UNIVERSITA' DEGLI STUDI DI PADOVA

DIPARTIMENTO DI SCIENZE ECONOMICHE ED AZIENDALI "M.FANNO"

CORSO DI LAUREA MAGISTRALE / SPECIALISTICA IN

BUSINESS ADMINISTRATION

TESI DI LAUREA

"PROXIMITY AND INNOVATION: A META-ANALYSIS"

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ANNO ACCADEMICO 2015 – 2016

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Contents

INTRODUCTION

The present study investigates the relation existing between proximity and innovation by means of a meta-analysis.

First of all, a literature review is proposed in the first chapter that, in a chronological way, presents the various theories that have followed one another, from the first conceptualization given by Alfred Marshall, to the most recent approach of the 'Evolutionary Economic Geography'. Throughout this chapter, the transition from an idea principally based on the sole geographic dimension to the introduction of new and diverse aspects of proximity is dealt with. According to the recent developments made in this field, and in particular considering the known article published by Ron Boschma in 2005, *Proximity and Innovation: A Critical Assessment*, five different dimensions of proximity are outlined: geographical, cognitive, organizational, social and institutional.

The second chapter deals with each of these dimensions separately, examining their key aspects and peculiarities as well as the consequences at which they lead to, following Boschma's interpretation. Moreover, an examination of empirical researches exploring the causal relation between proximity and innovation is presented, many of which have been used for the construction of the meta-analysis's sample. Therefore, for every proximity dimension such empirical studies have been used to analyze the relative measurement methods and they way in which they have been accounted for, as well as the results achieved in relation to the characteristics of the studies, carrying on a sort of 'theoretical comparison' that showed very disparate situations.

The last chapter deals with the meta-analysis developed, explaining the data and methodology used and the construction of the model step by step. Initially, descriptive statistics are displayed to give an overview of the analysis and of its fundamental aspects and characteristics. Then, the results achieved by the meta-analysis implementation are presented, principally providing for a neutral outcome with respect to the proximity dimensions, and the relevant role instead played by other independent variables in the determination of a positive outcome.

1. PROXIMITY AND INNOVATION: A LITERATURE REVIEW

The innovative activity seems to have a natural tendency to cluster spatially, and this has been confirmed by the numerous empirical researches that have been conducted in the past decades. The reasons why this phenomenon happens is one of the main issues that many economists have tried and are still trying to understand. The literature on innovation is therefore very ample, with various visions and interpretations of the innovation phenomenon, of its impact and on the variables and causes that determine it. Furthermore, the innovation problem has been analyzed from various points of view, due to the interest disclosed on this subject also by branches of research beyond the regional economics. Among those, the industrial economics investigated the "intra-firm" determinants of innovation as starting point of research, such as the firm size and R&D expenses, which however underlined the necessity to take in consideration also variables "external" to the firm, related in particular to the firm's productive field and localization.

Through the analysis of the spatial dimension of the innovative processes and the related empirical observation it has been noticed in fact that the production of innovations co-locates in certain regions, cities or areas. The main reason behind this agglomeration process depends on the fact that the geographical concentration of different actors allows and facilitates the relations and cooperation between agents, the reduction of the uncertainties intrinsic in the innovative activity and fosters the share of knowledge.

It must be specified that the knowledge can be divided into two different components: the codified or explicit part and the tacit or implicit one. The first one is composed of those notions that are easy to share, communicate and transmit by means of standard methods and general instruments, such as books, computers, technical and scientific publications and licenses. The second one instead is an individual property, related to the personal experience and the application of the codified knowledge and for this reason it is difficult to spread with method that differ from the personal interaction. Composed of family traditions, personal relationships with clients and suppliers, professional training courses and informal share of technical information this knowledge can actually be transmitted and increased only through social relations.

The creation of technological innovation is mainly based on tacit knowledge, and therefore requires it in order to communicate and share the relevant knowledge, resulting in a fundamental necessity of geographic proximity.

Although an always increasing portion of knowledge is codified as a consequence of the important role played by the information and communication technologies (ICT) nowadays that allows an easily transmission also over long distances, the two facets of knowledge are complementary to each other, because the creation of both types depends on their combination, and therefore the proximity turns out to be an important characteristic under different dimensions. In the actual globalization phase, where the products and processes are increasingly standardized, the tacit knowledge plays an even more important role to ensure a long lasting competitive advantage: being difficult to transfer, it prevents imitation processes that could take place.

The geographic proximity becomes an even more important condition when dealing with the development of an innovation or technology in the initial phase or with particularly complex innovative processes. In these cases the spatial proximity can reduce the related uncertainties and the research costs for knowledge and information needed, allowing an easier access to services and competencies external to the firm, and hence a better coordination. The geographical concentration in fact usually brings together a high density of various functions, knowledge, competences and services, increasing therefore the possibility for actors to access them at lower costs and waste of time.

Many empirical studies also revealed that some of the areas of geographic concentration have registered a consistent and superior innovative capacity compared to others. The reasons behind these differences is explained on one hand by the structural factors, which consist of the presence of R&D laboratories and other innovative inputs, and on the other hand by the innovative environment, such as institutional and infrastructural factors that are specific of a determined geographic area. Nevertheless both variables used to explain the different performance of regions are related to the external environment and the specific characteristics of a geographical area.

In particular these aspects are usually easy to explain in relation to the urban areas, which have always been considered the privileged location of the innovative activity due to the presence and concentration of both productive and residential activities, qualified labor market, advanced services that support the innovative activity, the density of contacts and the easy access to information and knowledge.

However the reality shows that also some non metropolitan areas, even if of small dimensions, are able to register this superior innovation capacity, proving the existence of some form of ascending performance in the concentration of the innovative activity. Some examples can be found in what has been called the ‘holy trinity’ of regional studies- the Silicon Valley in California, in the Baden-Württenberg region in the south of German and the central and northwest Italian regions denominated ‘Third Italy’- that between the end of the 1980s and the beginning of the 1990s became three important cases of regional success.

The dynamic and competitive element that allows this higher innovative ability lies in the firms and economic agents’ capacity to gain knowledge over time and renew it through learning processes which are settled in the local context. The firms diffuse their technological and organizational know-how in the surrounding environment, which in turn provides support for their activities, resulting in a strengthening of the natural tendency of spatial concentration of innovation over time.

With few exceptions, it is only since the mid 1970s that begun a real interest for the spatial dimension of the technological change, probably associated with the more recent capacity to formulate analytical models able to incorporate the presence of increasing returns. Different strands of thought has followed one another investigating the role played by the space, the possible various determinants and implications of this phenomenon, and debating on the importance of the different dimensions of proximity on the innovative activity of firms, moving from a pure physical concept, to a multi-dimensional one.

1.1 The Marshallian Theory of ‘Agglomeration Economies’

The first economist that had the intuition that similar or complementary economic activities tend to concentrate in the geographical space was Alfred Marshall (1890) with the formulation of the concept of ‘agglomeration economies’. The idea is that, as a consequence of the geographical agglomeration of the productive activities, firms can benefit not only from the economies of scale generated internally, that is the benefits deriving from the increase of the production volumes and the consequent decrease of the average production costs, but can also take advantage of the so-called agglomeration economies. These are also known as ‘external economies’ because their effects derive from the geographical co-location and allow the reduction of the unitary costs of the firms’ production when located in a certain area.

In particular, small firms are not able to exploit the economies of scale because of their size, but the presence of localized economies deriving from a concentration seems to be able to compensate for this disadvantage. He identified three main factors able to explain the spatial concentration of firms: the access to specialized and skilled labor, to specialized suppliers of intermediate industries and the knowledge spillovers among firms.

Moreover, Marshall also explained that the geographic concentration favors the creation of an 'industrial atmosphere', thanks to the presence of a diffuse industrial culture, constituted by intangibles assets and of very strong relations that make the industrial concentration the privileged places for intensive innovative processes and their relative diffusion. In this sense it can be said that the agglomeration economies present in this context work as 'dynamic economies', that is, as sources of entrepreneurial creativity and innovation. It this sense, the 'space' started to assume an active role in the determination of the development.

Anyway, the real change in the interpretation of the space as an active element in the development process is attributable to innovative models of local development that derived from 'neomarshallian' schools of thought. In 1990s the concepts of cluster and industrial district were minted, characterized by both differences and common features.

1.1.1 The Industrial District

The original definition of the industrial district was made by Giacomo Becattini (1990, p.38), who defined it as "a social and territorial entity that is characterized by the active presence of both a community of people and a group of enterprises in a natural and historically determined area. In the district, unlike in other environment, such as manufacturing towns, community and firms tend to merge". Essentially the industrial district is defined as a territorial area with a high concentration of manufacturing small and medium sized firms, characterized by high flexibility and adaptation capacity, each specialized in one or few phases of the productive process of a single industry or in subsidiary activities.

The starting point of the analysis of the role and dynamics of the industrial district used by Becattini was the locality and its social structure. The territory is considered the element able to decrease the uncertainty associated with innovative processes, and able to generate the advantages that allow for both productive and innovative efficiency.

Therefore, the fundamental element that outlines and characterizes the entities is the spatial proximity between firms, which however reveals to be a necessary but not sufficient characteristic, and the socio-cultural proximity, meant as the presence of a shared system of institutions, codes of behavior and rules that allows for cooperation and interaction.

This social and cultural system of shared common values is at the base of the increasing returns and the localized advantages of the district firms and can even be considered as the typical element characterizing the industrial district. Indeed, the pure geographical dimension of proximity revealed to be not enough in the explanation of the phenomenon: the socio-cultural proximity instead, which is embedded in the local area, is considered to be able to strengthen the spatial dimension in the expression of the advantages deriving from the agglomeration. Moreover, this could be a possible explanation of the difference observed in the degree of agglomeration in regions and areas that appear to be similar in terms of size, density and industrial specialization, but are not in terms of networks.

