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## **The Impact of the Geographical Distance on the External Sources of Knowledge Spillover?**

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### **Abstract**

This paper focuses on private sources of knowledge specifically customers and competitors as sources of innovative activity. Our main argument is that the two sources are correlated even after controlling for several factors at the level of technology, individual and organization. What is more, we show that the geographical distance of these sources modifies the intensity of this correlation, in a way that locally the two sources are more correlated. The underlying theoretical mechanism that explains the different roles is the randomness of local interactions as opposed to planned-ness of distant interactions.

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This paper focuses on private sources of knowledge specifically customers and competitors as sources of innovative activity. Our main argument is that the two sources are correlated even after controlling for several factors at the level of technology, individual and organization. What is more, we show that the geographical distance of these sources modifies the intensity of this correlation, in a way that locally the two sources are more correlated. The underlying theoretical mechanism that explains the different roles is the *randomness* of local interactions as opposed to *planned-ness* of distant interactions.

## **Introduction**

Innovative capability lies at the heart of firms' competitive advantage in several industries (Mowery et al 1998; Eisenhardt and Martin, 2000; Helfat and Raubitschek, 2000). However, innovation is subject to depreciation and competitive erosion (Tushman and Anderson 1986, Anderson and Tushman 1990; Christensen and Rosenbloom 1995; Christensen, 1997). Thus, firms should constantly seek to keep alive or renew innovative trajectories (Garud and Kumaraswamy, 1993). However, new ideas are rarely born in a vacuum. Recent stream of literature has focused on the importance of external sources of knowledge (Chesbrough, 2003, 2008; Giarratana, 2004; Christensen et al, 2005). Particularly the importance of the signals received from competitors and customers (Adner and Levinthal, 2001; Adner and Kapoor, 2010).

Even largest innovation-active firms cannot rely solely on the internal R&D to keep their innovative engines up and running. Prior research has shown that external knowledge can enhance and complement firm-level innovation process. Cassiman and Veugelers (2006) found a complementarity effect between internal R&D and external knowledge acquisition. The previous studies in the literature have focused on the effects of formal external business activities on firms' innovation. Scholars have shown that corporate venture capital investments (Dushnitsky and Lenox, 2005), alliances (Ahuja, 2000), joint ventures (Oxley, 1996, Oxley and Wada 2009, Inkpen and Crossan, 1995), and acquisitions (Ahuja and Katila, 2001) are positively related to the innovative performance.

However, also informal external sources play a role in innovation. The informal perspective was mainly approached by geographical scholars. Despite all the early hype about digital era, geographical distance of these sources of ideas is still a relevant matter. Firms still locate in places to be close to customers, talent pool and likeminded firms, trying to maximize their benefit from the externalities that physical location can provide for them (Almeida and Kogut, 1999; Owen-Smith and Powell, 2004; Saxenian, 1994; Stuart and Sorenson, 2003; Gambardella and Giarratana, 2010). Hence, also the business press recognizes that hasty waves of excitement about “death of distance” and “end of geography”, that rose in the beginning of digital era, not only turned out to be much exaggerated, but the digital technologies have increased the returns to geographical agglomeration (*The Economist*, 2012).

Collocation of innovative activity is a complex strategic decision. At one hand, the literature on economic geography (Jaffe et al, 1993), knowledge spillover (Audretsch and Feldman 1996) and clusters (Porter, 2000), magnify the benefits and externalities that proximity of market players provides for firms (Krugman, 1991). On the other hand, other studies indicate that firms may intentionally decide to reside isolated and far, due to protective reasons and imitation threats (Liebeskind, 1996; Shaver and Flyer 2000, Chung and Alcácer 2002).<sup>1</sup>

This article tries, first to complement the line of studies on informal sources of knowledge by disentangling *jointly* the importance of two different sources of informal knowledge spillovers: customers (Von Hippel, 1988) and competitors (Markedis and Geroski, 2004). These two sources are the most important sources of private knowledge. The fact that these sources are near to the downstream market makes them crucial for firms. The role of customers as a driver of innovation is deep-seated in the literature however when it comes to competitors existing literature mainly approaches them as (imitation) threats and focuses on protection perspective. Our study is an attempt to take a fresh look on competitors as sources of innovation. Hence approaching them as an opportunity rather than a threat.

Additionally, we add geographical distance as an important element in our picture, because it can play a decisive role on the level of importance of the competitors and customers as drivers of innovation.

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<sup>1</sup> Note that in our study we assume the location of the focal firm is fixed and therefore exogenous from location decisions.

There is a trade-off between local externalities and protective or imitation issues. Firms may decide to remain geographically far from competitors and customers but more protected or being close, but more prone to local spillover. In order to do so, we try to juxtapose local and distant customers and competitors- as main external sources of knowledge. Precisely, we explain how geographical distance can affect the correlation between these two sources of knowledge for firms' innovation process.

