ARE THERE ANY DIFFERENCES BETWEEN FAMILY AND NON-FAMILY FIRMS IN THE OPEN INNOVATION ERA? LESSONS FROM THE PRACTICE OF EUROPEAN MANUFACTURING COMPANIES

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Abstract: Although there is an increased interest in studies on FFs and open innovation (OI) the existing knowledge is rather limited. This study explores the open innovation choices, their determinants and the relative innovation performance in FFs with respect to non-family firms. By means of an European survey involving Italian, Swedish, Finnish and UK family and non-family firms we aim at investigating whether FFs are adopting a peculiar behaviour in the open innovation era. In order to achieve this goal, we rely on concepts and constructs already defined by open innovation literature and we explore the behaviour of FFs and non-family firms. Analysis of differences show that family firms are in general less open than non-family firms, when we consider openness in terms of breadth, while they show a higher intensity of collaboration behaviour when we consider the measures of depth. FFs perceive as slightly higher the competitive pressure, but very similar is the perceived technological pressure. Also drivers of collaboration and innovation strategy are on average very similar. Significant differences between FFs and non-FFs are found as concerns the use of IP legal rights (lower for FFs). On average, FFs declare a slightly higher novelty performance. A first type of regressions shows the contribution of some environmental and internal firm-specific factors as explanatory variables of openness degree and thus allow to depict the specific profile of FFs.
When we explore differences on the supposed mediating factors of the relationship between openness and innovation performance, the organizational-managerial mechanisms emerge as factors over which FFs exert particular care. A second type of regressions shows that, beside the external social capital, organizational-managerial mechanisms emerge for FFs as a relevant mediator in the relationships between OI depth and innovation performance.

Keywords: open innovation breadth, open innovation depth, family firms, non-family firms, openness determinants, innovation performance, open innovation supporting context

INTRODUCTION

Since the '80s, many companies have been successfully developing internal and external innovation through collaboration with other parties (von Hippel, 1988). More recently, the 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. There are different degrees of openness that reflect how broadly and intensively a firm uses external sources of information in innovation (Dreschler and Natter, 2012), and such degrees are all strategically valuable (Lazzarotti and Manzini, 2009). In particular, Laursen and Salter (2006) show that there is an optimal degree of openness in innovation in terms of collaborating with different external parties. Hence, several scholars (Hagedoorn, 1993; Colarelli O' Connor, 2006; Lazzarotti et al., 2011) have recognized that it is important to identify the underlying mechanisms or determinants to understand why this open behaviour occurs. Investigated determinants are firm-specific (e.g. size, drivers or goals pursued through collaboration, IP strategy) or arise due to environmental/external factors (e.g. technological and market dynamics). For example, the searching for new ideas encourages collaboration with customers, while cost reduction purposes may favour partnerships with suppliers; universities are called on for advanced technologies (De Backer, 2008).

Moreover, 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 & Salter, 2006). Thus, in addition to seeking the determinants of openness, literature aims also at searching factors which supports the OI success. In particular, the firms' internal organizational-managerial (Ritala et al., 2009; Foss et al., 2011; Lazzarotti et al., 2015), context seems to be crucial as well as the quality of the internal relationships (internal social capital: Lewin et al., 2011; Burcharth et al., 2013) or those between the focal firm and the external partners (the external social capital: Inkpen and Tsang, 2005; Cuevas-Rodríguez et al., 2014).

In any case, although the interest on the topic of OI is also growing in FFs' literature, there is an empirical lack as regards OI behaviour adopted by FFs and remarkable is the call for focused investigation (Classen et al., 2012; Kotlar et al., 2013; De Massis et al., 2014). The importance of FFs is due not only to their economical relevance (Miller et al., 2003), but also to their recognized peculiarities (specific goals, values, attitudes and resources) (Cassia et al., 2011). Thus, this paper aims at understanding more thoroughly the behaviour of FFs in terms of OI, by comparing them with non-family firms with regards the main variables identified in OI literature as the more relevant to understand the opening of the innovation process and its relative innovation performance.

The paper proceeds as follows: section 2 reviews the literature which provides the theoretical foundations to the investigation framework and research questions; section 3 describes the methodology and variables; section 4 reports results, while section 5 discusses results and concludes.

THEORETICAL BACKGROUND

Conceptions of Openness

Many studies describe OI as the phenomenon where firms rely increasingly on external sources of innovation (Chesbrough, 2003; Tidd, 2014). Previous research used a number of different approaches and definitions of openness (Dahlander and Gann, 2010; Huizingh, 2011). One important distinction was made between inbound (the search for and absorption of external knowledge and technologies into the innovation process) and outbound OI (the externalization of internally developed ideas and innovation). Later

studies have also identified the concept of coupled innovation processes (Gassmann and Enkel, 2004). Most studies seem to agree that openness should be regarded as a continuum between end points of open and closed innovation. However, the degree of openness could differ depending on one's perspective. For example, Lichtenthaler (2008) defines the degree of openness by crossing the critical OI processes and defines the extent of external technology acquisition and exploitation. The openness degree has also been explored by Laursen and Salter (2006) with their concept of breadth (number of used sources) and depth (intensity of collaboration with each source). Lazzarotti and Manzini (2009) integrated two variables: the number/type of partners and the number/type of phases of the innovation process, open to external contributions. Huizingh (2011) suggested the concept of "collaboration content" (explorative or exploitative).

In this plethora of contributions, this paper considers the OI concept as strictly linked to collaborative behaviour: the degree of openness reflects how diversely (breadth) and intensively (depth) a firm uses external information to sustain innovation (Laursen & Salter, 2006; Drechler and Natter, 2011; Garcia et al., 2014). Depth has considered in terms of intensity of collaboration with external partners and it is declined in two ways: intensity of collaboration with scientific partners (universities, research centres, etc.) and with business partners (suppliers, customers, etc.).

Internal and external determinants of openness

Previous research in OI literature has already studied the relationships among different OI degrees and several contextual factors (Lichtenthaler and Ernst, 2009; Lazzarotti et al., 2011; Drechsler and Natter, 2012): variables representing the external environment (e.g. an industry's R&D intensity or industry's type - traditional versus high-tech sectors), or the firm-specific situations (the R&D investments; the firm's innovation strategy; the goals pursued through collaborations; the company size; IP strategy).

In this paper we focus on both two types of determinants, internal and external, chosen among the main ones studied by OI literature. As internal factors we consider the goals pursued through external knowledge search (hereinafter, OI "drivers"), the type of firm innovation & technology strategy, the type of IP strategy and the size. As external factors we consider the possible impact of market and technological environmental dynamics.

Regarding the *drivers of OI*, companies open their innovation process to reduce costs, time to market and business risks; to extend skills and creativity, and accessing advanced technologies to develop breakthrough advancement (Hagedoorn, 1993; Calantone and Stanko, 2007). Anyway, the drivers leading to OI must not be considered as alternative ones. Instead, OI breadth can be motivated just by pursuing of different goals simultaneously. For instance, the goal of searching for new ideas, or ways to reduce the uncertainty associated with the market introduction of innovation, seems to encourage collaborations with customers (von Hippel, 1988); cost reduction or input quality improvements should favour partnerships with suppliers (Gassmann and Enkel, 2004); universities and research institutes are usually called on to provide advanced technologies and radical product innovations (De Backer, 2008; Tether, 2002).

