Distance to customers, absorptive capacity and innovation in high-tech firms: the dark face of geographical proximity.

Abstract

This paper investigates the impact of both geographical and relational proximity on the innovative performance of the firm. We address the role of a firm characteristic, i.e., its absorptive capacity, as a specific contingency affecting the relationship between different proximities and innovation. Using data from 158 high-tech firms located in the Tiburtina Valley in Italy, we studied the relationships between firms and their key customers. Our findings support the need to downsize the role of geographical proximity in promoting innovation. Our results also show that firms' strategic decisions to invest in distant relationships and in internal R&D activities are among the main determinants of innovation.

Keywords:
innovative performance; geographical proximity; relational proximity; absorptive capacity; industrial cluster; inter-organisational relationships.

Introduction

A steady stream of literature on industrial clusters, also known as industrial districts (Piore and Sabel, 1984) or hot spots (Pouder and St. John, 1996), has long maintained the importance of geographical proximity between organisations for innovation processes (Almeida and Kogut 1999; Folta et al., 2006; Scott, 2006; Woolley and Rottner, 2008). However, some scholars have recently questioned the relationship between geographical proximity and innovation (Owen-Smith and Powell, 2004; Stuart and Sorenson, 2003), arguing that the organisation's knowledge base is rarely tied

exclusively to local networks, even in the most advanced industrial clusters (Felzensztein et al., 2010; Molina-Morales and Martinez-Fernandez, 2010). In addition to these widely held viewpoints, two more recent developments addressing the core issue of innovation in industrial clusters have emerged (Camison and Villar-Lopez, 2012). On the one hand, some authors have argued that the concept of proximity is multidimensional and not exclusively associated with the physical or geographical dimensions (Boschma, 2005; Knoben and Oerlemans, 2006). On the other hand, other scholars, explaining the determinants of innovation in industrial clusters, have highlighted the uneven distribution of local knowledge resources due to firms' internal organisational resources and absorptive capacities (Cepeda-Carrion et al., , 2012; Giuliani and Bell, 2005; McCann and Folta, 2008; Munari et al., 2012; Li, Tan, 2013). Although the literature on innovation in clusters has argued that some firm characteristics might moderate the relationship between proximity and knowledge acquisition in start-ups (Presutti et al., 2013), empirical evidence has yet to be collected regarding the moderating role of a key characteristic, namely, absorptive capacity, in the relation between proximity and innovation.

Taking into account these more recent perspectives, questions arise about the real importance of the distance to key partners regarding innovative performance and, within this context, about the role played by a firm's internal attributes, such as absorptive capacity. In this study, we aim to answer two interrelated questions.

1) What is the direct impact of both geographical and relational proximities on the innovative performance of co-located firms?

2) What is the effect of the interaction between geographical and relational proximities *and* absorptive capacity on the innovative performance of co-located firms?

To contribute to the debate on the role of proximity in a firm's innovation performance, our framework conceptualises proximity as a multidimensional notion. First, we introduced the *relational proximity* dimension into the model (Morgan, 2004; Oinas, 1999). This captures both social and cognitive inter-organisational proximity (Leana and Van Buren, 1999; Moran and Galunic, 1998; Nooteboom et al., 2007). Second, we verified the effects of interaction between absorptive capacity (Hotho et al., 2012) and both relational and geographical proximities on the innovation activity of co-located firms (Hotko et al., 2012; Expósito-Langa et al., 2011).

We tested our hypotheses through a survey of 158 firms located in a geographical cluster of small and medium-sized high-tech firms in the centre of Italy, in the Tiburtina Valley, close to Rome. We focus our attention on a high-tech cluster for several reasons: in addition to the great importance of these types of clusters in the current environment (Fosfuri and Ronde, 2004), and given the nature and relevancy of the knowledge flows for innovation in high tech clusters, they constitute a suitable empirical context to address our research questions.

We found that geographical proximity between a firm and its key customer is always detrimental to innovative performance, regardless of whether there are high or low absorptive capacity levels. Moreover, we found that firms' innovation capabilities are positively influenced by high levels of relational proximity only for high absorptive capacity values.

These results are relevant, first, because they contribute to a better understanding of the importance of the different dimensions of proximity in fostering innovation. Second, they contribute in evaluating the contingency role of internal resources, such as absorptive capacity, in the relationship between different forms of proximity and a firm's innovation performance.

We structure the remainder of the article as follows. First, we propose the theoretical framework and justify our hypotheses. Then, we describe the empirical setting and method. We conclude with a discussion of the results and suggestions for further research.

Theoretical framework

Innovation process, dimensions of proximity and absorptive capacities

Over the last decades there has been increasing interest in proximity and its potential effects on competiveness and innovation of the firms. Authors have emphasized the importance of geographical proximity in the success and development of spaces characterized as Marshallian industrial districts (Brusco, 1982; Becattini, 1991). Districts and proximity have been seen as the source of innovation and the foundation of the development of winning regions (Piore and Sabel; 1984). More recently, the *Triple Helix* perspective has used the notion of proximity as a central element of the knowledge-based systems. The knowledge-based systems transforms the institutional conditions into a knowledge infrastructure or, in other words, a Triple Helix network of university-industry government relations (Etzkowitz and Leydesdorff, 2000). In a different context the proximity notion has been applied to the population density at the metropolitan level, demonstrating a positive effect of human capital on innovation to posit that high densities of human capital workers promote innovation (Knudsen, Brian, et al. 2008). Finally, from a strategic perspective Porter (1994) suggests the determinant role of proximity and location on competition and competitive advantage of the firms.

The analysis of factors that affect a firm's innovation process has been the focus of considerable recent research (Yli-Renko et al., 2001; Zahra and George, 2002). According to these studies, firms' innovation processes derive more from interactions with external business actors than from a "solitary genius" (Burgelman and Hitt, 2007; Davidsson, 2005; Smith and Cao, 2007; Woolley and Rottner, 2008). That is, innovation is not a discrete process resulting from knowledge developed by an isolated firm but rather emerges through an interactive process (Ahuja, 2000; Slotte-Kock and Coviello, 2010) based mainly on external social relationships (Squire, Cousins and Brown, 2009; Dyer and Singh, 1998; Tsai and Ghoshal, 1998). This is the case for innovations driven by customers, and it was consistently found true were drivers differ (e.g. for design-driven innovations Verganti 2011a; 2011b).