We claim that geographical proximity augments the level of correlation between these two sources. The underlying theoretical mechanism that we propose explains this stylized fact with the *randomness* of local interactions as opposed to *planned-ness* of distant interactions. (Gittelman, 2007)

Empirically, we use 9017 patent-level observations from a survey on inventors (Giuri et al, 2007) for our analysis. The data includes the level of importance of various sources of knowledge that had lead to each patent. In particular, it includes the importance of customers and competitors, as main sources of knowledge. The survey also provides us with information about importance of geographical distance of informal interactions.

In our study we assume that focal firm's location is already fixed and therefore exogenous from location decisions. However, our results can have implications for the decisions of such nature for entering a new market or opening new subsidiaries.

The remainder of this paper is structured as follows. First we formally elaborate on the mechanism and posit the hypothesis, and then we give a comprehensive description of the empirical setting for testing our hypotheses followed by the methodology used for our analysis. Finally, we conclude with discussing our results and implications

## **THEORY AND HYPOTHESES**

Knowledge is arguably firms' most important asset for achieving an innovation output (Grant, 1996). Recent advances in the innovation literature have shown how external sources of knowledge are as important as internal ones (Howells et al, 2003, Cassiman and Veugelers, 2006). Firms tap external knowledge sources in addition to their internal research and development (R&D) through licensing (Teece, 1986, Teece et al, 1997), R&D outsourcing or offshoring (Arnold, 2000; Grimpe and Kaiser, 2010 Doh, 2005; Howells, 2006a; Jahns et al., 2006; Weigelt, 2009), alliances (Ahuja, 2000; Oxley, 2009), company acquisition (Zhao,

2009, Katila and Ahuja, 2001), or the hiring of qualified researchers with relevant knowledge (Almeida and Kogut, 1999; Gambardella and Giarratana, 2010).

However, there are additional external sources of knowledge; in particular spillovers obtained through informal interactions with market players. We define informal interactions as all meetings, discussion or collaborations outside formal contractual format. So far literature has highlighted four types of main external knowledge sources: public knowledge (e.g. universities, literature, patents), suppliers, customers and competitors (Giuri et al, 2007). In this paper, we like to focus on the last two; we exclude public knowledge because while they tend to be informal they also tend to be too far away from market applications and therefore less strategic for firms. On the other hand, we exclude suppliers, because while are key for shaping downstream innovation, they are usually embedded in medium or long term contract relationships with firms, rendering this relationship less informal by default (Dawid and Kopel, 2003, Camuffo et al, 2007). Customers and competitors instead tend to be less structured inside contract relationships and also less bounded to firms decisions (more exogenous compared to who are the firm suppliers).

The customers' needs and ideas are important factors that can shape the direction of the innovation. Following the empirical studies, this appears to be particularly pertinent in sectors with rapidly changing user needs, such as high tech or extreme sports (Lüthje et al, 2005), although there is evidence in low-tech industries and services as well (e.g., Herstatt & von Hippel, 1992; Oliveira & von Hippel, 2011; Skiba & Herstatt, 2009).

Imitation from competitors has historically been crucial for firms to access unique, first-hand knowledge that provides competitive advantage. Competitors can act as a source of innovation primarily in terms of setting or raising industry standards. Firms tend to keep pretty close tabs on their competitors, and often copy and improve on competitors' products using their own applications. They strive to catch up with their competitors by tapping into each other knowledge and disrupting their cutting-edge technology. The literature indicates that firms that enter an industry at very early stages suffer from being "too fast to market" (Tellis and Golder, 1996) and often happen to be "first to market, first to fail" (Robinson and min, 2002) and face "first-mover disadvantage" (Lieberman and Montgomery, 1998; Dobrev and Gotsopolous, 2010). And in fact, it turns out that when it comes to new-to-the-world market pioneers almost always loose to their "fast seconds" competitors (Markedis and Geroski, 2004). Hence, the role of competitors as a trigger for consecutive innovations is very pronounced.

Geographical scholars have linked the importance of informal sources with geographical proximity, in particular in the case of innovative clusters (Jaffe, 1986; Jaffe et al., 1993, Saxenian, 1994, Alcacer, 2006). This line of research indicates that knowledge production has a spatial dimension and focuses on the role and significance of inherently informal spillovers among market players. Drawing upon this literature our study attempt to answer to the following questions: How does geographical proximity of customers and competitors affect the process of seeking, accessing, and accumulating external informal spillovers? Is the nature of interactions with *local* customers and competitors different from the geographically *distant* ones?

### **Geographically close informal sources of knowledge**

One main characteristic of local interactions is their *randomness*. Geographical proximity provides a dynamic, unplanned contact system. Additionally, provides a low-cost channel for new ideas and talent to make their way into existing activities. The randomness notion can be central for innovative processes because it can make the relationships easier, cheaper and much more effective than they would be without proximity. (Gittleman, 2007; Giuri and Mariani, 2013). We claim that though not all the local interactions are random, but majority of the random interaction happen locally.

