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Near or far? The role of micro-geographic distance in inter-organizational relationships in local innovation ecosystems.

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Abstract

While the role of spatial proximity on inter-organizational relationships has been widely debated, the issue of how the role of locational factors varies according to the nature of cooperation mechanisms has been less explored, except for a few cases. Also, extant studies tend to consider geographic proximity as the mere co-localization of partners (at the regional or national level) and do not provide measures of geographic distance to gain insights at the micro geographical scale. We have tried to fill this gap by analyzing the impact of micro-geographic distance among actors partnering in three different types of inter-organizational relationships, i.e. venture deals, IP transfer, R&D strategic alliances, in the specific case of Biopharma Innovation Ecosystem in Greater Boston Area. We show that the importance of geographic distance varies across different types of cooperation practices and, more specifically, that it has a negative effect on the formation and the strength of venture deals and IP transfer relationships. Our findings further show that micro-geographic distance matters. In fact, the likelihood of cooperation is significantly higher when the organizations are found at less than 1km compared to when these are at 20km or more of distance.

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Abstract: While the role of geographical proximity for the formation of inter-organizational relationships has been widely debated, the issue of how the role of locational factors varies according to the nature of cooperation mechanisms has been less explored, except for a few cases. Also, extant studies tend to consider geographical proximity as the mere co-localization of partners (at the regional or national level) and neglect to study the effect of geographic distance at the micro geographical scale. We have tried to fill this gap by analyzing the impact of micro-geographical distance among actors partnering in three different types of inter-organizational relationships, i.e. venture capital deals, IP transfer agreements, R&D strategic alliances, in the specific case of Biopharma Innovation Ecosystem in Greater Boston Area. We show that the importance of geographical distance varies across different types of cooperation practices and, more specifically, that it has a negative effect on the formation of venture capital deals and IP transfer agreements. Our findings further show that micro-geographical distance matters. In fact, the likelihood of cooperation is significantly higher when the organizations are found at less than 1km compared to when these are at 20km or more of distance.

Keywords**: inter-organizational relationships; innovation networks; knowledge transfer; venture capital deals; local innovation systems; geographical proximity.**

1. Introduction

Despite many recent studies have argued that globalization and the diffusion of new technologies have contributed to the emergence of the interactions among actors that are physically distant (Geldes et al., 2015; Broekel and Boschma, 2011; Cassi and Plunket, 2014), many empirical studies demonstrate that geographical proximity still plays an important role for the generation of innovation activities as it favors the process of interactive learning among the actors within innovation ecosystems (e.g. Balland, 2012). Since the 1980s, literature on innovation systems (Freeman 1987, De la Mothe and Paquet 1998; Cooke 2001, 2004; Asheim and Coenen, 2005) have defined the generation of innovation as a locally embedded process (Fagerberg 2004) assuming the importance of the geographical proximity in favoring the development of the relationships among different actors to facilitate the knowledge transfer and the generation of innovation (Lundvall and Johnson 1994; Etzkowitz and Leyedsdorff 2000). This argument is in line with the literary strands on clusters, networks and ecosystems that have emphasized how geographical proximity enhances collaboration and innovation from different perspectives (Harrison, 1994; Lagendijk & Oinas, 2005; Audretsch and Feldman 1996; Uzzi 1997; Bathelt et al. 2004; Agrawal et al. 2003; Dyer and Hatch

2006; Lundvall and Johnson 1994; Moulaert and Sekia 2003; McCann 2004). All these approaches emphasize the key role of geographical proximity in encouraging face-to-face interactions which, in turn, stimulate the establishment of personal networks across the organizations' boundaries (Feldman 1994; Uzzi 1997), facilitate the exchange of tacit knowledge (Bathelt et al., 2004; Agrawal and Johnson and Cockburn 2003) enhance the development of idiosyncratic language and collaboration routines (Uzzi 1997; Dyer and Hatch, 2006); stimulate processes of collective learning (Lundvall, Johnson, 1994; Lundvall, 2010; Audretsch and Feldman, 1996) and ultimately enhance mutual trust mechanisms (Moulaert and Sekia, 2003; McCann 2004). Consistently, a significant number of empirical studies demonstrate that geographical proximity still plays an important role for network formation (e.g. Balland, 2012) and that its absence needs to be necessarily compensated by other forms of proximity namely, *institutional, organizational, social* and *cognitive* - to counterbalance the lack of physical propinquity (Boschma 2005; Crescenzi, et al. 2016; Lagendijk and Lorentzen 2007; Lagendijk and Oinas 2005; Torre and Rallet 2005). While the concept of geographical proximity is straightforward as it refers to "the kilometric distance that separates two unites (e.g. individuals, organizations, towns) in geographical space" (Torre and Rallet 2005, p. 49), the other types of proximities tend to consider other forms of similarities. First, *cognitive proximity* considers the similarities in terms of actors' perception, interpretation and evaluation of the world (Nooteboom, 2000) achieved through similar knowledge base and experience. Secondly, *organizational proximity* is more generally defined as the nature of relations between the actors, spanning weak ties to more structured forms of cooperation (e.g. joint ventures) (Moore, 2006). Thirdly, *social proximity* takes its origins from the sociological concept of embeddness (Granovetter, 1985) and refers to friendship, kinship and experience relationships at the individual level conducive to trust mechanisms (Boschma, 2005). Finally, *institutional proximity* pertains to the social and cultural norms that rule business and non-business interactions in a certain context. All these proximities are interrelated and are positively influenced by the colocation of different actors. For instance, it has been shown that geographical proximity positively affects cognitive proximity (Parra-Requena, Molina-Morales and García-Villaverde, 2010) and that high levels of social proximity can reduce cognitive distance between business partners by broadening their common knowledge base and experience (Boschma, 2005).

In sum, by assuming that geographical proximity is an important driver for the establishment of knowledge transfer relationships and, as a consequence, for the generation of innovation activities in an innovation ecosystem, our paper tries to explore how close the ecosystem's members have to be in order generate these virtuous processes. In fact, despite the abundant literature from both knowledge management and economic geography focused on the effect of geographical proximity on cooperation dynamics, most studies (e.g. Messeni Petruzzelli et al. 2007; Broström 2010; Cassi and Plunket 2015; Steinmo and Erasmussen 2016) tend to consider geographical proximity as the general co-localization of partners within the same institutional borders and overlook the implications deriving from its operationalization in terms of geographical distance at smaller scales, from a micro-geographical perspective. With the exception of a few cases (Biggiero and Sammarra 2010; Molina Morales et al. 2015; Geldes et al. 2017; Huber 2011; Balland et al. 2016; Capone and Lazzeretti 2018; Belussi et al. 2010) empirical researches have focused on how network emergence, in general, is influenced by the spatial positioning of firms and research organizations from a macro perspective (e.g. at the national level), while less attention has been paid to the operationalization of the geographical distance to understand how close the organizations have to be to establish a relationship. On the other hand, some authors that have tried to delineate the spatial delimitation of clusters by providing metrics of geographical distance (Boix, Hervás-Oliver, and Miguel-Molina 2015) suggested that agglomeration benefits are not always evenly distributed in the cluster and that, in some cases, the organizations have to be very close to be able to benefit from the advantages of geographical proximity. Therefore, it is necessary to adopt a micro-geographical approach to ‘‘zoom-in’’ to a much smaller scale so to achieve a more realistic picture of locational (and relational) advantage, which can sometimes "be traced to very small neighborhood" (Mudambi et al. 2018). In this light, our objective is to analyze the role of geographical proximity in shaping the formation of inter-organizational relationships within an innovation ecosystem from a micro-geographical perspective. In particular, the study aims to answer to the following research question: *RQ1. Is the emergence of inter-organizational relationships within an innovation ecosystem related to the micro-geographical distance between organizations in that ecosystem?* Additionally, while adopting this micro-perspective, our paper tries to evaluate the complexity of the innovation ecosystems. Indeed, the issue of whether geographical proximity positively affects the emergence of inter-organizational relationships it is complicated by the fact that, due to their complexities, innovation-driven activities involve different kind of actors that implement a broader spectrum of cooperation practices ranging from contract research, patenting and licensing, venture deals, spin-off formation to the provision of industry training courses, consulting and creation of technology parks, with differences in terms of the characteristics of the exchanged knowledge (tacit and explicit) and the nature of ties (formal or informal) (Parmigiani and Rivera-Santos 2011). Accordingly, we assume that geographical distance exerts a different influence according to the form of cooperation, which leads to the formulation of our second research question: *RQ2. Does the role of micro-geographical distance vary across different types of inter-organizational relationships within an innovation ecosystem?* To this purpose, we take empirical evidence from the Biopharma Innovation Ecosystem in Greater Boston Area by analyzing the impact of micro-geographical distance on three types of inter-organizational links, i.e. Venture Deals, Joint R&D

