Social Capital and Innovation in a Life Science Cluster: The Role of Proximity and Family Involvement

SOCIAL CAPITAL AND INNOVATION IN A LIFE SCIENCE CLUSTER: THE ROLE OF PROXIMITY AND FAMILY INVOLVEMENT

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SOCIAL CAPITAL AND INNOVATION IN A LIFE SCIENCE CLUSTER: THE ROLE OF PROXIMITY AND FAMILY INVOLVEMENT

Abstract This paper investigates the effect of different typologies of a firm's relationships on innovation performance. Existing literature tends to emphasise the role of social capital in order to acquire knowledge and hence develop innovation. However, the literature is still ambiguous and reports conflicting findings about the effect of social capital on innovation outcomes, thus suggesting the need to examine differences in a firm's relationships. Findings from a survey conducted on 145 firms belonging to the Tuscan Life Sciences cluster show that: (i) the number of local relationships (i.e. relationships within the cluster) is curvilinearly related to R&D effectiveness (inverted U-shape); (ii) the number of distant relationships (i.e. relationships outside the cluster) is positively related to R&D effectiveness; and (iii) family involvement positively moderates the effect of local relationships on R&D effectiveness. Post-hoc analyses reveal a three-way interaction between the number of local relationships, number of distant relationships and family involvement, suggesting that family firms are particularly able to take advantage of the combination of local and distant relationships to produce innovation outcomes.

Keyword: Social Capital; Innovation; Technological Cluster; Life Science Industry; Family Business.

1 Introduction

In explaining the innovative capacity of the firm, innovation management scholars point out many factors. In particular, it has become clear that internal resources and capabilities are not enough to maximise firms' innovation outcomes and they therefore need to speed up the innovation process by leveraging on external knowledge (Hagedoorn and Wang 2012; D'Ambrosio et al. 2016). Within this broad stream of research, scholars have highlighted social capital as one of the most important antecedents of the innovative capacity of firms (Landry et al. 2012; Huggins et al. 2012). Since Nahapiet and Ghoshal (1998) proposed the social capital framework for the first time, many studies have investigated its different dimensions – structural, relational and cognitive – and how they are linked to innovation processes and outcomes (Zheng 2010). However, existing literature is still ambiguous concerning the ultimate role that social capital plays in the innovation process and in determining a firm's innovation performance. On the one hand, social capital has been showed to support creativity and the development of new knowledge and ideas, thus favouring a firm's innovation (Yli-Renko, Autio, Sapienza 2001; Yli-Renko, Autio, Tontti 2002; Moran 2005). On the other, scholars have also discussed the entrenchment effect associated with a strong network and its negative effects on a firm's innovation performance (Echebarria and Barrutia 2013). Consequently, empirical evidence on the social capital-innovation relationship has reported conflicting results (Echebarria and Barrutia 2013): a linear and positive relationship (e.g. Cooke et al. 2005), a non-significant effect (e.g. Smith et al. 2005) or even a negative one (e.g. Ahuja 2000a). In addition, some authors have suggested that social capital might have a non-linear relationship with innovation outcomes (Echebarria and Barrutia 2013; Vlaisavljevic et al. 2015).

One way to go beyond these conflicting perspectives and findings is to disentangle the effect of different typologies of social capital on innovation (e.g. internal vs external to the firm or, among the external aspects, relationships with different degrees of proximity) as they might entail different costs and benefits. Research on this is needed especially in industries where the phenomena of a firm's spatial agglomerations such as technological clusters are crucial to innovation (Echebarria and Barrutia 2013). A cluster is defined as "*a geographically proximate group of interconnected companies and associated institutions in a particular field, including product producers, service providers, suppliers, universities, and trade associations*" (Porter 1998, p. 197). In this context, "*social networks are an important part of the learning process in which firms discover new opportunities and obtain new knowledge*" (Molina-Morales and Martínez-Fernández 2010, p. 259). Literature on local systems (industrial districts, technological clusters) and networks relationships highlights that the geographic proximity is a key factor in innovative processes (Ben Letaifa and Rabeau, 2013) and it can explain the development and growth of firms in many industries (Guercini and Rufola, 2015). In this regard, some studies argued that firms localised within a cluster have better access to knowledge than geographically remote firms (Bell 2005). However, there is also a stream of research, highlighting the risk that local search behaviours prevent firms from exploring distant knowledge domains (Rosenkopf and Almeida 2003). Others argue that within the spatial agglomeration only few companies with certain characteristics (e.g. larger firms) are able to effectively manage social capital (Munari et al. 2011).

This works aims to address the social capital-innovation debate in technology clusters. We intend to go beyond the assumption that the social capital of firms located within a cluster is predominantly localised. Building on social capital theory, this work tests the effect of structural dimensions of social capital (in particular the size and the spatial dimension of the firm's network) on a firm's R&D effectiveness – an indicator of innovation outcomes that has recently received scholarly attention (De Luca et al. 2010). This is meant to provide a more nuanced and conceptually grounded perspective of the role of local (i.e. relationships within the cluster) vs distant (i.e. relationships outside the cluster) social capital, which might help to reconcile the above-mentioned debate. Moreover, in this paper we examine the moderating effect of family involvement on the relationship between the different typologies of social capital and innovation performance. Innovation literature has recently emphasised the role of family involvement in firms, and many theoretical and practical arguments suggest that family firms behave distinctively with respect to innovation (De Massis et al. 2013; Duran et al. 2016). There are three main reasons why we believe that including the "family" nature of a firm might be valuable in the context of our analysis. First, family firms represent the vast majority of firms in world economies and are thought to have a peculiar interest in innovation processes in order to preserve their longevity (Zahra 2005). They are also well represented in high-tech industries, such as life sciences (Marchisio et al. 2010). Second, family influence is known to extend over a firm's resources, knowledge and routines so as to turn them into distinctive sources of competitive advantage (or disadvantage) (Sirmon and Hitt 2003). Familiness, namely the unique bundle of resources and decision-making processes of a family firm, can offer a valuable perspective to distinguish family from non-family firms when they engage in innovation processes (Habbershon and Williams 1999; Kotlar et al. 2013). Third, these unique resources and capabilities are known to make family firms in general more productive and efficient in turning innovation inputs into outputs (Duran et al. 2016). Whether this is also true for the specific case of local as opposed to distant relationships and their impact on R&D effectiveness is a promising research direction, and has the potential to further enrich the picture we aim to draw. Our research questions are thus the following: (i) What are the effects of local and distant relationships on innovation performance in firms belonging to a cluster? (ii) How does family involvement affect these relationships?