Vicinity facilitates random face-to-face contacts. Evidence from Psychology literature shows that that face-to-face contact can reveal the intentions of another actor (Husserl, 1968). Particularly, for complex context-dependent information, the medium *is* the message. The most powerful such medium for verifying the intention of another is direct face-to-face contact (Breschi and Malerba, 2006). Human's finely tuned ability to read people unconsciously places a premium on facial expressions and intonation. A disembodied voice can't inspire trust.

The other reason for face-to-face contact is for development of the ability to check the trustfulness of information. Humans are highly effective at sensing non-verbal messages, particularly about emotions, co-operation and trustworthiness (Putnam, 2000). Mehrabian (1981) states that our facial and vocal expressions, postures, movements and gestures, are crucial in the course of communication. Trust depends on reputation effect or the multilayered relation between parties to a transaction that can create low-cost enforcement opportunities (Gambetta, 1988; Lorenz, 1992); proximity reduces the transactions costs of these informal

relationships. The trust literature (see Dirks and Ferrin 2001, Mayer et al. 1995 for reviews) provides considerable evidence that trusting relationships lead to greater knowledge exchange: When trust exists, people are more willing to give useful knowledge (Andrews and Delahay 2000, Penley and Hawkins 1985, Tsai and Ghoshal 1998, Zand 1972) and are also more willing to listen to and absorb others' knowledge (Carley 1991, Levin 1999, Mayer et al. 1995, Srinivas 2000). By reducing conflicts and the need to verify information, trust also makes knowledge transfer less costly (Currall and Judge 1995, Zaheer et al. 1998). These effects have been found at the individual and organizational levels of analysis in a variety of settings (Levin and Cross, 2004). The study by Bradner and Mark (2002) examines how geographic distance affects collaboration using computer-mediated communication technology. Their results indicate that cooperating members of a team are more likely to deceive, be less persuaded, and initially cooperate less, with someone they believe is in distant city, as opposed to in the same city as them.

Therefore, geographical proximity by providing frequent, face-to-face interactions results in more trust-conducive, effective and improved knowledge transfer among subjects and consequently simplifies exchange of ideas. Random local interactions facilitates these factors, increase their frequency of occurrence while reducing the cost of their planned arrangement.

To recap, face-to-face interactions reduce the uncertainty and noise of information spilled among the market players. This appeal makes firms more open to receive knowledge from external informal sources locally. In particular information received from both customers and competitors, which indicates positive correlation.

To better instantiate our conceptualization of positive correlation between firm's local customers and competitors consider the following scenario. Firms make random encounters with customers and receive innovative ideas and signals from them. However, due to proximity local circulation of information is convenient and effortless therefore, their competitors are subject to the same signal, i.e. they should respond to the same stimulus and solve the same customer need. As a result the competition pressure is increased among the firms and triggers them to tap into each other's knowledge more.

A second explanation is that customers are the medium of knowledge circulations among the competitors. The probability that a customer will have interactions with several competitors increases with proximity (i.e. just to evaluate different offers). In this case customers, as knowledge brokers (Aldrich and von Glinow, 1992; Hargadon and Sutton, 1997; Howells,

2006b) receive the knowledge from competitors from one end and then carry it among local competitors.

Thus we hypothesize:

*Hypothesis 1: For firms that claim geographically local, informal interactions are important for their innovative activities, there is a positive correlation between the degree of importance of customers and competitors as a source of innovation.*

### **Geographically distant informal sources of knowledge**

Distant interactions inherently lack spontaneity factor. Majority of distant interactions are planned, intentional and purposeful so that absorption of knowledge is not effortless, cheap and random. In studying inventive teams, Feldman and Bercovitz (2011) discuss the factors that might mitigate the disadvantages of distance. They show that those factors increase the likelihood that creative teams of academic scientists to include more geographically far-flung external members. They suggest three factors: prior experience of working together, strong social ties, and reputation. All these factors support the “planned-ness” of the distant interactions. In other words, while firms may interact with both distant customers or competitors these interaction are planned and determined in advance and are less likely to be based on spontaneity or chance meeting.

The complexity of firms’ search pattern (Rivkin and Siggelkow, 2007) increases when they seek geographically distant knowledge. The cost of such search can become unmanageable, especially if it involves face-to-face encounter. Therefore, firms need to screen distant sources, plan in advance and decide with whom they want to interact (Breschi and Malerba, 2006; Gittleman, 2007; Giuri and Mariani, 2013).

All this means that they need to ex-ante invest in time and resources when scouting for knowledge beyond the boundaries of their region. Since these distant informal interactions are costly they also tend to be less frequent than local ones. However, once firms make the effort to go distant they try to maximize the benefits from distant customers and competitors. Therefore, these interactions although are less often can still be correlated (scale economies). But, scarcity of this type of costly interactions makes the information received from a distant source (customer or competitor) more prone to be forgotten or losing its effectiveness in time (Holan and Phillips, 2004). And in contrast to the local case, since interactions with distant customers and competitors are not necessarily happening at the same time, firms may

perceive the impact of the distant customer or competitor (as a source of knowledge) on one another less.