These studies have also considered the location of the knowledge exchange process among partners (Audretsch and Lehmann, 2006; Feldman, 1994; Jaffe et al., 1993), confirming the importance of geographical proximity given that knowledge spillovers are not without costs generated by geographical distance (Maskell and Malmberg, 2007; Scott, 2006). Central to this argument is the traditional assumption in economics and geography that knowledge spillovers are geographically localised and locally bound (Alcacer and Chung, 2007; Jaffe et al., 1993; Krugman, 1991; Arikan, 2009). Thus, stocks and flows of knowledge tend to be spatially concentrated and, to some extent, available only to the co-located actors (Bell et al., 2009). In this context, innovation can be understood as a joint action among neighbours (Camison and Villar-Lopez, 2012). Empirical studies confirm that spatially concentrated actors benefit from knowledge externalities, in that short distances literally bring people together, they favour contacts for information exchange and they facilitate reciprocal exchanges of tacit knowledge (Gordon and McCann, 2005; Maskell, 2001; Waxell and Malmberg,2007).

Ever since Marshall (1920) presented his seminal work on industrial districts, most scholars have accepted this positive view of co-location. However, an increasing number of subsequent studies have considered this argument too simplistic, if not unrealistic, and have argued that there is no obvious relationship between externalities and geographical proximity (Huggins and Johnston, 2010; Owen-Smith and Powell, 2004). According to Oinas (1999), few empirical studies have proved that the process of knowledge exchange is actually local (Cooke, 2001). Some studies even critically consider the role of physical or geographical proximity, arguing that it does not generate externalities *per se* (e.g., Boschma 2005). Conversely, they suggest that the creation of new knowledge and interactive learning is more likely to occur inside non-local relationships and that the knowledge base is rarely tied exclusively to local networks (Owen-Smith and Powell, 2004; Saxenian, 1994). Instead, global relationships provide crucial sources of knowledge that complement traditional local 'buzz' as a dispenser of knowledge for the innovation process (Bathelt et al., 2004; Presutti et al., 2013).

In summary, research suggests that not only is geographical proximity insufficient to account for all knowledge spillovers (Sorenson et al., 2006) but also the concept of proximity is not exclusively limited to physical or geographical proximity (Boschma, 2005; Knoben and Oerlemans, 2006). A way to explain these results would be to identify the different dimensions of proximity investigating the role of the relational, cognitive, and epistemic proximities in facilitating knowledge dynamics among entrepreneurs (Boschma, 2005). This framework indicates that including social and cognitive dimensions of proximity reduces the need for geographical proximity, especially in the case of tacit knowledge transfer. Specifically, relational proximity may capture both social and cognitive inter-organisational proximity (Leana and Van Buren, 1999; Nooteboom et al., 2007). Because other intangible dimensions of proximity are

crucial in order to transfer knowledge in network relations, it is recognised that relational proximity between actors, and not geographical proximity, fosters knowledge spillovers. In other words, there is nothing inherently spatial about the innovation process (Breschi and Lissoni, 2001).

To have a complete picture of the current debate about the role of proximity on firms' innovation processes, the firms' internal resources must also be included. Giuliani and Bell, 2005, for example, found that the uneven and selective distribution of local resources and of knowledge affects innovation activity. In the context of proximity, the individual firm's knowledge base is an additive and distinct attribute of its systemic resources and capacities. Consequently, firms vary in their capacity to exploit opportunities (Munari et al., 2012). The differences in the amount of internal knowledge of the firm generate an uneven and selective distribution of resources and knowledge being transferred and received in a close environment (Cepeda-Carrion et al., 2012; Giuliani and Bell, 2005; Sammarra and Biggiero, 2008). Among a company's internal attributes, R&D efforts related to the firm's knowledge base, and thus its absorptive capacity (Hervas-Oliver et al., 2012)2012), are particularly significant. Previous research has associated a firm's absorptive capacity with organisational learning and the ability to apply information received from external sources (Valdaliso et al., 2011; Cohen and Levinthal, 1990). In addition, empirical findings demonstrate that such absorptive capacity exerts a positive influence on innovation (Hotho et al., 2012; Cassiman and Veugelers, 2002; Huergo, 2006). Literature on innovation in clusters still has to develop a focused analysis on the contingency role of absorptive capacity on the relation between proximity and innovation.

Hypothesis development

The current study focuses on firms' relationships with their key customers. Key customers are defined as a firm's largest customers in terms of proportion of sales revenue. Supplier–customer relationships are universally recognised as crucial for innovation (Von Hippel, 1977) and have become an integral part of business-to-business operating strategies (Squire et al.,2009; Felzenstzein et al., 2010; Langfield-Smith and Greenwood, 1998).

  More specifically, at the empirical level, we first consider the direct effects of geographical proximity (Hp. 1) and relational proximity (Hp. 2) on the innovation performance of the high-tech firms of our sample. Then, we consider the interaction effects of absorptive capacities with geographical and relational proximity on innovative performance (Hp. 3; Hp. 4).

Geographical proximity and innovative performance

The role of geographical proximity is still hotly debated, with some authors currently suggesting a positive effect of co-location but others arguing that geographical proximity has a negative impact on innovation (Hoppmann et al., 2013; Gilsing et al., 2008). In recent times, an increasing number of scholars have challenged the view that physical proximity, in the contexts of industrial clusters, favours firm innovation (Antonelli, 2000; Breschi and Lissoni, 2001). Some authors maintain that the negative effects are particularly strong in high-tech contexts (e.g., Breschi and Lissoni, 2001), where the links with dispersed sources of knowledge distributed worldwide is essential (Friesl et al., 2008). When firms focus on close networks, it limits their capacity to respond to new external opportunities and developments (Boschma, 2005). Moreover,

local interactions can generate spatial lock-in situations, which are detrimental to learning interactions and, ultimately, for innovation (Capo-Vicedo et al., 2008). Close networks might even isolate firms from external and profitable sources of knowledge and information through a lock-in effect (Bathelt et al., 2004; Romanelli and Khessina, 2005). To avoid such spatial lock-in, firms might pursue distant relationships that provide access to the outside world (Hendry et al., 2000). We share these perspectives and, by focusing on the relationship with key customers, argue that geographical proximity with them might have a negative impact on innovation.