Driver of OI are obviously linked to a firm's *innovation & technology strategy*, which is the second determinant of OI, giving the theoretical foundation of our work. The innovation & technology strategy is that part of strategy which deals particularly with the growth of an organization through the development of new products, services, processes or business models (Cooper, 2000). Two typical approaches are normally distinguished (Bessant et al., 2005): radical (whether the goal of innovation strategy is

to develop and bring to the market something which represents a breakthrough advancement) versus incremental strategy (whether the goal is to develop only a minor improvement over the status quo). Of course, these two strategic orientations can coexist within the same firm, which selects its own particular strategic balance. Concerning the relationship between innovation strategy and open innovation, literature suggests that when the emphasis is on radical innovation, OI is expected to increase: in fact, firms that emphasise radical innovation are not able to develop all knowledge internally, but must strongly rely on complementary external sources (Colarelli O'Connor, 2006). Emphasis on radical innovation is also studied as an element in a more specific construct, i.e. technological aggressiveness (Lichtenthaler and Ernst, 2009; Garcia et al., 2014) and on the business strategy concept in terms of Miles and Snow (1978)' prospector and defender. Prospectors usually enact in dynamic environments and have a reputation as innovators. They try to continuously find and exploit new product and new market opportunities in order to be the creators of change and of new technologies. In order to successfully achieve such innovation goals, firms which follow a prospector strategy require the expansion of their domains of knowledge or knowledge bases, thus showing a higher open innovation breadth than defenders (Lefebvre et al., 2014).

To sum up, it seems that an innovation strategy characterized by intensive technological pressure fosters a company's propensity to search out external sources of knowledge. In other words, the technology variable emerges as a key determinant for greater open innovation degree (Garcia et al., 2014). Therefore, this has been selected as a relevant determinant, whose role we shall also investigate in the context of family firms.

Regarding *IP strategy*, literature distinguishes legal and contractual mechanisms (patents, design registration, trademarks, copyright, trade secrets, employee agreements, NDAs, confidentiality agreements) from strategic ones (mainly product and process complexity and lead time advantage) (Arundel, 2001; Gallié and Legros, 2012; Laursen and Salter, 2014). Legal mechanisms provide companies with legal rights or contracts that can be used in case of litigation, infringement, and counterfeit. Several studies alert firms about the hazards that openness and collaborations could cause in terms of innovation appropriability (Gulati and Singh, 1998). A tension between protection requirements and sharing has been brought into evidence (Bogers, 2011), which leads firms to face a paradox: on one hand, they have to protect their technological competencies in order to capture the value created through innovation; on the other hand, they have to collaborate with other organizations and thus share knowledge. Studies in this area aim to investigate whether IPPMs act as enablers or disablers for OI. For example, the study by Alexy et al. (2009) and the work by Bader (2008) find that legal IP rights, such as patents or design registration, can become the 'currency of OI' and facilitate collaborative research and development activities. According to this perspective, tacitness and trade secret are seen as disablers of OI because they inhibit potential collaborations and compromise the success of ongoing ones by highlighting the lack of trust among the partners. In this study, we thus consider the intensity of use of different IP mechanisms (legal versus strategic) and we test their impact on openness in FFs and non-family firms.

Size is another firm-specific factor that has been investigated but it is still controversial, regarding to what extent it influences openness degree choices. Extant literature suggests that OI is mainly driven by larger companies: this can be justified by the more systematic approach they have in their innovation processes and by the larger resources they possess with respect to small and medium enterprises (De Backer et al., 2008; Drechsler and Natter, 2012). However, some literature emphasizes that especially small

companies, which often lack resources and competence to innovate by themselves, would benefit greatly by exploiting the OI model; indeed, small and medium enterprises (SMEs) are increasingly adopting OI practices (van de Vrande et al., 2009; Spithoven et al., 2013). Therefore, in this study, size is considered as control variable which can contribute to explain the openness choices.

As concerns environmental *external factors* literature identifies the technological dynamics as another relevant OI driver: technology intensity (Gassmann and Enkel, 2004), technology turbulence (rapidly changing technology conditions: Schweitzer et al., 2011), technology convergence (high level of interdisciplinary research: Bröring, 2010) press firms to collaborate: in any case, a single company is not able to provide successful innovations using solely its own capabilities. Similarly, in order to face market turbulence and uncertainty (shorter product life cycles, rapidly changing customer/consumer preferences), companies seem to be forced to establish partnerships with external actors (Drechsler and Natter, 2012).

Openness and innovation performance: the role of the organizational-managerial and social context

The current competitive environment is characterized by elements such as rapid technological change, shortening of product life cycles, more informed and demanding customers. In such an environment, firms' sustainable competitiveness depends on two innovation outcomes (Alegre et al., 2006): on the one hand, efficiency and, on the other hand, novelty. Efficiency regards things such as the reduction of the innovation risks, the compression of both the costs for the development of new products/processes and the time to market; novelty regards things such as the introduction of new or significantly improved products/services or processes and the opening up new markets. Opening the innovation processes to different types of partners seems to be the right way for improving both sides of the innovation performance. For instance, goals of searching for new ideas, but also for ways to reduce uncertainty, risks and costs associated with market introduction of innovation, seem to encourage collaborations with customers (von Hippel, 1988; Tether, 2002). Cost reduction purposes and input quality improvements, but also experimentation of new technologies, should favour partnerships with suppliers (Hagedoorn, 1993; Gassmann and Enkel, 2004; Tether, 2002). Moreover, while scientific partners (universities, innovation intermediaries and research institutes) are usually called for providing advanced technologies and novelty (Parida et al., 2012: De Backer, 2008), literature suggests that such partners are also able to support the efficiency of the innovation process (Faems et al, 2005; Janeiro et al., 2013). This is because firms rely on scientific partners not only to experiment with new technologies, but also to refine existing technologies (Perkmann and Walsh, 2007), so fostering efficiency.

However, evidence on whether such goals are effectively achieved has been controversial (Pertuzè et al., 2010), and thus literature states that an appropriate context is the way to support OI success in terms of innovation performance. For example, Foss et al. (2011) study the relationships among interaction with customers, organizational-managerial context and innovation. The authors find that such context provide a strong mediating effect between customer involvement and innovation. Lewin et al., (2011) provide examples of a broad set of internal routines, aimed at favouring knowledge sharing, problem solving and autonomy of employees, which in combination with external routines (i.e. open innovation practices such as collaborating with suppliers, networking with universities, etc.) are proved to result in improvement of innovation performance. Other authors assign such mediating or moderating role to the external

dimension of the relational social capital. Again the quality of the relationships (in this case, external) provides the rationale for improving performance. The partners' intention and willingness to cooperate, based on trust, encourages the exchange of knowledge, the acquisition of tacit knowledge (Nonaka, 1994), the absorptive capacity of new technologies (Cohen and Levinthal, 1990), the joint problem solving and coordination of complex tasks (Gulati and Singh, 1998), the experimentation with different knowledge combinations (Cuevas-Rodríguez et al., 2014). All these factors likely have positive impact on both sides of innovation performance (Phelps, 2010).