There are also forces that go against the correlation between customers and competitors as sources of knowledge. If the main reason to tap geographically distant knowledge is to access customer knowledge, protection reasons and imitation threats could make a firm reluctant about further interaction with distant competitors. On the other hand, when firms' main intention is accessing their distant competitors' knowledge it is more likely that the nature of this knowledge is more at technological level and technical know-how (Oxley, 1999). Therefore, inherently this type of knowledge is less likely to have sound link with the customer side. This situation makes their distant customers knowledge less desirable. These scenarios indicate that when firms are determined to access distant knowledge the correlation between importance of customers and competitors (as sources of knowledge) could even be negative. Thus we hypothesize two contrasting hypotheses: if cost reasons are greater than fear of imitation and basic science project bias we will observe a positive correlation, otherwise a negative. :

*Hypothesis 2a: For firms that claim distant interactions are important for their innovative activities, there is a positive correlation between the degree of importance of customers and competitors as a source of innovation.*

*Hypothesis 2b: For firms that claim distant interactions are important for their innovative activities, there is a negative correlation between the degree of importance of customers and competitors as a source of innovation.*

## **METHODS**

### **Sample**

The empirical setting for this research is a survey based on 9,017 patents. These patents are granted by the European Patent Office (EPO) between 1993 and 1997, located in France, Germany, Italy, the Netherlands, Spain and the United Kingdom. This survey covers all technological fields, deals with both for-profit and non-profit applicants, and collects information on small, medium and large business companies. The respondents in the survey is (first) inventor(s) since the inventors are likely to have excellent information on their own biography and the invention process. The survey's patents are classified into five "macro"-

technological classes: Electrical engineering, Instruments, Chemicals and Pharmaceuticals, Process engineering, and Mechanical engineering. The survey also provides information about inventors' employers: small firms, medium firms, large firms, universities, public or private research institutions, and others. The survey provides a unique opportunity to explore the characteristics of individual inventors, such as their sex, age, education, motivations to invent, and job mobility (Giuri et al, 2007).

The strength and advantage of our survey is that it provides us with direct measures for our variables. The data allows us to separately consider various sources of spillovers and knowledge flows without resorting to conventional patent citation measures, because the inventor assesses it directly. Other indicators from survey let us examine the importance of geographical proximity of interactions with different sources of knowledge in the invention process.

## **Variables**

### *Dependent Variables*

For our analysis we use two sources of innovation, customers and competitors (defined in Table 1a) as our dependent variables. The respondent of survey has rated the importance (from 0 to 5) of the two types of sources of knowledge: customers and competitors (CUSTOMERS, COMPETITORS), for the innovative process that lead to a patent. The data also compares the extent to which geographical proximity encourages interactions. The survey asked inventors to rate from 0 to 5 the importance of two types of interactions in the development of the patented invention: (1) interactions with people not in the inventor's organization, and geographically close, meaning those located within-1-hour (W1R); (2) interactions with people not in the inventor's organization, and geographically distant, those beyond-1-hour (B1R) reach. We then define the local category as those firms that have assigned very high score (4, 5) to importance of geographically close interactions and at same time ranked distant interaction not so important (0, 1, 2). The reverse holds for the distant category. In so doing, we create two sub-samples from the original dataset: observations in which distant interactions are the only importance sources, and observations in which local interactions are the only important sources. We use CUSTOMERS and COMPETITORS as our dependent variables, once for the local case and then for the distant one.

<Insert Table 1a here>

### ***Control Variables***

We use a list of control variables as our regressors. This list includes variables at individual, patent, firm, and regional levels. Table 1b includes detailed definition of our controls. The goal is to remove the effect of these factors and obtain the most random white noise residuals from our regressions. At the individual level we control for the educational level, age, gender and experience of the (first) inventor (EDUCATION, AGE, GENDER, TENURE). At the patent level in order to remove the impact of size of the innovative team we control for the number of inventors involved in the patent process, (# INVENTOR). Additionally we include the total cost of the research for the specific patent (TOTAL COST), also the IPC classification of the patent (IPC TECHNOLOGY DUMMY) and the number of claims mentioned in the patent application (CLAIMS). We also control for the number of patents that account for the overall patent family of this innovation (PATENT FAMILY SIZE). And finally, the year of application of the patent is included as different dummies. At the firm level, we also control for firm size with two dummies, LARGE FIRM and MEDIUM FIRM, leaving as a base line the small firm case. In addition to that total number of patents per firm is also taken into account (#FIRM PATENT STOCK). For regional controls, we include the area and population of the region (REGION AREA) where the parent firm was located at the NUTS3<sup>2</sup> level. Finally, we control for the country where the patenting firm is located (Country Dummy).