Findings from the Tuscan Life Sciences cluster show that local network size has a curvilinear relationship (inverted U-shape) with R&D effectiveness, while the effect of the distant network size is linear and positive. Family involvement positively moderates the effect of local relationships and R&D effectiveness. Post-hoc analyses reveal a three-way interaction between the number of local relationship, number of distant relationship and family involvement, suggesting that family firms are particularly able to take advantage of the combination of local and distant relationships in order to produce innovation outcomes.

This work offers two main contributions. First, we shall clarify the relationship between social capital and innovation performance by distinguishing between different degrees of proximity in a firm's relationships. In doing this, we hope to disentangle the controversial effects of social capital in explaining a firm's innovation performance. Second, we hope to contribute to a further understanding of the role played by family involvement in innovation processes, in particular in influencing the social capital-innovation relationship.

2 Theoretical background and hypotheses

2.1 Social capital, proximity and innovation

Social capital theory suggests that social networks underlie learning processes through which firms search and use new knowledge (Molina-Morales and Martínez-Fernández 2010). This is particularly relevant in life science (Powell et al., 2002). Laursen et al. (2012), for instance, argue that social capital is a critical precondition to the search for complementary knowledge. Many studies have demonstrated that the embeddedness of the company within its own network of relationships helps to develop the learning capability of the organisation, and thus its capacity to innovate (Ahuja 2000b; Soh 2003). An embedded logic of exchange fosters a firm's economic and innovation results, through the sharing of resources, cooperation and adaptation (Uzzi 1996). Thus, the networks of relationships external to the firm provide a great contribution to its performance (Uzzi 1997; Nahapiet and Ghoshal 1998; Stam and Elfring 2008). Companies interact with suppliers and other partners not only to gain access to resources (Pfeffer and Salancik 1978) that are complementary and interdependent with those held internally, but also to enhance their learning capability and then to use such knowledge to develop innovation (Dyer and Singh 1998). In other words, firms do not form alliances just to have access to new resources, but also to learn and be able to take advantage of their resources to develop innovation (Dyer and Singh 1998). In fact, a learning network stimulates innovation performance, namely new ideas generation (Lazzeretti et al. 2011), creativity (Von Held 2012), effectiveness in the development of new processes and products (Westerlund and Rajala 2010) and patenting (Belussi et al. 2010). According to Powell et al. (1996), especially when the knowledge at the basis of an industry is complex and competences are broadly dispersed and fragmented, the source of innovation must be found in a learning network rather than in a single firm (*learning effect of social capital*).

Zheng (2010) indicates that most existing literature suggests a positive relationship between network size (the number of relationships that a company has with other actors) and innovation. According to the author, this seems attributable to two distinct benefits: (i) the possibility of access to new knowledge; (ii) the possibility of using resources more efficiently (reducing transaction costs, economies of scale, complementarities). However, other authors suggest that social capital may also limit innovation (e.g. Echebarria and Barrutia 2013; Vlaisavljevic et al. 2015). With particular reference to the structural dimension of social capital, Vanhaverbeke et al. (2002) highlighted an inverse quadratic relationship between the portfolio of technological alliances of a firm and its innovative capacity, attributing this result to a "*saturation and overembeddedness effect of social capital*". Overall, existing literature reports ambiguous perspectives and conflicting findings about the effect of social capital on innovation outcomes. These inconsistencies suggest the need to further examine this relationship by, for example, untangling the different typologies of social capital owned by a firm.

Literature suggests that different degrees of proximity and, in particular the network size (a specific structural dimension of social capital) can affect firm's R&D effectiveness and innovation performance (cf D'Ambrosio et al., 2017; Ben Letaifa and Rabeau, 2013). Network size indicates the number of the firm's relationships on two geographical levels: inside and outside the technological cluster. Moreover, the concept of proximity is multidimensional; Boschma (2005) in particular identifies and conceptualises five forms of proximity: geographical, cognitive, organisational, institutional and social. These may influence the formation and evolution of innovative networks in different ways, as Lazzeretti and Capone (2016) have recently shown. Italian clusters – legal entities recognised by the National Research Plan issued by the Ministry of Education, University and Research and by specific regional resolutions – represent an helpful research context in this respect, since geographical proximity overlaps with both institutional proximity (common norms and values of conduct at the macro-level) and cognitive proximity (shared knowledge and expertise) (cf. Boschma 2005).

The learning process related to social capital is particularly important for firms belonging to territorial agglomerations (Ruiz-Ortega et al. 2016). Geographical proximity, as a structural dimension of social capital, facilitates "face-to-face" relationships (Molina 2005; Rutten and Boekema 2007; Lazzeretti and Capone 2016), improves knowledge exchange (particularly of tacit knowledge) and, consequently, innovation (Hauser et al. 2007). Despite this evidence, the relationship between spatial proximity and innovative performance today is still highly debated (Belussi et al. 2010). For example, Bell (2005) demonstrated that Canadian companies located in an industrial cluster and central in their network have high innovation capacity. Similarly, Aharanson et al. (2004) in their study of the biotech industry claim that clustered firms are more innovative than those that are geographically spread out. Sonn and Storper (2003) and Almeida and Kogut (1999) reached similar conclusions. However, some scholars have recently highlighted that being located inside industrial districts or clusters is not enough to prompt the innovation performance of firms: network effects persist both independently and interdependently with geographic variables, and regional characteristics influence the degree to which centrality enhances innovation (Whittington et al. 2009). Moreover, as highlighted by Boschma (2005, p. 61), low flexibility and openness to new knowledge coming from outside of the local system, can produce a *lock-in* effect that it can make innovation processes less effective. Drawing on Vanhaverbeke et al. (2002), we may thus speculate that also the effect of saturation and overembeddedness can exist for firms within a cluster. However, we maintain that such an effect on R&D effectiveness is only exerted by local relationships. Initially, the forms of proximity characterising a cluster – geographical, institutional and cognitive – enhance trust, communication and cooperation among firms belonging to the cluster (Molina-Morales and Martínez-Fernández 2010). This promotes knowledge transfer and the development of innovations. Subsequently, however, after a certain threshold, the search behaviour tends to become increasingly local (Rosenkopf and Almeida 2003), crystallising the knowledge domains owned by firms (Tripsas and Gavetti 2000; Giuliani 2013): one the one hand, proximity helps to strengthen trust on the internal network relationships, but, on the other hand, prevents the access and the learning of new external knowledge (Molina-Morales and Martínez-Fernández 2009). The firms therefore remain anchored to their network of local relationships and associated routines, the technological knowledge circulating within the cluster is not renewed, and this phenomenon leads to the deterioration of R&D effectiveness. Furthermore, maintaining dense and strong local relationships may represent a cost in terms of time, energy and resources that diminish the benefit of local network size (cf. Echebarria and Barrutia 2013; McFadyen and Cannella 2004).

