Is Your Open-Innovation Successful? The Mediating Role of a Firm's organizational and social context

Abstract

Open firms are not equally successful. This is because, in order to benefit from external sources of knowledge, they have to be able to absorb them should be able to absorb it. The paper outlines a firm's context as a set of organizational and social features, which may be considered as absorptive capacity antecedents. It explores the mediating role of such antecedents in the relationship – hitherto insufficiently researched – between the degree of openness and innovative performance.

The use of a methodology combining both direct interviews and a survey of Italian firms has allowed us to confirm the alleged supposed mediating role. We also identify different modes for companies to open up their innovation process and, for each of them, the antecedents that are consistent with choices regarding the degree of openness.

Key words: Open Innovation degree; Technological Collaborations; Intellectual capital; Organizational and Social Context; Absorptive capacity; Innovative performance

Introduction

Since the '80s many companies have been successfully developing innovation, not only internally, but also externally through collaboration with other parties (von Hippel, 1988). More recently, open innovation (OI) literature (Chesbrough, 2003) suggests that firms can improve their innovation performance by learning from a large set of actors in the innovation process. The extant literature suggests that OI can be adopted with many different models, corresponding to different degrees of openness, and that they are all strategically valuable (Chesbrough, 2006). The need for companies to tailor their own firm-specific OI models is determined by a set of contextual factors (internal and environmental) according to a contingency perspective (Drechsler and Natter, 2012). Literature also recognizes that greater degrees of openness bring about increasing organizational and managerial complexity (Enkel and Bader, 2012). Even if OI is claimed to be a great opportunity for companies, the success of such a new paradigm in terms of innovation performance is still debatable (Laursen and Salter, 2006). Beyond the unquestionable role exerted by external contextual factors, it is also accepted that the internal context is crucial to explaining the success or failure of the new approach (Foss et al. 2010) which, in any case, is a matter of firm absorptive capacity (Cohen and Levinthal,

1990). Despite these shared assumptions, the firm's internal context has been poorly investigated, apart from a few exceptions concerning large companies (e.g. P&G in Dodgson et al., 2006). Some authors have recently written about the connections emerging among the absorptive capacity of a company, the OI model and the related performance, but further investigation is needed in that contributions are limited, especially with reference to OI models which involve a wide range of external actors (Foss et al., 2011).

Absorptive capacity (Acap) was originally defined as a firm's ability to learn from external sources (Cohen and Levinthal, 1990). Such ability would subsequently be better defined by Lane et al. (2006) as the firm's ability to utilize externally held knowledge through three sequential processes: recognizing and understanding potentially valuable new knowledge outside the firm through exploratory learning; assimilating valuable new knowledge through transformative learning; using the assimilated knowledge to create new knowledge and commercial outputs through exploitative learning. However, an understanding of what factors can be indicated as leading to the effective functioning of such processes is still lacking. R&D intensity is the variable traditionally identified as an explanatory factor of Acap processes (Veugelers,1997), while the most recent literature argues that a better understanding can be achieved by considering a set of internal intellectual capital components as Acap micro-foundations or antecedents (Volberda et al., 2010; Foss et al., 2011). Such antecedents should lead to an understanding of how absorptive capacity is working and thus explain the firm's capacity to learn from external sources. This capacity, in turn, affects the firm's innovative performance (Lane et al. 2006).

This paper attempts to answer this call, by investigating whether and how Acap antecedents, openness and innovative performance are inter-related. In particular, we aim at understanding why some companies are able to extract value from collaborations and others are not, by investigating whether the firm's internal context mediates the relationship between collaborative behaviour and innovative performance. For the purpose, we adopt a concept of internal context as a set of organizational and social capital components, which can be considered antecedents of the Acap processes: individual roles, organizational roles, processes and internal social capital features.

The study is based upon previous literature and an empirical study composed of a qualitative and a quantitative analysis. These two approaches to the empirical study complement and integrate each other, thus enabling a rich and in-depth investigation of the topic.

The study is conducted within the empirical setting of *Made in Italy* companies belonging to industrial machinery sectors. These fields are traditionally characterized by a medium-to-low level of technology intensity, but are now experiencing increasing technological dynamism dynamic and turbulence (Coltorti et al., 2013). Technological evolution, which is recognized by literature as the main driver for openness (Fortuin and Omta, 2008), together with the fear of imitation by developing countries, are pushing companies to look for innovative solutions and thus search for,

activate and manage new knowledge inputs, including external ones (Chesbrough and Crowther, 2006). Such a circumstance gives importance to OI studies in these more traditional sectors as well. Moreover, traditional Made in Italy companies represent an interesting context for our investigation, since it is recognised in literature that their organizational and social practices represent a relevant source of their competitive advantage (Grimpe and Sofka, 2009; Spithoven et al., 2010).

The paper is organized as follows: first, we define the conceptual background, then describe the methodology, report the results and discuss them. Finally we draw conclusions, highlight some implications for human resource management and point out the limitations of the work.

Theoretical Background

The theoretical foundations of our work can be found in streams of literature which are closely interlinked: these range from areas dealing with the recent OI paradigm, to ones focused on the absorptive capacity concept, both grounded in the more longstanding strand focused on knowledge management, intellectual capital, human resource management (HRM) and innovation. In this section, after introducing some preliminary concepts, we explain the theoretical arguments used to define the Acap antecedents and we outline the research gap we address.

Preliminary concepts

In this paper we shed light on how companies can adapt the internal context in order to facilitate the use of outside knowledge in the innovation process and achieve a satisfactorily innovative performance. While there are many definitions of innovation (OECD, 2005; Damanpour, 1991), the most appropriate for our goal is the one that considers knowledge as the core of innovation. Innovation cannot occur without knowledge. Indeed, innovation is a process that covers the creation and use of knowledge for the development and introduction of something new and useful (Abetti, 1989; Wallin and Krogh, 2010). Accordingly, the OI paradigm suggests that the knowledge can also stem from outside (Chesbrough, 2003), so defining the appropriate internal context is a matter of integrating different knowledge sources.

The concept of OI has received a considerable amount of attention from practitioners and researchers, but limitations have also been outlined. In particular, the artificial dichotomy between closed and open approaches has been criticized (Dahlander and Gann, 2010), whilst the idea of exploring different degrees of openness in a sort of continuum seems to provide a more interesting way path for investigation (Gassmann, 2006). For example, Laursen and Salter (2006) define the concept of breadth (number of sources used for OI) and depth (intensity of collaboration with each source) of external sources. Lazzarotti and Manzini (2009) develop a concept of openness degree by integrating

the type of partners and the type of phases of the innovation process open to external contributions in and/or out. The degree of openness thus reflects how broadly and intensively a firm uses external information in innovation (Drechler and Natter, 2011). It refers to firms' use of external sources of innovation by collaborating with other companies, institutions or people. Collaboration concerns the joint development of knowledge through relationships with external partners. Such collaboration implies that partners share their resources and knowledge.

Previous research also attempted to study the relationships among different degrees of OI, innovative performance and several contextual factors, driven by the idea that these factors could be the determinants of OI approaches and their success in terms of innovative performance (Sofka and Grimpe, 2010; Lazzarotti et al., 2011; Drechsler and Natter, 2012). Context factors can be both variables representing the external environment (e.g. type of industry) as well as the internal context, in so far as they represent firm-specific situations (e.g. type of innovation; size; organizational practices). Among these contributions, two of them in particular provide the theoretical premises of our work: studies about the type of industry and studies regarding the openness degree in an organizational and social context.

Studies on industry-type justify the choice of our setting (traditional Made in Italy sectors). Indeed, literature suggests that OI is useful as a paradigm for industrial innovation even beyond high-tech industries such as *Made in Italy* ones (Chesbrough and Crowther, 2006).

The second line of contributions attributes a critical role to the organizational and social context regarding the implementation of OI. In other words, an internal context must be suitable for this purpose (Pisano and Verganti, 2008; Lazzarotti and Manzini, 2009; Wallin and Von Krogh, 2010). The change of approach, from closed to open innovation, requires a structured approach involving not only the tools necessary for identifying technological trends, but also the organizational mechanisms for managing people and culture. Indeed, higher open degrees are likely to require more sophisticated organizational and procedural responses, because of the growing complexity generated by a wide range of external knowledge inputs (Foss et al., 2011).