<Insert Table 1b here>

### **Data Analysis**

Our objective in this section is to test how much the degree of importance of customers and competitors as sources of knowledge are correlated with each other depending on their geographical distance from a focal firm.

However, this correlation argument cannot be tested directly. The main reason is that, there are some unobservable factors at the geographical level that affect the importance that a firm attaches to its consumers and competitors as a source of knowledge, it is not possible to

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<sup>2</sup> NUTS3: Third subdivision (group of districts) of Nomenclature of Units for Territorial Statistics, that is a geocode standard for referencing the subdivisions of countries for statistical purposes. The standard is developed and regulated by the European Union and Eurostat.

include a variable that directly measures the role of geography. Thus, we are constrained to testing an important implication of correlations by using the residuals of our regressions. In order to do so we use the same methodology explained in Arora and Gambardella (1990).

To instantiate the method, consider the following. For instance, suppose the two sources; customers and competitors are complements, but there is third exogenous and unobserved source that is a substitute for customers and a complement for competitors. It is then possible that correlation between customer and competitors move in opposite directions if both these sources are more strongly related to third source than to each other. Along the same lines, the reader may have noticed that we have ignored the importance of these knowledge sources to other characteristics of the firm, its environment and institutional setting. It is possible, for instance, the two focal sources are positively correlated because they are strongly correlated to a particular characteristic of the firm, e.g. size. Similarly, institutional peculiarities of specific countries and regions may encourage or discourage external linkages of the kind that we are studying. In order to avoid these sorts of problems in our study we work with the residuals of the regressions rather than looking at the coefficients of regressors. And analyze the correlation between the residuals obtained from the regressions.

Meaning, if an increase in the importance of local interactions with customer raises the marginal effect of the interaction with local competitors, it seems intuitively compelling that we would expect to observe that firms, which have assigned high ranks to interactions with their local customers have also given high ranks to importance of interactions with their local competitors. That is to say, one would expect them to be positively correlated. In contrast, if assigning high ranks to the importance of one of the two sources results in decrease of importance of the other source it means they have negative correlation.

## **RESULTS**

Table 2 provides descriptive statistics and correlations. The difference between the number of observations is due to missing variables. Moreover, some cells of Table 2 do not show any correlation because variables belong to different samples. The table shows that among the two sources, customers on average have higher importance (2.9) compared to competitors (2.2) as a source of innovative ideas. And when it comes to geography variables, beyond-1-hour interactions seem to be slightly more important on average (1.3) as oppose to within-1-hour interactions (0.9).

<Insert Table 2 here>

As we mentioned earlier, our analysis is focused on the two sub-samples, local and distant. In order to have a better understanding of these sub-samples we provide an additional descriptive statistics of the main variables in the sub-samples in Table 3. The two sub-samples are defined in the way that include only the extreme cases, meaning that we only considered those who have simultaneously attached very high ranks to within-1hour-reach interactions and very low ranks to beyond-1hour-reach for the local case and vice versa for the distant case. Therefore the number of observations is reduced drastically to around 140 for the local and 450 for the distant case. In both sub-samples customers remain to be the more important source of innovation.

<Insert Table 3 here>

To operationalize the method explained in the previous section, we propose a Heckman selection model for our estimations to avoid any endogeneity or selection bias problem. First, we impose a first step estimation on local and distant categories, i.e. the firm first of all decides if using local or distance sources of knowledge. Then, given the chosen category, we estimate the importance of customers and competitors as sources of knowledge. The final dependent variables are then local customers, local competitors, distant customers and distant competitors. We once regress our list of controls on customers, conditioning they belong to local category. Then we run similar regression, this time regressing on competitors. We repeat the two regressions, but this time based on the condition the pair regressions belong to distant category.

The education level of the inventor is our selection variable for the Heckman model. We believe education level is a suitable selection variable since it indirectly differentiates between the distant and local categories without affecting the customers and competitors importance. We ground this assumption from a recent study (Giuri and Mariani, 2013) that found that inventors with higher level of education not only are less dependent on proximity to access external knowledge but also they might even prefer to go distant. In other words, highly educated people have less transaction costs in the ability to recognize the value of, assimilate, and exploit knowledge that is distant. Reliance on local spillovers remains a better option for inventors who lack the capacity to move beyond their regional setting, therefore reducing the potential pool of knowledge spillovers to develop new ideas. Their study shows that less educated people need to remain in vicinity of each other to maintain the benefits of unplanned local interactions. The empirical results of the Heckman model are reported in the Tables 4a and 4b.

<Insert Table 4a here>

<Insert Table 4b here>

We are interested in the correlation coefficients between the residuals of customers and competitor regressions in the two cases of local and distant, after removing the effect of the firm characteristics and other controls. The results indicated in Table 5 shows that the off diagonal correlation between the residuals of customer and competitor regression is 0.87, strongly positive and significant, for the local case. Whereas, in the distant case, this correlation is still positive but of lower magnitude 0.37; the strength of correlation is almost half the local case.