These features that are representative and at the same time constitute the base of the industrial district, provide numerous benefits for the firms that locate there, not only in terms of reduction in the production and transaction cost, but also in increase efficiency of the productive factors, and in particular in the increase of the innovative capacity. For what concerns this last factor, the industrial district theory underlines the importance of the cumulative knowledge at the local level as an element able to determine the level of innovative capacity of firms. Furthermore, an additional element that sustains the efficiency of the district firm in terms of innovative activities is the reciprocal integration of cooperation and competition: the balance of the two allows the survival of this organizational model. In fact, on one hand the competition acts as a vital force of the firms located in the industrial district, which are in this sense obliged to maintain high level of quality, a good reputation and to innovate often; on the other hand, an equally important role is played by the cooperation, the face-to-face interaction and exchange of information between agents. Moreover, the innovation activity of firms is also fostered by the presence of R&D activity, of advanced services and of qualified labor force.

The industrial district model has the quality to emphasize the endogenous elements of the development, such as the flexibility in the production process, the entrepreneurship, the presence of a social and cultural context and of an institutional structure able to support it.

1.1.2 The Cluster

According to Michael Porter’s ‘diamond framework’ discussed in his book *The Competitive Advantage of Nations (1990)*, the economic success of various territorial contexts depends on four interrelated forces able to create a combination of advantages, being geographically specific and difficult to replicate somewhere else.

The first one is the factor conditions, that is, the national position of the production factors necessary to compete in the industry, such as the geographic location, the raw materials, the professional skills and competences. The second concerns the demand conditions, outlined by the demand's nature of products and services of the related industry, which is valued in terms of dimension, capacity and supply interaction. The third factor is the presence of related and supporting industries, located upstream and downstream in the production process, which enable a greater coordination. The last one is related to the firm's structure, strategy and rivalry, that is, the presence of a competitive environment determined by the firm's structure and strategy.

This model, firstly created to explain the national differences in industrial competitiveness was later extended for the interpretation of the innovative power of the localized clusters.

The cluster concept is defined by Porter (1998) as the "geographic agglomeration of companies, suppliers, service providers, and associated institutions in a particular field, linked by externalities and complementarities of various types".

This definition is built on three key pillars: the geography, the activity and the business environment. The first one relates to the fact that the clusters born the spatial agglomeration of actors in particular area, region or city. The second dimension deals with the interconnection existent among the firms of different industries for the production of goods and services. The last pillar considers the conditions of the environment that influence the cluster, such as the result of both individual and collective actions taken by companies, universities, public institutions, government agencies and others actors. These entities are able to sustain and provide innovation, due to the stimulating nature of the relative environment, based on a concentration of knowledge and needs[1].

Clusters may take different forms and arise from various situations, such as developing around universities and research centers, from networks of SMEs, or from the presence of large companies that either need supporting activities, attracting therefore specialized firms in specific fields, or spin-off different functions that locate near the parent company. Moreover, clusters are not static but evolve over time.

The creation of this concept was influenced by the Marshall's work as well as the one of industrial district, but creating a much broader notion, that allows for many configurations, among which the industrial district is actually one type. Although the cluster and the industrial district differ for many aspects, they both emphasize the significant effects that the concentration and interaction of economic activities have.

[1] See Porter, Ketels, in Becattini et al. (2009).

1.1.3 The Industry Life-Cycle Theory

An alternative theory on industry clustering was that developed by Steven Klepper (1997) that challenged the Marshallian idea of agglomeration economies. This new theory was developed based on the Industry Life Cycle (ILC) approach, considering the spinoff as the main driver for cluster formation. In fact, according to this new point of view, clusters are formed as a consequence of the presence of few successful parent companies that spinoff firms in the same location. The peculiarity of the new firms that emerge is the fact that they own particular competencies that derive directly from firm heritage. Therefore, the pre-entry background of companies turns out to be the key element for the creation of the cluster, given the fact that is not entry rate per se that enables the cluster formation, but is the entrance of specific firms that, given their inherited superior competencies, have higher probabilities to survive and consequently lower exit rates.

In many empirical studies made by Klepper itself, he found evidence that these spinoff firms located in clusters outperformed not only the other firms of the clusters, but also other spinoff firms located elsewhere. Moreover, his analyses confirmed that this superior performance derived from the parental heritage of such firms.

As a consequence of the results achieved, the Marshallian economies seem to be not needed anymore in order to reach some form of spatial clustering in certain circumstances. This does not mean that the two theories are mutually exclusive: even if the agglomeration externalities are not considered in this respect as the reason behind the cluster formation, they are still perceived as playing a role. In fact, the spinoff process alone is not able to explain the creation of clusters, which is influenced also by location factors. Moreover, the link existing between local externalities and spinoff process is evidenced by the fact that, given the superior capabilities of spinoff firms that derive from parent heritage, they are also more able to exploit such externalities and consequently reach better performances.

1.2 The ‘Milieu Innovateur’ theory and the concept of *relational proximity*

During the 1980s the ‘Milieu Innovateur’ theory[2] was conceived in France from the common work conducted by the *Groupe de Recherche Eurpéen sur les Milieu Innovateurs* (GREMI), composed by researchers coming from all European countries (mainly France, Italy, UK and

[2] The main contributors of this theory, authors of the main publications of the GREMI group are Philippe Aydalot, Roberto Camagni and Denis Maillat.

Switzerland), founded in 1984 by Philippe Aydalot, professor at the University of Paris 1, Panthéon-Sorbonne.

This theory moved a step forward in the analysis of the geography of innovation, considering for the first time the existence of other kinds of proximity, different from the pure spatial one, able to explain the localization of the innovative processes. In fact, it introduced the 'relational proximity' concept, identified by the social interaction, the cooperation among local actors and the interpersonal synergies embedded in a local context. In this sense, the firm is seen as part of an environment able to determine its actions, rather than as a single agent.

The Milieu Innovateur theory is therefore based on the hypothesis that "local environments play a determinant role as innovation incubators, they act like a prism through which innovations are catalysed and which give the area its particular complexion. A firm is not an isolated innovator, it is part of an area which makes it act and react. The history of an area, it's organisation, it's collective behaviour and it's internal structure of unanimity are the principal components of innovation" (Aydalot, 1986, p.62).

The innovative milieu is hence defined as "the set, or the complex network of mainly informal social relationships on a limited geographical area, often determining a specific external 'image' and a specific internal 'representation' and sense of belonging, which enhance the local innovative capability through synergetic and collective learning processes" (Camagni, 1991, p.3).

This theory shows an evident influence of the Marshallian industrial district theory, bringing the territorial conditions back in the consideration of the endogenous innovative capacity of a local context and attributing to the space an active role in the creation and exchange of knowledge, recalling also the importance of the socio-cultural proximity in the creation of cooperative relations. However, the innovative milieu theory introduces the economic and social relations between local actors as the key element that influences and determines the innovative capacity of specific local contexts. These relations are implemented by the geographic proximity and by the cultural and social homogeneities, which constitute the base of the cooperative learning processes. Here the space becomes therefore a 'relational space' made of shared values, norms of behavior and interpersonal relations between population, organizations and institutions, that foster interactions, exchange of knowledge and synergies through which the collective learning process can take place.

In this approach, the collective learning turns out to be the territorial counterpart of the learning processes that takes place inside the firms[3]. Therefore, it is identified as "the knowledge growth inside of a technological trajectory, incorporated in a local context" (Camagni, Capello, 2002) and defined as "the dynamic and cumulative process of knowledge production, transfer and appropriation, taking place thanks to the interactive mechanisms typical of an area with a strong sense of belonging and strong relational synergies" (Camagni, 1995).

These learning processes generate a virtuous cycle in terms of development, through a higher innovative capacity of firms, an evolution of the employment, an industry diversification, a modernization of the economy and therefore a higher competitiveness and a more rapid evolution of the knowledge at the local level that in turn foster the process of local collective learning[4].

This process occurs inside the *milieu* in a spontaneous way through solid and long-lasting forms of collaborations, such as forms of networks among economic agents localized in a specific area. These relations are based on values such as trust, loyalty, common culture, share behavioral codes and strong sense of belonging, which generate a transfer of both tacit and codified knowledge. In this sense, the importance of this theory also relies on the understanding of how the local network acts on knowledge, which is collected and incremented over time promoting the innovative activity through its exchange, creation and diffusion.

The relational proximity is therefore able to explain the common knowledge through the inclination of firms to form network relations. The limits that the small firms face in terms of knowledge base creation can be overcome thanks to the *milieu* and the relations established in it: due to their very short life cycles, those firms find some obstacles in the development of an own strong knowledge base, but this limit is overcome by the relations inside the *milieu*.

These economic and social relations inside the *milieu* can be both formal and informal. The former are represented by simple cooperation agreement among firms, public institutions and other actors between different territories. Formal relations carries out a complementary function with respect to the informal ones, and are characterized by networks system in which the territorial dimension assumes a relevant role in determining the location choice of the cooperative partners. The latter are instead processes of informal transfer of knowledge that take place in particular through imitative innovation processes and is what really binds the *milieu*.

However it exist a third type of relations that promotes learning through strategic alliances and agreements that the firms obtain from the outside, allowing an inflow of new knowledge,

[3] See Capello, 2005.
[4] See Camagni, Capello, 2002.

while remaining simultaneously part of other finalized relations. This is an important intermediate practice that permits, on one hand, an enlargement and renew of the local knowledge, avoiding on the other hand the risk of knowledge lock-in and its transformation into exit-barriers in terms of technologies.

The main aim of this theory was related to the understanding of the conditions external to the firm, favorable for the conduction of innovative activity, focusing in particular on the territory as a generator of dynamic efficiency. The cultural proximity, that is, the share of knowledge, common values, sense of belonging and interaction capacity, is the determinant of the so-called relational capital. This capital, considered as the base for the collective learning, is identified by the set of relations, such as implicit and explicit cooperation among economic actors, but also between private and public entities, that act in a specific territory characterized by geographic and socio-cultural proximity. Under this approach, the means through which this capital can be transformed into collective learning are identified by knowledge diffusion channels such as stable relationship with local clients and suppliers, spin-off processes and a high mobility of the local labor market.

Hence, the relational capital is the source of the dynamic advantage for the firms. These advantages realized by the *milieu* context are characterized by different kinds: first of all, firms can reduce the uncertainty related to the innovative processes thanks to the information collection, evaluation and elaboration that are carried out by the local *milieu* in a collective way. A second important element is the creation of norms of conduct, shared codes and rules that favor an ex-ante coordination of routine decisions and strategies, thanks to the reduction of transaction costs and of opportunistic behaviors. A final factor is the creation of personal interaction networks that act as a fundamental guarantee.