The Process-oriented Perspective of Acap

In Cohen and Levinthal's original version (1990), three types of abilities are included in the concept of absorptive capacity: the ability to recognize the value of new external knowledge; the ability to assimilate it; the ability to commercialize the new external knowledge. In 2002, Zahra and George re-thought the concept of Acap by splitting the ability to assimilate into two: assimilation as the ability of the firm to understand external knowledge through its specific routines; transformation as the ability to internalize and convert the new assimilated knowledge in order to recognize entrepreneurial opportunities. Moreover, the authors extend the concept by specifying two capabilities: potential and

realized absorptive capacity. Potential capacity enables firms to be receptive to external knowledge and it involves the dimensions of knowledge acquisition and assimilation. Realized capacity concerns a firm' s ability to transform and exploit the new knowledge by combining it with its existing knowledge. The basic assumption of this further specification of Acap is that a firm's capacity to evaluate and acquire external knowledge does not guarantee that the firm will be able to exploit this knowledge.

Lane et al. (2006) suggest that, with respect to Cohen and Levinthal's original definition which focused only on a firm's ability, a process-oriented perspective is more useful in order to understand the concept. Acap may be obtained through the activation of some processes within the organization and each process requires a different type of learning. Acap is thus defined as the firm's ability to utilize externally held knowledge through three sequential processes: 1. recognizing and understanding potentially valuable new knowledge outside the firm through exploratory learning; 2. assimilating valuable new knowledge through transformative learning; 3. using the assimilated knowledge to create new knowledge and commercial outputs through exploitative learning. Exploratory learning involves searching for and experimenting with new technologies or entrepreneurial opportunities (March, 1991), thus it is used to recognize and understand new external knowledge. Exploitative learning deals with the refinement and extension of known technologies and thus it is used to apply the assimilated external knowledge. Finally, transformative learning links the exploratory and exploitative ones: new knowledge is combined with existing knowledge, allowing the use of the latter in new ways.

Innovative Performance

Innovative performance is usually evaluated by means of objective indicators (e.g. number of new products: Lichtenthaler, 2009) or by means of the respondents' subjective perceptions with regard to the success of the innovation (Chiang and Hung, 2010). Other authors (West and Gallagher, 2006) measure innovative performance as the improvement of the company innovation processes, rather than the end result in terms of number of new products or sales deriving from them (e.g. enlargement of firms' competence base or time to market reduction).

Antecedents of Absorptive capacity and Innovative Performance

Micro-foundations of Acap are based on the insights provided by intellectual capital, HRM and innovation approaches. In particular, there are two relevant strands of literature, the latter of which may be considered a sort of evolution of the former. This provides interesting arguments about the key role of the intellectual capital for innovative performance. The second one tries to extend such a role to a situation in which innovation is carried out through collaboration, by supposing that

intellectual capital components are able to enhance innovative performance. In the following, we analyse both lines of the literature and we identify in the second one the research gap to which we are attempting to give a contribution.

Intellectual Capital and Innovative Performance within the company

Intellectual capital (IC) is conceptualized as the knowledge and knowledge capability of an organization (Nahapiet and Ghoshal, 1998) and it is considered one of the most relevant antecedents of innovation (Subramaniam and Youndt, 2005). It is widely accepted that IC is characterized by three components: human, social and organizational capital (Davenport and Prusak, 1998). The human capital is defined as the knowledge, skills and abilities residing with and utilized by individuals (Subramaniam and Youndt, 2005). Social capital is defined as the knowledge embedded within, available through and utilized by interactions among individuals and their networks of interrelationships (Nahapiet and Ghoshal, 1998). Several researchers have highlighted the two main aspects of social capital (Cabello-Medina et al., 2011): the structural and the relational dimension. The former relates to the structure of networks, determining with whom each person maintains contact, while the latter focuses on the quality of these relationships (Moran, 2005). Moran (2005) suggests that the relational dimension influences innovation tasks more than the structural dimension. Lastly, organizational capital is defined as the institutionalized knowledge and codified experience residing within and utilized through structures, systems and processes (Youndt et al., 2004).

Several studies have demonstrated the importance of the three components of IC in order to achieve innovative performance. The result linking such studies is that human, organizational and social capital are all crucial in creating a conducive context which enables firms to share knowledge internally and improve innovative performance. For example, Cabrera et al. (2006) identify the socio-psychological and organizational determinants of knowledge sharing: some personality dimensions (e.g. openness to experience), a strong relational dimension of social capital (e.g. trust and group identification), some features of the organizational environment (e.g. rewards achievable as a result of collaborative behaviour) are tested as factors driving knowledge sharing within the firm. Cabello-Medina et al. (2011) had studied the relationship between the relational side of social capital and innovative performance and found a positive association. Following Subramaniam and Youndt (2005), the authors conclude that, due to the fact that innovation is essentially a collaborative effort, communication and the sharing of knowledge are vital elements of innovative capabilities. According to Nahapiet and Ghosal (1998), they suggest that the relational dimension of social capital represents an increased willingness to experiment with different types of information and thus develop new knowledge and increase innovative performance. Moreover, they demonstrate that social and individual capital are not independent variables, rather they interact in order to improve innovative

performance. They argue that high levels of relational social capital can enhance the skills and capabilities of individuals. Liu (2013) shows that high levels of social interaction improve individual creativity because they foster trust, encourage risk taking and reduce the distractions created by uncertainty concerns. Yang and Lin (2009) studied all three components of IC and conclude that they are of benefit in creating value for the firm and its stakeholders.

Several authors outline the crucial role of human resource management (HRM) practices in order to develop IC (Gittell, 2000; Cabrera and Cabrera, 2005). Examples of relevant HRM practices are work design interventions (e.g. the creation of cross-functional teams and liaisons) that, while shaping the organizational capital, also affect social capital by establishing interdependencies, frequency of interactions and information flows among employees.

Intellectual Capital and Innovative Performance through collaborations: the research gap

Lin and Chen (2006) take as a starting point the importance of cross-functional integration between marketing, R&D and manufacturing in order to favour knowledge sharing and innovative performance. Then they argue that such conventional wisdom is still valid in the case of collaborative innovation. The only difference is that employees of the partnered firms can also join the cross-functional teams. Jolink and Dankbaar (2010) propose a reinterpretation of Cabrera et al.'s (2006) work by arguing that the socio-psychological and organizational determinants, which foster knowledge sharing within a company, are a valid means of determining collaborative behaviours even among employees from different firms. Other studies suggest that successful collaborative behaviours require relevant changes in the organizational and managerial practices. For instance, Ritala et al. (2009) investigate which individual and which organizational capabilities (*orchestration* capability or *collaboration* capability: see also Dhanaraj and Parkhe, 2006; Blomqvist and Levy, 2006) exert a beneficial role for collaborations. The authors find that certain individuals act as internal change agents, crucial both in supporting meetings among members of different companies and in favouring cooperation inside their own firm. Such individuals are named scouts or boundary spanners. Moreover, the authors recognized as relevant organizational capabilities those capabilities which enable the creation of an atmosphere conducive to collaboration. Petroni et al. (2012) studied companies engaged in OI projects and find that open initiatives lead to significant changes in the organization of R&D and in HRM practices.

Although these studies are important to outline the relevance of a company context, they do not explicitly refer to absorptive capacity and its processes. However, the reference to Acap processes is crucial for a deep understanding of the role of the contextual antecedents. The rationale is the following: components of IC are considered as antecedents of Acap because they enable the effective working of the Acap processes. Consequently, they enhance the innovative performance resulting

from collaboration. In this vein, the first relevant contribution is by Jansen et al. (2005) who have studied three types of antecedents of Acap: coordination capabilities; system capabilities and socialization capabilities. Among the coordination capabilities, the authors include cross-functional interfaces. Among system capabilities, they consider formalization and the existence of routine tasks for employees. Concerning socialization capabilities, they use previously developed scales representing the level of connectedness among individuals. The authors investigate how antecedents influence the process dimensions of absorptive capacity, i.e. potential (acquisition and assimilation processes) and realized (transformation and exploitation processes). Coordination capabilities primarily enhance the potential absorptive capacity because they encourage lateral communication and reciprocal information. Moreover, coordination capabilities enhance the realized absorptive capacity because they facilitate commitment and the implementation of decisions. Socialization capabilities are instead negatively related to potential Acap because they limit the openness to alternative ways of doing things. However, they are positively related to realized Acap by encouraging trust, cooperation, communication and thus improving the efficiency of knowledge sharing. The authors also find that system capabilities are related to realized Acap because they improve efficiency and task coordination. Such capabilities do not decrease even the potential Acap: some degree of formalization seems instead to favour the acquisition and assimilation of new knowledge.

Lane et al. (2006) elaborate a theoretical framework which consists in a process model of Acap, its antecedents and outcomes in terms of performance. The authors call for empirical testing of their model, which assigns the role of Acap antecedents to individual capability (mental models can drive recognition, assimilation and application), as well as to organizational capabilities (structures and processes can drive the efficiency and effectiveness of assimilation and application).