While Boschma and Ter Wal (2007) argue that, similarly to local relationships, global relationships can initially boost innovative performance, we argue that having more distant relationships exerts different effects on innovation. Notably, we claim that relationships with actors outside the cluster do not activate the downside effects described for local relationships. Ben Letaifa and Rabeau (2013), through the analysis of several case studies, suggest that "*geographic distance is seen as an accelerator for entrepreneurship and innovation*" (Ben Letaifa and Rabeau 2013, p. 1). An opening up to relationships external to the cluster, by introducing new knowledge, prevents lock-in effects (cf. Boschma and Ter Wal 2007) and avoids the saturation effects that the increasing network size may produce. Access to distant *non-redundant* knowledge (cf. Rosenkopf and Almeida 2003) helps to overcome the problems of path dependency characteristic of innovation processes, due to which the firm is more likely to explore cognitive domains in its neighbours (Fontes 2005). Distant networks, albeit possibly more resource consuming, thus increase innovation outcomes by supporting access to innovation-producing knowledge and capabilities not held by the local firms (West and Bogers 2014).

Based on these premises, our first two research hypotheses are:

Hp. 1a) In a technological cluster, there is an inverted U-shaped relationship between local *network size and R&D effectiveness.*

Hp. 1b) In a technological cluster, there is a positive relationship between distant *network size and R&D effectiveness.*

2.2 Family involvement and the social capital-innovation relationship

Family firms, compared to non-family firms, behave distinctively with respect to innovation (Habbershon and Williams 1999; De Massis et al. 2013; Kotlar et al. 2013). Despite a huge consensus on this claim, the scholarly debate on innovation in family firms is still open, vivid, and yet inconclusive regarding a number of topics: whether family firms are more willing or more able to innovate (Chrisman et al. 2015); whether they actually innovate more and with different patterns (De Massis et al. 2015; Sciascia et al. 2015); how family influence shapes innovation activities and processes (Bigliardi et al. 2013); and whether these considerations are different when considering different types of innovation (Cassia et al. 2011; McCann et al. 2001). Needless to say, literature is replete of contradictory predictions and conflicting findings, but also a number of research avenues that emerge in response to these findings (De Massis et al. 2013).

One aspect of the debate on innovation in family firms on which scholars have recently agreed is that, compared to non-family firms, family firms invest less in innovation inputs (e.g. R&D or human capital), but have higher conversion rates of innovation inputs into outputs and are thus capable of obtaining superior innovation performance (Duran et al. 2016). In other words, compared to non-family firms, family firms have a lower willingness yet superior ability to engage in innovation (Chrisman et al. 2015). According to behavioural agency theory, wealth concentration and a high priority given to non-economic goals (e.g. maintaining high levels of control over the firm, cf. Gomez-Mejia et al. 2014), which characterise family firms, make their owners particularly sensitive to the uncertainty of investments (Bianco et al. 2013; Duran et al. 2016). The result is that family firms are less willing to pursue innovation than non-family firms (Chrisman et al. 2015). On the contrary, a resource-based view helps us to depict the other side of the coin, namely that family firms can leverage on the distinctiveness of their processes (Chrisman et al. 2016) in orchestrating resources and thus have an advantage over non-family firms in terms of innovation outcomes (Carnes and Ireland 2013; Duran et al. 2016). Although family members' specific interests and preferences are likely to result in lower R&D investments, their unique resources – such as financial or social capital – as well as their unique ability to combine them (for example, a family firm's ability to cultivate and nurture long-standing relationships, or to take rapid decisions), are likely to have an impact on the innovation outcome of a firm (Llach and Nordqvist 2010; Chrisman et al. 2013; Duran et al. 2016). Compared to non-family firms, family firms benefit from access to a bundle of distinctive resources and capabilities – referred to as familiness – resulting from the interaction of the family unit, the business entity and individual family members (Habbershon and Williams 1999). These resources and capabilities have been shown to affect family firms' outcomes and to create the conditions for transgenerational wealth creation (Habbershon and Pistrui 2002; Habbershon et al. 2003). For example, Matzler et al. (2015) show that family firms, because of their unique process of social capital building at the intersection of the family and the business, are more efficient in exploiting their R&D investments. The strong relational ties within the family could influence relationships across the organisation – internal social capital – and between the organisation and external actors – external social capital (Sirmon and Hit 2003; Arregle et al. 2007). In particular, family firms (compared to non-family firms) tend to establish long-standing relationships based on trust and reciprocity with external partners, and to benefit more from these relationships compared to non-family firms because a family firm's priorities of command – "the freedom and ability to make adaptive decisions" – and continuity – "the firm's pursuance of long-term objectives" – provide a credible signal to partners (Chrisman et al. 2009, p. 740; Miller and Le Breton-Miller 2005; De Massis et al. 2015). Family firms also tend to develop relationships with key stakeholders in order to raise the visibility and reputation of the family and the family business (Deephouse and Jaskiewicz 2013). This kind of relationship is also likely to have an impact on a family firm's innovation process and outcomes (De Massis et al. 2015).

However, pursuant to the above-mentioned discussion about research on social capital and innovation in general, the role of different degrees of proximity in relationships and their effect on family vs non-family firms' innovation performance deserves further consideration. For example, Sanchez-Famoso, Maseda and Iturralde (2017) show that family involvement in management has a negative effect on the relationship between a family firm's internal social capital and innovation. More generally, the role of family firms in clusters has been largely neglected and requires further investigation (Cucculelli and Storai 2015). What we know already is that family firms – because of their distinctive characteristics, goals and behaviours, combined with the territorial embeddedness of both the family and the business – do contribute to the economic growth and development of the area in which they operate (Basco 2015; Stough et al. 2015). For example, due to their social and affective ties to the regional context, family firms are in a unique position to alter social and economic relationships in their territorial area (Stough et al. 2015).