Another important consideration, made by Aydalot (1986), recognizes how different kinds of innovations localize in different contexts, depending on their nature and their source of creation.
He identifies three different kinds of 'technological trajectories' and their related environment. The first one refers to the incremental innovation, which appears to be dependent on the past experience and the knowledge accumulated from the firms located in a specific area where an industrial pattern exists. For this reason, this kind of innovations usually concentrate in mature industrial areas, characterized by a concentration of small and medium specialized enterprises that frequently interact with each other. Both the second and third types of innovation are identified by radical products. However, one arises from the knowledge generated by the R&D

departments inside big firms, and usually tends to locate in urban and metropolitan areas where these big firms locate, due to the maintenance of some sort continuity with the competences gathered inside those firms. The other depends instead on the universities and R&D public laboratories knowledge and is realized by new firms that generally born through spin-off processes and therefore usually locates close to research centers.

The identification of these differences in the innovations and the related context underlines the fundamental role played by all the various market actors, such as universities, big firms, research centers, various associations and public institutions that participate in the organization and coordination of the actions of the local economic environment.

1.3 The 'Learning Region'

Around the same period, another strand of thought started to set in at the international level, which was developed by the Danish school of Aalborg and the works of its founder, the economist Bengt-Åke Lundvall, on the concept of 'learning region'[5].

The learning region is considered a region characterized by the presence of rules of conducts able to support the collective learning that encourage the exchange of knowledge that, in the modern economy, is considered the most important resource available. This exchange takes place mainly through cooperation and interaction not only intra-firm, that is between the various internal functions, but also with external entities such as producers, customers, competitors, universities, R&D laboratories, public and private research organizations, development agencies, and many others.

The basic consideration made by this school of thought concern the fact that, in this phase of internationalization, the innovation process is experiencing a change of nature, characterized by an increase in its complexity due to the shortness of products life cycles. For this reason the innovation process is becoming the result of a non-formalized and an always more socially organized learning process, an idea that has been emphasized by Lundvall and Johnsons's (1994) concept of 'learning through interacting'.

The literature on learning regions also explored and underlined the importance of the tacit knowledge in this setting of globalization, as explained by Maskell and Malmberg (1999, p. 172):

[5] Behind the main contributors belonging to this school of thought, such as Lundvall, Johnson, Asheim, Malmberg, Maskell and Edquist, other papers were drawn from authors also from UK and USA, where this theory was widely adopted, where we find Cooke, Morgan, Boekema and Florida.

“though often overlooked, a logical and interesting consequence of the present development towards a global economy is that the more easily codifiable (tradable) knowledge can be accessed, the more crucial does tacit knowledge become for sustaining or enhancing the competitive position of the firm. […] In other words, one effect of the ongoing globalization is that many previously localised capabilities and production factors become ubiquities. What is not ubiquified, however, is the non-tradable/non-codified result of knowledge creation- the embedded tacit knowledge- that at a given time can only be produced in practice. The fundamental exchange inability of this type of knowledge increases its importance as the internationalisation of markets proceeds”.

Moreover, the interactive learning process occurring between actors is not unidirectional, but rather both the production and transmission of tacit knowledge occur at the same time, creating further knowledge, made possible only through this reciprocal learning.

What contributes to the stickiness of this kind of knowledge is essentially the presence of basic common factors that partners share, such as conventions, norms and language that are fundamental in the creation of trust and confidence. This seems to be the main reason behind the strong localization of innovative processes, depending not only on the geographical proximity, but especially on socio-cultural and institutional context. In fact these factors, suited for the production and transmission of tacit knowledge, are supported by a shared institutional environment.

The focus moved therefore to institutional and cultural aspects of the territory, such as all the economic, social and cultural rules embedded in a local context, rather than concentrating in those of the organization. Accordingly, the innovative process reveals impossible to be understood if not considered in relation with the socio-cultural and institutional environment in which it takes place. For this reason, it was introduced the concept of ‘institutional proximity’, defined as the set of shared rules, codes, traditions, behavioral habits, cultural practices and social conventions that facilitate the interactive learning of economic actors. However, the geographical proximity maintains a strategic role in the creation and share of tacit knowledge.

The interactive share of knowledge between organizations in the regions becomes one of its intangible collective assets, developed by the socio-economic system and able to determine the competitiveness of the region, that is, the condition that actually identifies a region as ‘learning’. In fact, these regions are characterized by the presence of localized capabilities that produce benefits that can be exploited only by organizations located in it. Among these intangible assets, Maskell and Malmberg (1999, p.181) include the region's 'distinct institutional endowment', stating that "it is the region's distinct institutional endowment that embeds knowledge and allows for knowledge creation which- through interaction with available physical and human resources- constitutes its capabilities and enhances or abates the competitiveness of the firms in the region.

The path-dependent nature of such localized capabilities makes them difficult to imitate and they thereby establish the basis of sustainable competitive advantage".

As also stressed by Florida[6] (1995), the new era of capitalism, has shifted to the competition of ideas as the principal vehicle to become competitive, requiring therefore a new kind of region that adopts principles of knowledge creation and continuous learning, becoming therefore 'learning'. To achieve this goal, the region must be composed by different infrastructure that facilitates the learning, ideas and knowledge flows: a manufacturing infrastructure of networks between firms and suppliers; a human infrastructure able to ensure a continuous education and training of workers; a physical and communicational infrastructure that allows an easier and just-in-time movements of goods and services, people and information; and finally the industrial governance system creating a flexible regulatory framework. In this way, "learning regions function as collectors and repositories of knowledge and ideas" (Florida, 1995, p.528).

In order to investigate how the interaction between actors involved in the innovation process is influenced by social, institutional and political factors, it was developed the 'National System of Innovation' (NIS). A further development was then made to account for the differences existing between various geographic areas of the same country that could differ significantly, elaborating the 'Regional Innovation System' (RIS) that is, the institutional infrastructure supporting the innovation process within a region, which is able to explain the regional differences in innovation capacity.

[6] Florida also developed an alternative way of thought, expressed in his book *The Rise of the Creative Class* (2002). The main idea is that the new driver of the economy is creativity rather than knowledge, which instead is considered, together with information, the 'tools and material to creativity', that produce innovations.
The group of creative people, considered by the author as an 'economic class', appears to be fundamental in the innovation process, generating added economic value through the members' creativity, which is completely intangible because hidden in their mind, and consequently creating economic growth and competitive advantage.
For this reason, is in the region's interest trying to attract and retain the creative population. This can be achieved by means of low entry barriers for people and the simultaneous presence of three fundamental characteristics called the '3T': technology, talent and tolerance.
The geographical concentration plays also in this case an important role. This concept has been able to explain the diversity in terms of economic growth and innovation among different cities and regions in the US. Given a positive and statistically significant correlation between the location of Creative Class and rates of patenting and high-tech industry, a higher competitive advantage is registered by those areas in which this class tends to concentrate.

These systems have been classified in three categories, both by Asheim (1998) and Cooke (1998) in a quite similar way, depending on their governance dimension. According to the latter author, the first kind of RIS, defined ‘grass roots’, refers to an innovation system which is generated and organized through learning processes at the local level. The second type, identified as ‘network RIS’ differs for the more planned characters given by the policy interventions aimed at the improvement of the regional’s institutional infrastructure. The last RIS called ‘dirigiste’ is a system stimulated mainly by institutions outside or above the region through the cooperation with actors outside the region itself.

Among these three types, the ‘network RIS’ is considered to be the favorite one under this theory, where an agglomeration of firms is encompassed by a supporting institution infrastructure, all at the regional level, helping innovation processes to take place.

1.4 Knowledge Spillover theory

During the 1990s, another application of the concept of proximity was made by the industrial economists with the so-called ‘knowledge spillover’ theory[7]. This theory was based on the main idea that an innovative firm localized in a concentrated area, is able to create advantages and positive effects for the other firms’ innovative activity in the surrounding environment by means of positive feedbacks of its R&D activity that ‘spill-over’ in the space. In fact, these knowledge spillovers arising from an entity research usually have positive consequences on the innovative processes of their ‘neighbors’, when localized within a certain distance from the source of knowledge.

Under this view, the space becomes again the fundamental element and the center of attention, since the geographical proximity appears to be the essential factor that allows firms to absorb these spillovers, which justify higher innovative capacity regardless of the firm’s specific characteristics. Indeed, the proximity with universities, research centers and other innovative firms belonging both to the same sector and to different sectors is the necessary condition for the realization of the knowledge spillovers, that is, voluntary and involuntary flows of scientific and technological local knowledge between innovative agents.

However under this approach the ability to exploit the knowledge spillovers is considered to be homogenously distributed in the space, considered to be a purely geographical dimension

[7] The principal empirical contributions to this theory were made by Audretsch, Feldman, Acs and Jaffe.

measured by the physical distance between actors and where the transfer of knowledge takes place only by means of ‘pure probability contacts’ that increase when the distance decreases[8].

However, the main lack of this theory is related to the fact that it focuses on the knowledge diffusion rather than on the knowledge creation. Therefore it is not able to understand the means through which the knowledge spillovers are able to spread in the local context, moving a step backward and ignoring all the other dimensions of proximity identified by the literature so far, hence not taking into consideration the learning process.

One of the main problem, related to the difficulty in the measurement of this knowledge flows and the interaction among regions, was overcome by the industrial economists due to development of advanced econometric models and statistical tools that, moving to an approach based on a spatial vision, captured the role of space in a more sophisticated way.

Many empirical analyses were conducted, considering as starting point the higher efficiency in the innovative activities resulting from the acquisition of knowledge from the external environment, enabled by the geographic proximity between the innovative firms and the sources of knowledge. The so-called Knowledge Production Function (KPF)[9] is the main method used to account for these effects, relating the innovative input, calculated by the R&D expenses, necessary to obtain innovative output, usually determined by the number of patent.