Volberda et al. (2010) develop an integrative framework of Acap that specifies the organizational antecedents of Acap by distinguishing them in managerial, intra-organizational and inter-organizational antecedents. The definition of the managerial and intra-organizational factors usefully synthesize the IC capabilities available within firms. The managerial antecedent is defined as the capacity of managers to create, extend or modify the knowledge resources of an organization. To achieve these goals, managers should be able to develop the Acap for new knowledge scanning by encouraging the development of employees' roles as gatekeepers and boundary spanners. The authors also include among the managerial antecedents those cross-functional interfaces identified by Jansen et al. (2005) as coordination capabilities. The intra-organizational antecedents deal instead with socialization and internal communication aspects, while inter-organizational ones refer to the mechanisms for managing relationships among the organizations which are involved in collaboration and knowledge sharing.

Interesting insights are also provided by studies focused on collaborations with suppliers and customers. Indeed, these types of collaboration can be considered as a particular form of OI, characterized by a lower degree of openness (Laursen and Salter, 2006). By exploring the links between internal and external cooperation in product development, Hillebrand and Biemans (2004) find that internal cooperative norms and mechanisms may be useful to coordinate effectively external collaborations with suppliers as well. Lawson et al. (2009) find that the creation of social ties with customers and suppliers in new product development increases the flow of knowledge and improves product development outcomes.

Foss et al. (2011) make a further advance in exploring the relationships among interaction with customers, organizational practices and innovative performance. The authors find that organizational practices provide a strong mediating effect between customer involvement and innovation. They argue that there is not a direct relation among such variables: firms, attempting to leverage customer knowledge in the context of innovation, must design an internal organization appropriate for supporting it. The authors underline the need for future research dealing with appropriate organizational responses to a much wider range of external knowledge sources. Brunswicker and Vanhaverbeke (2011) and Ihl et al. (2012) respond to this call. The former study identifies five internal organizational facilitators and analyses a sample of European SMEs. The authors define clusters of firms depending on their degree of openness and find that the more open and higher performing clusters are characterized by a higher level of the internal facilitators. The second study analyses a sample of German firms and carries out regressions in which the dependent variable is innovation performance, the independent variable is the degree of openness and moderation variables are three internal organizational factors. Despite having different methodologies, these two studies suggest that open firms do not seem to be able to achieve high levels of innovative performance in the absence of internal organizational and managerial capabilities.

Although studies of this type have increased in recent years, their number is still limited and the empirical evidence is not conclusive, especially if the number of partners is as wide as in open innovation. The call for further investigation has encouraged our work.

Hypothesis Development

Managerial/Organizational antecedents and Innovative Performance

Literature analysis has highlighted the crucial role of human and organizational capital and related HRM practices in creating a context which favours knowledge sharing (and thus innovative performance) within the company (Gittell, 2000; Cabrera and Cabrera, 2005; Yang and Lin, 2009). Appropriate roles, structures, procedures and systems are also relevant in order to enable effective knowledge flows when innovation is carried out in collaboration (Ritala, 2009; Jolink and Dankbaar,

2010; Petroni et al., 2012). Individual change-agent roles have been proven to enhance the firm's potential absorptive capacity. This is due to their capacity to promote non-routine and reciprocal information processing and to overcome differences, interpret issues and build understanding about new external knowledge (Jansen et al., 2005). Of particular interest are boundary persons, people that transfer information among organizational groups or among organizations (Hillebrand and Biemans, 2004; Ritala, 2009). By bringing differences in mental and coding schemes, such roles enhance firms' exploratory learning, which is used to recognize and understand new external knowledge (Lane et al., 2006). Exploratory learning serves the goal of seeking and experimenting with new technologies or entrepreneurial opportunities, which is a basic premise for innovative performance in terms of the expansion of a firm's competence base, access to advanced technologies, the stimulation of creativity and idea generation capacity (March, 1991). An increase in the flow of knowledge is also provided by cross-functional interfaces (e.g. cross-functional teams and task forces) that, by integrating diverse knowledge components, are able to support members in rethinking the systematic nature of existing products and services (Jansen et al., 2005). Therefore, cross-functional interfaces enable employees to combine sets of existing and newly acquired knowledge, which is transformative learning (Lane et al. 2006). Moreover, cross-functional interfaces provide an effective way of generating commitment and facilitating the implementation of decisions (Jansen et al., 2005; Petroni et al., 2012). Thus, cross-functional interfaces increase exploitative learning, which is used to apply the assimilated external knowledge (realized Acap). Lastly, systems to manage collaborations reduce the likelihood that people will deviate from established behaviour (Volberda et al., 2010); enhance the causal links among tasks and thus increase the likelihood that people will identify opportunities for the transformation of new external knowledge (Jansen, 2005); enable the identification of best practices so as to facilitate knowledge application (Lawson et al., 2009). Therefore, systems for managing collaborations increase both transformative and exploitative learning.

When put together, managerial and organizational antecedents create a conducive context for firms to share knowledge and foster the entire set of Acap processes and types of learning, thus creating the premises for all the facets of innovative performance. In general we can state that:

Hypothesis 1: A higher intensity of the managerial and organizational antecedents of Acap will lead to higher levels of innovative performance achieved through collaboration.

Social antecedents and Innovative Performance

Literature has also shown the crucial role of social capital (in particular its relational dimension) in favouring knowledge sharing and innovative performance within a company (Subramaniam and Youndt, 2005; Cabrera and Cabrera, 2005; Cabello-Medina et al., 2011) and among companies (Jolink and Dankbaar, 2010). Again we follow those studies that have looked into the effect of social

capital on Acap processes (Volberda et al., 2010; Foss et al., 2011; Hillebrand and Biemans, 2004). Firms which are already used to communicating and cooperating internally are also inclined to be flexible and share information with external partners. Close and frequent interactions between R&D and other functions serve to interpret, evaluate, disseminate and apply new knowledge acquired from external partners, by improving integration and coordination of different bodies of knowledge (Hillebrand and Biemans, 2004). In other words, people who are already used to communicating and cooperating internally are likely to be more receptive and able to carry out the processes underlying Acap. Accordingly, a beneficial effect provided by internal communication and interactions on exploratory, transformative and exploitative learning may be deduced.

Thus, in general we can state that:

Hypothesis 2: A higher intensity of social antecedents of Acap will lead to higher levels of innovative performance achieved through collaboration.

Antecedents as mediators in the relationship between Openness and Innovative performance

Supposing that antecedents enable innovative performance, a step forward is taken by wondering what would happen if they were not already in existence or thoroughly in operation. This entails investigating their mediating role between openness and innovative performance. Foss et al. (2011) find that customer interaction enhances innovative performance only through the implementation of some organizational practices. This leads to the supposition that, without the beneficial implementation of such practices, customer interaction will not improve innovative performance. Hillebrand and Biemans (2004) find that, without internal communication and cooperation, organizations are unable to implement externally acquired knowledge throughout the organizations. Knowing that innovative performance deriving from OI is still debatable (Laursen and Salter 2006) and that a firm's context seems crucial in order to explain the success or failure of OI (Pisano and Verganti, 2008), we can state the following:

Hypothesis 3: Managerial/organizational antecedents and social antecedents mediate the relationship between openness and innovative performance achieved through collaboration.

Antecedents and the Degree of Openness according to a contingency perspective

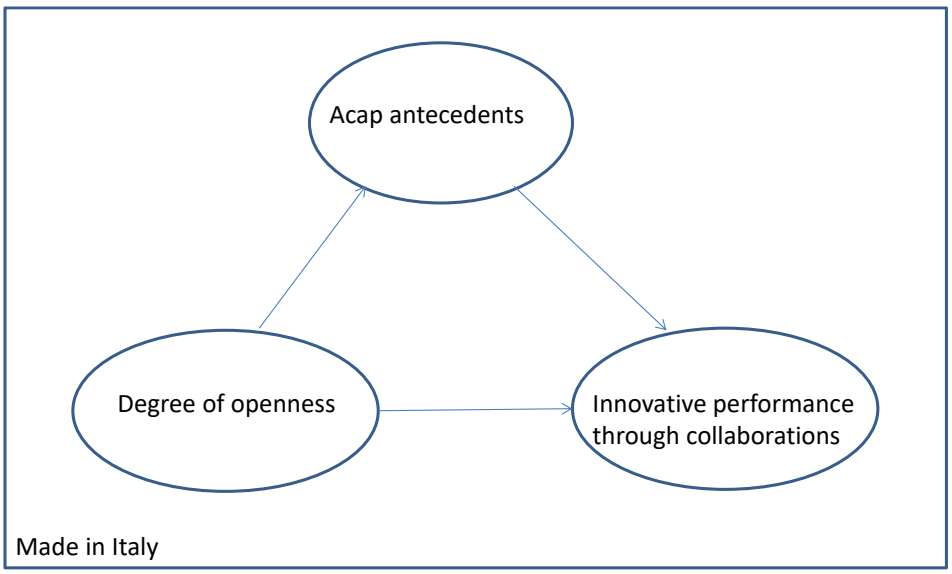
Until now, we have considered what happens *given* a certain degree of a firm's openness: antecedents enhance different types of learning, which in turn are used to recognize, assimilate and apply external knowledge and thus extract value from collaboration. Moreover, we have supposed that without the implementation of the antecedents, firms are not able to benefit from collaborations. In other words, they act as internal facilitators of OI (Brunswicker and Vanhaverbeke, 2011). However, this does not