In this study, we rely on three types of moderators and we investigate their role respectively for FFs and non-FFs firms:

- a set of organizational-managerial factors to search potential valuable partners and to manage collaborations (Ritala et al., 2009);
- the value embedded in internal relationships among employees (Tsai and Ghoshal, 1998; Moran, 2005), which concerns the quality of such relationships in terms of employees' knowledge exchange habits, propensity to interact and to work in groups (internal social capital);
- the value embedded in external linkages among employees and external partners, which concerns the partners' intention and willingness to cooperate and exchange knowledge at the inter-organizational level and it depends on factors such as commitment and trust (external social capital: Inkpen and Tsang, 2005).

FFs and OI

As regards the relationship between family business and OI behaviour, the research results are controversial. On the one hand, scholars of behavioural theory state that FF owners aim to protect their socio-emotional wealth (SEW), so reducing their propensity towards collaborative innovation. Gomez-Mejia et al. (2007) show that family-owned businesses are more hesitant to join collaborative projects due to the fear of losing control, even though the collaboration may lead to economic gains (Chrisman and Patel, 2012). Similarly, Classen et al. (2012) find that FFs prefer a less diversified set of partners (low OI breadth), because of their focus on SEW preservation. They have also identified a further reason to explain the lower level of OI breadth of FFs with respect to non-family firms: their limited cognitive diversity and absorptive capacity. They argue that FFs often encounter limits to the quality and quantity of human capital because of their inability to recruit outside professional managers. As a result, FFs often have an undiversified set of cognitive resources and a low level of potential absorptive capacity (Zahra, 2012). Consequently, Classen et al. (2012) claim for FFs a lower receptiveness (compared to non-family firms) to broad external knowledge sources.

On the other hand, resource-based view scholars suggest that the unique characteristics of FFs' social capital ("resources embedded in the relationships among people": Hoffman et al., 2006), could encourage collaborative innovation by leading FFs to rely more on the contribution of external sources during the innovation process. The social capital is unique because FFs are characterized by a superior ability to develop prosperous and long-standing relationships with the stakeholders, in particular suppliers and customers (Sirmon and Hitt, 2003; Miller and Le Breton-Miller, 2005). These unique features are possible explanatory variables of a greater openness of the innovation process for FFs with respect to comparable non-family businesses. By analysing ten FFs, De Massis et al. (2014) conclude that FFs are more inclined to rely on external sources of knowledge during innovation activities. Moreover, the authors attempt to solve the contrast between their findings and behavioural theory propositions by using the concept of SEW preservation: they state that the type of technological

collaborations set up by the investigated FFs basically involve universities, public research centres and suppliers (these bound by severe intellectual property agreements), all of whom are likely to lead to a lower loss of SEW if compared with other types of partners (e.g. competitors).

To sum up, the research results about FFs' openness innovation propensity are still inconclusive. Opposing forces are outlined as capable of shaping FFs' behaviour and additional contributions are required in order to deeply understand the previously mentioned topics (De Massis et al., 2013). As a matter of fact, studies which consider the variables identified by OI literature (openness degree, openness determinants, innovative performance deriving from OI, context supporting factors), but focused on FFs, are still few (Classen et al., 2012; Lazzarotti and Pellegrini, 2015). This study aims at contributing to cover such gap by investigating FFs' behaviour in terms of openness choices, their determinants and their impact on innovation performance.

The research framework (Figure 1) summarizes our investigation to compare FFs and non-family firms in terms of:
- Different conceptions of openness;
- Main determinants of openness;
- Relationships between openness and innovation performance, supposing that the organizational-managerial mechanisms, the internal social capital and the external one exert a mediating role.

Figure 1 The investigation framework
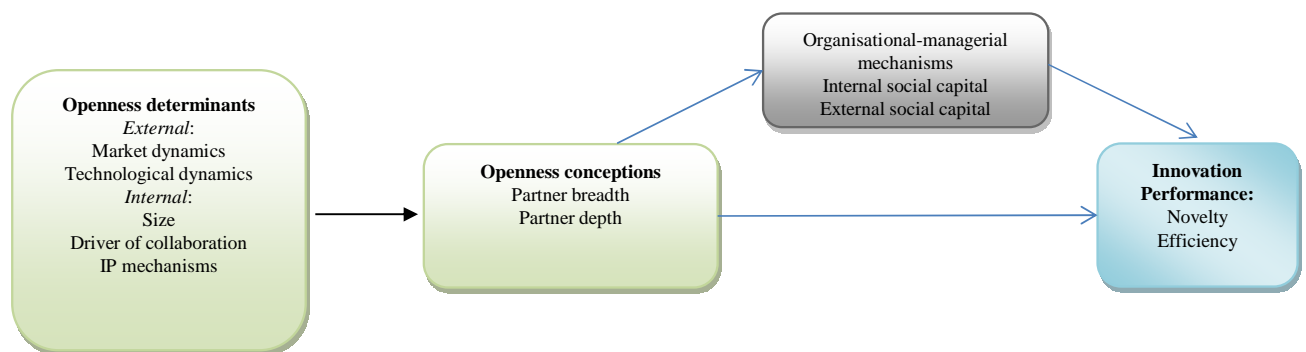
METHODOLOGY

Field research

The study is based on data from an international survey on open innovation collected during 2012 and 2013 by universities in Italy, Sweden, Finland and UK (for more details on the project, see Manzini et al., 2013). In order to ensure comparable results across the nations common guidelines were used for the survey design and the data collection process in accordance with Forza (2002).

The target and frame population is manufacturing industry firms (codes 10-32 and 98 in NACE Rev. 2) with more than 10 employees. From this population a representative and randomized sample of firms (N=4000) was drawn to ensure representativeness of the sample and, hence, the generalizability of results.

The data was collected by means of questionnaires distributed by email to the participants. The respondents are R&D managers or similar persons knowledgeable about open innovation. After three reminders we finally obtained in total 477 complete answers (response rate of about 12%) from firms that state they have collaborated with external partners in innovation (i.e. development of new products, services or processes) during the past five years. Of the 477 answers used in the current analysis, 152 come from Italy, 176 from Sweden, 87 from Finland and 62 from UK. The complete questionnaire covers questions on strategy, context (size, industry, etc.), openness, organizational-managerial mechanisms, relational factors (internal and external social capital) and innovation ambidexterity.

A pilot test of the questionnaire was conducted on two groups - colleagues and target respondents in selected firms - in order to improve the quality of the instrument.