partnerships and Intellectual Property (IP) transfer agreements. We identify an initial sample of 450 organizations belonging to the Biopharma ecosystem in the Greater Boston Area. After adding relational data to the initial sample of organizations, our final sample counts 289 ties (180 venture deals, 60 R&D alliances and 49 IP transfer agreements) involving 164 organizations. We rely on the dyad as the unit of analysis to estimate the likelihood of inter-organizational tie formation (Dieste and Rajagopalan, 2012). More specifically, we built three separate samples for each deal type namely, venture capital deals, R&D alliances and IP transfer agreements. We then considered all the possible combinations between nodes in each sample. For each of the three samples of potential ties, we then run a probit model where the dependent variable is a dummy that equals 1 if the two organizations had established a tie. Our findings show that geographical distance is relevant for the establishment of IP transfer and venture capital deals, while its effect it is not statistically significant for R&D alliances. This, from a policy perspective, suggests that the co-localization in the same region - even in the same urban area - it is not a sufficient condition to enhance innovation in a specific region. Hence, regional innovation strategies should be oriented to reduce the geographical distance and to favor the concentration of innovative activities in very small areas, at the micro-geographical scale. The paper is structured as follows. Section 2 sets the theoretical background for hypothesis development by reviewing the literature on the role of geographical proximity in inter-organizational collaborations. Section 3 develops the research hypotheses. Section 4 presents the empirical setting, the data sources and the methodology. Section 5 reports the results of the econometric estimates. Section 6 compares our findings with those of related studies while section 7 concludes the paper by discussing directions for future research and policy implications.

2. Theory

The largest part of studies exploring the effect of geographical proximity on the knowledge transfer relationships tends to focus on the dyadic linkages among specific actors - firms to firms, universities to firms, venture capitals to firms - and considers geographical proximity in terms of mere co-localization, usually at the national scale (D'Este et al. 2012; Broström 2010; Cassi and Plunket 2015; Steinmo and Erasmussen 2016; Crescenzi et al. 2016).

Only a minority of scholars focuses the empirical analyses at the micro-geographical level and "zoom-in" to the cluster to give more precise indications about the desirable levels of inter-organizational geographical proximity to create effective collaboration. In this vein, Messeni Petruzzelli et al. (2007) explore whether and how technology districts implement proximity dimensions as a communication resource to access external knowledge, by considering both the local and global network in the case of the organizations within the ICT cluster of Torino Wireless (north-west of Italy), by the mapping all their formal arrangements, including research consortia, hierarchical dependences (subsidiaries) and R&D alliances. A key finding is that geographical proximity (i.e. co-location in the cluster) between the actors facilitates the formation of formal organizational arrangements (i.e. organizational proximity) and that, conversely, cognitive proximity is mostly adopted to link organizations that are geographically distant from the district. Indeed, the physical distance from the technology district positively affects the number of organizations connected to the district's actors by the means of cognitive proximity. However, although the authors map different kinds of relationships they do not analyze the effect of geographical proximity on the different relationships. Biggiero and Samarra (2010) took empirical evidence from the aerospace cluster in Rome to compare the amount of knowledge exchanged by the means of intra and extra-cluster relationships. The authors found out that even if external cooperation was more diffused, more knowledge was exchanged through local linkages and that firms were more inclined to transfer the most critical type of knowledge with co-located partners rather than with external ones. Interestingly, even if the empirical focus is on a single cluster, the authors limit their analysis to a comparison of internal and external relationships instead of analyzing intra-cluster relationships. Moreover, the authors do not analyze how geographical proximity can affect the different kinds of intra-cluster relationships. Molina Morales et al. (2015) explore the effect of proximity dimensions on the dynamics of network formation in mature foodstuff cluster in the Valencian region (Spain) by analyzing inter-firm knowledge sharing practices and linkages within the cluster. The analysis shows that geographical proximity – measured by the physical distance between two firms – favors, along with social proximity, the creation of inter-firm relationships, especially during advanced stages of the cluster life cycle when a trusting atmosphere arises from face-to-face interactions and leads to higher levels of knowledge sharing and cooperative behavior.

While the studies above recognize the importance of geographical proximity in fostering cooperation within the cluster, another strand of empirical research scales back its role for the establishment of relationships. As a way of illustration, Geldes et al. (2017) adopt the proximity perspective to explore marketing cooperation among firms co-localized in a Chilean agribusiness cluster. The authors show that interfirm marketing cooperation in the selected agribusiness clusters mostly rely on social proximity, while geographical proximity is not particularly relevant. However, according to the authors the minor role played by geographical proximity can be explained by the specificities of the industry and the economy under analysis. First, the country risk level and poor institutional conditions and purchasing power - that are typical of an emerging economy - may inhibit inter-firm cooperation compared to developed economies. Secondly, due to the high level of competition in commodity industries as in the case of the agribusiness sector, interfirm cooperation could be less stimulated at the local level. From a different perspective, Huber (2012) explores whether geographical proximity can be considered as a driver of firm localization in Cambridge Information Technology Cluster (UK). The study shows that after the localization only a small group of sampled firms actually benefit from local horizontal and vertical business relationships and that, ultimately what really drives the choice of locating in the area is not necessarily linked to the advantages of geographical proximity, but rather to the affiliation to a brand of excellence and to the possibility of attracting high skilled labor. Aguilera et al. (2012) explore the role of geographical and other forms of proximities in determining inter-firm relationships in the Brittany region (France) to ultimately identify a typology of the relationships based on a wide variety of configurations of proximities, which depend mainly on the nature of the relationship, and particularly on the need for coordination. The authors suggest that geographical proximity is not systematically combined with non-spatial proximities, which may play only a limited role in coordination when partners are close.

Within the studies that adopt a micro-geographical approach to the study of network emergence and geographical proximity, only a few scholars explore the differential effect of geographical proximity upon different types of relationships. In this vein, Balland et al. (2016) explore the dynamics of formal and informal relations by taking evidence from a Spanish toy cluster. More specifically, the authors analyze the impact of geographical distance between two firms (in kilometers) on the dynamics of technical and business relationships and find out that it plays a much more significant role on the first type of relationship. Technical networks, compared to business knowledge, are generally associated with procedural knowledge, which is more difficult to transfer information across organizations due to the high content of know-how and tacit knowledge. Within this strand, Capone and Lazzeretti (2018) examine the role of various forms of proximity for the emergence of three different types of informal ties, i.e. the firms' *innovation, technical advice* and *friendship* networks within the Italian technological district cluster of goods in Tuscany. Their study confirms the importance of geographical proximity (co-located at the municipality level) as, compared to other kinds of proximity, it has a positive effect on all types of relationships considered, especially in the case of friendship networks. Belussi et al. (2010) explores the geographical scale of innovation relationships, by taking empirical evidence from the life science industry cluster in Emilia Romagna (Italy) (firm-to-firm relations and firm-to-public research organizations (PRO) relations) showing that firms tend to form the greatest part of their research collaborations with organizations located outside the region. More specifically, inter-firm relationships are mainly national, European and extra-European, while links with regional enterprises are much less frequent. On the other hand, half of the firms' links with PROs are regional, and the other half are trans-regional. These results, although showing that location matters, also suggest that firms' behavior is heavily characterized by research collaborations with distant PROs.