Thus, we formulate the following hypothesis.

H1: *For firms located in industrial clusters, the geographical proximity to key customers is negatively associated with their innovative performance.*

Relational proximity and innovative performance

The relational proximity dimension refers to both social and cognitive inter-organisational proximity (Leana and Van Buren, 1999; Moran and Galunic, 1998; Nooteboom et al., 2007). According to reports on embeddedness (Granovetter, 1985; Uzzi, 1997), social proximity entails the level of trust between a local firm and its customers. Cognitive proximity focuses on the similarities in the way actors perceive, interpret, and evaluate the world. High levels of social and cognitive proximity can reduce the knowledge distance between business partners (Boschma, 2005), broadening their common knowledge base and expertise. Therefore, relational proximity facilitates knowledge acquisition and, particularly, tacit knowledge exchange. When relational proximity between partners is high, agents act similarly, and more knowledge can be

transferred when practices, institutional legacy, and work culture are common (Mowery et al., 1996). According to Dakhil and Clercq (2004), higher levels of shared values and common culture are typically associated with higher levels of innovation. When agents are involved in the same network and have a shared vision, reinforced by reciprocal trust, they tend to have similar perceptions about how to act, promoting mutual understanding and the exchange of ideas and resources (Tsai and Ghoshal, 1998). Moreover, when firms have similar referral structures, knowledge can be communicated, transferred, and acquired more effectively and efficiently (Knoben and Oerlemans, 2006). In this context, parties tend to share goals and have a common understanding of which innovation is needed. In turn, a common attitude regarding how to perform research activities emerges, leading to an improvement in innovation performance (Krause et al., 2007). Shared vision can be regarded as a mechanism favouring knowledge integration between parties in a network (Inkpen and Tsang, 2005); in this sense, it is a critical element in the innovation process. Finally, the presence of trust in business relationships makes reciprocal knowledge exchange more efficient, thus becoming a substitute for formal contracts, incentives, and monitoring mechanisms associated with typical business transactions. This, in turn, reduces the risk of reciprocal opportunism and, more generally, lower transactions costs, promoting knowledge exchanges among partners (Nahapiet and Ghoshal, 1998)

Conversely, cultural conflicts and misunderstandings between firms and their customers can limit information and knowledge acquisition and inter-organisational learning. When goals and cultures are incongruent, misunderstandings and conflicts between firms and customers are more likely to arise. Parties may become disappointed and likely to restrict information exchanges, which will negatively affect outcomes for the firms (Inkpen and Tsang, 2005; Krause et al., 2007). In summary, relational proximity

facilitates interactions between actors and access to external knowledge, regardless of geographical distance. These arguments suggest a positive association between social and cognitive proximity and knowledge acquisition and, thus, innovative performance. This leads to our second hypothesis.

H2: *For firms located in industrial clusters, the relational (social and cognitive) proximity to key customers is positively associated with their innovative performance.*

The moderating role of absorptive capacity

Firms vary in their capacity to understand, develop, and use certain external resources, particularly those related to knowledge and innovation. Previous studies have identified a firm's absorptive capacity as a key factor in improving its ability to benefit from external resources (Valdaliso et al.,, 2011; Cohen and Levinthal, 1990). This capacity is also considered a measure of the firm's capacity to innovate and to develop new knowledge (Zahra and George, 2002).

Extant research argues in favour of a positive relationship between absorptive capacity and innovative performance (Hotho et al., 2012). Consequently, it can be expected that exploitation of the external resources provided thanks to proximity will be greater for companies with higher levels of absorptive capacity (Cepeda-Carrion et al., 2012).

In the case of key customer relationships, the propensity to use knowledge depends on the firm's own absorptive capacity and on the level of integration into networks (Tether and Tajar, 2008).

Knowledge provided by key customers typically requires complex and intensive

interaction between companies, in which both parties participate in interactive learning (Hertog, 2000; Sundbo, 2001). For example, studying the case of firms based in Hong Kong, Wu (2008) empirically demonstrates that repeated transactions among partners promote knowledge exchange, leading to a positive impact on firm performance. The literature has emphasised the complementarities between external knowledge provided by customers or knowledge providers and a company's resources and capabilities (Friesl, 2012; Tether and Tajar, 2008).

As Zaheer and Bell (2005) suggest, external and internal resources must be analysed together to offer a complete explanation of a firm's performance, also in terms of innovation. External and internal resources can interact, thereby affecting each other. Different scholars have started to look at internal contingency, for example, absorptive capacity, in the firm's use of external alliance (Park et al., 2002) and in its capacity to extract value from its network position (Shipilov, 2009).

Studies on firms located in clusters suggest that a firm's internal resources, such as absorptive capacity, might improve its exploitation of external resources, thereby enhancing its innovation performance (Presutti et al., 2013; Hervas-Oliver et al., 2012). In particular some researchers claim that cluster literature over-emphasizes the importance of geographical proximity, while underestimating the role of network relations and the capacity of the firms (Ter Wal and Boschma, 2011)

In our context, because firms vary in terms of internal resources, we expect that those resources (i.e., absorptive capabilities) moderate the relationship between geographical and relational proximity and the firm's innovative performance. More specifically, higher levels of absorptive capacities should mitigate the negative effects of geographical proximity to customers on a firm's innovation activity. Moreover, we

expect that higher levels of absorptive capacities will strengthen the positive effects of cognitive and social proximity from customers on innovation activity.