When it comes to the innovation of firms within a cluster, the crystallisation of the knowledge domains held by firms (Tripsas and Gavetti 2000), can be even more pronounced for family firms due to their tendency to develop common mental frameworks and knowledge (Basco 2015). Scholars suggest that, within a family firm, both family and non-family members are characterised by cognitive and emotional attachments to the family and the firm. This results in the emergence of common values, traditions and systems of interpretation, and is strengthened by socialisation processes limited by the family and the firm (Webb et al. 2010; Basco 2015). Compared to non-family firms, family firms are more anchored to their local network and the associated knowledge and routines. This means that the saturation and overembeddedness effect described between the high level of local network size and innovation is strengthened when the family is involved in the ownership and management of the firm. However, two additional effects have the opposite impact. First, trust-based social relationships, which characterise family firms (Arregle et al. 2007), enhance the positive effects of belonging to a cluster on innovation. In other words, a family firm's tendency to establish long-lasting relationships based on trust and reciprocity with external partners perfectly matches with a spirit of trust, communication and cooperation, which stimulates firms belonging to a cluster (Molina-Morales and Martínez-Fernández 2010). The positive effects of a local network on innovation due to the cluster's institutional proximity is thus strengthened by family involvement in the firm. Second, the continuous interplay between the family, the firm and family members within a common organisational arrangement favours the development of communication channels, reduces uncertainty and facilitates the transfer and exchange of information among actors. This results in a reduction of the coordination costs encountered by firms when the number of local relationships grows, and thus enhances innovation (Knoben and Oerlemans 2006). Combining the above-mentioned arguments, we can thus conclude that family involvement positively influences the effect of local network size on innovation outcome, by making the growth path steeper and the decline path smoother.

When partners are distant (namely they do not belong to the cluster), the benefits of trust-based relationships and the reduction of coordination costs characterising family firms weaken, because developing trust-based relationships and communication channels with distant partners is more difficult, complex and takes longer than with local partners. To properly manage this network thus requires a high endowment of human capital, skills and capabilities by the firm. However, family firms are known for being generally undercapitalised in terms of human capital compared to non-family firms (Llach and Nordqvist 2010; Colombo et al. 2014). At the same time, cognitive and emotional attachments induced by family involvement in ownership and management are relevant also in the case of distant relationships. Cognitive proximity that characterises family firms equates to the crystallisation of the knowledge domains owned by firms within the cluster, thus reducing the positive effect of distant relationships on innovation outcome. In sum, family firms (compared to non-family firms) are less able to benefit from knowledge coming from distant partners in order to increase their learning capability and to use that knowledge to generate new ideas, be creative and be effective in the development of new processes and products, and thus to increase innovation outcomes.

Hp. 2a) In a technological cluster, family involvement positively moderates the inverted U-shaped relationship between local *network size and R&D effectiveness.*

Hp. 2b) In a technological cluster, family involvement negatively moderates the relationship between distant *network size and R&D effectiveness.*

Insert Figure 1 here

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3 Data and methods

3.1 Data collection and sample description

The context of this research is represented by the life sciences industry and in particular by the technological cluster of the Tuscany region (Italy). Activity in the life sciences industry is composed of two fundamental and distinct elements: firstly, the scientific knowledge developed is aimed at understanding why a certain therapy influences humans in a given way; and secondly, the curative or preventive therapies developed by the industry are directly connected to improving peoples' quality of life (Stremersch and Van Dick 2009, p. 5). The main industries included within the broader field of life sciences are pharmaceuticals, biotechnology and medical devices, along with a fourth and emerging segment of firms specialised in the production of cosmetics (cosmeceuticals) and food products with therapeutic characteristics (nutraceuticals). Lastly, there is a fifth segment of firms specialised in delivering services to support these industries; this segment includes laboratories for analysis and clinical tests, diagnostic services, bioinformatics and bioelectronics laboratories, and contract research organisations (CRO).

The Tuscan Life Sciences cluster provides an appropriate context to respond to our research questions for four main reasons. First of all, the biotech industry and life sciences in general tend to cluster geographically (Casper 2007; Moodysson et al. 2008). Second, the Tuscan cluster is third in Italy for its concentration of pharmaceutical and biotechnological industries, only preceded by Lombardy and Piedmont (Farmindustria 2011; AssoBiotech 2012). Third, the cluster evolved from a local level, first as a grouping of firms centred around a scientific park and then at a regional level, and is preparing to evolve to the next level, namely national and international. Lastly, the geographic proximity between the research team and the empirical setting has simplified control of the consistency and quality of research data.

Initially, all 317 firms that operate in the life sciences sector in Tuscany were taken into consideration. The list was taken from national censuses of professional associations for the biotech industry (AssoBiotech 2012), pharmaceuticals (Farmindustria 2011) and medical devices (AssoBiomedica 2012) respectively, and subsequently integrated with data from the Chamber of Commerce. Data on these firms has been updated to December 2012 and includes only those firms that satisfy four specific criteria: (1) they operate in the above-reported sectors of the life sciences industry; (2) they are for-profit; (3) they are not only commercial; and (4) they have operational units in Tuscany. This group of firms employed a total of 19,419 people and had an overall turnover of approximately EUR 7 billion in 2011.

The questionnaire was initially tested on founders and managers of five of the firms respectively representing the five segments of the life sciences industry, along with two managers from the Toscana Life Sciences (TLS) foundation (a non-profit organisation that has been active in the region since 2005 in order to support research activities in life sciences and specifically to sustain the development of projects from basic research to industrial application), and two members of the Steering Committee of the Tuscan Regional Life Sciences District[1]. The data was gathered through e-mail surveys from March to May 2012. All 317 firms were contacted by means of a presentation letter, in which the research objectives were outlined and the privacy of the data collected guaranteed. Subsequently, the information obtained through the questionnaire was verified and, where necessary, integrated through follow-up telephone interviews with the person who had completed the questionnaire in each firm (entrepreneurs/owners or CEOs, and R&D Director for R&D questions). Questionnaire data concerning the number of employees, the sales of the firm and the number of patents registered was verified through secondary sources, namely the Chamber of Commerce for the structural data of the firms, and the number of patents in the QPAT database. A total of 151 completed questionnaires were returned for a response rate of 47.63%. Six out of the 151 questionnaires obtained refer to large multinational companies and therefore have been excluded from the analysis. It is generally accepted in literature that larger and multinational firms behave differently compared to localised firms in the management of innovation processes (cf. McCann et al. 2002; Vera-Cruz and Dutrénit 2005).

3.2 Measures

Dependent variable

R&D effectiveness is the dependent variable in our study. This was measured through a multi-item construct validated in literature. In accordance with De Luca et al. (2010), we have chosen to use the R&D effectiveness as proxy of innovation performance. As these authors claim, in high-tech industries (e.g. biotech or life sciences in general), the innovation capacity of a firm is not always well represented by other more commonly used indicators in literature (e.g. new product introduction rate). De Luca et al. explain the firm's ability to manage innovation processes, but not all the specific activities performed and results achieved by the R&D function (De Luca et al. 2010, p. 302). The variable was operationalised using a six-item, seven-point Likert scale anchored 1 = not at all and 7 = to a very great extent, evaluating the interviewees' self-assessment of the firm's R&D effectiveness over the last three years (2009-2011). Items refer to the generation of new innovation projects, new patents, the quality and relevance of scientific output, the industry reputation for scientific results, the generation of new knowledge on target technology/market domains and the ability to attract and recruit new scientists with outstanding knowledge and skills (De Luca et al. 2010, p. 320). The reliability test conducted on the scale provided satisfactory results (Cronbach's alpha = 0.91; Average Variance Extracted (AVE) = 0.62).