Measures

- We distinguished family firms from non-family firms according to an ownership criterion (Chua et al., 1999). A family firm is defined as one where the first shareholder is family-type and holds at least 25% of shares. The identification of the first shareholder and his type is possible through the information regarding each respondent available in Amadeus (Bureau van Dijk) database. Unfortunately, the available information allows to clearly identify only 355 cases (83 FFs and 272 non-family). Table 1 in Appendix shows sample statistics;

- we measured openness in different ways following the available literature suggestions: OI breadth (Laursen and Salter, 2006) is calculated as the combination of 7 external sources of knowledge and technology for innovation. Breadth ranges from 0 (a firm does not use an external search channel) to 7 (a firm relies on all the channels listed in the survey during the innovation process); scientific-partner depth and business-partner depth are derived by applying explorative factor analysis (EFA: see Table 2 in Appendix) to the 7-point measures of single-type partner depth. The distinction between scientific partner (SP) and business partners (BP) takes inspiration from the works of Du et al. (2014) and Bengtsson et al., 2015, who employ two different constructs to measure external partnership: on the one hand, science-based partners and, on the other, business-based partners;

- determinants of openness (drivers and innovation & technology strategy, for brevity innovation strategy) were measured through 7-point Likert scale variables taken from literature (Miles and Snow, 1978; Hagedoorn, 1993; Lichtenthaler and Ernst, 2009; Lazzarotti et al., 2011). Table 3 in Appendix shows how both innovation strategy and drivers were operationalized. Although taken from literature, determinants of open innovation (both innovation strategy and drivers) were tested according to EFA techniques in order to ensure validity and reliability. Table also reports the values of Cronbach's alpha. One factor was obtained for the strategic items (innovation strategy) and one factor synthesized items concerning cost saving, risk reduction, time to market improvement, flexibility increasing (driver cost/time/risk/flexibility: RCTF [1]). External determinants of openness were measured through 7-point Likert scale variables taken from literature (Miles and Snow, 1978; Lichtenthaler and Ernst, 2009; Lazzarotti et al., 2011). Again Table 3 in Appendix shows the specific items of

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[1] Drivers indicated by literature as typically technological (e.g. access to advanced technology) are not explicitly considered because redundant with respect to the construct of innovation & technology strategy.

each construct, the factor loadings and the values of Cronbach's alpha. We obtained two factors for IP mechanisms (legal and strategic) and two factors for the environment (market and technological);

- we also controlled the effect of size by defining a dummy variable (0=small; 1=medium and large) based on the number of employees according to European Commission rules (2005), due to the fact that size is also identified as a potential driver for OI and for innovation performance (Lichtenthaler, 2008);

- as regard the two sides of innovation performance (novelty and efficiency) we rely on Alegre et al., (2006) distinction between efficacy and efficiency. The specific items used to operationalize both the two constructs follow the work by Lazzarotti et al., (2011) and are reported in Table 4 in Appendix. The items corresponding to novelty outcomes is represented by the introduction of new products, processes and markets, whereas efficiency outcomes are lower development risks, costs and time to market;

- as concerns organizational-managerial mechanisms, we rely on items drawn from the MINE SURVEY TOOLS 2.1. Attention is focused on the use of: Internet-based systems for searching potential partners; systems for formally assessing the advantages of collaborations, their progress and results; reward systems stimulating collaborative behaviour of the employees. Internal relational social capital has got theoretical foundations in the Tsai and Ghoshal (1998) conception and, in particular, in its internal relational aspect (Moran, 2005; Lewin et al., 2011). The operationalization focuses attention on employees' knowledge exchange habits, propensity to interact and work in groups as well as on firm practices which encourage their professional development with regards innovation topics. To measure external social capital we developed items based on Cuevas-Rodríguez et al., 2014. See Table 4 in Appendix for item details.

Procedures

In order to investigate the differences between FFs and non-family firms, we firstly carried out a series of t test, which is appropriate also in the case of subgroups composed of a different number of cases (Tabachnick and Fidell, 1996). The analysis of differences concerns all the types of variables considered in the study, following OI literature suggestions: openness measures, openness determinants, innovation performance and supposing managerial and social moderators. Then, in order to understand the FFs' behaviour more in depth, we carried out two types of regressions, both hierarchical. The first type (Tables 7a and 7b) is executed respectively for FFs and for non-family firms with the purpose of identifying specific determinants of openness. Thus, independent variables are the main internal and external variables which literature indicates as OI determinants, while the dependent variables are the two types of partner depth (scientific and business).

The second type of regressions (Tables 8a and 8b) aims at exploring the relationships between the two types of partner depth (now independent variables) and innovation performance (dependent variables).

The regressions are hierarchical because the considered variables are progressively introduced step by step until obtaining a final model which includes all the variables. In this procedure the observation of Beta coefficients is not so important, while it is relevant to evaluate, by observing R^2 change and its significance through F (ΔR^2), the incremental contribution provided by each introduced variable to the explanation of the dependent variable.

RESULTS

Descriptive evidences

The results of the t test (Table 5) show that average OI breadth is higher and significantly different for non-FFs with respect to FFs. Instead, it emerges that both types of average depth are higher for FFs than for non-FFs.

FFs perceive as slightly higher the competitive pressure, but very similar is the perceived technological pressure. Also drivers of collaboration are on average very similar as well as the innovation strategy. Significant differences between FFs and non-FFs are found as concerns the use of IP legal rights (lower for FFs) and the declared implementation of organizational-managerial mechanisms supporting OI (higher for FFs). On average, FFs declare a slightly higher novelty performance.

Table 5 Differences between FFs and non-family firms

	FFs (N=83)	Non-family firms (N=272)	Overall (N=355)	t test
Openness:				
OI breadth	4.76	5.36*	5.22	2.497
Scientific-partner depth	4.42*	3.90	4.00	-2.010
Business-partner depth	4.52*	3.88	3.99	-2.442
Determinants of openness:				
External:				
Market environment dynamics	4.69*	4.30	4.39	-2.361
Technological environment dynamics	4.28	4.22	4.23	-412
Internal:				
Size	1.26 (N=72)	1.60** (N=248)	1.52 (N=320)	5.167
Driver cost/risk/time/flex	4.57^	4.26	4.33	-1.883
Innovation strategy	3.65	3.94^	3.87	1.865
IP legal	3.32	3.90**	3.76	3.305
IP strategic	3.53	3.68	3.64	.748
Innovation performance				
Novelty	4.44*	4.12	4.20	-2.071
Efficiency	3.99	3.93	3.94	-371
Supporting organizational-managerial and social context				
Organizational-managerial mechanisms	3.90**	3.43	3.54	-3.558
Internal social capital	4.71	4.50	4.55	-1.528
External social capital	4.54	4.61	4.60	.481

Note: Significance levels: ^ p<0.1; * p<0.05; ** p<0.001.

Regression results

Table 6 shows descriptive statistics and correlations among all the variables included in the subsequent regressions.

Table 7 reports the results of the first type of hierarchical regressions. The purpose of these regressions is to understand the contribution of the environmental and firm-

specific internal factors as explanatory variables of FFs and non-FFs' openness degree, both in terms of scientific-partner depth and business-partner depth. In both cases, we analyse separately FFs from non-FFs. "ΔR2" (in bold) identifies which factor provides the highest contribution in explaining the variance of the dependent variable.