From reviewed studies, it emerges a lack of general agreement regarding the relationship between geographical proximity and network emergence at the micro-geographical level. This is also due to the fact that, although many studies focus their attention on a single cluster, some of them tend to compare the relationships inside and outside the cluster, assuming that co-localization in a specific context reflects a sufficient level of geographical proximity. We claim that, in order to better analyze the effect of geographical proximity, it is necessary to adopt a micro-geographical perspective by providing measures of geographical distance within the cluster. Moreover, despite some scholars suggest that the impact of geographical proximity varies significantly across diverse kinds of knowledge flows (Huggins et al. 2012; Grillitsch et al. 2015; Quatraro and Usai 2017; Lazzeretti and Capone, 2016; Balland et al. 2016) and that, in some cases, it is mediated by other forms of proximities, too little empirical effort has been devoted to the analysis of the differential role of geographic proximity upon different types of relationships at the cluster level.

3. Research hypotheses

Studies that analyze the effect of geographical distance on the relationships' development inside the cluster often find contrasting results (Messeni Petruzzelli et al. 2007; Biggiero and Sammarra 2010; Molina Morales et al. 2015; Geldes et al. 2015; Aguilera et al. 2012), probably because these do not consider the variety of the relationships in the cluster. From a micro-perspective, we argue that in order to better understand the role of geographical proximity in the formation of collaborative networks, it is important to investigate the intra-cluster relationships by taking in due account the diverse nature of collaborative linkages. Indeed, the relationships within innovation ecosystems are characterized by a number of different cooperation practices depending on the resources that are needed to be transferred during the innovation process (e.g. capital; knowledge; human resources) and on the actors included in the process (e.g. university, large and small firms, venture capitals) and each of them being more or less sensitive to geographical proximity. Traditionally, studies on inter-organizational relationships have considered R&D alliances (Hagedoorn and Schankenraad, 1994; Shan et al. 1994; Walker et al. 1997; Ahuja et al. 2008) and forms of IP and technology transfer (as licensing agreements) to assess the level of cooperation within an innovative network and as indicators of innovative performance (Powell et al. 1996; Ahuja, 2000). Among the main arguments underpinning the privileged focus on licensing agreements and R&D alliances agreements is that, despite their formal nature, these types of linkages also represent channels for informal knowledge flows, which not only enhance the foreseen knowledge exchange, but also allow for labor mobility between the partner organizations and enable access to extra knowledge through informal ties between those individuals engaged in the technology development, thereby creating an opportunity for making use of the partners' personal networks. On the other hand, these types of linkages involve tighter, more proprietary conduits which are more effective to sustain the sources of competitive advantage derived from networks over-time (compared to more loosen forms of ties) (Owen-Smith and Powell, 2004). A growing body of literature argues that venture capital deals are a major source of robustness of the innovative complex network (Ferrary and Granovetter 2009) for both innovative start-ups that benefit from seed stage capital, as well as for large high tech firms that are increasingly backed by venture capital. Consequently, studies on high-tech clusters reveal the spread diffusion of venture deals as a key inter-organizational cooperation practice equal to R&D alliances and technology transfer practices (Lee et al. 2000; Zhang 2007; Kenney and Florida 2000). On this basis, and similarly to Owen-Smith and Powell (2004), we focus our empirical analysis on *venture capital deals*, which are key during the early stages of innovation development (Kortum and Lerner 2001; Wright et al. 2006); *joint R&D alliances* that integrate complementary skills required for innovation development and knowledge (Sakakibara 1997; Powell et al. 1996) and *IP transfer* for the commercialization of research results (Teece 1986; Arora and Ceccagnoli, 2006; Perkmann and Walsh 2007).

It has been argued that venture capital has an important role in promoting regional economic growth and innovation, which is why governments tend to promote public policies to foster the local establishment of venture capitalists (Lerner 2009; Martin et al. 2005) and a growing body of literature has been concerned with addressing the impact of geographical distance on venture capital investments (Sorenson and Stuart 2001; Dai et al. 2012; Cumming and Dai 2010; Makela and Maula 2008; Tian 2011). In general terms, extant studies have provided empirical evidence about the importance of social relationships between the venture capital investor and the investee, as these are deemed to foster mutual trust and cooperative mechanisms (De Clercq and Sapienza 2001), limit the asymmetry of information and increase its reliability (Nahapiet and Goshal 1998; Shane and Cable 2002) with the aid of more frequent and less formal channels of communication. Social relationships between the investor and the investee are deemed to arise more frequently when these are found in spatial proximity, as this reduces long journey times (Lutz et al. 2013) and monitoring efforts (Chemmanur et al. 2016) to manage the investment. Also, geographical proximity increases the chance of casual and first encounter as well as supporting the frequency of face-to-face interaction, that are important to initiate and maintain the relationship between the portfolio firm and its capital provider (McPherson et al. 2001), especially in those cases in which the intensity of managerial advice is high. Therefore, we can expect that:

Hypothesis 1. Micro-geographical distance is negatively associated to the establishment of a *venture capital deal type of relationship within an innovation ecosystem.*

In this work we refer to joint R&D alliances as those partnerships where the parties co-develop an innovation on the basis of complementary skills, and where knowledge transfer is involved (Pisano, 1990; Mowery et al.1996). Early literature on knowledge transfer has demonstrated that knowledge is geographically bounded (Jaffe et al. 1993; Phene and Tallmann 2002) and a consistent body of research has shown that knowledge is more efficiently transferred among actors found in spatial propinquity (Rosenkopf and Almeida 2003; Morgan 2004; Storper and Venables 2004; Knoben and Oerlemans 2006). Coherently, R&D alliances among geographically close partners have proved to be successful in terms of knowledge transfer and innovation performance (Gomes-Casseres et al 2006; Audretsch et al. 2005; D'Este and Iammarino 2010; Paier and Scherngell 2011). Apart from the well-known advantages of increased frequency of direct interaction among partners (Ganesan et al. 2005; Weterings and Boschma 2009), main reasons for the positive impact of geographical proximity on R&D alliances have been appointed to the establishment of collaborative routines (Galunic and Rodan 1998), to the reduction of risks of selecting adverse partners and to the facilitation of monitoring activities against opportunistic behavior as misappropriation hazards during the collaboration process (Reuer and Lahiri 2014). Also, geographical proximity would help the development of idiosyncratic language for the exchange of fine-grained information (Uzzi, 1997) for the mutual understanding of both partners' technologies (Singh et al. 2016) or to overcome organizational differences (Ponds et al. 2009). Finally, Grillitsch et al. (2015) while investigating the relationship between geographic proximity and the variety of knowledge sourcing in the ICT sector, show that R&D cooperation occurs more frequently regionally.

Hence, we can expect that:

Hypothesis 2a. Micro-geographical distance is negatively associated to the establishment of an R&D alliance type of relationship within an innovation ecosystem.