Independent variable

The structural dimension of social capital was operationalised by two variables that measure the number of relationships that the firm established internally to the regional life sciences cluster (*local network size*) and externally (*distant network size*). The actors listed in the questionnaire were: customers, technology providers, suppliers of raw materials and intermediate goods, universities and other public research centres, private research organisations, companies in the same industry, companies in different industries, hospitals, distributors, and advisors. Respondents were asked to list the number of relationships that they have established with such actors in the 2006-2011 period and to indicate the geographical location of each partner.

Moderating variable

According to Sirmon et al. (2008), family firms are firms in which the family is involved in both ownership – owning at least 50% (+1) of shares – and management – a family member is the CEO of the firm. The variable *Family Involvement* takes a value of "1" if the firm is a family business and "0" otherwise.

Control variables

During the tests conducted to verify the relationships hypothesised, several control variables were introduced that could have an influence on the R&D effectiveness of the firms. We use the natural logarithm of the expenditures in R&D (*RD_exp_LN*) allocated on average by the firm in the 2006-2009 period (cf. Belussi et al. 2010; Lee et al. 2001). The choice to use the mean R&D expenditures in the 2006-2009 period was made in order to allow for a temporal lag from the investment in R&D to the period of R&D effectiveness (cf. Lee et al. 2001).

The sector that a firm belonged to was controlled by introducing three dummy variables for the pharmaceutical, biotech and medical devices sectors. The cosmeceuticals and nutraceuticals sector was not operationalised due to the low number of observations in the sample. Age and size were also controlled (Belussi et al. 2010), where the age (*Age*)

[1] The Tuscan Regional Life Sciences District was established by means of Decision No 603/2010 of the Tuscan Regional Executive; the Steering Committee is composed of representatives from industry and research and provides strategic direction for the District.

of the firm was measured by the number of years passed since the firm was founded. We then used the number of employees (expressed in natural logarithms) as the measure of size: *Size (LN)*. Some studies have recently suggested that the level of internationalisation of the firm could influence the degree of innovation outcome (cf. Castellani and Zanfei 2007; Shearmur et al. 2015), so we therefore introduced a dummy variable, *Foreign Markets*, that assumes a value of "1" if the firm operates in international markets and "0" otherwise. Because some studies have hypothesised that government R&D subsidies can stimulate the innovation capability of a firm, we finally introduced a dummy variable, *Public Funding*, to indicate if the firm received public subsidies for R&D (cf. Czarnitzki et al. 2007; David et al. 2000; Xu et al. 2014).

Table 1 shows the descriptive statistics of all variables and their correlation coefficients.

Insert Table 1 here

The variance inflation factor (VIF) was run to test for multicollinearity among the variables. The mean VIF equal to 1.13 is acceptable and well below the cut-off value of 10.0 recommended in the literature (Kutner et al. 2004). This evidence also excludes the possible direct effect that family involvement could have on the accumulation of social capital (local and/or distant network size).

4 Results

In order to investigate the relationship between R&D effectiveness and social capital we have chosen to use a linear regression model.

Tables 2 reports the results of the regression for the study of the effect of the explicative variables on the R&D effectiveness of the firms.

Insert Table 2 here

In the first model (Model A), the control variables were entered. In the second model (Model B), the main effects were entered. In the third model (Model C), the quadratic effect of local network size was tested. In Models D to G, interactions were entered.

Results show that local and distant network size are positive predictors of R&D effectiveness, but that there is a curvilinear relationship (with an inverted U-shape) between local network size and R&D effectiveness, thus confirming hypothesis 1a. The curvilinear relationship is proven by the three-step procedure suggested by Lind and Mehlum (2010): the coefficient of the quadratic term is significant, the slope is sufficiently steep at both ends of the data range, and the turning point is located within the data range. The network size that firms establish internally to the technological cluster initially seems to favour the performance of R&D processes. However, beyond a certain threshold, local relationships become very large, influence search behaviours very strongly (Rosenkopf and Almeida 2003) and produce an effect of overembeddedness and saturation that crystallises the stocks of knowledge exploited by firms (Tripsas and Gavetti 2000) and, thus, their innovation performance.

Relationships external to the cluster have a positive and linear effect on the innovation outcome, thus confirming hypothesis 1b. We also checked the existence of a quadratic effect of the distant network size on R&D effectiveness, but the tests suggested by Lind and Mehlum (2010) lead to the rejection of a non-linear relationship for this variable. Our result shows a monotonic and positive relationship between distant network and innovation performance, thus confirming hypothesis 1b.

The moderating effect of family involvement is confirmed by the statistically significant interaction between the family involvement dummy and the local network size squared term. In order to better interpret this moderating effect, in Figure 2 we plot the effect of local network size on R&D effectiveness for family and non-family firms. The moderating effect of family involvement is positive since, for family firms, the steepness of the curve growth for smaller local networks is higher and the decline at larger local networks is weaker. This confirms our prediction that family firms are particularly capable to turn innovation input (local network) into output (R&D effectiveness).

Insert Figure 2 here

Contrary to our expectations, family firms do not differ from non-family firms in the translation of distant network into R&D effectiveness. The coefficient of the linear interaction between family involvement and distant network size is actually not significant. To provide some initial clarification on the reasons behind this evidence, we ran a three-way interaction between network size (both local and distant) and family involvement (Figure 3). As shown in Model G, the model that best fits our data ($R^2 = 0.700$), the interaction is significant. In Figure 3 we decompose the three-way interaction by plotting the linear effect of distant network size on R&D effectiveness according to the size of the local network: low, medium and high local network size, for both family and non-family firms. In this manner, we split the local network moderator into three subsamples since both the linear and the squared local network size terms are significant in the three-way moderation. The results are quite interesting: family involvement can moderate the distant network size effect on R&D effectiveness, but the local network is needed to trigger and shape this moderating effect. In fact, with small local networks, the moderating effect of family involvement is negative, meaning that family firms are less capable of leveraging on distant network to obtain R&D effectiveness. Instead, when local networks grow in size, the moderating effect of family involvement turns positive, meaning that – in such circumstance – family firms are more capable of taking advantage of distant network to obtain R&D effectiveness. These results offer an even more nuanced description of a family firm's distinctiveness in innovation processes, as they indicate that it is only through smaller local networks that family firms deploy the negative influence (due to their relative disadvantage in managing complexity in too many distant relationships) that we hypothesised. Conversely, with larger local networks, family firms seem particularly able to take advantage of the distant network, and to combine and integrate the two structural components of social capital – i.e. local and distant relationships – with positive complementarities. This might indicate a superior capability to draw upon local networks to obtain the resources and skills that are needed to manage distant networks. Such capability to take advantage of localised social capital confirms our reasoning in hypothesis 2a, and extends to the conceptual arguments advanced for hypothesis 2b. This suggests that learning processes might occur to compensate for the disadvantage in human capital that family firms are likely experience with the development of a substantial local network. Overall, these findings substantiate the distinctiveness of family firms' innovation processes (De Massis et al. 2013; Duran et al. 2016).