mean that organizational and social practices need to be intensive in absolute terms and the higher, the better. Indeed, a contingency perspective suggests that models with a different degree of openness do exist and that they are all strategically valuable (Chesbrough, 2003). Literature also claims that they show a growing organizational and managerial complexity with the increase in the degree of openness (Foss et al., 2011; Enkel and Bader, 2012). For example, managing different sources of knowledge likely requires more articulated and intensively applied project management systems. The required number of boundary persons and their breadth of competencies reasonably increase when the variety of possible partners grows. Cross-functional interfaces become crucial as coordination mechanisms in order to ensure knowledge sharing among several partners. Complex collaboration with many partners also calls for the involvement of various individuals and departments in a position to exchange information, and thus characterized by an appropriate mindset (Jolink and Dankbaar, 2010; Petroni et al., 2012). Therefore, it can be supposed that higher levels of openness require a higher intensity and variety of the antecedents, as the following hypothesis states:

Hypothesis 4: There is a positive correlation between the degree of openness and the intensity and variety of the antecedents.

Figure 1 depicts the theoretical constructs of the study and their relationships. It also specifies that the setting of our research mainly consists of some of the traditional *Made in Italy* industries, characterized by medium-to-low technology intensity.

Figure 1. Effect of openness on innovative performance mediated by the antecedents of Acap processes



Methodology

Sample selection and data collection

Our target population was 'Italian manufacturing companies', defined according to NACE Rev2 Codes (from 10 to 32) and traceable in AIDA Bureau Van Dijk database. The target population was composed of about 70,000 companies distributed throughout the Italian regions. Our sample consisted of 7,000 cases, extracted in order to adequately represent the population in terms of industry (Table 7 in Appendix B). A brief preliminary questionnaire was sent to these firms to evaluate their general OI propensity as well as their willingness to participate in the study. Unfortunately, only 106 companies responded to our request, moreover biased towards specific sectorial categories. The sectorial composition of the respondents is reported in Table 8 of Appendix B. Indeed, most of them belong to Machinery and Equipment - NACE Rev2 code 28, as well as to 25 (Manufacture of fabricated metal products) and 27 (Manufacture of electrical equipment), recognized as medium-to-low technology intensive, within the *Made in Italy* categories (Bianchi et al., 2006; Vitali, 2010).

However, due precisely to the low response rate, we were able to contact all the 106 respondents, thus turning a weakness of the research into a strength. Over a three-year period, we followed a two-step methodology for data collection. First, we carried out a semi-structured 'interview phase', based on qualitative questions. Following this, we created a sort of 'laboratory survey' in which the same companies were asked to complete a questionnaire made up of Likert-type questions, derived both from literature and evidence from step one.

Measurement of the Variables

Appendix A reports the interview protocol regarding the first step of data collection. It includes open questions about the four variables used in the quantitative analysis: openness degree, managerial/organizational and social antecedents, innovative performance.

Closed Likert-type variables, used in the quantitative phase, are measured as follows:

Openness Degree

The measure of the openness degree is based on Laursen and Salter (2006); Lazzarotti and Manzini (2009) and Lazzarotti et al. (2011). It is calculated by composing two Likert-type scale variables: the *partner variety* and the *average intensity of collaboration*. The first variable aims at grasping whether the company collaborates with different-type partners or not. The second variable aims at grasping the depth of the collaboration with the partners along all the phases of the innovation funnel. It is an average measure because it is the sum of all the single *Intensity of collaboration with*

each partner on each phase, divided by the number of partner-types (see Appendix B for further details about this calculation).

The *openness degree* is the sum of these two (standardized) variables: high positive values indicated a great variety of partners and high intensity of collaboration with them along all the phases of the innovation process, and thus a high degree of openness. Negative values indicated the opposite (whereas, positive/negative values close to zero indicated intermediate approaches).

As regards the antecedents of Acap, we distinguished two groups:

1. managerial/organizational; 2. social.

Managerial/Organizational antecedents

The first group is defined following Subramaniam and Youndt (2005), Jansen et al. (2005), Lin and Chen (2006), Yang and Lin (2009) and Volberda et al. (2010). Attention is focused on the top management commitment, on the existence of individual change-agent roles, cross-functional interfaces and systems for managing collaborations. This variable (named ACAP-MO) is comprised of eight items, measured on a Likert scale from 1 (total disagreement) to 7 (total agreement). The exploratory factor analysis shows a unidimensional construct (Kaiser-Meyer-Olkin (KMO) = 0.908, with the Bartlett test significant at 99%) and Cronbach's alpha value is 0.922.

Social antecedents

The second group has theoretical foundations in Nahapiet and Ghoshal's conception (1998) of social capital and, in particular, in its internal relational aspect. Antecedents are then operationalized along the lines suggested by Hillebrand and Biemans (2004), Subramaniam and Youndt (2005), Ritala et al. (2009), Lawson et al. (2009), Yang and Lin (2009), Cabello-Medina et al. (2011). Attention is focused on relational communication skills. The variable (named ACAP-S) comprises nine items, measured on a Likert scale from 1 to 7. The exploratory factor analysis again shows a unidimensional construct (Kaiser-Meyer-Olkin (KMO) = 0.909, with the Bartlett test significant at 99%) and the Cronbach alpha value is 0.960.

Innovative Performance

The dependent variable has been operationalized by grasping the improvement in some company innovation capabilities and processes (West and Gallagher, 2006). It concerns the achievement, in collaborative innovation projects, of a series of items that represent the exploratory and exploitative goals traditionally assigned to collaboration (Hagedoorn, 1993). The variable comprises five items measured on a Likert scale. The exploratory factor analysis shows a unidimensional construct (Kaiser-

Meyer-Olkin (KMO) = 0.828, with the Bartlett test significant at 99%) and Cronbach alpha value is 0.876.

The observable indicators and the resulting factors concerning all the variables are reported in Table 6 of Appendix B.

Control Variables

- Size: a dummy variable searching for the effect of small-sized versus middle and large (0=small; 1=middle and large), according to European Commission's (2005) criteria;
- Industry: a dummy variable distinguishing the *Made in Italy* medium-to-low technology intensity industries from all others. Thus we grouped: 1= codes 28, 23, 25, 27; 0 = the other industries: low-tech; medium-high and high-tech (from 10 to 22, plus 24, 29, 30 and 32);
- R&D intensity: operationalized in terms of firm-level R&D expenditure as a percentage of sales (transformed into log10 to improve normality).

Procedure for the Quantitative Analysis

We aimed at studying the relationship between 'OI degree' and 'innovative performance', after removing the effects of the control variables and the antecedents, which are taken as mediators. Therefore, we chose the linear hierarchical multiple regression, which is the appropriate methodology for evaluating how much each independent variable adds in an explanation of the dependent variable, with respect to what was explained by the previously entered variables. Moreover, we needed to enter the 'OI degree' in the last step (Model 6), after all the other independent variables had been introduced.

Before running the model, all the relevant checks of the assumptions (outliers, normality, collinearity) were performed. We also controlled the effect of 'size', 'industry', and 'R&D intensity'

Results from the Quantitative Analysis

Table 1 shows descriptive statistics and correlations in the model.

Results from the hierarchical regression are reported in Table 2. Mediation occurs when the relationship between the independent and the dependent variable becomes non-significant with the effect of the mediator controlled for (Baron and Kenny, 1986). Four types of evidence seem to validate our basic hypothesis of mediation (hypothesis 3) and in the meantime give support to the others. Firstly, R^2 change shows that the most relevant explanation of variance is determined by the Acap-MO, followed by the Acap-S. R&D intensity provides a small but significant explanation. On the contrary, after the effects of these variables are removed, the 'OI degree' adds nothing (see R^2 change of OI degree variable in model 6).