On the other hand, a growing body of literature has scaled back the positive impact of geographical proximity on R&D alliances and argue that it is no longer a *conditio sine qua non* for the successful performance of R&D partnerships (Broekel and Boschma 2011; Ponds et al. 2009; Hermann et al 2012; Autant-Bernard et al. 2007). Within this strand, scholars appoint that R&D alliance success depends on factors other than the geographical proximity such as partners' commitment, existence of prior links (Mora-Valentin et al. 2004; Petruzzelli 2011), the scientific area and the sector (Meyer-Krahmer and Schmoch 1998; Anselin et al 2000), the partners size and the general industrial environment in which these operate (Laursen and Salter 2004) and argue that the advantages of geographical proximity can be easily compensated by other forms of proximities. In this regard, Crescenzi et al. (2016) examine the characteristics of UK co-patenting teams to assess the incidence of different proximities on collaborative networks and suggest that geographic proximity plays a secondary role as inventors seem to rely on spatial propinquity to form their teams, only when this is coupled with other forms of proximities. Moreover, it has been argued that excessive geographical proximity may be harmful for innovation collaboration as it may result in an exchange of too redundant information affecting the variety and novelty of knowledge (Notteboom et al. 2007) and lead to lock-in phenomena (Broekel and Boshma 2012; Weiss and Minshall 2014). Finally, R&D alliances are usually characterized by detailed and complex contracts about how knowledge flows are managed and expectations and assumptions that parties have when entering the alliance. This would not only prevent partners from opportunistic behavior (thus reducing the need of trust-based mechanisms typical of spatial proximity), but complex contracting also serves as a coordination tool (Teece 2008) that allows to avoid mis-communication between partners that are geographically separated (Kim and Globerman 2017). On this basis, we formulate the following alternative hypotheses:

Hypothesis 2b. Micro-geographical is distance positively associated to the establishment of an R&D alliance type of relationship within an innovation ecosystem.

As a third category of relationship, we analyze IP transfer agreements that include contract-based forms of collaboration aiming at commercializing the results of scientific research, i.e. patents and licensing agreements. Empirical research has demonstrated that geographical proximity plays an important role for market channels of interaction and knowledge trade (Agrawal 2001; Audretsch and Stephan 1996; Zucker et al 1998; Belenzon and Schankerman 2013), as this is deemed crucial for addressing a number of challenges related to IP transfer relationships. As a start, scholars suggest that there is a significant amount of information asymmetry marking the relationship between the inventor and the potential licensee (Shane 2002; Siegel et al. 2003; Lowe 2004). Indeed, in the context of license-based commercialization, the information about which inventions are available for licensing may not be systematically accessible and therefore, prior contacts of inventors with Technology Licensing Offices' Staff may be leveraged to get in contact with potential licensees (Buenstorf and Schacht 2013; Bercovitz and Feldman 2006). On this basis, the likelihood to learn about available inventions increases with personal communication, which, in turn, is eased by geographical proximity. Secondly, licensed inventions are frequently far from being readily marketable (Jensen and Thursby 2001) and the knowledge embedded in the original inventor may not be codified and easy to transfer (Agrawal 2006). As a consequence, when further R&D effort is needed to make the licensed technology ready for the market, the inventor's engagement becomes critical. Depending on inventor's opportunity costs of time (Stephan 1996), geographical distance can affect the relationship and the whole commercialization process (Beise and Stahl 1999; Santoro and Gopalakrishnan 2001), which in turn, may explain a preferential licensing of inventions within the region (Mowery and Ziedonis 2001). Hence, we hypothesize that:

Hypothesis 3. Micro-geographical distance is negatively associated to the establishment of an IP transfer type of relationship within an innovation ecosystem.

4. Research strategy

4.1 The Biopharma Innovation Ecosystem in the Greater Boston Area

In order to test our hypotheses, this work analyses the case of the Biopharma Innovation Ecosystem (IE) in Greater Boston Area (GBA) (MA, USA) for the period 2012-2017. Due to its high ranking position in the US Biotech Clusters rankings (JJL U.S. Life Science, 2016), the GBA Biopharma Ecosystem is considered as a successful case of study. The GBA ecosystem is along with the Silicon Valley one of the oldest, best-known and most successful IE in the US. Moreover, it is together with San Francisco, one of the two key geographical clusters that nowadays dominate the biopharma landscape thanks to a unique blend of science, entrepreneurship skills, risk-taking culture and spatial concentration especially in the City of Cambridge, where most biotechnology-related companies cluster around Kendall Square, which hosts, among the others, the Massachusetts Institute of Technology (Saxenian 1994; Breznits and Anderson 2005; Owen-Smith and Powell 2004). The GBA covers about 8042.7 square meters. The rise of biotech industry in this area traces back to the 1970s, with the development of genetic engineering and the establishment of Biogen through the endorsement of the Cambridge City Council, after recognizing the potential of this new field during a time in which molecular biology was predominant. However, it was not until more recent years that the cluster reached its biggest growth. In 2008, the governor of Massachusetts promoted the *Massachusetts Life Sciences Act* that promised to invest 1 billion dollars for the development of the biotech industry. This led to a tremendous increase of jobs, capital flows and buildings that contributed to turn the area in one of the leading US Life Science cluster for the number of patent ownership per capita, venture capital funding and number of IPOs (JJL U.S. Life Science, 2016). The region is home to many of the leaders in tech and life science (eighteen out of the top twenty drug companies have a major presence in GBA) as well as world-class academic and research institutions as Harvard and MIT. The area hosts approximately 250,000 students across 52 higher education institutions and can rely on the largest concentration of life science researchers in the country, as well as world-class medical facilities, including the top three NIH-funded hospitals. As a result of direct access to top talent, the GBA ecosystem has attracted a dynamic community of investors. More precisely, venture capital funding is of 2,580 millions of dollars, which represents the 38% of the total funding of United States in GBA, which in turn, makes the area particularly attractive to innovative entrepreneurs (JJL U.S. Life Science, 2016).

4.2. Data

In order to collect data on the organizations of GBA Biopharma IE, we combined several data sources. First, we used MassBio, the freely available membership directory of the Massachusetts Biotechnology Council. MassBio counts more than 975 members dedicated to advancing cutting-edge research in life science industry in Massachusetts and provides information on their location, typology and area of specialization. Members range from academic hospitals and non-profit organizations to pharmaceutical biotech companies and capital providers. We selected those organizations with headquarters or branch offices having mailing addresses in the GBA. Additionally, we considered only those members belonging to the Biopharma industry mainly specialized in drug development. According to the criteria defined above, we were able to identify an initial list of 450 organizations belonging to the Biopharma IE in the GBA, including hospitals, universities, research institutes, government agencies, incubators, capital risk providers, and firms operating in the biotech and pharmaceutical industries.

Second, we identified the relationships among organizations considering formal relationships among them. It is worth mentioning that previous studies found that organizations within the GBA tend to rely more on "standard contracts" compared to Bay Area where weaker hierarchical contractual governance structures prevail (Kim and Globerman, 2017). On this basis, we decided to focus our analysis on formal relationships namely, venture capital deals, R&D alliances and IP transfer agreements. To obtain information on the three types of relationships (i.e., R&D alliances, IP transfer and VC deals) we relied on two sources of relational data. Data on venture capital deals comes from Preqin (Preqin Ltd. 2017), which is a comprehensive and historical database on the private equity industry offering detailed information and analytics on firms, funds, deals and portfolio companies dating back to 1999 on over 5,000 funds and 11,000 hedge funds. We selected venture deals (i.e. series A-E/round 1-5; grant; seed; PIPE; add-on; venture debt) between portfolio companies and investors located in Massachusetts completed within the period 2012-2017 in biotech and pharmaceutical industries. We then matched information on venture deals with the initial list of organizations identified in MassBio. To gather information on R&D alliances and IP transfer agreements we collected data from the Strategic Transactions Database (Pharma & MedTech Business Intelligence) that summarizes deals by type, industry and sector from 1995 to date. We collected this information within 2012-2017 time frame and matched it with the initial list from MassBio. Overall, we were able to identify 289 ties (180 venture capital deals, 60 R&D alliances and 49 IP transfer agreements) that involved 164 organizations in the GBA during the period 2012-2017.