Insert Figure 3 here

While our conceptualisation of the relationship between social capital and innovation moderated by family involvement is based on ability-related arguments, literature suggests the importance of controlling for both a family firm's ability and willingness to show its particularistic behaviour (De Massis et al. 2014a), and particularly its engagement in innovation (Chrisman et al. 2015). This is referred to as the *sufficiency condition* argument. Hence, for a proper research design, this argument suggests that both dimensions should be taken into account, or at least controlled. According to existing literature, a family firm's proactivity – namely its attitude towards pursuing new opportunities – can be assumed as a proxy for the willingness dimension, and is associated with the age of the firm through a (cubic) S-curve (De Massis et al. 2014b). This suggests that controlling for the terms Age^2 and Age^3 could be a valid and suitable approach to satisfy the sufficiency condition. As a robustness check, we then inserted both terms as control variables; results remained unchanged.

The control variable R&D expenditures is also not significant in any model when we insert the covariates. This evidence seems to confirm some conflicting or not significant results highlighted in literature on the effect of R&D intensity on innovation performance. In particular, when the pharmaceutical and biotech industries have been used as research fields (cf. Rothaermel and Hess 2007), the effects of R&D intensity on innovation performance have been highly debated. The process of R&D is highly risky, especially in the life sciences industry, and may lead to unsatisfactory results independent from the level of technological research intensity available (cf. Pammolli et al. 2011). This is why many pharmaceutical companies are outsourcing their R&D function (cf. Howells et al. 2008) and developing their innovation process with networks of actors (cf. Riccaboni and Moliterni 2009).

5 Discussion and conclusions

Within the broader research area of innovation, social capital and innovation networks, there are topics that have attracted paramount attention from scholars. However, the literature still reports ambiguity and conflicting findings regarding the effect of social capital on innovation performance. This work contributes to this debate and suggests that distinguishing between different degrees of proximity in relationships (e.g. local vs distant network) is important, especially in industries where the phenomena of a firm's spatial agglomerations are crucial to innovation. In line with recent trends in the innovation debate, it also considers the case of family vs non-family firms, focusing on two specific research questions: (i) What are the effects of local and distant relationships on innovation performance in firms belonging to a cluster? (ii) How does family involvement affect these relationships?

Findings from a survey conducted on 145 firms belonging to the Tuscan Life Sciences cluster showed that (i) the number of local relationships is curvilinearly related to R&D effectiveness (inverted U-shape); and (ii) the number of distant relationships is positively related to R&D effectiveness. The first result is explained by the emergence of a "*saturation and overembeddedness effect*" (cf. Vanhaverbeke et al. 2002) and by the presence of cognitive lock-in effects. It is true that firms can benefit from keeping strong relationships with local players characterised by common beliefs and values typical of the geographical and institutional proximity of the cluster. This allows the firm to benefit from the increased trust that is established among the actors belonging to the cluster, to increase cooperation and to reduce transaction cost. However, when local network size grows, the marginal benefit of new local relationships on innovation decreases. In fact, the complexity of managing a growing local network (cost in terms of time, energy and resources) leads to an increase in coordination costs and to a crystallisation of the knowledge held. The final result of this process is the deterioration of the firm's innovation performance when the number of local relationships grows beyond a certain threshold.

On the other hand, the growth of the distant network increasingly allows the firms belonging to the cluster to achieve R&D effectiveness. Whereas the benefits and costs of an increasing network size also stand in the case of distant relationships, access to distant knowledge prevents the lock-in cognitive effect and the overembeddedness effect typical of the local network. The final result is that distant networks increase innovation outcomes. The coordination costs necessary to manage the relationships external to the cluster thus seem to be lower than the marginal benefit that arises from the growth of this type of network. This is in line with other empirical analyses on Italian clusters that have highlighted that innovation openness of a firm's networks at international level significantly influences its innovative performance (Belussi et al. 2010; Belussi and Sedita 2012).

When looking at family vs non-family involvement, our results show that family involvement positively moderates the effect of local relationships on R&D effectiveness. This is due to the fact that long-lasting and trust-based relationships that characterise family firms, as well their ability to develop communication channels and facilitate networks, simultaneously enhance the positive and weaken the negative effects of the cluster on innovation performance. Whereas the moderating effect of family involvement is not significant with regard to the relationship between distant network size and R&D effectiveness, post-hoc analyses reveal a three-way interaction between the number of local relationships, the number of distant relationships and family involvement. This suggests that family firms are particularly able to take advantage of the combination of local and distant relationships in order to produce innovation outcomes.

This work offers two main contributions. Firstly, we have clarified the relationship between social capital and innovation performance by distinguishing between different degrees of proximity in relationships. In doing so, we have contributed to disentangling the controversial effects of social capital in explaining innovation performance. Secondly, we have contributed to better understanding the role played by family involvement in innovation processes and particularly in the social capital-innovation relationship.

The research study has some limitations. First, we do not empirically investigate the different dimensions of proximity, which characterise a cluster and in particular cognitive and institutional proximity (cf. Marrocu et al. 2013). Firms belonging to spatial agglomerations can develop different behaviours in knowledge search activities based on their technological specialisation (cf. Boschma 2005). Future studies could investigate the effect that different technological distances between internal actors of a cluster and between internal and external actors have on innovative performance. Second, we do not distinguish between different sources of knowledge. Some recent studies are trying to reconcile the theory of social capital with that of open innovation (cf. Rass et al. 2013), and further research developments could also consider the intensity and importance of relationships established by the firm for each knowledge source (i.e. the breadth and depth dimensions of the open innovation framework proposed by Laursen and Salter 2006). The third limitation is connected to the common problem of survey research: although the controls did not indicate significant problems of common method variance, its potential influence cannot be completely excluded in a self-report research study (Podsakoff et al. 2003; Podsakoff and Organ 1986). Moreover, a research design based on individual responses may also be limiting. Fourth, the cross-sectional nature of the research could be a potential source of criticism, and future studies could employ a longitudinal research design to observe the dynamics and timing of the examined relationships. Lastly, the work is entirely based on evidence from a particular technological cluster. If, on the one hand, the Tuscan cluster represents the third-largest life sciences cluster in Italy, on the other, the specific characteristics of its context might limit the generalisability of the results obtained. A national or international comparison between clusters at the same developmental level would help to further validate the results.