As concerns scientific-partner depth (Table 7a), significant explanatory factor for FFs' openness are as follows:

- the dynamic of the technological environment is the most relevant factor, while competitive one does not seem to exert a role (although on average the competitive pressure was perceived as higher for FFs than non-FFs);
- goal of reduction/sharing of risks and costs of innovation, reduction of time to market and increasing of flexibility (RCTF) provides another relevant contribution as well as the innovation strategy (more aggressive strategy, higher the degree of openness).

Neither the size nor use of IP rights seem to provide a significant contribution.

Also non-FFs' propensity for scientific partners seem to be slightly encouraged by technological environment dynamics as well as by drivers of RCTF, while innovation strategy is even less influent. The most relevant factors are size and the use of IP legal rights, which thus seem to work as factors enabling collaboration with scientific partners. However, it is worth noting that the explanation of variance provided by each factor as well as by the overall model is extremely low.

Collaboration with business-partners (Table 7b) for FFs seems again to be motivated by technological pressures but firms seem to face them moved only by goals of RCTF. Innovation strategy is instead insignificant. A similar situation emerges for non-FFs, although again with an explanatory value very low.

In sum, it seems reasonable to say that both FFs and non-FFs are encouraged in collaboration with both scientific and business partners by technological trends, as already outlined by several contributions regarding manufacturing companies in general (Gassmann and Enkel, 2004; Schweitzer et al., 2011) or specifically FFs (Lazzarotti and Pellegrini, 2015). The goals of reducing/sharing risks, costs and time to market and increasing flexibility as well an aggressive innovation strategy seem to be relevant especially for FFs. Instead, non-FFs have other tools available (e.g. IP legal rights), which seem to encourage collaboration. An aggressive innovation strategy is relevant to collaborate with scientific-partners while business partners are associated to goals of RCTF. However, scientific-partner depth is also related to RCTF driver, at least for FFs.

Table 6 Descriptive statistics and correlations

		Mean (SD)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Scientific-partner depth	4.00 (1.3)	1													
2	Business-partner depth	3.99 (1.07		1												
3	Firm size	1.52 (0.5)	,239**	,058	1											
4	Market Environment dynamics	4.39 (1.33)	,059	,108*	-,004	1										
5	Technological Environment dynamics	4.23 (1.2)	,279**	,221**	,074	,220**	1									
6	Driver cost/risk/time	4.33 (1.32)	,271**	,251**	.038	,105*	,302**	1								
7	Innovation strategy	3.87 (1.23)	,342**	,240**	,278**	,048	,518**	,300**	1							
8	IP legal	3.76 (1.39)	,326**	,152**	,310**	,097	,307**	,261**	,487**	1						
9	IP strategic	3.64 (1.6)	,126*	,185**	-,001	,122*	,310**	,224**	,414**	371**	1					
10	Novelty	4.20 (1.25)	,269**	,248**	-.019	,184**	,370**	,338**	,363**	,198**	,252**	1				
11	Efficiency	3.94 (1.36)	273**	,237**	.069	,104	,339**	,425**	,315**	,249**	,127*	,496**	1			
12	Organizational-managerial mechanisms	3.54 (1.07)	,409**	,296**	,088	,163**	,395**	,368**	,456**	,382**	,326**	,440**	,335**	1		
13	Internal social capital	4.55 (1.09)	,266**	,183**	-,006	,153*	,451**	,302**	,525**	,321**	,352**	,356**	,274**	,542**	1	
14	External social capital	4.60 (1.10)	,227**	,173**	,115*	,086	,296**	301**	,301**	,289**	,251**	,318**	,448**	,308**		1

Note: Significance levels: ^ $p<0.1$; * $p<0.05$; ** $p<0.001$; N=355

Table 8a and 8b report the results of the second-type of regressions. Here the purpose is to understand whether partner depth (respectively scientific-partner depth and business-partner one) is related to innovation performance, both in terms of novelty and efficiency, and whether the context (organizational-managerial, internal social and external social) exerts a role in influencing such relationship.

The first type of investigated relationship is between scientific-partner depth and both sides of innovation performance (respectively the first 5 models and the second ones in Table 8a). Then, the procedure is repeated for business-partners (Table 8b). In both cases, we analyse separately FFs from non-FFs. Models "1" test always the direct relationship between the partner-type depth and the innovation performance (novelty or efficiency), with only size control inserted. Models "2", "3", "4" investigate the direct relationships between each supposed mediator (organizational-managerial "OM"; internal social capital "ISC"; external social capital "ESC") and the selected type of innovation performance as well as the specific contribution of each mediator to explain performance ($\Delta R2$). Models "5" consider both mediators and partner-type depth. According to Baron and Kenny (1986), when a mediating variable enters into the model, the contribution of a previously significant independent variable should drop significantly for partial mediation or even become insignificant for full mediation. Following this procedure, we can find whether the context is really important to support open innovation and making it successful in terms of achieved performance.

As concerns *scientific-partner depth (SP-depth) and novelty*, we can observe that for FFs (Table 8a, top left side) there is a positive and significant relationship between depth and novelty (model 1). However, when we test the relationship between each mediator and novelty, organizational-managerial mechanisms (OM) and external social capital (ESC) show respectively a positive and significant relation with novelty (model

2 and 4). In addition, they contribute to explain most of the variance (OM above all). Lastly, inserted all the variables (model 5), the contribution of scientific-partner depth is very small and it becomes insignificant. These are all clues in favour of a (full) mediating role exerted by OM and ESC. The quality of the employees' relationships (internal social capital) seems instead to be irrelevant. Thus, in order to obtain novelty-type performance from collaboration with scientific partners, it seems to be important to implement formal levers to manage them.

Table 7a Determinants of scientific partner depth in FFs and non-family firms

		Scientific-partner Depth					
		Mod 1	Mod 2	Mod 3	Mod 4	Mod 5	Mod 6
FFs	**Determinants**						
	External:						
	Market environment dynamics	-.136	-.131	-.127	-.134	-.133	-.126
	Technological environment dynamics	.484**	.479**	.376*	.182	.182	.223^
	Internal:						
	Size		.042	.043	.002	.003	-.008
	Driver cost/risk/time/flex			.301*	.242*	.243*	.245*
	Innovation strategy				.362*	.363*	.371*
	IP legal					-.005	.020
	IP strategic						-.137
	R^2	.209	.211	.291	.369	.369	.384
	Adj. R^2	.186	.176	.249	.321	.311	.317
	F value	9.109**	6.048*	6.875**	7.725**	6.341**	5.697**
	ΔR^2	**.209**	.002	**.08**	**.078**	.000	.015
	F (ΔR^2)	9.109**	.150	.7597**	8.180*	.002	.1528
Non-FFs	**Determinants**						
	External:						
	Market environment dynamics	.061	.048	.046	.064	.048	.049
	Technological environment dynamics	.191*	.170*	.110^	.028	.020	.021
	Internal:						
	Size		.270**	.260**	.218**	.173*	.169*
	Driver cost/risk/time/flex			.177*	.158*	.123*	.126*
	Innovation strategy				.172*	.070	.078
	IP legal					.263**	.268**
	IP strategic						-.026
	R^2	.045	.118	.145	.165	.213	.214
	Adj. R^2	.038	.107	.131	.147	.194	.191
	F value	5.830*	10.865**	10.336**	9.540**	10.896**	9.329**
	ΔR^2	**.045**	**.072**	**.028**	.019	**.049**	.00
	F (ΔR^2)	5.830*	20.029**	7.837*	.749	20.113**	.011