H3: *For firms located in industrial clusters, the effect of the geographical proximity to key customers on innovative performance is moderated by the level of their absorptive capacity, such that the geographical proximity will have a less negative effect if the levels of absorptive capacity are high.*

H4: *For firms located in industrial clusters, the effect of the relational (social and cognitive) proximity to key customers on innovative performance is moderated by the level of their absorptive capacity, such that the relational proximity will have a stronger positive effect if the levels of absorptive capacity are high.*

Methods

Sample and data

Over the last few decades, high-tech clusters have become a popular strategy for firms and regions, and successful high-tech clusters can attract capital, create jobs, and attract talent and many other resources (Fosburi and Ronde, 2004; Longhi and Keeble, 2000). In these contexts, innovation processes acquire full development, and due to their complexity, firms are much more dependent on external flows of knowledge resources (Bresnahan et al., 2001).

The field setting of this research consists of a geographical cluster of small and medium-sized high-tech firms located in one of the most important areas in central Italy, the Tiburtina Valley, approximately 14 kilometres from the centre of Rome. As in

Silicon Valley in the US, the high-tech firms located in this restricted urban context have created a homogenous agglomeration that currently represents the most typical example of a high-tech metropolitan cluster in Italy. This cluster is also known for its high export rates due to the presence of several important foreign multinationals. The high number of specialised firms located in such a small area has led to the development of new businesses and the rapid diffusion of knowledge among local actors. This urban cluster has already been the focus of previous international studies (Presutti, *et al.* 2011).

At the beginning of our data collection (September 2013), the sectors represented in this area were: 1) electronics (320 firms); 2) media (200 firms); and 3) new economy (e.g., manufacturers of new hardware, information services industry, Internet access providers, telecommunication network managers; 522 firms). We focused on the electronics sector, which, according to the definition of the National Federation of Electronics Firms, consists of the computer industry, electronics in the strictest sense, and telecommunications. Specifically, we tested our hypotheses using survey data from 158 high-tech firms in the electronics sector, defined according to standard industrial classification (SITC) codes, located within this cluster.

The data to test our hypotheses come from a direct survey using a specially designed questionnaire. The data collection process lasted approximately five months. The survey process was developed in four phases: 1) conducting literature reviews in order to develop the measurement scales; 2) developing the questionnaire (structured in the closed question-answer form); 3) randomly pre-testing the questionnaire on three sample firms; and 4) data collection. The firms in our sample belong to the "specialised suppliers" category according to the Pavitt classification in that they produce and offer technology and services mainly to their industrial customers. In this case, customers

access technology also through the acquisition of products from suppliers (Yanez et al., 2010) and the sources of firm knowledge acquisition and exploitation processes both for customers and suppliers depend to a great extent on interactive learning among them. This encourages local firms to become increasingly specialised, resulting in strong differentiation among their internal knowledge bases. The scope and extent of the launch of new products by the firms and their R&D activity are strongly conditioned by knowledge acquired from their customers because the new products need to be in line with customers' specific requirements (Dyer and Sing 1998).

To ensure that all firms in our sample were involved in innovation activities, we checked their business descriptions in the source database. Firms with no internal R&D activity or who only offered non-technical services were excluded from the study. This left a total of 275 firms, 158 of which accepted our request for a personal interview to complete the questionnaire (58% response rate). A comparison of differences in the mean values of the responding and non-responding firms revealed no statistically significant response bias in terms of their 3-year average sales revenues, firm age, and the number of employees.

Our key informant was the entrepreneur. Firms were contacted by telephone to obtain the names of potential respondents (the entrepreneurs) and to determine whether they would agree to complete the survey through face-to-face interviews. The focus of our empirical research was on the vertical relationships between each firm and the customer that accounts for the highest proportion of sales revenue for the previous year (Yli-Renko et al., 2001). Using a semi-structured questionnaire, entrepreneurs were asked to use 7-point Likert scales to express their opinion about all items. These were selected to measure relational proximity with the firm's key customers. Moreover, entrepreneurs

were asked to indicate the customer's location, the duration of their business relationship, the size and age of both firms, and the ratio of R&D expenditures of both firms to total sales. Finally, to capture innovation activity, firms were asked to indicate the number of new products developed as a result of this key customer relationship.

Overall, the firms in the sample developed an average of 7.3 new products per year (range 1-25). The average sales of the respondent firms amounted to €814,000, with an average age of 18.10 years. In addition, the average R&D expenditure in relation to total sales was 3.67% (range 0.01-15%). The key customers are similar in age to their suppliers (M = 18.16 years) but were on average smaller (M_{sales} = €530.63). The number of key clients located within the district is 54. Table 1 reports the descriptive statistics for the untransformed variables.

Measures

Dependent variable: *innovative performance*

We measured innovation activity by asking the firms how many new products or services they had developed during the previous three years as a result of the relationship with their key customer, in line with Yli-Renko et al. (2001).

Independent variables

Absorptive capacities (AbsCap). Following other recent research on measuring absorptive capacities (e.g., Cohen and Levinthal, 1990; Meeus et al., 2001), we used R&D spending as a proxy to measure the level of a firm's investment in absorptive capacities useful to its innovation activity. This was measured by considering the log value of the average ratio between R&D expenditures and total sales during the previous three years.

Geographical proximity between actors (GeoProx). In accordance with previous studies (Boschma, 2005; Rallet and Torre, 2000), we distinguished between key customers located within the district and those located outside. We defined a dummy variable equal to 1 for customers located inside the cluster and 0 otherwise. The number of customers located within the district is 54 (34,1%).