In sum, our work offers a novel perspective to innovation processes within a cluster, by suggesting a nuanced view of social capital and by indicating family firms as a motivating actor (due to their innovation ability and behaviour within the cluster). Taken together, these perspectives offer insightful avenues for future investigation, which we hope will be prompted by future research.

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Figure 1. The conceptual model

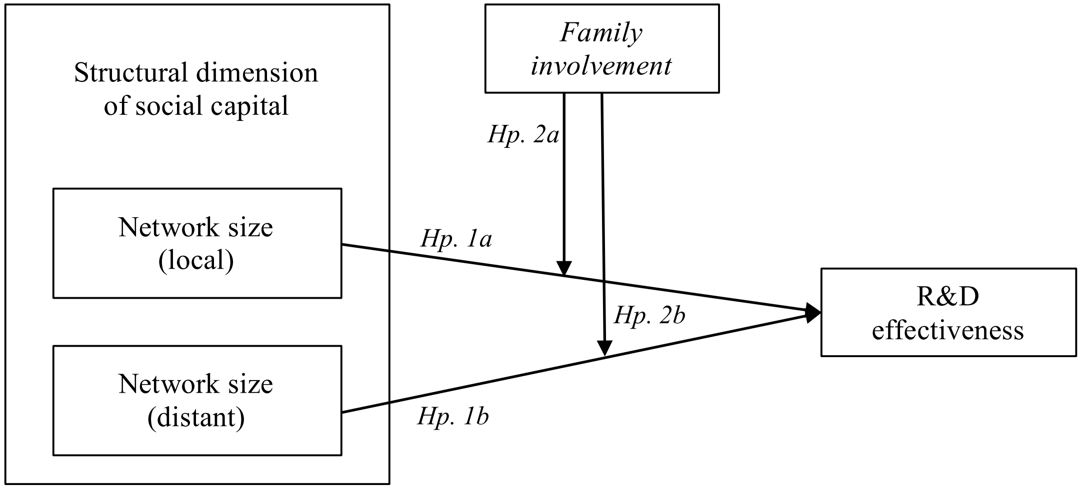

Figure 2. The moderating effect of family involvement on the local network size–R&D effectiveness relationship

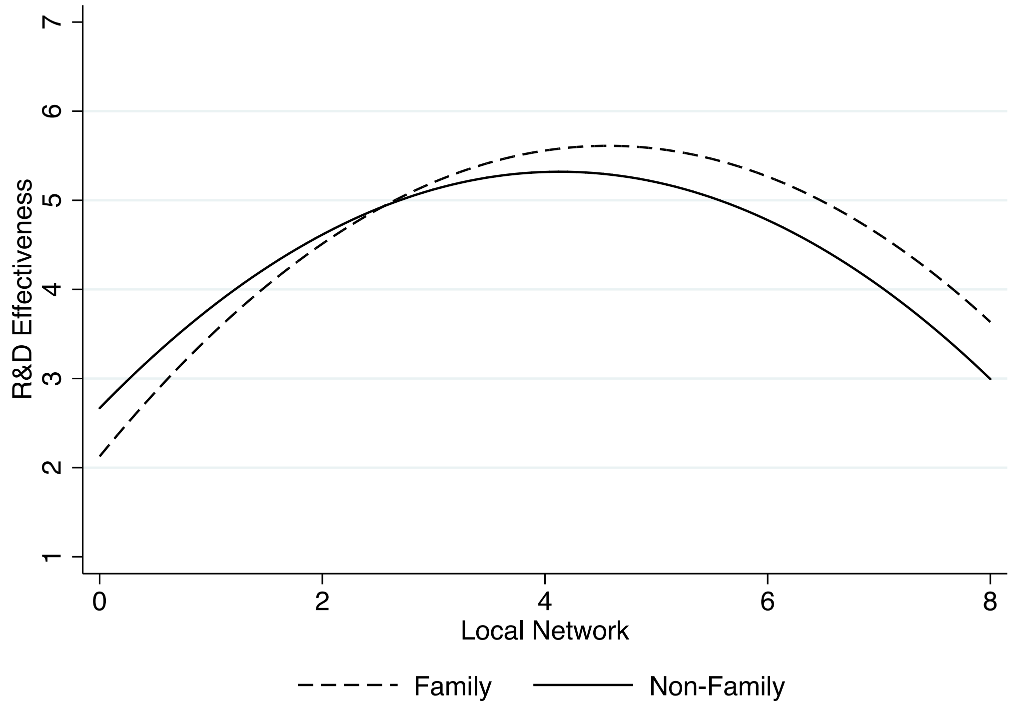

Figure 3. A 3-way interaction among local network size, distant network size and family involvement on R&D effectiveness