4.3 Method

We rely on the dyad as the unit of analysis to estimate the likelihood of inter-organizational tie formation (Dieste and Rajagopalan, 2012). More specifically, we considered realized and potential ties for each deal type, namely venture capital deals, R&D alliances and IP transfer agreements. As to venture deals, we started from the 180 ties that involved 61 firms that received venture capital and 67 investors in the reference period. We then considered all the possible combinations between each of the 61 firms that received venture capital and the 67 investors with which the focal firms could potentially have established a venture capital tie, resulting in 4,087 potential venture capital ties. As to R&D alliances, we started from 60 R&D alliances that involved 51 organizations in the reference period. We then considered, all the possible combinations between each of these 51 organizations and the remaining 50 organizations with which the focal organizations could potentially have established a R&D alliance (51×50 = 2,550). After the elimination of duplicated ties, we came up with 1,275 (i.e., 51×50/2) potential R&D alliance ties[1]. As to IP transfer agreements, we used a similar approach. Starting from the 46 organizations involved in one of the 49 IP transfer agreements in the reference period, we considered all the 46×45/2=1,035 potential ties. Unfortunately, for some organizations we were not able to collect information on the main variables of interests. This led to a small reduction of the sample of realized and potential unrealized ties. Table 1 shows details concerning the composition of the final sample.

Table 1. Final sample for each deal type

	N. of organizations	**N. of realized ties**	**N. of realized ties**	**Total N. of ties**
Venture capital deals	124	175	3,731	3,906
R&D alliances	50	57	1,132	1,189
IP transfer agreements	44	46	912	958

For each of the three samples of potential ties, we then run probit models to estimate the role of distance for inter-organizational tie formation, according to the following econometric model:

$$Realized_{i,j} = \alpha + \beta D_{i,j} + \gamma X_{i,j} + \varepsilon_{i,j}. \quad (1)$$

In each of these samples (venture capital deals, R&D alliances or IP transfer agreements)*,* the dependent variable is *Realized*, which is a dummy that equals 1 if the organization *i* had established

[1] An example could be of help to clarify our approach. Let us consider 4 organizations, named A, B, C and D. In this case, the total number of potential ties is 4*3/2 = 6, namely A-B, A-C, A-D, B-C, B-D and C-D. According to our approach the tie is bidirectional, implying that A-B = B-A.

a tie with the organization *j*, and zero otherwise. The intercept term is denoted by α.

To assess the role of distance for inter-organizational tie formation, we considered alternative distance measures, denoted with $D_{i,j}$ in equation (1). All these distance measures have been calculated starting from information about the geographic location (i.e., latitude and longitude retrieved from Google Maps) of each organization's address in the GBA. First, we used the kilometric distance between the two organizations (*Distance*) expressed in absolute value. Second, we considered the logarithm of the kilometric distance (*Distance (log)*). Third, we included in the regressions two dummy variables that equal 1 if the two organizations are located within a radius of 10 km (*Distance 0-10 km*) or between 10 and 20 km (*Distance 10-20Km*) from each other. Finally, we used a Google API to obtain travel times between the different locations in our samples (*Distance (time)*).

The vector $X_{i,j}$ includes variables that take into account for the role of other types of proximities (Boschma, 2005) in inter-organizational tie formation. Specifically, we considered measures for social, cognitive and institutional proximities. Social proximity is a dummy variable that equals 1 if the two entities are both located in the GBA for more than five years, assuming that organizations that are co-located for a longer span of time had the chance to establish more prior contacts than those organizations that located in the area more recently. To obtain information on the year of location in GBA, we used Orbis and Crunchbase databases and, whether the information was not available, we relied on secondary data (firm's websites; public statements). However, in case of organizations that are younger than 5 years (i.e., startups), *Social proximity* equals 1 if at least one of the startup's founders has a prior work experience in the other entity of the dyad. For each startup founders in our sample, we collected this information by extracting all organizations mentioned as "Education" and "Previous experience" from their professional LinkdIn web pages. As to cognitive proximity, we consider the industry overlap among the two organizations. Specifically, *Cognitive proximity* is a dummy variable that equals 1 if the two entities share the same NAICS code at the 3-digit level, 0 otherwise. For professional venture capital investors, the dummy equals 1 if their industry focus is on pharma/biotech industries. In the first case, we obtained industry information from Orbis database, while for investors we relied on secondary data as the venture capital fund's website. We also controlled for institutional proximity, which is usually defined as when organizations share the same institutional structure (Balland 2012). Therefore, we classified organizations based on the following five classes: (i) corporate, (ii) SMEs, (iii) research and no-profit organizations; (iv) government; (v) risk capital providers and considered a dummy variable (*Institutional proximity*) that equals to 1 if both organizations fall in the same category. Finally, we controlled for the number of metro stations (*T-stops*) within each city of GBA in which the organization is located, as an indicator of location connectivity and reachability. In all estimates, we also included industry and organization types dummy variables. Table 2 shows the description of all variables included in the regressions. Table 3 and Table 4 report summary statistics and the correlation matrix, respectively.

Table 2. Variables description

Variable	Description
Dependent variable	
Realized	Dummy that equals 1 if the two organizations in the dyad have been involved in a venture capital deal, a R&D alliance or a IP transfer agreement.
Independent variables	
Distance	Distance in km between the two organizations.
Distance (log)	Logarithm of the distance in km between the two organizations.
Distance 0-10km	Dummy variable that equals 1 if the two organizations are located within a radius of 10km from each other.
Distance 10-20km	Dummy variable that equals 1 if the two organizations are located at more than 10km but less than 20km from each other.
Distance (time)	Travel time by car between the two organizations.
Controls	
Social proximity	Dummy variable that equals 1 if the two organizations are both located in the GBA for more than five years. For organizations incorporated after 2011 (i.e. startups), the variable equals 1 if at least one of the startup founders has a prior work experience in the other entity of the dyad.
Cognitive proximity	Dummy variable that equals 1 if the two organizations share the same NAICS code at the 3-dig level. For professional venture capital investors, the dummy equals 1 if their industry focus is on pharma/biotech industries.
Institutional proximity	Dummy variable that equals 1 if the two organizations fall in the same category (corporate, SMEs, research and no-profit organizations; government; risk capital providers).
T-stops	Sum of the total number of T-stops in the cities in which the two organizations are located.

Table 3. Summary statistics

Variable	Obs	Mean	Std. Dev	Min	Max
Realized	5,968	0.046	0.210	0	1
Distance	5,968	7.121	10.914	0.003	60.282
Distance (log)	5,968	1.103	1.390	-5.938	4.099

Distance 0-10km	5,968	0.769	0.422	0	1
Distance 10-20km	5,968	0.187	0.390	0	1
Distance (time)					
Social proximity	5,968	0.438	0.496	0	1
Cognitive proximity	5,968	0.361	0.480	0	1
Institutional proximity	5,968	0.243	0.428	0	1
T-stops	5,968	40.894	36.191	0	148

Table 4. Correlations

	Variable	1	2	3	4	5	6	7	8	9
1	Realized	1.000								
2	Distance	-0.019	1.000							
3	Distance (log)	-0.026	0.751	1.000						
4	Distance 0-10km	0.015	-0.753	-0.728	1.000					
5	Distance 10-20km	-0.005	0.366	0.559	-0.873	1.000				
6	Distance (time)						1.000			
7	Social proximity	0.048	-0.007	0.061	-0.059	0.089		1.000		
8	Cognitive proximity	-0.019	0.084	0.077	-0.066	0.039		0.038	1.000	
9	Institutional proximity	-0.010	-0.055	-0.074	0.012	0.016		-0.006	-0.068	1.000
10	T-stops	0.023	-0.090	0.124	0.100	-0.044		0.121	-0.089	-0.110

5. Findings

5.1 Main results

We first performed a univariate analysis to verify whether there are statistically significant differences in the average distance in km when considering realized and potential unrealized ties for the three types of inter-organizational ties considered in this study. Results from this analysis are shown in Table 5.