Our results show support for Hypothesis 1a and 2. As mentioned earlier, the results indicates that in the distant case while the two sources are still positively correlated, due to the cost reasons this correlation is of lower magnitude. Whereas, in local case the two sources the positive correlation is very strong. Possible explanation is that proximity facilitates random interactions of a focal firm with its customers and competitors and as a result provides a strong correlation between the two local sources.

<Insert Table 5 here>

Furthermore, we try to test whether the two above correlations are statistically different from each other. In order to do so, we regress the residuals of local customers on local competitors and repeated the same for the distant residuals. Table 6 shows these two regressions. Statistically, the coefficient of the estimates in these two regressions is similar to the correlation between the regressor and dependent variable, in our case the correlation between the residuals of customers and competitors. We then made a T-test to test whether the coefficient of the local regressions is equal to the coefficient of the distant case. Table 7 shows the result of the t-tests. The equality of the coefficients is rejected.

<Insert Table 6 here>

<Insert Table 7 here>

## **CONCLUSION**

In this study we explored the impact of geographical distance of two main private knowledge sources (with respect to a focal firm) on firms' benefits from knowledge spillovers. The

customers and competitors' knowledge were our main interest. We posited that for firms that claim local interactions are important for their innovative activities, there is a strong positive correlation between the degree of importance of customers and competitors (as a source of innovation). Whereas, for firms that claim distant interactions are important for their innovative activities, strength of this correlation diminishes.

Our study is an attempt to disentangle two main external sources, customers and competitors, analyze the nature of their correlation. We later juxtaposed the correlations in the two cases of local and geographically distant interactions and observed whether they play differently. Our results confirmed that for firms that claim local interaction is important for innovative activities there is positive correlation between the customers and competitors (as a source of knowledge). And the weaker correlation holds for distant customers and competitors. The underlying mechanism is the presence (absence) of randomness in local (distant) interactions. The randomness factor facilitates the cheap effortless and incidental contacts for market players.

By showing that geographical distance results in changes between correlation between customers and competitors- as firm's external sources of knowledge- we contribute to the growing literature highlighting the strategic value of geographic distance. Moreover, from managerial perspective, the results can have implications for firms for their future strategic location choices.

Moreover, a richer theoretical framework for the study of location-related innovative strategies emerges. Our findings extend the economic geography literature (Jaffe et al, 1993, Shaver and Flyer, 2000) by demonstrating that the strength of correlation among external sources depends on their distance from a focal firm. This study was an attempt to shed light on the micro-foundations of agglomeration by introducing finer-grained perspective to the external knowledge spillovers.

Several avenues for further inquiry arise. First, other sources of knowledge spillover might also play as complements or substitute of each other. Identifying which other sources and under what conditions can play such a role can give a better understanding about how to use them strategically. Identifying under what circumstances one mechanism is more appropriate than another calls for more future research.

Second, although our empirical approach confirms that strong correlation occurs in local interactions for customers and competitors and weaker one in distant case, but does not

distinguish what factors might intensify or mitigate these mechanisms. In other words, understanding what variables can have a modifying role in this process (e.g. competition level) would offer a better insight about when firms benefit or suffer from intentional or unintentional spillovers.

Finally, a growing body of research suggests that firms use spillover strategically in their location decisions to acquire capabilities (Alcácer and Zhao, 2012), taking the perspective discussed in our study for strategic use of spillovers in location choices can help this line of research put one step further. Specifically, results highlighted in this study can be beneficial for both classic and new multinationals strategic location choices when entering a new market.

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## Tables

**Table 1a. Definition of the variables**

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**a. Definition of the Variables in the Empirical Analysis**

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<b>Customer</b>	Importance of customers or product users as sources of knowledge for the research that led to the patented invention
<b>Competitor</b>	Importance of competitors as sources of knowledge for the research that led to the patented invention
<b>Within 1hr-reach interaction</b>	If interactions -discussions, meetings, sources of ideas, etc.- with people (apart from co-inventors) belonging to organizations other (unaffiliated) than the inventor's and located within a one hour reach, were important during the research that lead to this patent.
<b>Beyond 1hr-reach interaction</b>	If interactions -discussions, meetings, sources of ideas, etc.- with people (apart from co-inventors) belonging to organizations other (unaffiliated) than the inventor's and located beyond one hour reach, were important during the research that lead to this patent.
<b>Local</b>	Those who have assigned high ranks (4,5) to within 1-hr-reach interaction (W1R) and the at same time low ranks (0,1,2) to beyond 1-hr-reach
<b>Distant</b>	Those who have assigned high ranks (4,5) to beyond 1-hr-reach interaction (B1R) and at the same time low ranks (0,1,2) to within 1-hr-reach

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**Table 1b. Definition of Control Variables**