Table 7b Determinants of business partner depth in FFs and non-family firms

		Business-partner Depth					
		Mod 1	Mod 2	Mod 3	Mod 4	Mod 5	Mod 6
FFs	**Determinants**						
	External:						
	Market environment dynamics	-.002	.015	.018	.022	.025	.025
	Technological environment dynamics	.453**	.438**	.350*	.360*	.364*	.364*
	Internal:						
	Size		.146	.147	.155	.160	.160
	Driver cost/risk/time/flex			.257*	.281*	.292*	.292*
	Innovation strategy				-.042	-.044	-.044
	IP legal					-.029	-.029
	IP strategic						.002
	R^2	.205	.226	.285	.286	.286	.286
	Adj. R^2	.182	.192	.242	.232	.22	.208
	F value	8.899**	6.662**	6.670**	5.278**	4.345**	3.667*
	ΔR^2	**.205**	.021	**.059**	.001	.001	.000
	F ($\Delta R^{2)}$)	8.899**	1.848	5.500*	.077	.056	.000
Non-FFs	**Determinants**						
	External:						
	Market environment dynamics	.130*	.131*	.129*	.114	.114	.111
	Technological environment dynamics	.144*	.145*	.093	.079	.073	.059
	Internal:						
	Size		-.017	-.027	-.032	-.038	.-027
	Driver cost/risk/time/flex			.156*	.113	.108	.095
	Innovation strategy				.100	.100	.103
	IP legal					.023	-.005
	IP strategic						.093
	R^2	.046	.047	.068	.075	.075	.082
	Adj. R^2	.038	.035	.053	.056	.056	.056
	F value	5.952*	3.461*	4.432*	3.914*	3.268*	3.078*
	ΔR^2	**.046**	.000	**.021**	.007	.000	.007
	F ($\Delta R^{2)}$)	5.942*	.075	.5.589*	1.786	.112	1.865

Also for non-FFs, the relationship between scientific-partner depth and novelty is positive and significant, but the quantity of explained variance is very low. The most important factor is OM, slight is the relevance of the external social capital and of the

internal one. In any case, the significance of SP-depth drop when all the variables are inserted (clue of full mediation).

As concerns *SP-depth and efficiency*, we can observe for FFs a relationship positive and significant, but again the contribution partially drops when supposed mediators are inserted (clue of partial mediation in model 5). OM and external capital still provide the most of the variance explanation. Thus, in order to obtain efficiency-type performance from innovation activities carried out with scientific partners, it is still important to implement organizational-managerial mechanisms to manage collaboration. The quality of external relationships (ESC) is anyhow relevant, while the quality of the internal relationships seems even to adversely affect performance (model 5).

For non-FFs, the relationship is slightly positive and significant, but the quantity of explained variance is very low. It seems that scientific partners do not provide great benefits in terms of efficiency-type performance, despite the positive contribution of ESC and OM. The already weak relationship weakens further (from model 1 to model 5) when all the variables are inserted, by outlining in any case ESC and OM mediation.

Also *business-partner depth (BP-depth)* is positively related to *novelty* for FFs, but again OM and ESC act as full mediator by explaining the greater portion of variance.

For non-FFs, the relationship between BP-depth and novelty is still weak and even weaker when we insert OM and ISC. No role emerges for ESC.

Finally, as concerns *BP-depth and efficiency*, for FFs the significance of direct relationship drops in the presence of OM and ESC, by suggesting that they are crucial to profit from collaboration with business-partners.

For non-FFs, BP-depth does not explain efficiency-type performance in a relevant way and the mediators change only slightly the situation.

In sum, even when collaboration with partners (scientific and/or business-type) seems to be profitable, the organizational-managerial context as well as the quality of external relationships are crucial to explain the achieved innovative performance.

DISCUSSION AND CONCLUSION

Despite the proliferation of studies on FFs and innovation (De Massis et al., 2013) as well as some seminal works on FFs and OI (Classen et al., 2012; Kotlar et al., 2013; De Massis et al., 2014), the research results on FFs' behaviour about OI are still controversial. It seems that conflicting forces are at work in shaping FFs' behaviour, as has been documented by different scholars who rest the foundations of their work on different theories. Resource-based view scholars predict that FFs are more inclined to rely on external knowledge sources due to the particular nature of their social capital, while followers of the behavioural theory suggest the opposite, because of socio-emotional reasons. This work attempts a contribution to such a debate by firstly analysing differences between FFs and non-FFs on a series of variables which OI literature has defined to understand the open innovation phenomenon: openness degree in the double conception of breadth and depth, involving two types of partners (scientific and business); internal or firm-specific and external determinants; types of innovation performance achievable through open innovation; supporting contextual factors (organizational-managerial and social ones). Second, the work aims at understanding which are, if any, the specific determinants explaining FFs' OI behaviour and whether and how OI choices benefit innovation performance, both in terms of improvements in innovation process efficiency and novelty.

Results confirm that FFs manifest some peculiarities in open innovation behaviour, consistently with previous studies (Classen et al., 2012; De Massis et al., 2014).

First of all, family firms are on average less open than non-family firms, when we consider openness in terms of breadth, while they show a higher intensity of collaboration behavior when we consider different measures of depth (scientific partner depth and business partner depth). This result can be interpreted by relying respectively on behavioural and on resource-based view theory, which in turn provide controversial interpretations. In fact, on the one hand, behavioural theory states that FFs' owners aim to protect their socio-emotional wealth, so reducing their propensity towards collaborative innovation and this is consistent with a lower OI breadth. On the other hand, resource-based view scholars suggest that the unique characteristics of FFs' social capital could encourage collaboration intensity with those external sources with which trust has been built over the time and this seems consistent with higher levels of OI depth.

Second, by exploring through regressions the OI determinants, it is evident, and consistent with previous studies (Schweitzer et al., 2011), that technological trends are crucial to shape firms' OI behaviour, both that of FFs and non-FFs. However, FFs seem to be more strongly encouraged towards openness by both an aggressive innovation strategy and goals of innovation efficiency (reduction and sharing of innovation costs and risks, improvement of time to market and flexibility). A such result is indeed clearly understandable, by considering the complex balance of factors which seems to characterize FFs (Cassia et al., 2011 and 2012): on one hand, "a long term orientation and ambition of FFs to expand the entrepreneurial dream", which results in an aggressive innovation strategy; on the other, some constraining factors (e.g. aversion to risk and limited resources), which results in a careful evaluation of costs and efficiency in general. In any case, both FFs' goals of RCTF and aggressive strategy drive collaboration depth with scientific partners and this is consistent with the idea the scientific partners not only are useful to experiment with new technologies, but also to support the efficiency of the innovation process (Janeiro et al., 2013). Business partners are instead mainly related to RCTF purposes, even though the technological pressures remain the most relevant factor.

