and about our understanding of their needs. Hence, we had to create a rigid contract that defined all the specifics of the collaboration and the expected outcomes. However, now, after a year, we are perfectly aligned in terms of the objectives, and we trust each other. We can define the next steps of the collaboration with just a phone call (University Professor).

On this basis, we can affirm that the collaboration during the testing phase creates trust among both parties and facilitates university knowledge about the needs of the SME, fostering partner and technological familiarity. According to Sherwood and Covin (2008), trust, partner familiarity and technological familiarity play an important role in establishing fruitful collaborations. These factors have an influence in two respects. First, they lower the total cost of collaborations in research or development, making them more attractive. Secondly, as shown by Sherwood and Covin (2008), they increase the likelihood of successful knowledge exchange, increasing the effectiveness of the collaboration.

5.2 SMEs' capabilities

The other variable that affects the success of SMEs in managing complex collaborations is based upon the SME capabilities. In the research framework, we identified two main capabilities affecting UICs:

(1) technology management capabilities; and

(2) project management capabilities.

The importance of these capabilities was also confirmed in the case studies:

> We need to maintain a certain amount of research within our internal R&D laboratory. Otherwise, it is not possible for us to guide the university research or understand how to integrate their technologies within our products (CEO of Firm B).

> University professors are not used to work with strict deadlines. Hence, in addition to our research effort, we must also schedule and control the university work to keep it on time with our business deadlines (CTO of Firm A).

We investigated the relationship between these capabilities and the firms' ability to manage complex collaborations (e.g. during the research phase). Based on Figure 1, it appears that SMEs perform differently on these capabilities. Some firms, such as Firm A, have a high level of capability in both areas. Other firms, such as Firm B, are highly capable in only one area (in this case, technology management). Finally, other firms, like Firm E, perform poorly in both areas.

Based on the evidence from the progressive behavioral model of SME-university collaboration, we find that these capabilities are intimately related to the phases of the NPD process in which these collaborations take place (Figure 1). For instance, Firm A, the only firm in the sample that collaborates successfully with universities during the research phase, presents a high level of technology management capability and project management capability. In contrast, collaboration during the testing phase seems to require a lower level of both capabilities, as in the case of Firm D. Finally, collaboration during the development phase requires at least a high level of one of these two capabilities, as Firm C possesses. Firm E, the SME that declared itself to be unsatisfied with its collaborations with universities, has the lowest level of both capabilities.

The quantitative analysis supports the qualitative evidence. Again, we observed no significant relationships between the capabilities of the SMEs and their size. Instead, there is a relation between the capabilities and the phases during which the SMEs engaged in collaboration with universities.

Table V shows that only those SMEs that collaborated with universities during the entire NPD process show a high level of both technology management and project

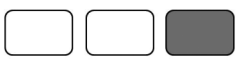
SMEs	TECHNOLOGY MANAGEMENT		PROJECT MANAGEMENT		Progressive behavioral Model (Phases in which collaborations took place)
	Capability level	Brief description	Capability level	Brief description	
FIRM A	HIGH	R&D activity is one of the strengths of the firm. The research and development department is made up of five people, either graduates or undergraduates, who are committed to research full-time. Two percent of sales are dedicated to research. Another 20%-30% is used to improve collaboration with universities.	HIGH	The company employs project managers who can define the strategic activities and the budget. However, when a new product is developed in collaboration with universities, the CTO leads the project. "We used to manage the professors' innovation activities through projects."	
FIRM B	HIGH	The company has an internal R&D department that employs about thirty people. 50% of them do testing, whereas the other 50% do the real research. The employees are graduates, except for the technical staff working in the test laboratory. Between 8% and 10% of sales proceeds are re-invested in the company.	LOW	The company usually does not employ project managers to track the development of the projects. Formal procedures and tools for planning and controlling the projects are not used.	
FIRM C	LOW	The company has no internal R&D laboratory because of the high cost it would entail.	HIGH	Each university collaboration is managed through the launch of a new project, usually a thesis project. The head of the laboratory is the formal project manager.	
FIRM D	LOW	The company has no formal R&D laboratory. The research activities are performed in the laboratory used for testing finished products.	LOW	The firm has no structured project management approach. "The management of the project with universities is characterized by a lot of improvisation."	
FIRM E	LOW	The company has not an internal R&D department due to the progressive downsizing of the firm.	LOW	The firm has not created a specific project team and has not assigned a project manager to control the progress of collaborative projects.	