Table 5. Average distance in km of realized and potential unrealized ties

	Realized ties (A)	**Unrealized ties (B)**	**Difference (A-B)**	**t-test (p-value)**
Venture capital deals				
N. of observations	175	3,731	-	-
Average distance (km)	5.92	6.99	-1.07	0.031
R&D alliances				
N. of observations	57	1,132	-	-
Average distance (km)	8.07	6.43	1.64	0.254
IP transfer agreements				
N. of observations	46	912	-	-
Average distance (km)	5.06	8.69	-3.64	0.040

Results from Table 5 seems to suggest that geographic distance is negatively associated to the formation of venture capital and IP transfer agreements ties. The average distance of realized ties is indeed lower than the corresponding figure in the case of potential unrealized ties for these two types of inter-organizational relationships. These differences are statistically significant at the 5%. On the contrary, we do not observe statistically significant differences in the average distance when focusing on R&D alliances. This preliminary evidence is therefore in line with hypothesis 1 and hypothesis 3, while we do not find any supporting evidence for either hypothesis 2a or hypothesis 2b.

Let us now consider the results from the multivariate analysis on the probability of tie formation. Table 6, Table 7 and Table 8 show the results for venture capital deals, R&D alliances and IP transfer agreements, respectively. Each table shows the coefficients from probit regressions, using distance in km (model 1), its logarithm (model 2), the two distance thresholds (model 3) or travel time (model 4) as main independent variables.

Table 6. Results from probit regressions – venture capital deals

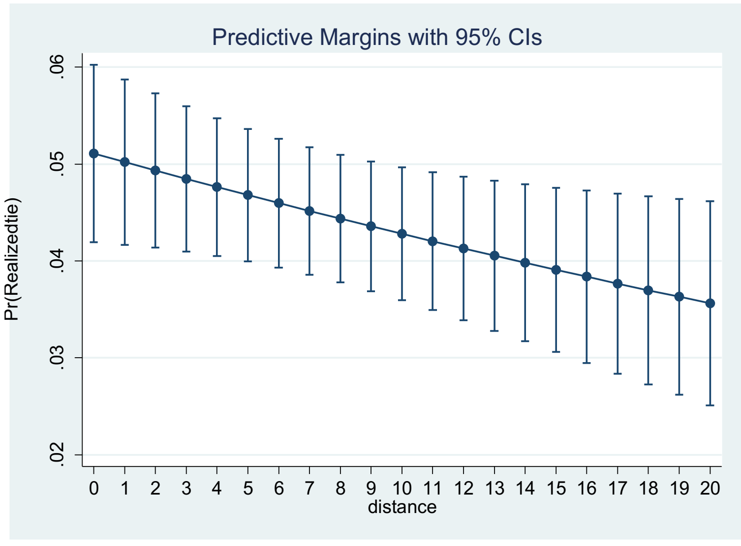
	Model 1		Model 2		Model 3		Model 4	
Distance	-0.009	**						
	(0.004)							
Distance (log)			-0.058	*				
			(0.030)					
Distance 0-10km					0.754	**		
					(0.366)			
Distance 10-20km					0.718	*		
					(0.369)			
Distance (time)							-0.008	*
							(0.004)	
Social proximity	0.044		0.045		0.036		0.044	
	(0.077)		(0.078)		(0.076)		(0.078)	
Cognitive proximity	-0.094		-0.089		-0.100		-0.095	
	(0.078)		(0.079)		(0.078)		(0.078)	
Institutional proximity	-0.094		-0.093		-0.106		-0.092	
	(0.095)		(0.095)		(0.096)		(0.095)	
T-stops	-0.000		-0.000		-0.001		-0.000	
	(0.001)		(0.001)		(0.001)		(0.001)	
Entity type dummies	YES		YES		YES		YES	
Industry dummies	YES		YES		YES		YES	
Constant	-1.767	***	-1.771	***	-2.527	***	-1.720	***
	(0.331)		(0.330)		(0.490)		(0.332)	
N. observations	3,843		3,843		3,843		3,843	
Log-likelihood	-698.949		-698.507		-697.347		-698.912	
Pseudo R^2	0.018		0.018		0.020		0.018	

***, **, and * indicate significance at 1%, 5% and 10%, respectively. Robust standard errors in round brackets.

Results from Table 6 are still in line with hypothesis 1. We find that, when considering venture capital deals, geographical distance is negatively associated to the likelihood of tie formation. The coefficients of the distance variable in model 1 is indeed negative and statistically significant at the 5%. Results from models 2-4 in Table 6 are qualitatively similar to those of model 1. In terms of magnitude, it is worth noting that the average marginal effect of distance on the probability of tie formation calculated on the basis of the coefficients of model 1 is – 0.001 (p-value = 0.051). The estimated probability of tie formation for venture capital deals as distance varies is shown in Figure

1. The likelihood of tie formation is 0.051 when the distance between the two organizations is less than 1km. When distance is 20km, the probability of tie formation is 0.035. Therefore, distance matters in venture capital deals at the micro-geographic scale.

Figure 1. Probability of tie formation as distance varies – venture capital deals



Conversely, we do not detect any significant association between distance and tie formation when considering R&D alliances (Table 7). All the coefficients associated to distance variables are indeed not statistically significant the conventional confidence levels.[2] Hence, our results do not support either hypothesis 2a or hypothesis 2b. This result might be driven by a combination of the positive and negative effects associated to geographical proximity in R&D alliances.

Finally, evidence shown in Table 8 is consistent with hypothesis 3. All the coefficients of distance variables are indeed negative and statistically significant at least at the 5%. Distance appears to be even more detrimental in the case of IP transfer agreements than in the case of venture capital deals. According to the coefficient of the distance variable of model 1 of Table 8, the average marginal effect of distance on the probability of tie formation is – 0.003 (p-value = 0.012). Probability of tie formation as distance varies is shown in Figure 2, which shows that the likelihood of tie formation is 0.080 when the distance between the two organizations is less 1km. When distance is 20km, the probability of tie formation becomes 0.025 (and not statistically different from 0).

Table 7. Results from probit regressions – R&D alliances

	Model 1	Model 2	Model 3	Model 4
Distance	0.003			

[2] The average marginal effect of distance (model 1) on the probability of tie formation is indeed 0.000 (p-value = 0.568).

	(0.006)							
Distance (log)			-0.030					
			(0.051)					
Distance 0-10km					-0.241			
					(0.349)			
Distance 10-20km					-0.174			
					(0.388)			
Distance (time)							0.002	
							(0.006)	
Social proximity	0.442	**	0.460	***	0.440	**	0.441	***
	(0.160)		(0.160)		(0.161)		(0.160)	
Cognitive proximity	-0.006		0.015		-0.008		-0.003	
	(0.194)		(0.193)		(0.194)		(0.194)	
Institutional proximity	-0.255		-0.260	*	-0.254		-0.254	
	(0.158)		(0.155)		(0.157)		(0.157)	
T-stops	0.005	*	0.005	**	0.005	**	0.005	*
	(0.002)		(0.002)		(0.002)		(0.002)	
Entity type dummies	YES		YES		YES		YES	
Industry dummies	YES		YES		YES		YES	
Constant	-2.675	***	-2.693	***	-2.432	***	-2.679	***
	(0.722)		(0.734)		(0.809)		(0.733)	
N. observations	1,179		1,179		1,179		1,179	
Log-likelihood	-203.305		-203.215		-203.217		-203.380	
Pseudo R^2	0.098		0.098		0.098		0.097	