Relational proximity (RelatioProx). We used multi-item measures to analyse the relational proximity between the firm and its key customer because they provide considerable advantages over single-item measures (e.g., Churchill, 1979). In our research, we use the relational proximity dimension to capture both social and cognitive inter-organisational proximity, in accordance with many significant studies (e.g., Leana and Van Buren, 1999; Moran and Galunic, 1998; Nooteboom et al., 2007). According to literature concerning embeddedness (Granovetter, 1985; Uzzi, 1997; Presutti et al., 2011), the social proximity dimension measures the level of trust between a local firm and its customers. In particular, we focus on three dimensions of inter-organisational trust: lack of opportunistic behaviour, creation of common investments (degree of commitment), and presence of informal relationships. In line with Yli-Renko et al. (2001), we selected six items to measure these dimensions of trust that have been used in many previous studies on trust, networks, and social capital. The cognitive proximity dimension encompasses similarities in the way firms and customers perceive, interpret, and evaluate the world. Therefore, a high level of cognitive proximity (Boschma, 2005) can reduce the distance between knowledge bases of the business partners, thus broadening their common knowledge base and expertise. In line with previous studies (Nahapiet and Ghoshal, 1998; Yli-Renko et al., 2001), we measured the cognitive proximity between business partners with six items using 7-point Likert scales. These items capture two interconnected aspects of relational cognitive proximity. First, they

reflect the extent to which the business relationship is characterised by the development of common goals, norms, and reciprocal expectations involving the goodwill and trustworthiness of the exchange partner (Tsai and Ghoshal, 1998; Yli-Renko et al., 2001). Second, the selected items verify the overlap of personal and business interests among partners, that is, the extent to which the business relationship is characterised by personal social ties (Nahapiet and Ghoshal, 1998).

To verify the unidimensionality of the relational proximity construct (Churchill, 1979), we submitted the scales used to analyse both cognitive and social dimensions to a factor analysis. Our original selection of 12 items was unsatisfactory from a statistical viewpoint (Kaiser, 1960) because some single factors have eigenvalues greater than 1.0, and the loadings of some items do not exceed the cut-off point of 0.30. Moreover, our scale shows a low degree of internal reliability (Nunnally, 1978). Thus, by submitting the items to factor analysis, we reduced the number of items from 12 to 6 (3 items for social and 3 for cognitive proximities) to measure relational proximity. With this reduced combination of items, the measurement model performed well. The selected constructs demonstrate good internal consistency and reliability (see details in the next section). The measure is a reflective manifestations of the underlying constructs as defined by Edward (2011) since our measure is the outcome of unobserved latent variables. Because we expected the effect of relational proximity to decrease for higher values of the variable, we considered a logarithmic specification of this variable.

Table 1. Descriptive statistics of the untransformed variables.

	Average	S.D.	Min	Max
Innovation	7.3	6.1	1	25
Size (€0.000)	814.33	1116.75	100	10,000
CustSze (€0.000)	530.63	542.68	40	3,000
CustAge	18.01	12.86	2	90
FirmAge	18.16	13.44	2	80
AbsCap	3.67	3.04	0.01	0.15
RelProx	4.13	2.29	1	7

Control variables

We included some control variables to isolate the effect of the independent variables in the model. First, an important factor influencing innovation activity is the size of the involved partners (Acs and Audretsch, 1991; Mowery et al., 1996; Tsai and Ghoshal, 1998), in line with the idea that larger firms may invest more resources in R&D activities. As several studies suggest (e.g., Kogut and Zander, 1992), both superior resources and economies of scale allow larger firms to exploit external knowledge successfully for their innovation process. We controlled for the effects of size by including the total sales of both the firms (*Size*) and their customers (*CustSize*).

Moreover, we included two additional control variables to evaluate the age of the firm (*FirmAge*) and of its customers (*CustAge*). We assume that these elements will have an influence on the firm's learning ability and its knowledge exploitation process (Zahra et al., 1999). We computed the age of the firms and of their customers as the number of years since their foundation. We used the log of these values to account for declining effects at higher values. Table 2 reports the descriptive statistics of the variables and their correlations.

Table 2. Descriptive statistics and correlations.

	Average	S.D.	Size [1]	CustSize [2]	CustAge [3]	FirmAge [4]	AbsCap [5]	RelProx [6]	Geo Prox [7]
[1]	814.33	1116.75	1						
[2]	530.63	542.68	0.287***	1					
[3]	2.70	0.60	0.189 **	0.354***	1				
[4]	2.68	0.65	0.471***	0.409***	0.584***	1			
[5]	0.739	1.35	0.354***	0.271***	0.395***	0.575***	1		
[6]	1.18	0.751	0.054	0.066	0.183 **	0.205***	0.201 **	1	
[7]			–0.281***	–0.211***	–0.382***	–0.481***	–0.584***	–0.289***	1

Reliability, Validity, and Data Analysis

Several precautions were taken to ensure that our data are reliable and valid. First, as mentioned previously, we pre-tested the survey with 3 entrepreneurs from our sample. Second, we used multi-item measures for measuring relational proximity because they provide considerable advantages over single-item measures (Churchill, 1979). We measured these items on the questionnaire using 7-point Likert scales. As a first step of measure validation, to assess the unidimensionality of the research constructs (Churchill,, 1979), we factor-analysed the final scales with six items using the principal axis method, positing a single factor (exploratory factor analysis). After exploring the factor structure of the data, we submitted the data to confirmatory factor analysis. The results of this analysis verify that the measurement model performed well because the selected constructs demonstrate good internal consistency and reliability: the standardised factors are all above the recommended minimum of 0.40, and the average variances extracted are all above the recommended minimum of 0.50 (range 0.59-0.88). The composite reliabilities are all above the recommended minimum of 0.70 (Table 3).

Finally, the CFA showed that the measurement models fit the data reasonably well, with a goodness-fit-index superior to 0.9 (GFI).

Table 3. Factor analysis on relational proximity.