<b>b. Control Variables</b>	
<b>Age</b>	(Logarithm) Inventor's age
<b>Gender</b>	Inventor's gender dummy
<b>Tenure</b>	(Logarithm) Number of years inventor has been in the firm till the application date of patent
<b>Education</b>	Inventor's highest academic degree when the research leading to this patent was conducted. The dummies are defined as below:  1: Secondary School or lower  2: High School Diploma  3: University BA or equivalent  4: University Master or equivalent  5: University PhD or equivalent
<b>Year</b>	Year of the patent application dummy
<b>Total cost</b>	Inventor's best estimate of the total cost (in Euro) of the research leading to this patent up to the date of application –excluding legal fees or any other fees related to the patent application
<b>Claims</b>	Number of claims in the application
<b># Patents per firm</b>	Total stock of firm's patents till filing date
<b>Patent Family Size</b>	Number of the set of patents filed with different patenting authorities that refer to the same invention
<b>Number of inventors</b>	Number of inventors participating in the process that lead to the patent
<b>IPC</b>	4-digit Classification dummies
<b>Size</b>	Large firm (> 250 employees), Medium firm (100-250 employees)
<b># Patents per region</b>	(Logarithm) Average # of patents by region (NUT3)
<b>Parent Country</b>	The country where the patent was issued
<b>Geographical size of region</b>	(Logarithm) The geographical size of the region (NUT3) in km.
<b>Population</b>	(Logarithm) Population of the geographical (NUT3)

**Table 2. Descriptive statistics and correlations.**

<b>Variables</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>
<b>1. Customer</b>	1.000							
<b>2. Competitor</b>	0.394*	1.000						
<b>3. Within 1-hr</b>	0.125*	0.154*	1.000					
<b>4. Beyond 1-hr</b>	0.174*	0.125*	0.373*	1.000				
<b>5. Customer if Local</b>	1.000	0.4164	-	0.096	1.000			
<b>6. Competitor if Local</b>	0.416	1.000	-	0.143	0.416	1.000		
<b>7. Customer if Distant</b>	1.000*	0.317*	0.007	-	-	-	1.000	
<b>8. Competitor if Distant</b>	0.3174*	1.000*	0.026	-	-	-	0.317*	1.000
<b>#Observations</b>	9119	8959	8623	8708	153	151	516	515
<b>Mean</b>	2.935	2.207	0.882	1.313	2.816	2.317	3.358	2.260
<b>Std. dev.</b>	1.956	1.860	1.456	1.770	2.011	1.994	2.005	1.901
<b>Min</b>	0	0	0	0	0	0	0	0
<b>Max</b>	5	5	5	5	5	5	5	5

\* P&lt;0.01

**Table 3. Descriptive statistics for the Local and Distant sub-samples**

<b>Variable</b>	<b>Local</b>					<b>Distant</b>				
	<b>Obs</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min</b>	<b>Max</b>	<b>Obs.</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min</b>	<b>Max</b>
<b>Competitor</b>	132	2.42	2.02	0	5	444	2.38	1.89	0	5
<b>Customer</b>	134	2.89	2.00	0	5	444	3.50	1.95	0	5
<b>Large Firm</b>	141	0.71	0.46	0	1	452	0.75	0.43	0	1
<b>Medium Firm</b>	141	0.06	0.25	0	1	452	0.09	0.29	0	1
<b>Age</b>	138	44.87	9.94	23	75	445	45.53	9.082	27	67
<b>Tenure</b>	140	21.61	8.94	6	45	451	22.96	10.07	7	55
<b>Sex</b>	140	1.04	0.19	1	2	451	1.03	0.18	1	2
<b>Inventors</b>	141	2.31	1.53	1	9	452	2.38	1.51	1	14
<b>Claims</b>	133	11.18	7.28	1	44	428	11.07	6.81	1	45
<b>Family size</b>	133	7.18	4.17	2	29	428	7.24	3.91	2	26
<b>Average patent</b>	133	20.94	24.92	1	137.7	434	25.57	30.73	0	237.2
<b>Population</b>	134	795.81	680.87	105.2	3723.2	439	743.34	725.13	39.7	3723.2
<b>Area</b>	133	2766.33	2686.07	77.7	12028	438	2130.99	2357.52	43.8	17252