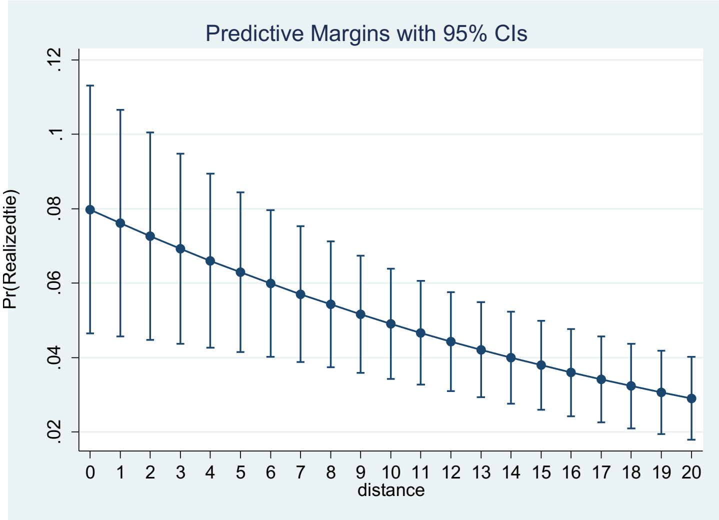
***, **, and * indicate significance at 1%, 5% and 10%, respectively. Robust standard errors in round brackets.

Table 8. Results from probit regressions – IP transfer agreements

	Model 1		Model 2		Model 3		Model 4	
Distance	-0.030	**						
	(0.012)							
Distance (log)			-0.091	**				
			(0.044)					
Distance 0-10km					6.349	***		
					(0.550)			
Distance 10-20km					6.173	***		
					(0.608)			
Distance (time)							-0.018	**
							(0.007)	
Social proximity	0.480	***	0.470	***	0.496	***	0.477	***
	(0.168)		(0.166)		(0.168)		(0.167)	
Industry overlap	-0.183		-0.178		-0.200		-0.182	
	(0.215)		(0.214)		(0.218)		(0.214)	
Same entity type	-0.014		-0.035		-0.001		-0.026	
	(0.175)		(0.173)		(0.174)		(0.174)	
T-stops	-0.001		-0.000		-0.001		-0.000	
	(0.003)		(0.003)		(0.003)		(0.003)	
Entity type dummies	YES		YES		YES		YES	
Industry dummies	YES		YES		YES		YES	
Constant	-5.175	***	-5.263	***	-11.881	***	-5.375	***
	(0.483)		(0.511)		(0.630)		(0.506)	
N. observations	946		946		946		946	
Log-likelihood	-167.483		-170.658		-166.500		-169.115	
Pseudo R^2	0.090		0.072		0.095		0.081	

***, **, and * indicate significance at 1%, 5% and 10%, respectively. Robust standard errors in round brackets.

Figure 2. Probability of tie formation as distance varies – IP transfer agreements



5.2 Additional evidence

The low pseudo-R^2 values (around 0.02) reported at the bottom of Table 6 seems to suggest that the probit regressions on venture capital deals have a limited explanatory power. In order to be reassured about the validity of our results, we run two additional analyses to model the probability of tie formation for venture capital deals. Results from these additional regressions are shown in the Appendix.

First, we included a measure for the venture capital investor's reputation to take into account that more reputable investors are more attractive for firms looking for venture capital. The variable *VC reputation* is a dummy variable that equals 1 if the investor appears in the list of reputable investors according to the Lee-Pollock-Jin VC Reputation Index (Lee et al. 2011)[3]. Results when including *VC reputation* suggest that investor's reputation is positively related to the probability of tie formation. The coefficient of *VC reputation* is indeed statistically significant in all model specifications at the 1%. More importantly, results concerning the distance variables are qualitatively similar to those presented in Table 6, while we observe an increase in the value of the pseudo-R^2 in all specifications (with a maximum value of 0.03).

Second, we checked whether the explanatory power of the model on venture capital increases when focusing the analysis on startups, i.e. organizations incorporated after 2011 (i.e. startups). Younger firms are more likely to be resource constrained (Nightingale and Coad 2014) and have time-constrained owner-managers (Sine et al 2006). Consequently, a distant search for financial partners could absorb an excessive amount of managerial time and divert them from the firm's core business (Rosenkopf and Almeida 2003). Furthermore, younger firms might be perceived as riskier (Bertoni et al. 2015). For these firms, the role for geographical proximity in facilitating intensive monitoring

[3] The list is available at http://www.timothypollock.com/vc_reputation.htm.

by the venture capital investor is likely to be even more relevant. Results from these additional estimates are line with the arguments above. We indeed observe an overall increase in the magnitude of all the negative coefficients associated to distance variables. Quite interestingly, the role of social proximity seems relevant for startup. The coefficient of *Social proximity* is indeed positive and statistically significant at the 1%. It is also worth pointing out that for startups we have a much more precise measure of social proximity, which is based on the education and prior work experience of their founders (as explained in greater detail in section 4.3). Overall, we also observe a dramatic increase in the value of the pseudo-R^2**,** ranging from 0.07 to 0.08 depending on the specific measure of distance included in the regression.

6. Discussion

The aim of this paper was to explore the role of micro-geographical proximity in multiple types of inter-organizational relationships within an innovation ecosystem. Specifically, the study analyses how the importance of micro-geographical distance varies across three types of inter-organizational relationships (Aguilera et al. 2012; Balland et al. 2016; Capone and Lazzeretti; Belussi et al. 2010). More specifically, our empirical analysis suggests that micro-geographical proximity matters when considering the formation of venture capital deals and IP transfer agreements, while we do not find any significant association with the formation of R&D alliances.

More specifically, in the case of venture capital deals, our findings show that geographical distance is negatively associated to tie formation confirming our hypothesis 1. This result is consistent with the arguments made by those scholars supporting the importance of physical proximity between the venture capitalist and his investee (De Clerq and Sapienza 2001; Nahapiet and Goshal 1998; Shane and Cable 2002; Lutz et al. 2013; Chemmanur et al. 2016) for investment management and monitoring reasons. This negative association is probably due to the fact that geographical proximity, apart from increasing the likelihood of first-encounter, reduces information asymmetry, monitoring efforts as a result of the emergence of trust mechanisms. When considering the role of other forms of proximity, our findings show that social proximity is not particular relevant to the emergence of venture capital deals (with the exception of firms incorporated in more recent years). This is partly in contrast with the mainstream literature arguing a sort of moderating effect of social proximity in the relationship between spatial proximity and venture capital deals emergence, that consider the emergence of social relationships among the deal's parties as a major determinant for the development of their relationship (Nahapiet and Goshal, 1998; Shane and Cable, 2002; De Clercq and Sapienza, 2001). In case of IP transfer agreements, our findings show that micro-geographic distance is negatively related to establishment of this type of linkage (hypothesis 3 is confirmed), with a magnitude that appears even stronger with respect to venture capital deals. This finding is in line with the stream of studies that supports the importance of geographical proximity for the channels of knowledge trade (Agrawal 2006; Audretsch and Stephan 1996; Zucker et al. 1998; Belenzon and Schankerman 2013; Beise and Stahl 1999; Santoro and Gopalakrishnan 2001; Beise and Stahl 1999; Santoro and Gopalakrishnan 2001) as in the case of licensing agreements, for which geographical distance between the licensor and the inventor becomes critical when the inventor's engagement is required, especially whereas the technology is not readily marketable and the knowledge required to use it, is hard to be codified and demands a higher frequency of interactions. However, differently from venture deals, the control variable for social proximity is particularly significant. This may be explained by the fact that when the knowledge that is object of the exchange is harder to transfer or embodied in the inventor due to a low degree of codification, a greater level of personal communication is needed (Agrawal 2006). Finally, in case of R&D Alliances geographical distance is not statistically significant (both hypothesis 2a and hypothesis 2b are not confirmed). We could only suggest that this null effect may be due to a "compensation effect" of the risks of too much proximity (as lock-in phenomena and lack of novelty information) (Broekel and Boshma 2012; Weiss and Minshall 2004), versus the agglomeration advantages (as the establishment of collaboration routines, discouragement of misappropriation hazards, development of idiosyncratic language for the exchange of fine-grained information) (Galunic and Rodan 1998; Reuer and Lahiri 2014; Singh et al. 2016; Ponds et al. 2009). Another explanation may be due to the fact that locational factors may exert a secondary role in case of long-term R&D alliances with a high degree of contractualization. In these cases, a detailed definition of the division of tasks and competencies among the parties is generally defined in detail in the contract, and the modalities of information exchange are usually formalized in protocols (especially in biopharmaceutical industry), thus making frequent face-to-face interactions no longer needed. Moreover, this result is coherent with the studies on R&D alliances showing that other dimensions of proximity are more effective than geographical one. Social proximity appears to be significant to R&D alliances formation, which is in line with the strands of studies that scale back the role of physical proximity maintaining that the existence of prior links (Mora-Valentin et al. 2004; Petruzzelli 2011) among the partners contribute more to the successful outcome of the alliance. Also, social proximity would contribute to the development of idiosyncratic language for the exchange of fine-grained information (Uzzi 1997) necessary for the mutual understanding of both partners' knowledge (Singh et al. 2016) which is key in an R&D type of partnership. In general, we observed that the probability of tie formation decreases with distance for both IP transfer and venture capital deals in a significant way, especially while comparing the likelihood of tie formation among the organizations that are less distant than 1km compared to those found at 20km of distance. This result suggests the importance of being geographical proximity at the very small scale for cooperation dynamics. This in turn emphasizes the importance of adopting a micro-geographical perspective and to provide measures for distance in order to emphasize this "neighborhood effect", which would not be possible while considering spatial proximity in terms of mere co-location.