Moreover, coefficients (beta values) of model 6, with all the variables entered into the equation, show that there are only two variables that make a statistically significant unique contribution: ACAP-MO and ACAP-S, thus giving support also to hypotheses 1 and 2. On the contrary, the coefficient of OI degree is very low and non-significant.

Third, there is a positive correlation between openness degree and both ACAP-MO and ACAP-S, which gives support to hypothesis 4 at least as far as the relationship between openness and the intensity of the antecedents is concerned.

Lastly, while zero-order correlation (Pearson) between performance and OI degree is positive and statistically significant (r = ,33 in Table 1), partial correlation shows that the direct relationship between 'OI degree' and 'performance' is very weak: after removing the effect of both ACAP-MO and ACAP-S, the relationship is small and not significant (r = ,02 in Table 2, Model 6).

Table 1. Descriptive statistics and correlations

Variables	Mean	S.D.	1	2	3	4	5
1. Innovative performance	4,26	1,3	1	,22*	,47***	,47***	,33***
2. Log_{10} R&D	,52	,47			,12	,04	,33**
3. ACAP-organizational	4,46	1,7				,37***	,40***
4. ACAP-social	4,8	1,3					,41***
5. OI degree	-,03	1,6					1

* p< .05; ** p<.01; ***p<.001, number of observations: 106

Table 2. Hierarchical regression

Hierarchical						
Dependent variable: Innovative performance	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Independent variables and controls:						
Size	,02	,02	,04	,02	-,01	-,01
Industry		,09	,08	,13	,10	,10

Log_{10} R&D			,22*	,16	,16	,15
ACAP-MO				,46***	,33**	,33**
ACAP-S					,33**	,33**
OI degree						,02
R^2	,001	,01	,06	,265	,361	,361
R^2 change	,001	,01	,05	,205	,096	,00
F change	,048	,715	3,84*	20,132***	10,635**	,034

* p< .05; ** p<.01; *** p<.001, number of observations: 106

To sum up, the results of the regression model seems to support our hypotheses:

- managerial/organizational and social factors are positively associated with innovative performance (hypotheses 1 and 2);
- without a favourable context, openness is not effective, which bears out the mediation effect of the antecedents (hypothesis 3);
- the level of openness degree is positive when related to the intensity of the antecedents (hypothesis 4).

Qualitative results

The statistical significance of the Acap mediator role, which emerged from the regression, pointed to the existence of a relationship, but this is too generic to provide any useful managerial suggestions. Moreover, the quantitative analysis supports the positive correlation between the openness degree and the *intensity* of the antecedents, but it lacks an understanding of their *variety* aspect.

In order to better understand the studied relationships, eight interviews were carefully considered as they turned out to be particularly insightful.

The main evidence from the interviews is reported in Table 4, where a short profile of the companies is also given. Before analysing such experiences, an insight regarding all the 106 companies must be reported. It provides evidence that companies open up their innovation process to different degrees. Four modes can be identified (see table 3), described briefly hereinafter (Lazzarotti and Manzini, 2009).

The *open innovators*, mainly big companies, are involved in a wide set of technological relationships, which impact on the whole innovation funnel. Although the open innovators extensively collaborate with the suppliers in the engineering and experimentation phases, many other types of partners (firms operating in different sectors of activity, customers, universities, technical and scientific service companies, governmental institutions) are involved at different stages (idea generation, experimentation and engineering). At the opposite end, *narrow collaborators* (mainly small

companies) access external knowledge sources only for a specific phase of the innovation funnel and typically in dyadic collaborations (with suppliers and customers). Companies in the third group, which can be called *specialized collaborators* (all medium and small companies) are in an intermediate situation. This group is similar to open innovators regarding the variety of partners (suppliers, customers, universities), but they concentrate their collaborations on a single/a few points of the innovation funnel (typically idea generation and experimentation). The smallest group can be named *integrated collaborators* (all medium and small companies). Similarly to the *narrow collaborators*, these companies collaborate with few types of partners (typically suppliers and customers), but along the whole funnel.

Table 3. Four basic modes of collaboration

	Open innovators	***Narrow collaborators***	***Specialized collaborators***	***Integrated collaborators***
No. of companies	45	40	12	9
Size	18 big 16 medium 11 small	10 big 8 medium 22 small	6 medium 6 small	6 medium 3 small

Eight cases were selected as follows. Two cases for each of the four collaboration modes: a subject who declared benefit from OI and another who complained of having no benefit from openness. Each pair of cases was made up of companies characterized by similar size in order to exclude the size effect. In addition, cases were selected within the subsector emerging as prevalent among the respondents (NACE code 28, Machinery and Equipment) in order to exclude any potential industry effect.

Starting from situations declared as satisfactory, it is possible to note that, in the case of *open innovator* (Company A), the set of organizational and managerial mechanisms is very broad. The internal change agents are recognized as crucial in the early building phases. Cross-functional interfaces are implemented and systems to manage collaborations are highly structured and formalized. Top management is engaged to ensure that any conflicts arising during collaboration may be overcome (a sort of champion, keeping enthusiasm alive in the project teams). Formalized management techniques (rules, written plans and contracts) are applied, although some flexibility is maintained, especially with universities. The social context is characterized by high levels of the propensity to exchange and share information, ideas and knowledge with colleagues, even in areas

distant from one's own expertise. The implementation over time of a reward system (made of intrinsic incentives in this case) aims at enhancing employees' collaborative attitudes and it is one of the key elements for encouraging the willingness to collaborate also with external parties. Concerning innovative performance, the open innovator declares positive results both in terms of exploratory items (expansion of competence; access to advanced technology; creativity) and exploitative ones (sharing/reduction of risks and costs; reduction of time to market).

Specialized collaborator (Company B), declares that scouting profiles are very active, cross-functional interfaces are designed, while project management techniques show a low frequency of application, at least in the past. 'Universities must be kept under control', because the normal divergence of objectives between universities and firms may inhibit the achievement of a useful result for both sides. Clarity of objectives from the beginning of the collaboration, research contracts and IP agreements are carefully developed. The social context also shows high values in collaboration propensity. Concerning performance, company B declares satisfaction above all with exploratory items.

The *integrated collaborator* (Company C) declares relationships with long-standing partners (customers and suppliers), built up over time. Low-frequency milestones and active control from top management about timing and costs are applied, as well as contractual agreements to formalize relationships. As a small company, the social context is informal and relationships 'naturally collaborative'. It does not declare the presence of boundary-spanner roles. Concerning performance, company C declares satisfaction with exploratory and exploitative items.

The *narrow collaborator* (Company X) declares collaborations with suppliers in the idea generation phase. As a small company, it has got little structured managerial/organizational context and a really informal social context. However, a clear assignment of tasks has been defined for work to be done in collaboration. It declares satisfaction with creativity and access to new technology.

Among the unsatisfactory experiences, Company D (the unsuccessful open innovator) stands out, as it regretted the lack of control over the increasing complexity of the relationships to be managed, as did Company E (the unsuccessful specialized collaborator), after the disaster accruing from collaboration with universities.

Discussion

Reasonable clues that the virtual loops posited in hypotheses 1 and 2 are operating can be found in two types of evidence observable in table 4. The first is the high level of all innovative performance items (explorative and exploitative ones) only for the large Company A, which shows a high level of antecedents; the second, the low level of innovative performance of Company D, which is also large and characterized by the same openness degree as Company A, but also by the lack of proper

organizational and social micro-foundations. Given a certain degree of openness, and by excluding the possible effects of other factors (size and industry), it thus seems that antecedents succeed in influencing innovative performance. Moreover, their presence or lack thereof, associated respectively with a high and a low performance, suggests they have the mediator role advanced in hypothesis 3. In other words, they effectively seem capable of driving openness by providing value creation for companies.

The successful open innovator (Company A) has got both types of antecedents and each of them shows a broad range of components: individual change agent roles, cross-functional interfaces, systems to manage collaborations, high levels of internal communication and a propensity to cooperate. Scouting people seem to be able to enhance the firm's exploratory learning, to be used in the process of recognizing and understanding new external knowledge, which in turn creates the premises for the enlargement of competences, access to advanced technology and higher creativity (Lane et al., 2006; Ritala, 2009; Petroni et al., 2012). By integrating diverse knowledge components, cross-functional interfaces stimulate the combination of existing and newly acquired knowledge (transformative learning: Jansen et al., 2005; Lane et al., 2006). Thus, the assimilation of valuable external knowledge can be achieved and, accordingly, the enlargement of competences as well as creativity. The systems for managing collaborations reduce the likelihood that people might deviate from established behaviour and, by coordinating causally the different tasks, facilitate not only transformative learning (Jansen, 2005), but also knowledge application (exploitative learning: Lawson et al., 2009). Lastly, internal communication skills, which figure prominently active in internal cooperation, create a conducive and receptive context to carry out all the processes underlying Acap (Hillebrand and Biemans, 2004).