Figure 1.
Technology management and project management capabilities of SMEs

Phase during which SMEs collaborate with universities	Technology management *and* project management capabilities	Technology management *or* project management capabilities	No technology management or project management capabilities
Testing	0	2	2
Testing and development	0	2	0
Research and development and testing	8	4	6

Table V. Relationships between the behavioral progressive model and SME capabilities

Note: The four companies in the sample that do not follow the progressive model were excluded from the analysis

management capabilities. Furthermore, all the SMEs that collaborate during the testing and development phases have developed at least one of the two main capabilities considered. Finally, half of the firms that engaged in testing activities do not present significant levels of either technology management or project management capabilities, compared to zero firms and one third of the firms for the other two categories.

Once more, this pattern may stem from the different transaction costs associated with the different phases of NPD. The more collaboration takes place during the research phase, the greater the complexity of the collaboration process and the greater the uncertainty of the expected outcomes. Hence, it is particularly difficult for a firm to define what activities are necessary (access costs), predict the progress of the activities and anticipate those exceptions that might affect their development (interface costs). According to the information-processing contingency theory (Tushman and Nadler, 1978; Egelhoff, 1982), under these conditions, the information needed to coordinate the collaboration is difficult to codify and exchange without misunderstanding and high costs. This difficulty increases the challenges that SMEs must face to engage in successful collaborations. Thus, project management capabilities increase their value. Absorptive capacity alone is no longer sufficient to guarantee a fruitful collaboration.

6. Conclusions

The results of this research shed some light on an important but rather under-explored topic: collaboration between SMEs and universities. Some relevant managerial and policy implications can be drawn from the research results.

We observed that the relationships between SMEs and universities vary across the different phases. More specifically, the total cost of the collaboration changes along with the complexity of the transacted service: it is lower for testing (a process in which it is easier to define the expected results in terms of quality and the activities to be performed) and higher for research (where it is difficult to determine the final outcome from the beginning and therefore to assess project success).

From the managerial point-of-view, we observed two main phenomena that explain why some companies are more able than others to engage in complex collaborations with universities and research centers. The first relates to trust, partner familiarity and technological familiarity. The companies in our sample that are able to push the

collaboration till the research phase follow a progressive collaboration model. They begin to collaborate on the testing phase and then move back along the process engaging on complex collaborations (e.g. collaboration on development and eventually, in some cases, research). In this way, the two parties develop their collaborative relationship step-by-step, learning to know and trust each other, increasing the likelihood of a successful collaboration. The second phenomena relates to capabilities. More specifically, technology management capabilities allow firms to reduce the cost and risk associated with correctly defining their needs (access costs) and assessing the results (interface costs). However, project management capabilities allow firms to manage the relationship (interface costs) with industrial standards, taking into account dimensions such as time and cost and thus increasing the chances of a successful collaboration. Our data show that SMEs engaging in collaborations during the research phase display greater capabilities in both areas.

Both phenomena identified have significant managerial and political implications. First, the capabilities identified have shown a relevant impact on collaboration success and deserve special attention from both firm managers and policy-makers. Many ways of fostering UICs have been studied, but limited attention has been devoted to increasing the capabilities required for firms to manage these relationships successfully. Second, the progressive behavioral model introduced suggests new strategies for fostering UICs. Firms who have not had previous collaboration experiences with universities on simple project (e.g. testing) might begin by collaborating on the first phases of the NPD process rather than immediately attempting complex collaborative projects, which can have a detrimental effect on the results attained and on the partner interest in future relationships.

However, this paper has limitations. First, we do not have quantitative performance measures indicating whether the patterns of SME-university collaboration identified positively affects SME results. The qualitative analysis seems to confirm this hypothesis, but more formal tests are needed. Second, this paper is explorative in nature. The quantitative data allow us to support and sustain the evidence from the case studies, but are too few for theory testing. It would be interesting to confirm our findings using a larger data set. Finally, we have considered the problem from the SME perspective. Because the literature has indicated that the characteristics of universities (e.g. intellectual property rules or culture) have an impact on the outcome of the collaboration process (Zilberman and Heiman, 2002; Kruecken, 2003), it will be important to combine the firm perspective and the university perspective in further research.

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