Table 4a. Heckman Regression

	Local		Distant	
	Customer	Competitor	Customer	Competitor
<b>Tenure</b>	1.974 (38.643)	1.181 (30.742)	0.027 (0.021)	0.001 (0.024)
<b>Gender</b>	14.954 (481.205)	21.757 (396.595)	0.096 (0.679)	-0.647 (0.847)
<b>Age</b>	-1.420 (22.152)	-0.523 (16.661)	-0.035 (0.023)	-0.024 (0.027)
<b># Inventors</b>	-0.864 (47.304)	-0.205 (32.453)	-0.043 (0.072)	-0.113 (0.090)
<b>Patent Family size</b>	0.219 (7.308)	0.582 (7.534)	-0.002 (0.030)	-0.033 (0.037)
<b># Claims</b>	0.355 (7.527)	-0.048 (3.753)	-0.005 (0.016)	-0.007 (0.020)
<b>Total cost</b>	-2.456 (52.123)	-1.333 (43.009)	0.011 (0.069)	-0.108 (0.078)
<b># Patents per region</b>	14.710 (247.735)	5.177 (177.356)	0.170 (0.140)	0.230 (0.170)
<b>Population of region (NUT3)</b>	-26.774 (385.158)	-9.577 (289.514)	0.105 (0.166)	-0.377 (0.206)
<b>Area of region (NUT3)</b>	7.608 (99.115)	0.542 (45.788)	-0.058 (0.146)	-0.118 (0.172)
<b>Large Firm</b>	26.070 (405.881)	8.244 (292.218)	-0.461 (0.342)	-0.097 (0.412)
<b>Medium Firm</b>	73.802 (1,139.322)	26.945 (830.527)	0.369 (0.437)	0.673 (0.552)
<b>IPC Technology dummy</b>				
<b>Country dummy</b>		Yes		Yes
<b>Year of application dummy</b>				

\* p<0.05; \*\* p<0.01

**Table 4b. Heckman Regression: Selection stage**

	Local		Distant	
	Customer	Competitor	Customer	Competitor
<b>Tenure</b>	-0.017* (0.008)	-0.018* (0.008)	-0.008* (0.004)	-0.007 (0.004)
<b>Gender</b>	-0.287 (0.416)	-0.270 (0.418)	0.202 (0.194)	0.206 (0.194)
<b>Age</b>	0.005 (0.008)	0.006 (0.008)	0.010* (0.004)	0.009* (0.004)
<b>Education</b>	0.026 (0.086)	0.019 (0.087)	0.088 (0.047)	0.095* (0.047)
<b>IPC Tech dummy</b>		Yes		Yes
<b>Family Patent Size</b>	-0.002 (0.014)	-0.003 (0.014)	0.011 (0.008)	0.011 (0.008)
<b># Claims</b>	-0.002 (0.009)	-0.001 (0.009)	-0.003 (0.004)	-0.003 (0.004)
<b># Inventors</b>	-0.009 (0.042)	-0.006 (0.042)	0.006 (0.021)	0.007 (0.021)
<b>Total cost</b>	0.027 (0.015)	0.030* (0.015)	0.038** (0.008)	0.036** (0.008)
<b># Patents per region</b>	-0.104 (0.062)	-0.098 (0.063)	-0.037 (0.035)	-0.039 (0.035)
<b>Population of the region</b>	0.140 (0.087)	0.147 (0.088)	0.000 (0.049)	0.003 (0.049)
<b>Area of the region</b>	-0.027 (0.054)	-0.012 (0.055)	0.070* (0.030)	0.068* (0.030)
<b>Large Firm</b>	-0.211 (0.159)	-0.178 (0.162)	0.063 (0.099)	0.038 (0.098)
<b>Medium Firm</b>	-0.453 (0.245)	-0.422 (0.248)	0.001 (0.130)	-0.035 (0.130)
<b>Constant</b>	-2.635** (0.831)	-2.857** (0.842)	-2.777** (0.463)	-2.738** (0.463)

<b>Mills Lambda</b>	-107.398 (2,166.616)	-64.497 (1,745.032)	0.715 (1.863)	-2.221 (2.178)
<b># Observation</b>	5524	5523	5523	5522
<b>Censored Obs.</b>	5450	5540	5219	5219
<b>Uncensored</b>	73	73	304	303
<b>Wald chi2</b>	0.09 (1.00)	0.27 (1.00)	325.37 (0.00)	136.16 (0.0258)

\* p<0.05; \*\* p<0.01

**Table 5. Correlations between the residuals of Heckman regression for the two case of local and distant.**

Local	Customer	Competitor	Distant	Customer	Competitor
Customer	1.00		Customer	1.00	
	<b>0.87*</b>	1.00		<b>0.37*</b>	1.00
Competitor	0.00		Competitor	0.00	

\*Sig. (.01)

**Table 6. Regressing Residuals of Heckman regressions**

	Local Customer	Distant Customer
Local Competitor	0.536** (0.004)	-
Distant Competitor	-	0.466* (0.021)
Constant	-17.612** (0.866)	-4.982** (0.032)
# Observations	5601	5061
R-squared	0.76	0.14

\* p<0.05; \*\* p<0.01

**Table 7. T-test of the equality of table 6 coefficients**

Test 1	Test 2
$\beta(\text{Distant Customer}) = 0.536$	$\beta(\text{Local Customer}) = 0.466$
F(1, 5599) = 11.38	F(1, 5599) = 405.48
Prob > F = 0.007	Prob > F = 0.000