Factor name	Measurement item	Standardised loading	Cronbach's alpha
Relational proximity			0.822
	Social dimension		
	The firm sends the products to the customer before receiving the entire payment.	0.88**	
	The transaction with the customer is based on usual procedures without formal agreements.	0.59**	
	The customer and the firm are strongly tied by common investments aimed to reinforce their growth.	0.65**	
	Cognitive dimension		
	The firm has never had problems with the client because it has similar interests.	0.71**	
	The customer often comes to the firm's head office without reasons related to work.	0.75*	
	The purchase order was defined in a non-working environment.	0.85**	
	Goodness-fit-index (GFI) > 0.91		

Analysis, techniques, and results

To test our hypotheses, four models were analysed using the ordinary least squares technique with Release 11 of the Stata software package. The estimated equation is:

Innovation= $\alpha_0 + \beta_1$ (*GeoProx*) + β_2 (RelProx) + β_3 (*Interactions*) + β_5 (*Controls*)+ε.

where α_0 is the constant intercept, β_i is the regression coefficients and ε is the error term.

Table 4 presents the regression results for all models. The results are fairly constant across all the specifications, and the explanatory power of the models is highly significant in terms of both R-square and adjusted R-square values. These results suggest that the models have been correctly specified and are stable. To determine whether our results are subject to multicollinearity, the variance inflation factors (VIFs) were also calculated for all models. The values of the mean VIF scores, well below the commonly used critical value of 10 (Cohen et al., 2003), and even the more restricted value of 5, suggest that, in our study, multicollinearity is not a concern. The first column, Model 1, shows the estimated coefficients for the model containing our four control variables and the variable measuring absorptive capacity. The coefficients of the size variables were positive and statistically significant for the firm and its key clients, as well as for absorptive capacity. These variables influenced the firm's level of innovative performance. In contrast, variables on the age of both the firms and their clients were <0, but were not statistically significant. Therefore, our results did not support the view that age was a critical issue in determining a firm's innovative performance.

Models 2-4 include the independent variables, leading to a significant increase in the overall explanatory power of the models and confirming the significance of our independent variables. In Model 2, we tested for the impact of the dummy variable that gauges the location of clients within the cluster (*GeoProx*). The coefficient of the variable was negative and strongly significant ($\beta = -3.23$; *p* < 0.01), suggesting a relevant negative effect of being located nearby. These results fully support Hypothesis 1 in the sense that geographical proximity with the key customers is detrimental to the innovative performance. Next, Model 3 determined whether relational proximity had a

positive effect on the innovative performance (*RelProx*). In support of Hypothesis 2, the coefficient is positive and significant ($\beta = 0.758$; $p < 0.10$).

Next, we tested Hypotheses 3 and 4 using interaction terms to investigate the role of absorptive capacity in moderating the impact of relational and geographical proximities. Hypothesis 3 predicted that absorptive capacity would mitigate the negative effect of geographical proximity, while Hypothesis 4 predicted that it would reinforce the positive effect of relational proximity on innovation activity. Model 4 showed that although the relational proximity loses its significance, there are significant interaction effects among the variables, as shown in Figures 1 and 2. To select high and low values, we followed the suggestions of Aiken, West, and Reno (1991) in using 1 and 0 for categorical variable, as in the case of our geographical variable, and in using values corresponding to 1 S.D. above and 1 S.D. below the mean for continuous variables, as in the relational proximity case. The Y axis represents the dependent variable (innovation activity), and the X axis represents the low and high geographical proximity, i.e., within and outside the cluster (Figure 1) and low and high relational proximity (Figure 2). Figure 1 clearly shows (both slope lines decrease) that Hypothesis 3 is not confirmed. Innovative performance is negatively influenced by geographical proximity, both for high and low absorptive capacity levels. Moreover, geographical proximity, i.e., being located in the same cluster of clients, has a particularly negative impact when the absorptive capacity is higher.

Figure 2 shows that innovative performance is substantially clearly not influenced by a high level of relational proximity when the absorptive capacity of the firm is low. Only for high absorptive capacity values is innovative performance positively influenced by high levels of relational proximity to customers.

Table 4. Regression results.

|	(1)	(2)	(3)	(4)
Size	0.00159***	0.00154***	0.00157***	0.0014***
	(0.000312)	(0.000296)	(0.000294)	(0.000294)
CustSize	0.00166***	0.00172***	0.00175***	0.00177***
	(0.000619)	(0.000588)	(0.000583)	(0.000561)
CustAge	−1.036	−1.348**	−1.398**	−1.422**
	(0.629)	(0.601)	(0.596)	(0.576)
FirmAge	−0.0531	−0.400	−.477	−0.458
	(0.700)	(0.669)	(0.664)	(0.648)
AbsCap	2.774***	2.271***	2.263***	2.257***
	(0.273)	(.285)	(0.282)	(0.408)
GeoProx		−3.233***	−2.948***	−2.007***
		(0.761)	(0.768)	(0.777)
RelProx			0.758*	0.269
			(0.395)	(0.417)
GeoProx×AbsCap				−1.732***
				(0.534)
RelProx× AbsCap				0.594**
				(0.270)
Constant	6.029***	9.291***	8.600***	8.266***
	(1.709)	(1.793)	(1.813)	(1.767)
Observations	158	158	158	158
R-squared	62.9%	66.9%	67.6%	70.40%
AdjR-squared	61.6%	65.5%	66.4%	68.60%
F(e;dof)	$F_{(5, 152)} = 51.50$	$F_{(6, 151)} = 50.75$	$F_{(7, 150)} = 44.80$	$F_{(9, 148)} = 39.11$
Prob > F =	0.0000	0.0000	0.0000	0.0000
VIF (mean)	1.61	1.67	1.60	2.16

Standard errors are in parentheses.