Moving on to the other successful cases B, C and X, characterized by a lower level of openness with respect to Company A, it may be seen that the antecedents are differently shaped: some decrease in intensity, while others are absent. The satisfaction declared by these companies suggests that a lower intensity and/or the absence of the antecedents are not necessarily a bad fact. Instead, their intensity may be lower (as stated in hypothesis 4), provided that the firm carefully takes into account the goals of collaborations (and thus the expected innovative performance) as well as the type of partner. For example, Company B aims at pursuing exploratory performance items by collaborating with universities. To achieve this goal, as suggested by literature (Jansen et al., 2005; Ritala, 2009), boundary persons play an important role in activating the virtual loop 'openness-exploratory learning-Acap process of recognizing and understanding the external knowledge-achievement of the performance items' creativity and access to advanced technology'. Cross-functional teams and systems are necessary in order to carry out a second virtual loop: 'openness-transformative learning-Acap process of assimilation-enlargement of the company competence base' in particular with partner-types such as universities which, compared to companies, are used to a more unstructured

type of approach and divergent goals (Lane et al., 2006; Lawson et al., 2009; Lin and Chen, 2006; Petroni et al., 2012). Phases of exploitation are not described for Company B because they are not carried out in collaboration: however, satisfaction with the reduction in time to market suggests that the company is able to apply the assimilated external knowledge. Also the social context for Company B may be considered indispensable to carry out the processes underlying Acap. In fact, people who are already used to cooperating internally are also inclined to share information with external partners. Such a propensity is an essential premise to interpret, evaluate, disseminate and apply new knowledge acquired from external partners (Hillebrand and Biemans, 2004).

Company C achieves exploratory and exploitative performance items by collaborating with longstanding suppliers and customers along the whole innovation funnel. To this goal, boundary people are probably not strictly necessary and exploratory learning is favoured by a naturally collaborative social context, due to the limited size of the company (Burns and Dewhurst, 1996). Similarly, cross-functional interfaces are not formally defined. Instead, systems for managing collaborations play a crucial role in activating the virtual loops between openness and transformative learning as well as between openness and exploitative learning.

Company X, which is very small and has an intrinsically communicative social context, is open to a very limited extent.. It achieves exploratory performance items by collaborating with suppliers. As in the case of the integrated collaborator, scouting persons are likely to be unnecessary, cross-functional interfaces are not formally defined, while the clear assignment of tasks seems to ensure the proper operation of transformative learning.

Firms E, with a lower level of openness F and Y represent the unsuccessful experiences. For them, by excluding the effect of size and industry, we can reasonably conclude that the performance is low with respect to their successful counterparts (B, C and X) because of the relative lack/absence of organizational and social antecedents of Acap .

Table 5 summarizes the link among antecedents, degree of openness, Acap processes and innovative performance in the case of successful companies. Open innovators show the highest complexity (intensity and breadth) in antecedents. However, even where a lower level of intensity or range of mechanisms occurs, all the successful cases are equipped in some manner with these antecedents. The expected performance, the type of necessary learning and the type of partner seem to play a relevant role in shaping the required antecedents. In addition, in the case of integrated collaborator and narrow collaborator, a small size strongly influences the nature of some micro-foundations, making them informal or naturally high. They are in any case relevant to achieving the goals pursued through collaborations with the selected partners.

Conclusions, Managerial implications and Limitations

In this paper, we investigate the mediating role of organizational and social antecedents in the relationship between openness and performance, *given* a certain level of openness. We also suppose that, in order to face growing managerial and organizational complexity, organizational and social practices are becoming more intense and more various, depending on the degree of openness.

The first finding of the paper is that organizational and social antecedents of Acap are positively associated with innovative performance. Second, we find that they mediate the relation between openness and performance, by proving that there is no direct relation between openness and innovative performance, but organizational and social antecedents are crucial for ensuring good innovative results through openness. Antecedents seem to influence positively innovative performance through their action on the different types of learning (explorative, transformative, exploitative), which in turn are used to carry out the three processes underlying Acap - recognizing and understanding new external knowledge, assimilating and applying it. Each of the antecedents serves a specific type of learning, used for a specific Acap process, which in turn is a premise for innovative performance. The third finding of the paper is that the intensity and the breadth of the organizational and social antecedents should be consistent with the degree of openness. Therefore, less (more) open models require a lower (higher) intensity and variety of such practices.

However, even the narrow collaborator requires some antecedents to profit from collaborations. Thus, the right set and the right level of antecedents seem to be totally contingent, depending on the expected innovative performance, type of partner and firm size. The fact that we find large companies as open innovators does not question this implication. Rather, big companies can in any case be useful references for smaller or medium companies that are growing.

Literature has already highlighted the importance of organizational and social factors in fostering innovative performance both within the company and among partnered companies. However, a call for further investigation was made (Foss et al., 2010; Foss et al., 2011). With our work, we contribute by extending the evidence in Foss et al. (2011) - that customer interaction enhances innovative performance only through the implementation of some organizational practices - to a situation in which innovation is carried out with different types of partners. In addition, our evidence expands on that of Hillebrand and Biemans (2004), who focused specifically only on suppliers and customers: high levels of an internal collaborative mindset are also crucial when companies are engaged in collaborations with several partners.

The need to design an appropriate internal context makes the role of the HRM practices crucial.

With regard to managerial implications, our work suggests that companies who would like to benefit from OI should define appropriate interventions so as to encourage collaborative behaviour and

knowledge sharing. Firms should carefully manage several levers, e.g. selection and recruiting of personnel with the proper socio-psychological traits; training and development in order to promote knowledge transfer; compensation and reward systems linked to collective results (Jolink and Dankbaar, 2010; Cabello-Medina et al., 2011).

Our work shows several limitations.

From a methodological point of view, the first limitation concerns the data collection. We did not conduct deep case studies, but only shorter direct interviews. Although we did not achieve the high level of detail permitted by deep case studies (Yin, 2003), the interviews allowed us to enhance our knowledge of the phenomenon and to refine the final questionnaire employed in the quantitative phase of the work.

Another significant limitation is the use of self-reported performance measures regarding the achievement of performance objectives. Additionally, the study only considers the incremental impact on innovation performance from OI strategies and not the overall innovation performance derived from all types of innovation activities (internal and external). Moreover, the different types of learning and the related underlying processes of Acap were not directly measured. We only measured the levels of the antecedents and of the achieved performance items at the moment of our investigation. Measuring the Acap processes and testing the relationships between antecedents and Acap processes could thus improve the robustness of our results. We also assumed that the two types of Acap antecedents were independent of each other. Instead, literature suggests that organizational practices can foster relational social capital (Cabrera and Cabrera, 2005). A more detailed model, which explicitly aims at testing the relation between the two types of antecedents, could therefore represent a further improvement of the research.

Lastly, our work is focused on traditional *Made in Italy* industries, whose challenges in terms of absorptive capacity are less compelling than in high-tech ones, the investigation of which may represent another interesting avenue for this research.

Table 4. Evidence and quotes from eight interviews

Company	**No. of employees**	**Key informant**	**Innovation process, openness and goals**	**Managerial/Organizational antecedents (ACAP-MO)**	**Social antecedents (ACAP-S)**	**Innovative performance through collaborations**
Successful experiences						
Company A (Open innovator)	400	Head of R&D	Large-sized company in the automotive field. It produces machinery for operations (structure, balancing and everything related to the adjustment of tyres). Market leader in Europe for dismantling tyres, an area where Company A invented brand new systems replacing older machines. Technological innovation is one of the main functions of the company. The R&D head is in constant contact with top management and other functional managers. The process of innovation is developed not only internally. Relationships are with universities when there is a need to study complex solutions (Milan Polytechnic and the University of Modena and Reggio Emilia). Total time of NPD is generally 5 years and the production phase is simultaneous with the marketing phase. Suppliers of complementary items are very important. Collaborations with them are frequent because of the automotive cuts across many businesses.	'We have various profiles of internal change agents: scouts people are searching for interesting technological partners and new business opportunities. I try to maintain high levels of enthusiasm in the project teams. A certain level of conflict is normal: it is my task to keep it in check, for the success of the projects '. 'Every time an innovation project is launched, an autonomous team is built by combining our employees and people from the partners' companies. If the project is complex, a cross-functional team is preferred with people coming from different functions. The leadership of the cross-functional team is usually given to the R&D department'. 'The breadth of relationships is such that we create complex projects to which an equally complex form of control is applied. A structured management control	'Employees' willingness to share information and ideas is crucial. Skill gaps exist due to the different areas of expertise, but their ability to communicate is already a step forward and is also helpful when relating to the other partners. We have no extrinsic incentive to promote such attitudes, but we are thinking about them. Intrinsic incentives are definitely in place: open-minded employees get a better evaluation in their annual assessment and this is favourable for their career. Training for the development of communication skills is planned in the near future'.	'Positive results in terms of several goals: access to advanced technologies and competence base extension thanks to relationships with universities/ research centres; creativity, risk and cost sharing, reduction in time to market thanks to relationships with suppliers and customers'.