Within the numerous empirical studies relative to the knowledge spillovers, Jaffe, Trajtenberg and Henderson (1993) compared the geographic location of patent citations with that of the cited patent, as evidence of the extent to which knowledge spillovers are geographically localized. Using data coming from U.S. Patent Office, they investigated the citation patterns considering that every patent document includes some kind of references to previous patents that therefore act as a ‘supplier’ of knowledge towards it. In addition, every patent contains detailed geographic information about its inventors, enabling the conduction of analysis on whether and to what extent spillovers are localized. The results achieved indicated that the U.S. citing patents originated mainly from the same geographic area of the cited patents, therefore reaching a positive conclusion on the question related to the tendency of knowledge spillovers to spread within geographically bounded areas. Moreover, the authors also observed a tendency of

[8] See Camagni, Capello, 2002.
[9] The Knowledge Production Function (KPF) is often used as the starting point of the analysis of the determinants of innovative activity. It was developed by Griliches Z. (1979) and later implemented by Jaffe (1989) who introduced the spatial context inside the function.

localization to slowly decrease over time, meaning that the localization of early citation is more likely than that of the later ones.

Another important empirical research was developed by Audretsch and Feldman that aimed to examine the extent to which industrial activity clusters spatially and to link this geographic concentration to the existence of knowledge externalities. In particular, they wanted to explain why the innovative activities have a tendency to concentrate geographically more in some industries than in others. They used a database of 4.200 manufacturing innovations by four-digit standard industrial classification (SIC) industries as direct measure and calculated the locational Gini coefficient[10] for the geographic concentration of innovative activity. The results reached my means of econometric analysis illustrate that the industries with higher inclination for the concentration of innovative activities are those characterized by a vast presence of knowledge spillovers, due to the greater importance that industry R&D, skilled labor and university research assume in those industries.

With respect to this finding, the kind of knowledge that prevails in a specific industrial sector is the key factor that outlines the necessity and convenience that innovative firms have to localize in close proximity to the source of knowledge. The more specific, complex and tacit is the relevant knowledge, the more concentrated the innovative activity will be[11]. Moreover, also the technological opportunities are considered a factor of influence in the localization choices.

In conclusion, the numerous researches on knowledge spillovers highlighted that the production and innovativeness of firms and industries is associated not only with their own effort in terms of R&D expense, but also with the one of other neighbor firms or industries.

1.5 French School of Proximity and the *organizational proximity*

At the beginning of the 1990s, a group of researchers known as the 'French Proximity School' started to investigate the concept of proximity related to the production and innovation process. Born as an informal group of young academics, both from regional science and industrial economy coming from various French research institutions, it was then officially created in 1991 with the name of 'Proximity Dynamics group'[12].

[10] The locational Gini coefficient is an index that takes values ranging from 0, that is the situation of an industry which is not geographically concentrated, to value 1 that constitutes a situation of high concentration. This coefficient is based on the industry value-added.
[11] See Breschi in Malerba, 2000.
[12] The main researchers part of this group are Bellet, Torre and Rallet for the duality concept of proximity; Kirat, Lung, Carincazzeaux for the three proximity dimensions idea.

The intention of their reflection was the convergence and coherence of the collection of the new theoretical approaches regarding the economic space. Their aim was to combine spatial and industrial dynamics but without considering the territory as the starting point of the analysis.

In 1993 their first publication entitled ‘Economies of Proximity’ appeared as special issue of the French scientific journal *Revue d’Economie Régionale et Urbaine*. Edited by Bellet, Colletis and Lung and entirely written by researchers of this group, it contained numerous articles presenting the concept of proximity.

Their main important reflection states that the pure geographical proximity is not enough to support the knowledge diffusion in space and that, to understand the knowledge process, the so-called ‘organizational proximity’ is at least as important[13]. Differently from previous strands of literature, the unit of analysis becomes the firm or the organization, rather than the local space, due to the ability of this new kind of proximity to have an influence even in non spatial contexts, reaching therefore a first conceptual differentiation from the geographical proximity.

These authors stress the fact that the concept of proximity is more ambiguous than that of localization, because “being in proximity to someone not only means being near him/her, but also means having a strong complicity with a person who is geographically distant, whether that person belong to the same circle of friends, family, or even to the same network of firms or professionals” (Torre, Rallet, 2005, p.48).

From this concept derives the idea of a duality of proximity, composed by the geographical and the organized dimensions, which differ in their nature. The geographical proximity is considered as a binary measure categorizing the possibilities in ‘far from’ and ‘close to’. It is measured by means of the kilometrical distance that separates two entities in the space. In this way it assumes a neutral role, in the sense that, if taken alone, is considered not to be able to generate synergies. The idea behind this concept is that the co-localization of actors cannot be considered the driver of coordination, because although it allows an easier interaction between agents, it does not necessarily imply the creation of direct relations between actors at the local level. In order to stimulate interaction and coordination, which are considered the main factors necessary for the information and knowledge exchange, and therefore for the innovation process, the geographical proximity must be activated by the organized proximity.

The reason behind this idea is that there are many elements that influence cooperation, such as friendship, trust, social ties and inter-firm relations, called ‘ties of the territory’, that are

[13] See Torre, Wallet, 2014.

considered to have the same weight and importance. The organized dimension of proximity is a relational concept, defined by Torre and Rallet (2005, p.49) as "the ability of an organization to make its members interact". The authors divide the reasons of the importance of being part of the same organization in two 'logics': the 'logic of belonging' that facilitate cooperation by following the same rules and routines of behavior, and the 'logic of similarity' that considers the share of the same knowledge, believes and system of representation that, in a tacit way, make the actors feel 'alike'. An important characteristic of this form of proximity is that it often exists also without any geographical closeness and has the capacity to cross regional and national boundaries, therefore increasing the possibilities of long-distance collaboration.

Moreover, the authors underline how the intersection between these two kinds of proximity provides a set of different types of geographical organizations (such as industrial districts and innovative milieu) characterized by the existence of both proximity dimensions. This so-called 'territorial proximity' is a concept that deals with the "complex interplay between productive relations and spatial relations and their being inextricably linked" (Torre, Wallet, 2014, p.17).

A variant school of thought, the 'institutional approach' considered instead the existence of three proximity dimensions, including also the institutional one. This is defined as "the actors' adherence to a space that is defined by common rules of action, representations, thought patterns" (Kirat, Lung, 1999). This approach considers the actors' sticking to common rules of action, system of representation and values, explaining the importance of the political and institutional dimension, that is the legal component and the rules related to the social and economic relations.

Focusing on the two-dimension proximity approach, another important consideration made was related to the fact that the search for geographical proximity seems to be no more the main element that highlights the strategies of firms, due to an increasing necessity of mobility of actors, goods and information. In addition, the need to realize cooperation between actors does not necessarily require the actors to locate close to each other, in particular because often the need for geographical proximity is not permanent, but is related only to certain phases of interaction. Indeed, the organized proximity can be transformed into geographical proximity through the implementation of non-permanent co-location, such as temporary meetings between researchers and sales representatives, which are able to bridge this gap.

This possibility represent a possible solution in light of the fact that the authors recognized for the first time the existence of negative aspects related to the geographical proximity, able to transform it into an element of conflicts and tensions. Negative externalities associated with the use of the space can arise in fact in situations of so-called ‘geographical proximity constraint’, that is, in case of actors forced to tolerate a proximity that is not welcome, due to different logics of belonging and similarity. However, this rivalry can be reduced by means of the organized proximity because the exchange of viewpoints between agents often allows to reach an acceptable compromise in an easier way.

1.6 Evolutionary Economic Geography Approach

The most recent strand of thought is the ‘Evolutionary Economic Geography’, developed in Netherlands around 2000s that increases the number of proximity dimensions because of the need to account for all its different aspects, particularly in consideration of the evident insufficiency of the simple spatial aspect.

This new approach makes use of the key concepts and methodologies of the evolutionary economics in the context of economic geography, considering the routines of firms as the base of analysis. The reason behind this choice depends on the fact that those routines are believed to influence firms’ behavior and success over time. Therefore, the interest is focused on the understanding of routines creation and spatial distribution.

In this sense, this theory explains the emergence of spatial agglomerations in terms of path dependence, that is, “in terms of the historically grown spatial concentration of knowledge residing in organizational routines” (Boschma, Frenken, 2006, p. 278). Accordingly, the spatial agglomeration is influenced by the past industrial evolution process, and itself in turn has an influence on the industry’s further evolution. This may be the result of different processes occurring at both firm and regional level, by means of positive feedbacks that allow to learns from firms own mistakes (and search for new routines) in the former, and increasing returns due to knowledge spillovers in the latter.

For its characteristics, this approach can be seen as standing in between the neoclassical and the institutional approaches because differs, but at the same times presents common features, with either approaches. The position assumed by this theory is therefore intermediate, sharing the use of formal models with the neoclassical approach, and the assumption of bounded rationality from the institutional one, creating a link between the two.

However, this approach is based on a dynamic perspective in which past organizational routines and previous decision taken determine the actual behavior and location decision of firms, and can be changed by innovation and relocation processes. Therefore, the focus is on the process of birth and death of firms and sectors, on the role of innovation and on the co-evolution of firms/sectors with institutions[14].