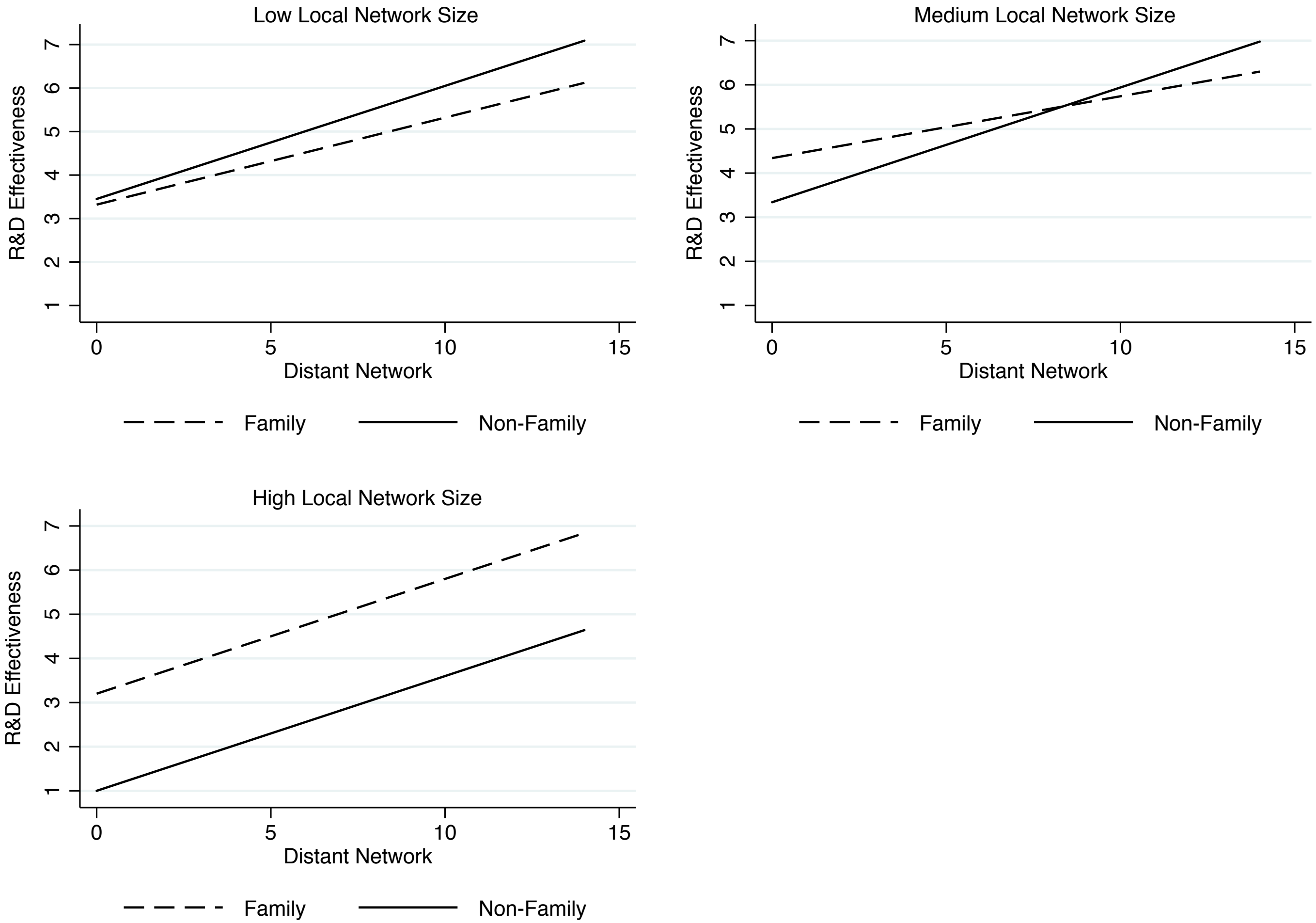

Table 1. Measures, correlations and descriptive statistics

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
[1] R&D Effectiveness	1.000											
[2] Local network size	0.324	1.000										
[3] Distant network size	0.701	0.227	1.000									
[4] R&D Exp. (LN)	0.364	0.311	0.441	1.000								
[5] Pharmaceuticals	-0.011	0.021	0.156	0.086	1.000							
[6] Biotech	0.093	0.135	0.075	-0.040	-0.179	1.000						
[7] Medical Devices	0.025	0.056	-0.063	0.144	-0.293	-0.293	1.000					
[8] Age	0.162	0.059	0.235	0.389	0.255	-0.221	0.006	1.000				
[9] Size (LN)	0.321	0.175	0.520	0.590	0.262	-0.113	-0.064	0.685	1.000			
[10] Foreign mark.	0.199	-0.060	0.252	0.205	0.083	0.044	-0.061	0.161	0.169	1.000		
[11] Public Fund.	0.257	0.105	0.307	0.272	0.059	0.136	-0.040	0.020	0.246	0.224	1.000	
[12] Family Involv.	0.104	-0.002	0.330	0.402	0.138	-0.145	0.087	0.406	0.474	0.192	0.122	1.000
Mean	4.808	3.724	2.855	9.483	0.152	0.152	0.324	17.145	2.299	0.448	0.476	0.345
Std. Dev.	1.084	1.861	2.614	4.847	0.360	0.360	0.470	15.583	1.694	0.499	0.501	0.477
Min	2.333	0	0	0	0	0	0	5	0	0	0	0
Max	6.667	8	14	18.642	1	1	1	85	7.615	1	1	1

Note: N = 145. ; Correlation coefficients greater than 0.169 in absolute value are statistically significant at 95%.

Table 2. Results of the linear regression

	Mod. A	SE	Mod. B	SE	Mod. C	SE	Mod. D	SE	Mod. E	SE	Mod. F	SE	Mod. G	SE
Pharmaceuticals	-0.190	0.227	-0.331*	0.160	-0.262^	0.148	-0.320*	0.147	-0.237	0.146	-0.241	0.150	-0.234	0.144
Biotech	0.275	0.282	-0.023	0.226	-0.117	0.190	-0.095	0.189	-0.144	0.193	-0.138	0.189	-0.089	0.193
Medical Devices	0.066	0.207	0.064	0.152	0.016	0.130	0.009	0.130	0.005	0.132	0.044	0.131	0.039	0.134
Age	-0.003	0.006	0.008	0.005	0.002	0.005	0.002	0.004	0.001	0.005	0.001	0.005	0.001	0.004
Size (Log)	0.136^	0.071	-0.072	0.056	-0.056	0.047	-0.044	0.045	-0.054	0.047	-0.049	0.049	-0.042	0.047
Foreign Mark.	0.227	0.172	0.097	0.131	-0.031	0.114	-0.042	0.111	-0.021	0.116	-0.008	0.112	-0.046	0.115
Public Fund.	0.254	0.184	0.099	0.139	0.100	0.124	0.089	0.123	0.097	0.124	0.076	0.125	0.097	0.124
R&D Exp. (LN)	0.047*	0.021	0.016	0.017	0.017	0.016	0.025	0.016	0.014	0.017	0.016	0.016	0.016	0.017
Local network size			0.0888*	0.043	0.940**	0.110	1.013**	0.122	0.923**	0.110	0.987**	0.123	0.943**	0.112
Distant network size			0.295**	0.028	0.225**	0.023	0.221**	0.023	0.263**	0.040	0.185	0.143	0.256**	0.039
Family Involv.			-0.352*	0.143	-0.207^	0.123	-0.274	0.360	-0.065	0.172	-0.210	0.127	-0.130	0.160
Local network size square					-0.114**	0.015	-0.131**	0.017	-0.111**	0.014	-0.126**	0.018	-0.117**	0.015
Family X Local network size							-0.229	0.194						
Family X Local network size square							0.052*	0.025						
Family X Distant network size									-0.050	0.044				
Local network size X Distant network size											-0.019	0.064		
Local network size square X Distant network size											0.006	0.007		
Family X Local network size X Distant network size													-0.070**	0.023
Family X Local network size square X Distant network size													0.014**	0.004
Constant	3.853***	0.203	3.577**	0.188	2.661**	0.165	2.629**	0.172	2.628**	0.167	2.695**	0.180	2.630**	0.165
F	5.24		20.58		40.52		38.22		40.19		38.38		44.56	
R^2	0.197		0.562		0.687		0.707		0.689		0.695		0.700	

Note: N = 145. ^ p < .10; * p < .05; ** p < .01.