Company	No. of employees	Key informant	Innovation process, openness and goals	Managerial/Organizational antecedents (ACAP-MO)	Social antecedents (ACAP-S)	Innovative performance through collaborations
				system monitors the innovation process in detail, with a stage-gate approach. We are aware that control stiffens the innovation process a little, but the people involved are so many that this is the *lesser evil*. Obviously we allow for the so-called contingencies, which enable us to make the innovation process more flexible. This type of flexibility is very important above all with universities, which are used to working in a more unstructured way'.		
Company B (Specialized collaborator)	170	Head of R&D	Medium-sized company in the field of steel, manufacturing equipment for the reduction of the thickness of the steel sheets, used in automotive, furniture and building construction. Worldwide leader for high-strength steels, which to date are still being produced. Internal R&D is highly competent, but also external knowledge is necessary. Collaborations are focused on the idea generation and experimentation phases: with universities (Milan Polytechnic) carrying out tensile tests for new-generation steels; with suppliers for issues on the high-strength steel components; with competitorsfor experimentation issues.	'Scouting profiles are very active. They led us to initiate collaborations with universities and with two of our important competitors. Relationships are formalized by means of contractual agreements'. 'Project organization is usually functional and assigned to the R&D department. Other functions (Marketing and Manufacturing) temporarily assign part of their HR to project activities. Suppliers and universities usually join the team'. 'In the wake of a negative experience of	'Our R&D employees are used to being very cohesive, with a powerful sense of membership. However, they are ready to exchange ideas and information when they recognize the value of partners' competences'.	'Benefits in terms of creativity, access to advanced technologies, enlargement of our competence base and reduction of the time to market'.

Company	No. of employees	Key informant	Innovation process, openness and goals	Managerial/Organizational antecedents (ACAP-MO)	Social antecedents (ACAP-S)	Innovative performance through collaborations
				collaboration with a university, based on an informal agreement and lacking any explicit control of project milestones, we decided to change our way of proceeding. We started to apply a formalized method with the aim of checking up on the progress of the innovation activities carried out in collaboration. The divergence of goals (disclosure and publication aims for universities, protection of IP for us) led to the adoption of strict contractual agreements. More in general, we focus our attention on a clear definition of collaboration goals and tasks from the beginning'.		

Company	No. of employees	Key informant	Innovation process, openness and goals	Managerial/Organizational antecedents (ACAP-MO)	Social antecedents (ACAP-S)	Innovative performance through collaborations
Company C (Integrated collaborator)	75	Head of R&D	Medium-sized company providing advanced solutions for wire control in automated textile processes. Long-time partner of major companies operating in the textile industry. Regarding suppliers, collaborations are strong in idea generation, experimentation, engineering and the production of the components, thus making the company's product so highly specific. Suppliers are long-term partners who get the most innovative contribution.	'Collaboration for innovation, principally with long-standing partners (customers and suppliers), largely depends on trust and self-organization. However, we periodically introduce (once or twice a year) intermediate milestones: a system of performance indicators is collected by the project leader. This system is made up of quantitative metrics about time and quality requirements. I personally control the working of collaborations in meetings organized on a bi-monthly basis. In these meetings, I receive updating on timing, costs and progress achieved'. 'Even though trust with strategic suppliers has been built up over time, relationships are formalized in long term contracts'.	'Project organization is functional, driven by R&D people. However, in our medium-sized firm, there are always informal occasions for employees to communicate, share information, exchange ideas with people of other departments. The climate is naturally collaborative and also facilitates collaborations with our partners. There are no formal initiatives for facilitating employee socialization, nor any extrinsic incentives to this end'.	'Benefits in terms of access to new technology, creativity, sharing/reduction of risks and costs, reduction of time to market '.
Company X (Narrow collaborator) ***Unsuccessful experiences***	20	Owner	Small company producing machines used in the cosmetic sector for powder pressing. It collaborates with suppliers in the idea generation phase of new and improved machines to be used in customers' production process.	'We try to assign clear tasks both to ourselves and to our partners for work to be done in collaboration'.	'Our few employees are used to exchanging information very informally'.	'Benefits in terms of creativity and the accessing of new technology'.

Company	No. of employees	Key informant	Innovation process, openness and goals	Managerial/Organizational antecedents (ACAP-MO)	Social antecedents (ACAP-S)	Innovative performance through collaborations
Company D (Open innovator)	400	Head of R&D	Large company, leader in the production of highly efficient and eco- friendly transmission systems in the fields of automotive and energy. Transmission systems, which represent the core business, have been profoundly changed through technological innovation. Innovation projects, lasting up to 10 years and started in accordance with a pull logic, involve customers from the early stages, suppliers and universities for any lack in know-how, above all in the energy field.	'We experienced rapid growth, coupled with increased pressure towards collaboration with several partners in new technological fields'. 'Although we are not used to employing structured and formal methods for monitoring projects, we are changing management policies due to the increasing complexity of the relationships to be managed'. 'Milestones and reports are increasingly needed to drive relations among partners and to coordinate project work'. 'Relationships with our traditional supplier are governed by long-term contractual agreements and are not usually problematic. Our greatest source of development is represented by relationships with universities and new partners operating in the energy sectors. To discover them, scouting profiles are becoming very important'.	'Our R&D people have a rather closed mind-set because they are used to working according to a functional logic. They are able to exchange and share information, but strictly within our area of expertise. Now that cross-functional projects are becoming the norm, employees' attitude to adapting to new situations needs to be improved. We are thinking about what to do: it is not easy to change people's mindst if they have been used to working in a certain way for years'.	'Performance is still not adequate, but it is improving with time.'
Company E	200	Head of R&D	Medium-sized company designing and producing	'Project organization is usually functional	'Employees involved in	'I consider

Company	No. of employees	Key informant	Innovation process, openness and goals	Managerial/Organizational antecedents (ACAP-MO)	Social antecedents (ACAP-S)	Innovative performance through collaborations
(Specialized collaborator)			customized lifts and elevators. Internal R&D is highly competent but the design and development of new traction systems require collaborations with universities and suppliers in the idea generation and experimentation phases.	and assigned to the R&D department'. 'Due, perhaps, to a feeling of respect towards the engineers from universities, we did not put in place any formalized forms of control, or an IP agreement'.	innovation projects are technicians, little accustomed to seeking solutions outside of their own working group. The interpersonal impact of people from universities has been problematic from the beginning'.	collaboration with universities a real *disaster*. Divergences of goals, timing and methods prevented us from obtaining the desired results'.
Company F (Integrator collaborator)	67	CEO	Medium-sized company operating in the development and construction of machines for dry-finishing in the textile industry. It is currently developing more sophisticated machines by using electronic technologies. The idea-generation phase is often performed in collaboration with customers who express their needs. Collaboration with customers also figures in subsequent stages of experimentation, engineering, and manufacturing set-up of the new machine. Long-term suppliers provide valuable know-how throughout the whole innovation process. Recently, suppliers have been involved in the development of the electronic part of the new machines. The company rarely relies on the contribution of universities and technical service companies (e.g. for machine prototyping).	'By working with long-time suppliers, we have never applied formal selection processes, nor any structured forms of control of the innovation projects. I personally follow up on keep up relationships with them. Due to the involvement of new suppliers, a more structured control of project progress is probably becoming indispensable'.	'We do not have a really formalized R&D department. We were founded as a group of technicians, internally very cohesive, competent in machine construction and capable of working with suppliers and customers in order to solve technical problems. With the increasing relevance of electronic competences, open-minded attitudes are definitely necessary for our traditional employees'.	'In collaborations we often face severe problems regarding delays and increasing costs'.

Company	No. of employees	Key informant	Innovation process, openness and goals	Managerial/Organizational antecedents (ACAP-MO)	Social antecedents (ACAP-S)	Innovative performance through collaborations
Company Y (Narrow collaborator)	50	Owner	Small company, producing boilers for industrial use, based on internal R&D, jealously guarded. It declares a low-intensity collaboration with suppliers in the idea generation phase.	'No formal procedure for monitoring collaborations is applied'.	'Internally, the sharing of information is normal, I think because of our limited size'.	'Collaboration was mainly a waste of time'.