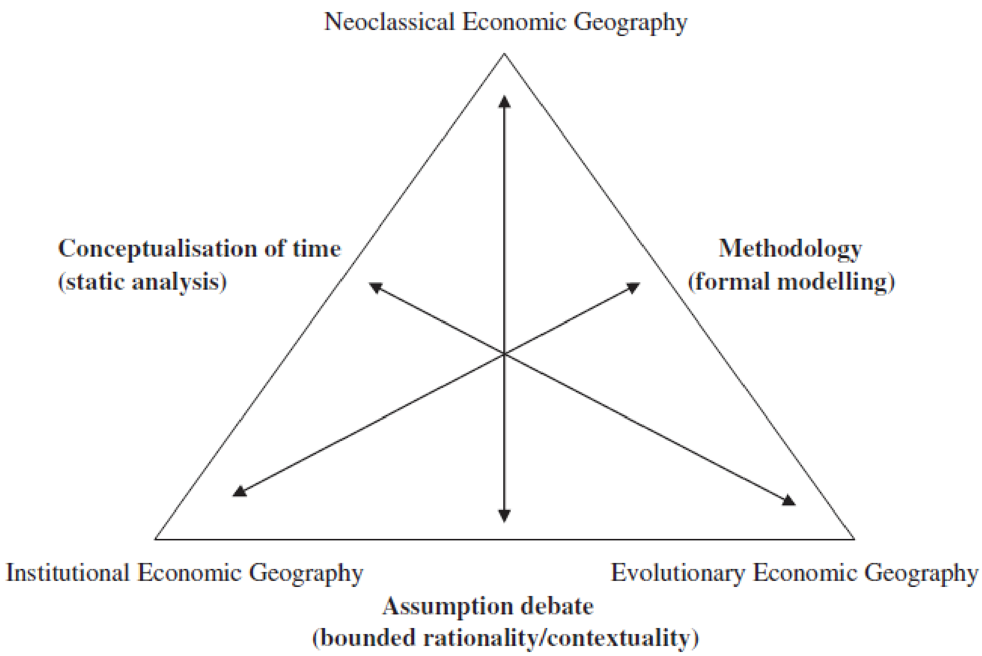

Figure 1: Three key issues within the triangle of neoclassical, institutional and evolutionary economic geography (Boschma, Frenken, 2006, p.281)

This theory moves from a static to a dynamic perspective, considering time as an important factor able to overcome the limits deriving from the static uni-causal relation between proximity and knowledge that has always been applied in the past. It is argued that, instead than looking at proximity between actors as the cause of their collaboration, it should be taken into account the co-evolution of proximity and networks ties. In fact, the time frame considered emerges as an important element, provided that "in the short run, proximity creates knowledge networks, in the long run, knowledge networks create proximity" (Balland et al., 2015, p. 911). This means that also knowledge networks play a role in this process, increasing the degree of proximity between actors involved.

Therefore, the main question under this approach, in order to analyze how the influence of proximity changes over time, is: "do actors chose others based on proximity characteristics, or do they become more proximate because they exchange knowledge?" (*ivi,* p.909*).*

[14] See Boschma, Frenken (2006).

In particular, the most known study is *Proximity and Innovation: a critical assessment* published by Boschma (2005) which considers five categories of proximity, distinguished into a geographic dimension and four non-geographic types. Within these four dimensions he identifies the organizational, social, institutional and cognitive proximity. The first one considers the relations and practices existing within an organization or between various organizations in terms of interaction and coordination. The second instead is a variable considered at the micro-level and is a matter of embeddedness in a social context, that is, of relations based on factors such as friendship, trust and experience. The third dimension is defined as the rules of the game, considering at the macro-level the rules and values of the institutional environment. Finally, the cognitive proximity concerns the closeness of actors in terms of shared knowledge base.

This last form of proximity, also referred to as technological proximity, allows to discriminate among the absorptive capacities[15] of various actors within a certain area. Therefore, the main idea behind this concept is that, given the fact that the knowledge base and the potential learning of actors is not always close, firms usually tend to cooperate with whom they are instead similar to them, in order to be able to understand each other and communicate more efficiently.

The use of different proximity dimensions on one hand strengthened the fact that, how already highlighted in previous literature, the pure geographical proximity is not enough to explain the localization of innovation processes and, on the other hand, disclosed the problem of the existence of negative aspects related to all the various forms of proximity. This is meant in the sense that proximity per se does not always have a positive cognition, indeed it could generate trap situations of 'lock-in' when being 'too much', but conversely it can also happen to be not enough or 'too little', using Boschma's words. However, every form of non-geographical proximity goes beyond the problems that could arise in such situations and fosters the effect of the geographical dimension.

Therefore, at present, the non-geographical forms of proximity seem to cover the main role in creating networks of actors, independently on their geographical location.

[15] The absorptive capacity is defined as "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends is critical to its innovative capabilities. Its a function of the firms prior knowledge" (Cohen, Levinthal, 1990).

2. THE DIMENSIONS OF PROXIMITY

Following the already mentioned analytical distinction on five dimensions of proximity proposed by Boschma (2005), that is, geographical, cognitive, organizational, social and institutional, this section presents a deep overlook into each dimension, highlighting the definition, pros and cons, and measurement method used in various empirical analyses.

One of the main goals of Boschma's work was to understand whether or not the geographical proximity still matters in inducing processes of interactive learning and innovation. The question is based on the awareness gained on the existence of multiple facets of proximity, all contributing in the reduction of uncertainties and in fostering the innovative activity, moving the geographical closeness into the background, due to the others' capacity to fulfill the same role. In fact, recently the geographical aspect is most seen as a mean through which strengthen the other dimensions, rather than as a direct input for innovation. This is the main reason behind the author's choice to analytically isolate the effect of this dimension from those of the others, in order to understand if it still actually plays a role.

2.1 The four dimensions of non-geographical proximity

2.1.1 Cognitive proximity as a prerequisite for learning

The concept of cognitive proximity was firstly introduced by Nooteboom (2000), who identified it as the "degree of similarity of the knowledge bases of organizations". The idea behind this notion is that, to achieve an effective transfer of knowledge between each other, which is a fundamental condition to start an innovation process, actors usually search for partners that share their same knowledge base. This happens because to reach this effective transfer and a mutual learning people need first of all to have a sufficient absorptive capacity to identify, interpret and exploit the new knowledge (Cohen, Levinthal, 1990). Consequently, in order to absorb this new knowledge, they require a successful communication with each other, a common understanding and processing of the information, that is, a certain degree of cognitive proximity.

The necessity of technological closeness depends therefore on the fact that, when people share the same knowledge base and expertise, they usually face an easier evaluation of external knowledge, but also a more simple combination and integration with the internal one and such condition may allows actors to learn from each other also in spite of geographical distance.

However, a fine line divides the benefits that could arise from a situation of cognitive proximity, from the constraints and disadvantages it could create. In fact, a 'too much' proximity condition, as identified by Boschma (2005), could become unfavorable and damaging for learning and innovation for three main reasons. The first one principally concerns the fact that, in order to create new knowledge, usually various aspects of knowledge itself are required, also different from each other in order to stimulate ideas and creativity, and the presence of a common knowledge base between actors lacks in this respect. The second possible negative aspect identified by the author that could arise is the so-called situation of 'lock-in': in order to reduce uncertainties, firms often behave according to routines and habits. However, these situations could act as a trap in the sense that it could become difficult to modify and change such repetitiveness and ordinary nature of actions, that impedes to gather new possibilities. The third risk related to a too close cognitive proximity is that of 'involuntary spillovers', that is, knowledge that spills over between organizations and that is impossible to prevent, therefore producing an undesirable benefit to those competitors able to exploit it.

Accordingly, a right trade-off between cognitive proximity and distance among organization should be achieved, in order for them to both be able to effectively communicate, transfer knowledge and learn, keeping away at the same time from trap's situations that would complex and meddle with the product innovation and novelty creation. This right balance between the maintenance of some cognitive distance to stimulate new ideas, guaranteeing at the same time enough cognitive overlap, has been identified by Nooteboom (2000, p.153) as a situation of 'optimal cognitive distance'. He states that "a tradeoff needs to be made between cognitive distance, for the sake of novelty, and cognitive proximity, for the sake of efficient absorption. Information is useless if it is not new, but it is also useless if it is so new that it cannot be understood".

In fact, it has been shown that the relationship between the cognitive distance among actors and their innovation performance follows an 'inverted U-shape', which means that neither 'too much' nor 'too little' cognitive proximity is optimal for the firm as shown in Fig.1. The right balance to be achieved is to find partners with which there exists a mutual understanding that allows collaboration, while maintaining enough distance to be able to learn and create innovations or, in other words, to keep a cognitive distance "which is sufficiently small to allow for understanding but sufficiently large to yield non-redundant, novel knowledge", (*ivi*, p. 72).

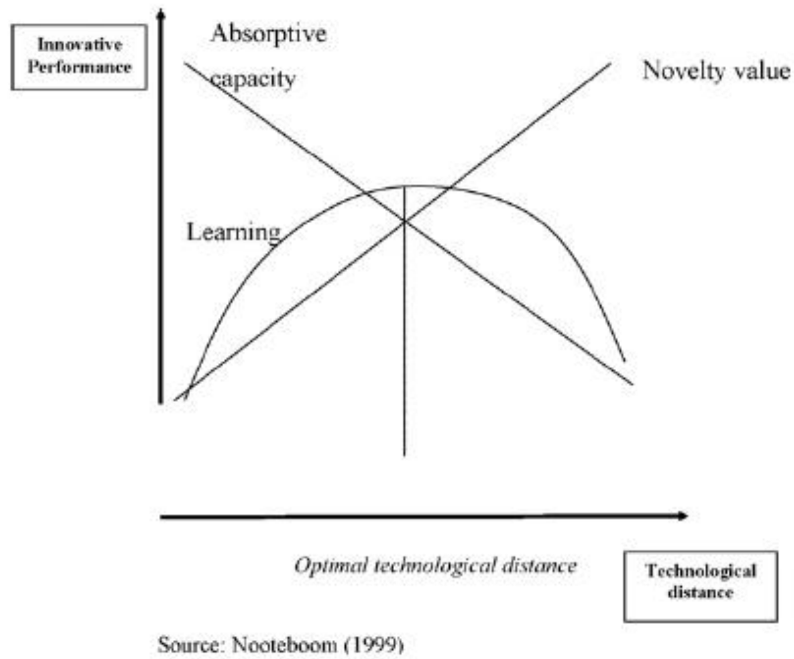

Figure 2: Optimal Cognitive Distance

This kind of relationship has been investigated and verified by numerous empirical analyses. Among these researches, Wuyts et al. (2005) conducted an analysis on 18 major pharmaceutical firms involved in 571 R&D agreements since 1985, in order to test the likelihood of technological innovation in relation to the cognitive distance of firms. They measured the cognitive distance by means of the ‘partner dispersion’ indicator, which characterizes a firm’s cumulative portfolio of R&D agreements. In order to test for the presence of an ‘inverted U’ effect, the authors included into the analysis also the squared of the partner dispersion indicator. By means of a logit regression model, the results reached provided significant influence of the partner dispersion index on the dependent variable, with a positive effect of the linear term and a negative effect for the squared term. This result indicate that “technological innovations are most likely to occur at intermediate levels of partner dispersion (in firms that strike a balance between engaging in different R&D agreements with the same partners and avoiding lock-in with a too narrow set of partners)” (Wuyts et al., 2005, p.288).