*** $p < 0.01$. ** $p < 0.05$. * $p < 0.1$.

Figure 1. Innovation activity: interaction effect of geographical proximity and absorptive capacity.
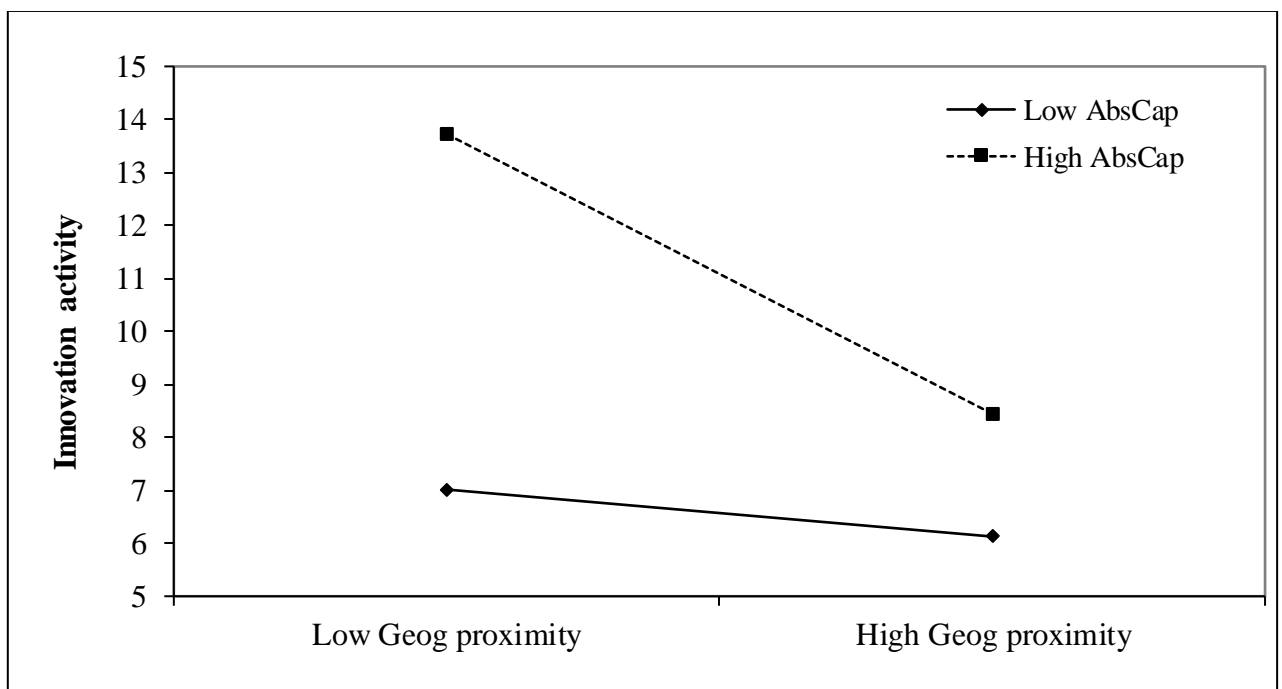
Figure 2. Innovation activity: the interaction effect of relational proximity and absorptive capacity.
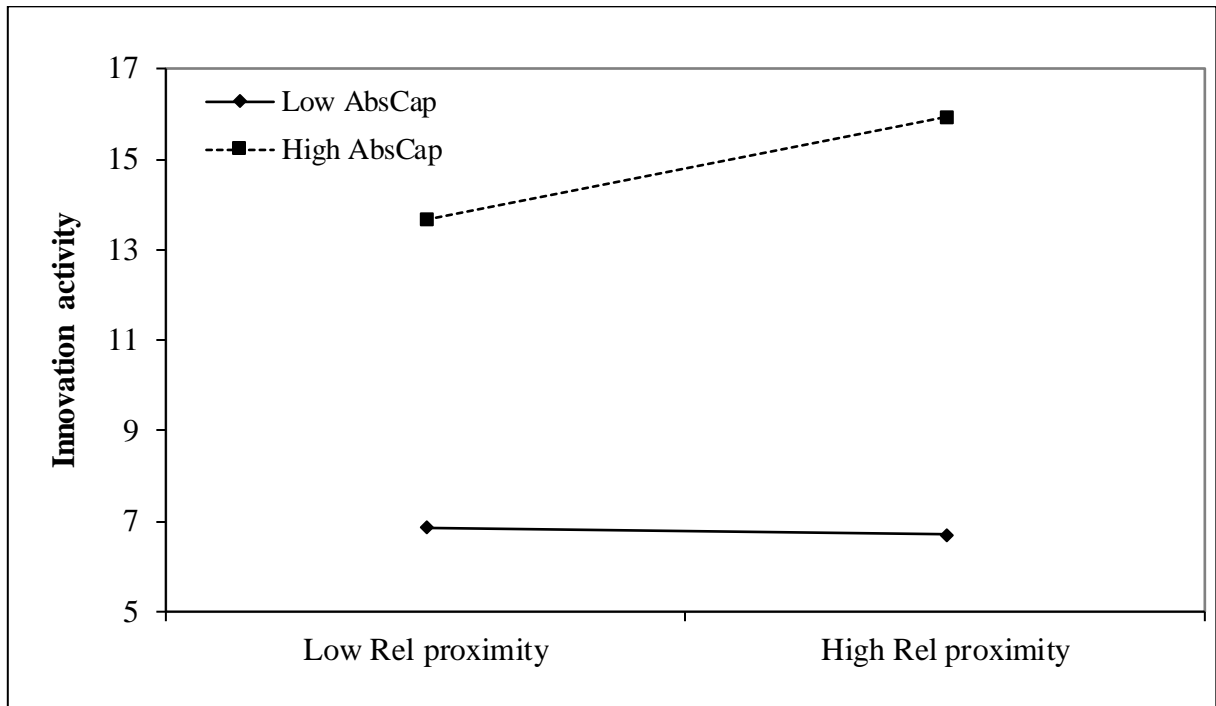
Discussion, implications and limitations

This paper adopted a multidimensional perspective on proximity to explore the effect of geographical and relational (social and cognitive) proximities of high-tech firms to their key customers in terms of innovative performance. Moreover, we investigated whether the firm's level of absorptive capacity moderates these effects.

First, our results suggest that the geographical proximity between firms and key customers reduces firms' innovative performance. Having customers located in the same cluster has a detrimental effect on firms' innovative performance. Geographical proximity with partners isolates firms from external sources beneficial to their innovation activity through a lock-in effect (Bathelt et al., 2004; Romanelli and Khessina, 2005). Along this direction, other studies explain the negative impact of

geographical proximity on innovation according to the network inertia problem (Boschma, 2005; Uzzi, 1997), which limits the ability of a firm to exploit knowledge from different external sources of innovation when under the condition of overembeddedness with geographically concentrated customers.