7. Conclusions

While the effect of spatial proximity on inter-organizational relationships has been widely debated, the issue of how the role of locational factors varies according to the nature of cooperation mechanisms has been less explored, except for a few cases (Huggins et al. 2012; Grillitsch et al. 2015; Balland et al. 2016: Quatraro and Usai 2017; Lazzeretti and Capone 2016). Also, extant studies addressing the impact of geographic proximity on patterns of inter-organizational cooperation, generally refer to the mere co-localization of partners and neglect to consider the micro-geographical perspective. We have tried to fill this gap by analyzing the role of micro-geographical distance among actors belonging to three different inter-organizational networks, i.e. venture capital deals, IP transfer agreements, joint R&D alliances, in the case of the Biopharma IE in GBA. Our findings show that the role of micro-geographic distance is important. In fact, the connected organizations present an average distance of 10 km and the likelihood of cooperation is significantly higher when the organizations are found at less than 1km compared to when these are at 20km or more of distance. Moreover, our studies confirm the necessity of considering the complex nature of innovation ecosystem because we show that the effect of geographical distance varies across different types of cooperation practices and, more specifically, that it has a negative effect on the formation and the strength of venture deals and IP transfer types of relationships. Conversely, no significant effect has been recorded for the establishment and intensity of R&D alliances, which may suffer from a null effect as a result of contrasting forces of positive and negative impacts of geographic proximity on local innovation capacity.

We believe that this work contributes to the studies on innovation ecosystems as it allows for a more comprehensive analysis of the role of micro-geographical proximity by taking in due account the network composition in terms of both actors' heterogeneity and relationships' variety whereas extant literature privileges the focus on inter-firm or university-industry relationships at the network structural level. Also, from an empirical standpoint, by adding measures of geographical distance, this study contributes to reduce the ambiguity of the notion of spatial proximity whether the majority of empirical studies on the geography of networks of innovation tend to consider it as the general co-localization of partners within the same institutional borders (at the national or regional level) and overlook the implications deriving from its operationalization at smaller scales from a micro-geographical perspective. Moreover, we believe that the results of this study may orient managers by providing a framework that can guide their R&D operations' delocalization decisions and their tie selection processes. Policy implications may also be derived regarding the selection of incentives for specific types of partnerships within the framework of regional innovation strategies. However, our results suffer from some limitations. First, the sample could be expanded to include a greater number of inter-organizational practices (including informal ties) within the IE in order to gain a deeper exploration of the distance effect on patterns of cooperation. Finally, a greater number of control variables could be included to improve the explanatory power of our model.

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Appendix

Table A1. Results from probit regressions – venture capital deals – control for VC investor's reputation

	Model 1		Model 2		Model 3		Model 4	
Distance	-0.008	*						
	(0.004)							
Distance (log)			-0.051	*				
			(0.030)					
Distance 0-10km					0.720	*		
					(0.369)			
Distance 10-20km					0.693	*		
					(0.372)			
Distance (time)							-0.007	*
							(0.004)	
Social proximity	0.018		0.019		0.011		0.018	
	(0.078)		(0.079)		(0.077)		(0.078)	
Cognitive proximity	-0.068		-0.063		-0.073		-0.068	
	(0.077)		(0.077)		(0.077)		(0.077)	
Institutional proximity	-0.093		-0.093		-0.104		-0.092	
	(0.096)		(0.096)		(0.097)		(0.096)	
T-stops	-0.000		-0.000		-0.000		-0.000	
	(0.001)		(0.001)		(0.001)		(0.001)	
VC reputation	0.223	***	0.220	***	0.224	***	0.225	***
	(0.083)		(0.083)		(0.083)		(0.083)	
Entity type dummies	YES		YES		YES		YES	
Industry dummies	YES		YES		YES		YES	
Constant	-1.842	***	-1.844	***	-2.568	***	-1.799	***
	(0.330)		(0.330)		(0.493)		(0.331)	
N. observations	3,843		3,843		3,843		3,843	
Log-likelihood	-695.675		-695.347		-694.055		-695.581	
Pseudo R^2	0.022		0.023		0.025		0.022	

***, **, and * indicate significance at 1%, 5% and 10%, respectively. Robust standard errors in round brackets.

Table A2. Results from probit regressions – venture capital deals – startups

	Model 1		Model 2		Model 3		Model 4	
Distance	-0.029							
	(0.020)							
Distance (log)			-0.171	***				
			(0.055)					
Distance 0-10km					3.225	***		
					(0.258)			
Distance 10-20km					2.687	***		
					(0.349)			
Distance (time)							-0.030	**
							(0.012)	
Social proximity	1.784	***	1.741	***	1.797	***	1.794	***
	(0.364)		(0.355)		(0.370)		(0.353)	
Cognitive proximity	0.165		0.188		0.162		0.178	
	(0.123)		(0.124)		(0.122)		(0.123)	
Institutional proximity	-0.158		-0.164		-0.143		-0.172	
	(0.214)		(0.216)		(0.211)		(0.217)	
T-stops	0.000		0.002		-0.001		0.002	
	(0.002)		(0.002)		(0.002)		(0.002)	
VC reputation	0.166		0.150		0.174		0.165	
	(0.135)		(0.137)		(0.137)		(0.135)	
Entity type dummies	YES		YES		YES		YES	
Industry dummies	YES		YES		YES		YES	
Constant	-1.691	***	-1.759	***	-4.951	***	-1.528	***
	(0.368)		(0.375)		(0.494)		(0.371)	
N. observations	1,512		1,512		1,512		1,512	
Log-likelihood	-240.196		-237.205		-239.658		-238.195	
Pseudo R^2	0.072		0.083		0.074		0.079	

***, **, and * indicate significance at 1%, 5% and 10%, respectively. Robust standard errors in round brackets.