Analogous conclusions have been achieved by Gilsing et al. (2008) in a study based on a panel data of 762 alliances and on patenting activities of 85 companies in the chemicals, automotive and pharmaceutical industries that composed the sample. They aimed at understanding whether the technological distance played a role in the innovation potential of these firms. Using the USPTO[16] patent count as dependent variable, they computed the technological profile of each firm to understand whether the patents registered could have been considered as 'explorative'. This status, which is considered to be kept for three years, is given according to the number of patents a firm successfully filed for in a given year within a patent class in which it has not been active in the previous five years. In this work the technological distance is measured within a range that goes from 0 to 100 as the average of the correlations between the focal firm's technology profile and that of each of its alliance partners: the higher the value, the greater the cognitive distance. Using a random-effect Poisson estimator, the results achieved are the same as that of Wuyts at al. (2005), a positive effect of the technological distance and a negative effect for its quadratic term, both statistically significant, therefore highlighting again a inverted U-shape relation between cognitive distance and innovation.

Measuring the cognitive distance with the same method, a very similar study was conducted by Nooteboom at al. (2007) that however investigated how far this inverted U-shaped relationship holds across different contexts, considering in addition to the explorative patents, also the exploitative class. As already mentioned, the former category comprises those patents registered by a firm in a given year in which the firm has not been active in the five precedent years, while the latter is instead a category in which the firm has been active. These two groups have been used as dependent variables in the analysis, made on 116 companies observed over a 12 years period, where the patent classes have been determined at two-digit level, resulting in about 400 classes. Moreover, two different regression approaches has been used: a Poisson and a Negative Binomial. The regression results confirmed those achieved by Gilsing at al. (2008) for what concerns the explorative patents. However, the exploitative class turned out to be not statistically significant, therefore finding no relationship between this kind of patents and the innovative performance of firms, meaning that 'the positive effects for firms is much higher engaging in more radical, exploratory alliances than in more exploitative alliances'. This finding is in line with the Schumpeterian economics in which innovation seems to be associated only with exploration, while diffusion with exploitation (Nooteboom, 2000).

A non significant effect of the cognitive dimension has been found also by Balland (2012) in his study on the evolution of the Global Navigation Satellite System (GNSS) collaboration networks aimed at understanding how organizations choose their partners. In this case, rather than measuring the cognitive distance, the author uses a binary variable to straightly account for

[16] The United States Patent and Trademark Office (USPTO) is the federal agency for granting U.S. patents and registering trademarks.

the proximity aspect, considering four core competencies within this the GNSS industry: infrastructure, hardware, software and the whole of applications and services. This variable takes value 1 when two organizations share the same knowledge base and 0 otherwise. However, the non significant results obtained from the traditional multinomial logistic regression indicate that organizations do not necessarily need to collaborate with partners that share their same knowledge base.

A probable situation of 'too much' proximity has been faced by Broekel and Boschma (2012) that instead achieved a negative influence of the cognitive proximity on the innovation performance. The study, made in the context of the Dutch Aviation Industry, is considered as an interesting case due to the change occurred in 1996 consequently to the bankruptcy of the Fokker Company. This was the most important firm present at that time, playing a crucial role in this industry that contrarily at this time is mainly composed by SMEs with the absence of a dominant player. In this study the cognitive proximity is measured by the similarity of a firm's technological profile to that of its direct contacts, that is, the organizations to which it is linked to, based on three-digit NACE[17] codes assigned to each firm. Their finding, based on the observation of 42 profit and non-profit organizations, did not meet the expectation of an inverted U-shape relationship between the variable of the cognitive proximity and the share of significantly improved products/processes on a firm's turnover. Although, the cognitive proximity showed a negative and significant influence on the dependent variable, meaning that the more the technological profile of the partners overlap with that of the firm considered, the lower the innovative performance of the firms will be.

Another example of the negative impact that a situation of closeness could have on firm's innovation is presented by Li and Vanhaverbeke (2009) in their analysis on the relationships between firms and suppliers. This study was based on 550 innovating firms and about 2.500 other companies, including suppliers and customers related to these companies, belonging to 79 different industries. Specifically, they focused on the pioneering innovations that are composed by those products which are technologically radical and present also an element of market novelty. These are then labeled into three different categories, depending on their degree of novelty that ranges from the newness limited to the firm only, from that of the entire world. However, despite the high level of innovation, the binary logistic regression brought to negative

[17] NACE (Nomenclature of Economic Activities) is the European statistical classification of economic activities. Organizations are grouped, accordingly to their business activities, into a hierarchical four-level structure: section, divisions, groups and classes.

results and again it was not possible to observe an inverse U-shape relationship, due to the non significance of the quadratic term. In fact, using the inter-industry difference between the innovative firm and its supplier as a measure of cognitive distance, the findings revealed that in this case, in order to increase the likelihood of generating pioneering innovations, the firm and its supplier should belong to very different industries. The authors justify this result with the need for the firms to get access to new or complementary knowledge to be recombined in order to develop such kind of innovations, that otherwise would not be possible. Therefore, the introduction of such radical kind of innovation seems to be dependent in this case from the active search for new knowledge outside the industry boundaries, rather than among similar technological fields.

Nevertheless, most of the empirical researches provide support for a positive impact of the cognitive proximity, both at the organizational and at the region level.

In particular, at the firm level the technological overlap seems to provide support for the cooperation among actors, as showed in Cantner and Meder (2007) and in Hardeman et al. (2015), which can be considered as a form of innovation.

At the regional level instead the specialization structure of each area is considered, given that a region's success in innovative capacity is affected by its own R&D activity, but also by that of its neighbors in the technological space, resulting therefore in technological spillovers. The dependent variable used in these analyses is mainly the patenting activity of a specific region, where the patents are usually disaggregated into several sectors for each region, usually according to the International Patent Code (IPC)[18] classification. What changes is however the way in which the cognitive proximity or distance variable is measured.

Most of the researches base their technological similarity calculation on Jaffe's (1986) methodology, resulting in a measure that takes value equal to unity in case of perfectly similarity in the technological structure of the regions, and zero otherwise. According to the author, the first thing to do to account for the effects of such spillovers is to identify the technological areas in which the firms are engaged in research. The very existence of these spillovers implies that the research activity of a firm's neighbors in the technological space affect its own R&D success. From this idea, Jaffe assumes that "the total relevant activity of other firms can be summarized by

[18] The International Patent Classification (IPC), established by the Strasbourg Agreement 1971, provides for a hierarchical system of language independent symbols for the classification of patents and utility models according to the different areas of technology to which they pertain. A new version of the IPC enters into force each year on January 1.

a 'potential spillover pool' that is simply a weighted sum of other firms' R&D, with weights proportional to the proximity of the firms in technological space" (*ivi*, p.986). Therefore, considering the organizational level, to measure the technological proximity between firms *i* & *j*, the author uses the 'angular separation' between them, that is, the 'uncentered correlation' between their respective vectors Fi and Fj of technological position, where $F_i=(f_{i1},\dots,f_{iK})$ and $Fj=(fj1,\dots,fjK)$; therefore the formula turns out to be:

$$Pij = \frac{\sum_{k=1}^{K} FikFjk}{\sqrt{\sum_{k=1}^{K} Fik^2 \sum_{k=1}^{K} Fjk^2}}$$

To measure the quota of research activity of firm *j* that spills-over to firm *i*, the potential spillover pool S_i is then constructed using this definition of proximity, weighted for the amount of R&D activity undertaken by firm *j*, denoted as R_j:

$$Si = \sum_{j \neq i} PijRj$$

The reasoning behind the spillover effects is that "since knowledge is inherently a public good, the existence of technologically related research efforts of other firms may allow a given firm to achieve results with less research effort than otherwise" (*ivi*, p. 984).

In order to account for the technological proximity of two regions, the same formula of technological proximity is applied, considering regions *i* & *j* and their relative patent class *k*. Some researches that make use of such calculation methodology are, for example, Moreno et al. (2005) and Greunz (2003) that accounted for the 'technological neighborhood'. The former determines such measure by computing a technological matrix calculated by means of patent application data disaggregated into 101 different sectors for each region, finding a strongly significant influence exerted by the innovation performed by contiguous regions on the patenting activity of the region considered. The latter identifies three orders of technological neighborhoods depending on the region's value of P_{ij}, and reaching a confirm on the importance of technological proximity between regions in Europe, given the statistical insignificance of the 2nd and 3rd order of proximity against a positive value, significant at the 5% level, of the 1st order of proximity, that is, the closest one. To control for existence of stronger spillovers between similar regions, Bottazzi and Peri (2003) used the Technological Proximity Index (TPI) developed by Jaffe

(1986), dividing patents into 30 technological classes, and weighting it to the R&D done in other regions, reaching again a slightly less, but still significant, positive result.

A quite different method used is that of Marrocu, Paci and Usai (2013) that measured the cognitive proximity across regions computing a 'similarity index' between regions *i* & *j*, based on the distribution of patenting activity among 44 sectors, which takes values that range from zero to one: the higher, the more similarity, and therefore the more the probability of knowledge exchange between the two regions. The index is computed for each couple of regions in order to build a technological proximity matrix, allowing an understanding of whether regions with a common technological background are more likely to benefit from mutual knowledge flows, regardless of their geographical location.

In conclusion, given the different technological base of various industries, there could be situations in which more or less cognitive proximity is needed, but at least in part both should be present because "a large cognitive distance has the merit of novelty but the problem of limited comprehensibility […]. People can collaborate without agreeing, it is more difficult to collaborate without understanding, and it is impossible to collaborate if they do not make sense to each other", (*ivi*, p.72, p.155).

2.1.2 Organizational Proximity

The second dimension of non-geographical proximity is the organizational form, defined by Boschma (2005, p.65) as "the extent to which relations are shared in an organizational arrangement, either within or between organizations. To be precise, this involves the rate of autonomy and the degree of control that can be exerted in organizational arrangements".