Regarding our specific context of high-tech firms, the results could be ascribed to the fact that close business partners already have the same technological information as local firms, whereas exposure to many different external sources of technological knowledge is essential to explore new innovation opportunities. This idea was supported by the characteristics of the larger and younger key customers of our sample; innovation opportunities could be better accessed through relationships with innovative and very active customers located far from the cluster. The diversity associated with distant contacts can be essential for innovative contexts such as the investigated cluster (Friesl, 2012; Hendry et al., 2000). This is very much in line with what specifically happens in our empirical setting, where high-tech firms require primary exploration activities to capture new ideas and improvements much more than exploitation of the elements/resources/products they already have. Moreover, according to our findings, these exploration activities are likely much better developed with distant rather than close partners (Hendry and Brown, 2006; Presutti et al., 2007; Hoppmann et al., 2013; Gilsing et al., 2008).

As expected, relational proximity was found to exert a positive impact on a firm's innovative performance. This result further supports the importance of following a broader multidimensional view of the proximity concept while also considering intangible proximity dimensions as important explicative factors of the innovation process (Breschi and Lissoni, 2001; Boschma, 2005; Ter Wal and Boschma, 2009; Torre, 2008). Our results confirm that for high-tech firms and their key customers,

relational proximity seems even more relevant for knowledge transmission. Key customers can reinforce both the creation of new products and the technological distinctiveness of their main suppliers (Yli-Renko et al., 2001). External knowledge is a particular requirement because high-tech firms must leverage inter-organisational customer relationships to broaden their stock of knowledge regarding both technology and R&D activity (Pirolo and Presutti, 2010).

We found that a firm's absorptive capacity influences the role of geographical and relational proximity in innovation. In particular, and contrary to our expectations, we found that innovative performance is negatively influenced by geographical proximity to customers, regardless of whether the firms has high or low levels of absorptive capacity. Geographical proximity to customers has a particularly negative impact when absorptive capacity levels are high, thus suggesting that knowledgeable firms could be harmed by geographically proximate key customers.

Finally, with respect to the role played by absorptive capacity in the relation between relational proximity and innovation, we found that innovative firm performance was positively influenced by higher levels of relational proximity to customers only for high absorptive capacity. In contrast, this proximity does not influence the innovation performance of firms with a lower level of absorptive capacity. This suggests that the combination of significant internal capacities and relational proximity is what matters most for innovative performance.

Our findings contribute to the literature on innovation in clusters, where the role of contingency factors in the relationship between proximity and innovation, although theoretically addressed (Presutti et al., 2013), still requires empirical evidence. In particular, our contribution focused on the moderating role of absorptive capacity.

Regarding the contingency role of absorptive capacity, our findings also illustrate that relational proximity has a complementary relationship with absorptive capacity, which positively moderates its influence on innovative firm performance. In contrast, the absorptive capacity is unable to substitute a high level of geographical proximity moderating its negative influence on innovative firm performance. A combination of high absorptive capacity and relational proximity to distant partners appears desirable.

By addressing the substitutive or complementary role of a firm's contingency, we also contribute to a growing focus in the literature on network advantage, which recognises that individual actors might differently benefit from their network relations according to specific external contingencies (such as industry context and uncertainty characteristics) (Hargadon and Sutton, 1997; Ahuja, 2000) and internal contingencies (such as absorptive capacity, bargaining power, and protection against non-cooperation of partner) (Shipilov, 2009).

Our findings contribute to the more general understanding of the internal heterogeneity of knowledge distribution in clusters and its relation with innovation. Firms' investments in high levels of absorptive capacity can help explain the access to external distant sources of knowledge, the impact on their innovative performance (Torre and Rallet, 2005; Romanelli and Khessina, 2005) and consequently the selective and uneven distribution of knowledge in the cluster (Giuliani and Bell, 2005).

Finally, the insights obtained from this study contribute, even if indirectly, to the debate on the role of heterogeneous, i.e., non-redundant, information and knowledge accessed through network relations and their impact on firms' innovative performance, a topic that is drawing greater attention in studies on geographical clusters and networks

(Molina-Morales and Martinez-Fernandez, 2006) .

A large set of managerial implications arises from this study. Cluster firms should actively develop relationships with distant customers to favour knowledge acquisition useful to innovative performance. Firms have to select those distant customers who can act as bridges to enable a local firm to enlarge its knowledge sources and innovation ideas. Thus, a well-developed system of 'global pipelines' connecting the local firms to customers spread around the world would be extremely beneficial for a firm's innovation activity. In addition, our study highlights the importance of investing in absorptive capacity to benefit from the relational proximity to customers. By combining high investments in absorptive capacity with relational proximity, firms are able to increase their innovative performance. Implications in terms of the role of non-redundant information accessed through relationally strong partnerships with geographically distant customers also arise from our study.

Some limitations of our study must be discussed in order to pinpoint opportunities for further research. First, our results refer to a high-tech cluster. To generalise our theory, a test with more traditionally oriented clusters should be performed. Second, our definition of innovative performance is limited to the number of products and services developed by the firms in the past three years, regardless of the drivers of innovation (customer, process, design etc..) and with no distinction between different kind of innovation (i.e disruptive and incremental). Further research could try to develop accordingly with heterogeneity in innovation process. Additionally, in this study, absorptive capacity was conceptualised only as an internal resource and as an indicator of capabilities Further research could extend into other dimensions of strategic internal assets in order to gain a more complete picture of the importance of the mediating role of firms' internal resources and capabilities (Fernhaber et al., 2009). Researchers could

also include other significant boundary conditions that might influence the importance of distant and near customer relationships for firms' innovation processes.

Finally, given that our study analyses geographic and social proximity separately, further research could consider more complex relationships among these factors, such as combining effects, in line with the previous works of Parra-Raquena et al., (2010) and Nooteboom et al., (2007).

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