Unfortunately, the significance and the explanatory value of the relationships found for non-FFs are too weak to draw inferential considerations. In any case, they also seem to be moved towards openness by technological pressures. In addition, they have other tools available, in particular the use of IP legal rights, which seems to be relevant in explaining collaboration with scientific partners.

Third, the paper explores the relationship between both partner-types depth and both types of innovation performance. Interesting, for FFs, scientific partners are positively related to each type of performance. Even, collaboration with scientific partners seem to explain more in terms of efficiency than of novelty (see R^2 value of model 5 in Table 8a, i.e. 45%, higher for efficiency than novelty, i.e.37%). Also business partner depth is related to novelty performance (Table 8b), but relation with efficiency is higher, as expected and consistently to the goals pursued in this type of collaboration.

However, the more interesting finding is relative to the role of the supposed context mediating factors, which, following literature (Foss et al., 2011; Burchart et al., 2013; Lazzarotti et al., 2015), concern organizational-managerial factors and social capital type (internal and external). For all the analysed relationships (SP-depth and novelty; SP-depth and efficiency; BP-depth and novelty; BP-depth and efficiency) and when they are significant (models "1"), it emerges that the context in crucial to explain the achieved innovation performance. In other words, the context is the means (the mediator) through which collaboration depth provides benefit in terms of performance. Indeed, with all the variables inserted in the model (see all models 5 for FFs), the significance

of the relationship between each type of collaboration depth and innovation performance drop or becomes insignificant. The managerial implication of this finding is strong: without an appropriate context, open innovation is not profitable (Foss et al., 2011). This is observable for both FFs and non-FFs, although the weakness of the relationships for non-FFs still prevent to draw inferential indications.

Instead, some further considerations seem worthy of note for FFs.

Organizational-managerial mechanisms exert the most relevant role in shaping the relationship between collaboration depth and innovation performance, by suggesting a counterintuitive conclusion that, however, it is now accepted in the pertinent literature (Pertuzè et al., 2010). In order to profit from collaborations, it is crucial to implement such mechanisms also when partner is scientific-type. In other words, it seems incorrect considering that this kind of partners, because of peculiar expertise and goals completely different from those of manufacturing firms, is not manageable (Du et al. 2014). Instead, autonomy, room for improvisation and creativity are not incompatible with managerial procedures. Obviously, the quality of the external relationships (external social capital) remain a relevant factor, but it was expected according to the huge available literature on social capital and its undisputed contribution to foster innovation performance (Cuevas-Rodriguez et al., 2014). Also some negative effect on performance, as we find concerning internal social capital (model 5, Table 8a) has been already outlined. In fact, it seems that external social capital may reduce the effectiveness of internal social capital on performance. This could occur because it is difficult to maintain very cohesive external and internal relationships at the same time.

In any case, specifically for FFs, it has been already argued that the quality of the external relationships (e.g. trust with the external partners) is important to shape openness behaviour (Classen et al., 2012). This work serves at most to raise awareness on the social capital importance. So, likely, the main practical suggestion of this work concerns the opportunity of developing and implementing organizational-managerial mechanisms. Although small in size, FFs of our sample prove that formally evaluate advantages and disadvantages of collaborations, have dedicated and competent roles to scan and assess external knowledge, apply project management techniques and design incentive systems, are essential tools for profiting from OI.

Although the evidence concerning non-FFs is weak, FFs can anyway learn from them on the fact that other tools are available to accompany openness. The low level of use of IP legal rights suggests that FFs could enlarge the set of own managerial levers.

The work shows important limitations, not last, from a methodological point of view, the limited number of companies in the group of FFs. Therefore, our results must be considered as preliminary explorative insights that may be useful in order to encourage further studies.

Table 8a Scientific-partner depth and innovation performance

		Novelty					Efficiency				
		Mod 1	Mod 2	Mod 3	Mod 4	Mod 5	Mod 1	Mod 2	Mod 3	Mod 4	Mod 5
FFs											
	Size (control)	.009	.043	.043	.030	.025	.025	.071	.071	.058	.029
	Scientific-partner depth (SP)	.343*				.058	.494**				.322*
	Organizational-managerial mechanisms (OM)		.483**	378*	.262*	.236*		.495**	.477**	.353*	.209 ^
	Internal social capital (ISC)			.159	-.028	-.041			.027	-.0173	-.248*
	External social capital (ESC)				.448**	.448**				.480**	.484**
	R^2	**.118**	.235	.249	.372	.374	.247	.249	.25	.392	.455
	Adj. R^2	.096	.216	.22	.334	.334	.228	.231	.221	.361	.42
	F value	5.349*	12.282**	8.729**	11.567**	9.216**	13.124**	13.289**	8.768**	12.566**	12.860**
	ΔR^2	.118	**.235**	.014	**.123**	**.002**	**.247**	**.249**	.000	**.142**	**.063**
	F ($\Delta R^{2)}$	5.349*	12.282**	1.478	15.328**	.254	13.124**	13.289**	.043	18.225**	8.927*
Non-FFs											
	Size (control)	-.071	-.076	-.065	-.075	-.103	.023	.022	.033	-.006	-.020
	Scientific-partner depth (SP)	.264**				.132*	.175*				.068
	Organizational-managerial mechanisms (OM)		.419**	.337**	.337**	.298**		.263**	.184*	.187*	.167*
	Internal social capital (ISC)			.165*	.120*	.121*			.156*	-.004	-.003
	External social capital (ESC)				.101	.089				.362**	.356**
	R^2	.065	.17	.19	.198	.213	0.033	.072	.090	.194	.198
	Adj. R^2	.058	.164	.181	.186	.198	0.026	.065	.080	.182	.183
	F value	9.289**	27.522**	21.001**	16.520**	14.384**	.4641*	10.381**	8.849**	16.067**	13.118**
	ΔR^2	.065	**.17**	**.020**	**.008**	.014	0.033	**.072**	.018	**.104**	.004
	F ($\Delta R^{2)}$	9.289**	27.522**	6.778**	2.681	4.880*	4641*	10.381**	5.443*	34.409**	1.259

Note: Significance levels: ^ p<0.1; * p<0.05; ** p<0.001; N (FFs)=83; N (non-family firms)=272