This dimension is therefore considered as an important aspect needed to foster interactive learning. In fact, the exchange of knowledge owned by many different actors both within and between organizations is needed to create new knowledge and consequently implement the learning process and create innovation. Therefore, actors that are organizationally proximate are able to take advantage of the possibility to reduce uncertainties related with the creation of new knowledge and innovation process but also to avoid the related opportunist behaviors. This is enabled by the presence of control mechanisms and ties that produce feedbacks needed to transfer complex knowledge, which are usually present inside hierarchical organizations or tight relationships among organizational units, given the frequent inability of the markets to fulfill these tasks because of the too high transaction costs that would be faced.

However as highlighted by Boschma (2005), also the organizational dimension of proximity presents some limits and negative influence under certain conditions. First of all, a situation of ‘too little’ organizational proximity represents a lack in the controls needed that could therefore result in a presence of more opportunistic behaviors that damage the knowledge creation. Contrarily, when there is ‘too much’ organizational proximity different disadvantageous situations could arise, such as ‘lock-in’ and lack of flexibility.

The former can take place in the form of high-dependency relations, due to an asymmetric structure of the relation itself, characterized by different power or size between the partners involved. The problem related to this condition is that the hierarchical structure, on one hand is usually composed of ties that are too strong and close, therefore reducing the possibilities of novelty for which is usually required to ‘go out of the established channels’. On the other hand, interactive learning becomes difficult to achieve because of the shortage of feedbacks issued by this governance structure that consequently provides very little rewards of new ideas.

It is the non flexible nature of the hierarchical organization that entails also the latter situation, hence reducing the possibilities of innovation: a too tight structure in fact often causes negative effects on innovation, given the fact that possible initiatives would not be rewarded and for this reason are not undertaken, as a result of the high dependence of the relations involved.

Also in this case a balance between control and flexibility should exist in the organizational proximity, with the presence of decentralized organizational units constituting a relatively flat network that is coordinated in a centralized manner. This would ensure both the potential to develop new knowledge and its integration into organizational routines. According to different authors this condition could be observed in the so-called ‘loosely coupled’, that is, systems including both flexibility and control, maintaining the advantages of the organizational proximity while keeping a certain degree of distance.

Moreover, the organizational dimension of proximity is also able to encourage the cognitive proximity by means of both relationships within an organization but also between various units belonging to different organizations, resulting in organizational arrangements among groups of people characterized at the same time by cognitive proximity and distance. An example of this situation is presented in the study of Cunningham and Werker (2012), aimed at testing the influence of various proximity dimension, including the organizational one, on the collaborations between agents in European nanotechnologies. This research, based on the 100 most productive European organizations, considers the organizational proximity in relation to the type of organization carrying out the research, divided into academic and non-academic, to account for the influence that similar structures with comparable background could have on the collaboration intensity, measured by the total amount of co-publications conducted between two organizations. Therefore, the authors consider the relations occurring among exclusively academic institutions, exclusively non-academic and a mix of the two forms using a categorical variable, finding however always non significant results of the negative binomial regression model applied. This implies that the organizational proximity seems to have no direct influence on the collaborations meaning that it is more important to rely on different kinds of collaborations to be able to benefit from the advantages deriving from a group. Nevertheless it emerged that the organizational closeness does have an indirect effect because both the academic and non-academic partnerships are able to mediate the technological proximity.

Relatively to the collaborations between actors in the innovation system, another empirical analysis is that of Hardeman et al. (2015), investigating the co-publication data in the field of type-2 diabetes. Using data on 1.218 distinct organizational branches, considers ‘Mode 1’ and ‘Mode 2’ knowledge production that is, respectively, production of knowledge when actors are close or distance to each other. Contrarily to the previous study, evidence of positive and significant influence of the organizational proximity was found at the global level, measured as a dummy variable that takes value equal to one when both the organizations *i* & *j* belong to the same hierarchical meta-structure, therefore showing a positive impact of cooperative relations of colleagues and the orientation towards a shared goal.

However, not always the organizational dimension appears to be significant. This result has been reached in particular by Broekel and Boschma (2012) in their already mentioned work on the aviation industry. The organizational proximity, calculated by the share of contacts or knowledge links that each firm has with no-profit organizations, is measured in this context according to a different concept that considers the degree of similarity in routines and incentive mechanisms between organizations. For this reason profit and no-profit organizations are counterpoised, presenting very different goals and therefore a low degree of organizational proximity that should therefore decrease the probability of collaboration. However, their findings turned out to be non significant with respect to this variable that does not matter for innovative performance.

However, many of the analyses made at the firm level concerning the organizational dimension of proximity actually find very different results according to both the kind of innovation considered but also the organizations themselves.

For example, Oerlemans and Meeus (2005) question whether there is a positive relationship between the extent to which innovating firms use their external resources base and their relative performance, considering the relative percentage changed process and products of 365 firms between 1989 and 1994. This question rises for the rare presence of all the necessary resources internally to the firms, which are therefore required to be acquired externally. In this study the organizational proximity is measured by two different variables: the R&D cooperation and the external contributions granted to the innovation process by different partners, specifically the intermediaries, the educational institutes, the business agents and the innovation advisers. Specifically, the survey conducted asked innovating firms how often in the last five years external organizations provided ideas for the realization of innovations, or at least contributed in this sense. However, the stepwise OLS regression analysis conducted brought to mostly non significant results. In fact, the only significant variable is the external contribution of business agents, that are important users and suppliers, which positively influences the innovation performance of firms.

Another case of contrasting results is the empirical analysis of Cusmano et al. (2009) that also considered the product and process innovations as dependent variables. However this study measures the organizational closeness in a different way, that is, taking in consideration the intra-group offshoring of various activities at least partially to foreign affiliated members belonging to the same group. The phases considered in this context are the production and assembly, the R&D and design and lastly the service activities. The results of the probit analysis conducted on 1.148 manufacturing firms showed no significant influence of this variable on the process innovation, while it does impact the product innovation but only with respect to the R&D and design phase. Moreover this seems to be closely related also to the geographical proximity in the sense that the higher the spatial distance, the greater the importance of organizational closeness in such activities between firms, meaning that in situations of geographically far outsourcing of activities is important to keep the R&D and design phases close at least in organizational terms.

Similar results but at the regional scale have been achieved by Ponds et al. (2010) in their analysis on the effects of knowledge spillovers from academic research on regional innovation. In particular the authors considered 40 regions at the NUTS[19] 3 level for 7 science-based technologies for a total of 280 observations in order to investigate the effect of both geographical and organizational proximity on the average number of patents applied for by firms at the European Patent Office (EPO)[20] between 1999 and 2001. The organizational proximity is considered in terms of research collaboration networks between universities and firms, measured by a network weight matrix, resulting in a positive and significant variable. This outcome provides evidence for the presence of collaborative research also over longer distances and at a multiple spatial scale.

In particular, almost all of the analyses carried out at a macro level, that is, on the regional scale, consider the patenting activity as dependent variable and brings to significant and positive influence of the organizational proximity.

An example is provided by the already treated study of Marrocu et al. (2013) that considers all the five dimensions of proximity, and refers to the organizational one as 'the relations within the same group of organization which influence the individual capacity to acquire new knowledge coming from different agents'. This variable is measured considering the relation associating inventors and applicants of patent residing in different regions, resulting also in this case to have a positive and significant influence on the dependent variable.

Another research to be mentioned is that of Maggioni et al. (2007) that considers about 30.000 EPO co-patents applications in 109 European regions. The organizational proximity is here measured as the number of joint membership of region within the considered subset of 5FP[21] and adopting an OLS procedure the results again show a positive and highly significant influence at 1% level of this variable.

All these studies provide diverse results and conclusions given the fact that the findings achieved clearly depend not only on the context analyzed, but also on the way variables are measured and taken into account.

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[19] The NUTS (from French *Nomenclature des unités territoriales statistiques*) is the Nomenclature of Territorial Units for Statistics, used to divide the countries members of the European Union for statistical purposes and the European Union's structural funds delivery. Introduced by the Eurostat in 1988, it considers the local administrative units according to three hierarchical levels: the smaller unit is the NUTS 3 composed of counties, municipalities, cantons, districts, etc. The second level is the NUTS 2, that is, regions, provinces, prefectures and so on. The last level is the NUTS 1, made of groups of NUTS 2 such as macro-regions.

[20] The European Patent Office (EPO), supervised by the Administrative Council, is the executive arm of the European Patent Organisation, offering inventors a uniform application procedure which enables them to seek patent protection in up to 40 European countries.

[21] The Five Framework Program (5FP) is a program that promotes scientific research and technological development within the EU financing research project within a time interval of five years.

2.1.3 Social Proximity

The concept of social proximity derives from the concept of 'social embeddedness' developed by Granovetter (1985). In his work he explains that behaviors and institutions are affected by social relationships, in which economic actions are embedded. However he also highlights that if on one hand social relations may be a necessary condition for a trustworthy behavior, on the other hand they seem to be not enough to avoid occasions for what he calls 'malfeasance', that is, conflicts that could even arise as a consequence of social relations themselves. He finds three reasons of this situation: the first one is that the trust produced by personal relations for its own essence intensifies the opportunity for malfeasance, given the fact that such kind of relations are based on confidence, and therefore higher vulnerability, but also on self-interest of the parties involved. A second reason provided by the author is that force and fraud are usually elaborated by teams, which are structured according to a level of internal trust that follows preexisting lines of relationships, and not by a single person. Therefore he stresses the idea that 'both enormous trust and enormous malfeasance may follow from personal relations'. Finally, the last reason he finds is highlights the importance of how such networks of social relations are structures. Moreover, he adds that "networks of social relations penetrate irregularly and in differing degrees in different sectors of economic life, thus allowing for what we already know: distrust, opportunism, and disorder are by no means absent", (*ivi*, p.491).

The embeddedness literature therefore considers not only the positive aspects related to the embeddedness of economic relations of a firm in a social context, such as the possibility to put in place an interactive learning process, increasing the innovative performance of firms, but also the negative aspects that could arise from such relations under various circumstances.

A further theoretical discussion on this idea was made by Uzzi (1997) that, based on Granovetter's thought of economic actions embedded in networks of relations, affirms that is fundamental to specify the dimensions of such relations and the mechanisms by which influence the economic actions. He sustains that "embeddedness is a unique logic of exchange that results from the distinct social structure of organization networks and the microbehavioral decision-making processes they promote. In an embedded logic of exchange, trust acts as the primary governance structure", (*ivi*, p.61). The step further taken by this author is in the assertion that the positive effects deriving from embeddedness rise up only to a certain threshold after which the embeddedness itself hinders firms' economic performance, given a higher vulnerability and a confinement inside the network that preclude the firms from external information.