(Company names are not reported for confidentiality reasons)

Table 5. Antecedents, Openness Degree, Acap processes, Innovative Performance

Antecedents	***Used by:***				***Used for:***			***Innovative performance***	
	Open	**Specialized**	**Integrated**	**Narrow**	Recognize and understand new external knowledge (exploratory learning)	Assimilate valuable external knowledge (transformative learning)	Apply assimilated external knowledge (exploitative learning)	Exploratory innovative performance	Exploitative innovative performance
Individual change roles	Highly active	Highly Active	Absent	Absent	X			X	
Cross-functional interfaces	Highly developed and always used for innovation projects	Developed and often used for innovation projects	Not formally defined	Not formally defined		X	X	X	X
Systems to manage collaborations	Highly formalized, articulated and always used to manage innovation projects	Formalized systems, especially used with particular types of partners (universities)	Formalized systems with a low frequency of control	Clear definition of tasks carried out in collaboration		X	X	X	X
Social antecedents	Highly open mind-set and great willingness to communicate among different areas of expertise	Employees ready to exchange ideas with competent partners	Informal climate due to the limited size of the firm	Informal climate due to the limited size of the firm	X	X	X	X	X

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Appendixes

A - Interview protocol for qualitative analysis

Openness, goals and performance

- Do you collaborate often with external partners during innovation activities?

- If you do, in which phases[1] of the innovation project?
- Who are the partners you most often collaborate with? In which phase/s?
- What are the goals for which you have decided to access external sources of knowledge and technologies?
- Is the relationship with your usual partners 'a long-term relationship'?
- Have you gained from collaboration? In terms of which types of performance?

Organization and management of collaborative innovation projects

- Does your firm employ any methods for monitoring the progress of innovation projects carried out in collaboration?
- If so, does it use milestones and metrics? How often are they measured? Are there any differences in the application of these methods depending on the characteristics of the innovation projects and the type of partner?
- Is the top management interested in the effective working of collaborations and their results?
- Are there organizational roles and/or units acting as facilitator for setting-up, building and handling collaborations? (i.e. 'internal change agents' such as boundary-spanner, scout, gatekeeper, champion)?
- Are there cross-functional interfaces?

Social context for innovation activities

- Are your employees encouraged to collaborate with other colleagues? (For example to exchange and share ideas, information, knowledge in order to pursue innovation, to diagnose and solve problems)
- If so, how? Are there formal moments to encourage this collaboration among employees or are they only informal?
- Does this collaboration involve one's own colleagues or does it involve colleagues from other departments and other areas of expertise?
- Are there any extrinsic (for example, monetary incentives) or intrinsic (for example, easier career progress) rewards for those employees who show a collaborative attitude? Do you think they might be useful for improving your 'profit from collaboration'?

B – Measures for quantitative analysis

Openness Degree

[1] Idea generation (identification of a technology opportunity through scouting, monitoring, market analysis, trends analysis); experimentation (from the idea to the prototype); engineering (transforming the prototype into an industrial project); manufacturing set up (defining and organising the 'plant'); commercialization (planning of commercialization and promotional activities).

We used a seven-point Likert-type scale (1=strongly disagree; 7 = strongly agree) variables and we asked companies to indicate their agreement/judgment with the following statements:

1. *Partner Variety*: 'Overthe last five years you have collaborated with a wide variety of external actors'.

2. *Intensity of collaboration with each partner on each phase*: 'Over the last five years you have extensively collaborated with the following partners (University and Research centres, Technical and Scientific Service Companies, Governmental institutions, Customers, Suppliers, Competitors, Firms operating in different sectors of activity) in the following phases (Idea generation, Experimentation, Engineering, Manufacturing set up, Commercialization)'. Each combination is a variable (minimum score 1 point; maximum score 7 points). After, we sum up all the combinations (minimum score 1 point * 5 phases * 7 typologies of partners= 35; maximum score 7 points * 5 phases * 7 typologies of partners = 245) and divided by 7 (typologies of partners) to obtain an *average measure of intensity of collaboration along the funnel* (regardless of the type of partner; minimum score 35/7=5; maximum score 245/7 = 35). This *average intensity of collaboration* is the variable that, together with the partner variety, makes up the openness degree.

Antecedents and Innovative Performance

Table 6. Factors and measured items

	ACPA-MO	**ACAP-S**	**Innovative performance**
ACAP-MO			
'These are our firm's organizational and managerial actions regarding collaboration with external partners in innovation activities'			
1. Top management is committed to the maximization of the collaboration results	.717		
2. For each collaboration project, there is an internal change agent (e.g. 'gatekeeper', 'champion', etc.) who facilitates the collaboration building and	.792		

management			
3. For each collaboration project, cross-functional teams are activated	.874		
4. Our company formally evaluates the objectives and risks of collaboration	.900		
5. Our company uses project management techniques to manage collaborations	.733		
6. Our company formally monitors the progress and potential problems of the collaborations	.872		
7. Our company formally measures the final performance and the results of collaborations	.871		
8. Our company formally and explicitly analyses the reasons for the success or failure of collaborations	.884		
ACAP-S			
'Our staff involved in technological innovation is characterized by the following individual and intercommunication skills'			
1. Our employees are skilled at collaborating with each other to diagnose and solve problems		.881	
2. Our employees frequently exchange information on their specific area of expertise		.887	
3. Our employees share information and learn from each other		.886	
4. Our employees interact and exchange ideas with people from different areas of the company		.891	
5. Our employees exchange their ideas with many colleagues		.877	
6. Our employees interact with people from other departments not only in relation to their areas of expertise		.860	
7. There are moments (formal or informal) for interaction with colleagues from other departments		.865	
8. In our company the information exchanged with colleagues regards various areas of expertise		.856	
9. Our employees can easily adapt to new situations		.844	

Innovative performance			
'How well collaboration with external partners in innovation activities has performed against the following objectives over the last 3 years'			
1. Expand the company competence base and access to advanced technologies			.809
2. Stimulate creativity and idea generation capacity			.862
3. Reduce/share the risks of innovation			.824
4. Reduce/share innovation costs			.807
5. Reduce time to market			.793
Variance explained	68.41	76.04	67.12
Cronbach alpha	0.922	0.960	0.876
N	106	106	106

Table 7. Sectorial composition of the population and of the sample

		Population		**Sample**	
NACE REV 2	**Description**	**N**	**%**	**N**	**%**
10-11	Manufacture of food and beverages	6,188	9%	620	9%
12	Manufacture of tobacco products	23	-	-	-
13	Textile	3,516	5%	340	5%
14	Manufacture of wearing apparel	2,575	4%	280	4%
15	Manufacture of leather and related products	2,631	4%	280	4%
16	Manufacture of wood and cork and wood products, except furniture; manufacture of straw articles and plaiting materials	2,113	3%	200	3%
17	Manufacture of paper and paper products	1,464	2%	140	2%
18	Printing	1,772	3%	200	3%
19	Manufacture of coke and refined petroleum products	212	0,1%	70	0,1%
20-21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	2,761	4%	280	4%

22	Manufacture of rubber and plastic products	3,617	5%	340	5%
23	Manufacture of other non-metallic mineral products	3,999	6%	420	6%
24	Manufacture of basic metals	1,490	2%	140	2%
25	Manufacture of fabricated metal products, except machinery and equipment	13,747	20%	1400	20%
26	Manufacture of computer, electronic and optical products	2,856	4%	280	4%
27	Manufacture of electrical equipment	2,930	4%	280	4%
28	Manufacture of machinery and equipment n.e.c.	9,444	14%	980	14%
29-30	Manufacture of motor vehicles, trailers and semi-trailers Manufacture of other transport equipment	2,042	3%	200	3%
31	Manufacture of furniture	4,937	7%	480	7%
32	Other manufacturing	717	0,1%	70	0,1%
Total		69,034	100%	7,000	100%

Table 8. Sectorial composition of the respondents

NACE REV 2	**Description**	**N**	**%**
28	Manufacture of machinery and equipment n.e.c.	44	42
25	Manufacture of fabricated metal products, except machinery and equipment	16	15
27	Manufacture of electrical equipment	16	15
23	Manufacture of other non-metallic mineral products	4	4
24	Manufacture of basic metals	4	4
29	Manufacture of motor vehicles, trailers and semi-trailers	4	4
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	4	4
30	Manufacture of other transport equipment	2	2
32	Other manufacturing	2	2
16	Manufacture of wood and cork and wood products, except furniture; manufacture of straw articles and plaiting materials	2	2
18	Printing	2	2

22	Manufacture of rubber and plastic products	2	2
14	Manufacture of wearing apparel	2	2
10	Manufacture of food products	2	2
Total		106	100