Table 8b Business-partner depth and innovation performance

		Novelty					*Efficiency*				
		Mod 1	Mod 2	Mod 3	Mod 4	Mod 5	Mod 1	Mod 2	Mod 3	Mod 4	Mod 5
FFs											
	Size (control)	-.016	.043	.043	.030	.015	-.001	.071	.071	.058	.027
	Business-partner depth (BP)	.329*				.092	.407**				.188*
	Organizational-managerial mechanisms (OM)		.483**	.378*	.262*	.230*		.495**	.477**	.353*	.288*
	Internal social capital (ISC)			.159	-.028	-.030			.027	-.173	-.177
	External social capital (ESC)				.448**	.436**				.480**	.457**
	R^2	.106	.235	.249	.372	.379	.165	.249	.25	.392	.419
	Adj. R^2	.084	.216	.22	.340	.339	.145	.231	.221	.361	.382
	F value	4.766*	12.282**	8.729**	11.567**	9.397**	7.926*	13.289**	8.768**	12.566**	11.119**
	ΔR^2	**.106**	**.235**	.014	**.123**	.007	**.165**	**.249**	.000	**.142**	**.027**
	F $(\Delta R^{2)}$	4.766*	12.282**	1.478	15.328**	.824	7.926*	13.289**	.043	18.225**	3.634*
Non-FFs											
	Size (control)	.001	-.076	-.065	-.075	-.070	.070	.022	0.03	-.006	-.002
	Business-partner depth (BP)	.219**				.117*	.152*				.075
	Organizational-managerial mechanisms (OM)		.419**	.337**	.337**	.307**		.263**	.184*	.187*	.168*
	Internal social capital (ISC)			.165*	.120*	.123*			.156*	-.044	-.002
	External social capital (ESC)				.101	.094				.362**	.358**
	R^2	.048	.170	.19	.198	.211	.028	.072	.090	.194	.199
	Adj. R^2	.041	.164	.181	.186	.196	.021	.065	.080	.182	.184
	F value	6.805*	27.522**	21.001**	16.520**	14.242**	3.902*	10.381**	8.849**	16.067**	13.239**
	ΔR^2	.048	**.170**	**.020**	.008	.013	.028	.072	.018	**.104**	.005
	F $(\Delta R^{2)}$	6.805*	27.522**	6.778*	2.681	4.312*	3.902*	10.381**	5.443*	34.409**	1.749

Note: Significance levels: ^ p<0.1; * p<0.05; ** p<0.001; N (FFs)=83; N (non-family firms)=272

Appendix

Table 1 Sample statistics

Sample	FFs		Non-FFs		Tot
	N.	%	N.	%	N.
	83	17	272	57	355
Firm size (employees)					
Small	53	74	100	40	320*
Medium and Large	19	26	148	60	
	72	100	248	100	
Country					
Italy	59	71	57	21	
Sweden	-	-	126	46	355
Finland	13	16	67	25	
UK	11	13	22	8	
Tot	83	100	272	100	

* 35 size missing

Table 2 Openness depth (intensity) in terms of partners (exploratory factor analysis)

	Scientific partners	*Business partners*
Please indicate your agreement with each of the following…		
… the extent to which your firm has collaborated with the following stakeholders over the last 5 years (1 = not at all; 7 = to great extent):		
Universities and research centres	.784	
Innovation intermediaries	.637	
Government agencies	.773	
Customers		.659
Suppliers		.765
Consumers		.632
Competitors		.572
(Companies operating in other industries)		
Variance explained	25%	25%
Cronbach's alpha	.625	.609
N=477		

Note: in brackets items which uploading is not univocal and thus are not included in any factor

Table 3 Internal and external determinants of openness (exploratory factor analysis)

	Innovation strategy	Driver cost/risk/time/flex	IP legal	IP strategic	Market Environment	Technological environment
Please indicate your agreement with each of the following…						
…statements with respect to your firm's innovation strategy (1 = strongly disagree; 7 = strongly agree):						
We aspire to be the technological leader	.761					
We focus on radical rather than incremental innovation	.706					
We try to hire the best scientists and experts on the market	.694					
R&D and marketing are our core competencies	.716					
We normally use innovative, flexible and non-routine technologies	.738					
We have a broad technology portfolio	.664					
…drivers of collaboration with external partners in innovation activities (1 = strongly disagree; 7 = strongly agree):						
Reduce/share the risks of innovation		.828				
Reduce/share innovation costs		.855				
Reduce time to market		.741				
Increase flexibility		.625				
…the extent to which your company uses the following intellectual property protection mechanisms when collaborating with external partners in innovation activities (1 = strongly disagree; 7 = strongly agree):						
Patents			.774			
Designs			.719			
Trademarks			.777			
Trade secrets			.585			
Non-disclosure agreements and other contractual agreements (e.g. joint development agreements)			.545			
Copyrights			.725			
Product complexity				.838		
Lead times				.825		
…statements with respect to your firm's environmental dynamics (1 = strongly disagree; 7 = strongly agree):						
Increasing technology development cost						.506
Shorter product life cycles					.599	
Customer/consumer product demands and preferences are highly uncertain					.854	
It is difficult to predict changes in customer/consumer needs and preferences					.860	
A large number of new product ideas have been made possible through technological breakthroughs in our industry						.695
The technology in our industry is changing rapidly						.711
Closing observing the technological development is important for long-term success in our industry						.801
In our industry complexity and inter-sector nature of new technologies is increasing						.834
In our industry the cross-fertilization of scientific disciplines and fields of technology is high						.832
In our industry there is the necessity of monitoring a spectrum of technologies						827
Variance explained	51%	31%	36%	22%	40%	20%
Cronbach's alpha	.807	.819	.815	.672	.694	.877

N= 477

Table 4 Innovation performance, organizational-managerial and social moderators (exploratory factor analysis)

	Novelty	Efficiency	Organizational-managerial mechanisms	Internal social capital	External social capital
Please indicate your agreement with each of the following…					
…how well collaboration with external partners in innovation activities has performed against the following objectives over the last 3 years (1 = not at all; 7 = to great extent):					
Reduce innovation risks		.782			
Reduce new product/process development cost		.849			
Reduce time to market		.832			
Introduce new or significantly improved products or services	.618				
Introduce new or significantly improved process of producing our products or services	.757				
Opening of new markets	.850				
…statements with respect to your firm's organisational-managerial actions regarding collaboration with external partners in innovation activities (1 = strongly disagree; 7 = strongly agree):					
We formally assess the trade-offs between internal development and external acquisition			.666		
We increasingly rely upon internal search capabilities to scan and assess external knowledge			.481		
We use project management techniques to manage the collaborations			.698		
We formally asses the performance and results of collaborative projects			.787		
We have a reward and incentive system to recognize the benefits of collaborative innovation			.673		
We use Internet-based systems to facilitate the search of potential partners			.581		
…statements with respect to your firm's staff involved in technological innovation: internal social capital (1 = strongly disagree; 7 = strongly agree):					
We give our staff time and resources to generate new ideas				.739	
Our staff easily adapt to new situations				.675	
We set our staff creative and challenging objectives				.816	
We are open to technologies/knowledge generated outside the company				.553	
We allocate resources for our staff continuous professional development				.700	
There is a high level of collaboration within functional areas to identify and resolve emerging issues in innovation activities				.803	
There is a high level of interaction across different functional areas in innovation activities				.769	
…statements with respect to your firm's experience in collaboration in innovation with external partners: external social capital (1 = strongly disagree; 7 = strongly agree):					
We share a similar management style with our partners					.472
There is a mutual interest in working collaboratively among partners					.845
There is a high level of trust among partners					.857
Partners' technological competences match up					.800
Access to partners' knowledge resources					.787
Synergy created by combining knowledge among participating firms					.812
Variance explained	39%	30%	43%	53%	60%
Cronbach's alpha	.704	.811	.729	.849	.856
N=477					

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