Based on this concept, Boschma (2005) builds his notion of social proximity, defined as "socially embedded relations between agents at the micro-level. Relations between actors are socially embedded when they involve trust based on friendship, kinship and experience", (*ivi*, p.66). This form of proximity is required in particular for the importance assumed by the tacit knowledge in the innovation process, which is more easily exchanged, communicated and traded by means of social relationships.

However, just as all the other proximity dimensions, also this one provides positive effects only up to a certain threshold, while negative situations could arise given the fact that this aspect of proximity is considered more importantly as a prerequisite needed to reduce possible opportunistic behaviors, however not enough to eliminate them. In fact, the opportunism is usually underestimated in presence of loyalty and friendship between actors, neglecting the fact that the greater the uncertainty in a given circumstance, the more the common attitude among actors would be the opportunism itself. This is one of the consequences of a situation of 'too much' proximity, together with the usual 'lock-in' risk, provoked by long-term relations or too much commitment that could result into a sort of conventional modes of operation among members of a networks, therefore reducing their learning and innovative capacity. As always, also in this case a 'too little' social proximity entails in the same way negative consequences, in particular precluding efficient innovations given the related lack of trust and commitment.

In sum, the social proximity is optimal when it consists of a combination of embedded social relations and arm's length ties, guaranteeing low transaction costs, loyalty and trust but also open-mindedness, flexibility and a certain degree of alert. Even this dimension is not isolated from the other, which instead it seems to be related with the cognitive, organizational and geographical forms. In fact the social proximity is considered to be able to decrease the cognitive distance over time; however, its combination with the organizational form does not provide a positive effect, due to the hierarchical structure of the latter which discourages it.

Moreover it is also supported by the geographical closeness, particularly by the agglomeration forms, considered to favor social interaction and trust among actors while offering a wide range of potential partners and external networks with whom interact. An empirical analysis based on this last consideration is that of Gurrieri (2008) that aims at confirming the idea that social proximity plays a crucial role. She focuses on the Italian clusters of small firms in the Apuleia textile network, considering a sample of 166, and accounting for the social capital as the co-operative potential of these firms. She concludes identifying the network inside this cluster as the 'mean for spreading competence and knowledge through the social substrate' and confirming the important role played by the social proximity in such contexts.

Most of the empirical analyses actually find evidence of the importance of the social proximity in various situations, both in relation to process and products innovation and to the creation of collaboration networks. Starting with the analysis of this latter situation, Ter Wal (2014) counterposes the geographical proximity to the so-called 'triadic closure', which is a specific case of social proximity that considers the case in which 'partners of partners becomes directly connected closing a triad in the network', in order to understand the related influence on the probability of collaboration. This study, based on the dyad level, that is, on inventor pairs, takes into account two different observations: 238.092 observations for USPTO and 2.044.711 observations for EPO the entire periods considered. For each pair of inventors at a certain point in time, the social proximity is then calculated as the 'inverse of the path length between them in the co-invention network at time t-5'. The results show a positive and significant impact on the creation of collaborations, being able even to overcome in terms of importance the spatial proximity after its initial role of collaboration driver.

A similar analysis that also carries out similar results was implemented by Autant-Bernrd et al. (2007). Using again the R&D collaboration as dependent variable, a sample of 139 entities of which 63 SMEs participating in the research project submitted to the 6th Framework Program[22] of the European Union was used, considering whether or not the entities involved submitted at least one proposal together. Through a logit model they achieved a positive and highly significant result for the social proximity, which was measured as the inverse of the geodesic distance between firms *i* & *j*, where the geodesic distance is the minimum number of links existing between the two firms in the network. These findings demonstrate not only that firms are more likely to cooperate when the social distance between them is small enough, but also that social dimension itself seems again to matter more than the geographical one.

Measuring the social proximity quite in the same way, that is, as the geodesic distance 2 between two organizations as if they have a partner in common, that is, partners of partners (considering that the geodesic distance 1 is the collaboration between partners), the already mentioned work of Balland (2012), using too the establishment of collaborations as dependent

[22] The Sixth Framework Programme covers Community activities in the field of research, technological development and demonstration (RTD) for the period 2002 to 2006. It is a collection of the actions at EU level to fund and promote research.

variable, find however no relevance for the social proximity. His results therefore imply that trust and friendship are less likely to occur when collaborations are made of multiple partners.

No significant results have been reached also by Fafchamps and Söderbom (2013) in their analysis on the networks of manufacturing firms in Ethiopia and Sudan. However, differently from the previous works mentioned, in this case the type of innovations considered were related to new products, investments in plants and equipments and the conduct of R&D. Using data regarding 304 firms in Ethiopia and 401 in Sudan, an OLS regression was performed. The variable of network proximity, measured as the firms *i* & *j* trade between each other, did not provide evidence of its influence on the various innovations considered, if not for the conduction of R&D activity in Sudan.

Still regarding product and process innovations made at the firm level, many analyses found instead an important value of the social proximity, which is however measured in various different ways. Among these, Capello and Faggian (2005) accounted for it considering the relational capital, that is, 'the set of all relationships, such as market, power and cooperation, established between firms, institutions and people that steam from a strong sense of belonging and a highly developed capacity of cooperation typical of culturally similar people and institutions', of which the social proximity constitutes the basis. A different measure was instead used by Broekel and Boschma (2012) that, in their previously mentioned work described in the first Section of this chapter, defined the social distance as a dummy variable taking value equal to unity in the case that the former employees if the Fokker B.V. are members of the top management of both firms. A third analysis computed by Agrawal et al. (2008) considers an even different measure of social proximity that is the co-ethnicity of inventors, taking into consideration the US resident Indian diaspora. This last measurement method however is explicitly not included in Boschma's (2005) identification of social proximity, which does not consider situations of shared ethnic and religious values, that is instead considered at a more macro-level as a cultural aspect of proximity.

Other works that measure the social proximity with more than one proxy rather find contrasting evidence. For example, Fitjar and Rodríguez-Pose (2011) account for the social proximity dimension, considering both the trust and open-mindedness of actors that, in a work-related context, show different results. In fact the OLS estimation conducted using data of 436 managers of regional businesses, shows a significant and positive influence of the former variable while does not find any significance for the latter when making no distinction in the geographical space. Looking in more detail however, while the work-related open mindedness does not change, the trust among managers and staff shows to be tied to the regional level, becoming no significant as the geographic distance increases. Considering the regional level, de Dominicis et al. (2013) instead found this variable to be no important. Their analysis, based on 146 NUTS 2 regions in Europe and taking into account as usual dependent variable the number of patent applications, considered the social capital as the 'set of institutions, relationships, attitudes and values governing interaction among individuals and contributing to economic and social development'. Two different variables were used to measure the social proximity: the trust that, as already said, showed no significant impact, and the entrepreneurial capital which instead turned out to have a positive influence on innovation. This latter variable reflects the participation and satisfaction of individuals to social and civic life and the attitude to assume a leading role, that afterward matters more than trust in such situation.

In conclusion it can be said again that, this proximity dimension brings to different results because it depends on the context, on the level of the analysis, but even more on the measure adopted to account for the proximity itself: the concept of social proximity in broad terms includes various facets, but as seen in these analysis, it could be that, depending on the context, not all its aspects and components turn out to be relevant.

2.1.4 Institutional Proximity

The concept of institutional proximity developed by Boschma (2005) considers the common idea of actors sharing the same institutional rules of the game, such as norms and values of conduct at the macro-level. Following North's (1990) distinction made between the macro and the micro level of institutions that is, respectively, the institutional environment and arrangements, Boschma does not take into consideration the latter, therefore not considering the cultural aspects such as habits and values incorporated in specific relations, that have been comprised in the other forms of proximity (specifically in the organizational and social ones).

The institutions, considered as composed by a combination of formal aspects, such as laws, rules and norms, and of informal features consisting of routine behaviors, habits and conventions, act in the regulation of the interaction and relations occurring among entities. In the execution of such operation the institutions have an effect on the reduction of uncertainties and transaction costs, therefore affecting the innovation capacity through the influence exerted on knowledge transfer, making the interactive learning process effective.

However, as already seen in all previously examined proximity dimensions, also the institutional one can transform into a constraint, precluding the realization of the conditions necessary for the interactive learning, hence producing negative consequences for the innovation process. This, as always, happens for the two extreme situations of ‘too much’ and ‘too little’ proximity. The first one could develop into a state of ‘lock-in’, providing no opportunities for new ideas and innovations due to the obstacles that newcomers have to deal with. Moreover, in could also evolve into a situation of ‘inertia’, that is a rigidity condition where no changes, reorganizations or adjustments are made, which would however be fundamental for the development of new ideas and innovations. The opposite circumstance concerns the absence of adequate institutional structures and a shortage of common values and social cohesion. Also in this case, Boschma explains that the exemplary solution would be to have a reasonable equilibrium between stability, openness and flexibility of the institutional structure.

This dimension of proximity appears to be strongly related to the others forms, with particular regard to the social and organizational ones. In fact, while the presence of institutional closeness between actors and organizations may enable the creation of organizational arrangements, in its absence the social proximity could act in compensation of such dearth. Also the geographical proximity seems to be linked with both the formal and informal kinds of institutions since the former type usually acts at the macro level (nations and states), while the latter is often more spatially localized.

However, many analyses conducted on this subject measure the institutional proximity in different ways. A classic study on institutional proximity is that of Gertler (1995), investigating not only the importance of closeness between collaborating parties (users and producers) in the successful development and adoption of new technologies, but also which kind of closeness among physical, organizational and cultural does actually play a role in this context. This research was carried out considering manufacturing firms in the province of Ontario, Canada, where the advanced machinery sector is considered relatively underdeveloped. The survey conducted highlight the considerable influence exerted by the cultural proximity, where culture is intended here as “a set of dominant workplace practices shaped in large part by legislative definitions of employment relations and the nature of the (public and private) industrial training system” (*ivi*, p. 6). Therefore, his findings underlined the importance of the countries’ regulatory and institutional framework in interfirm relationships.

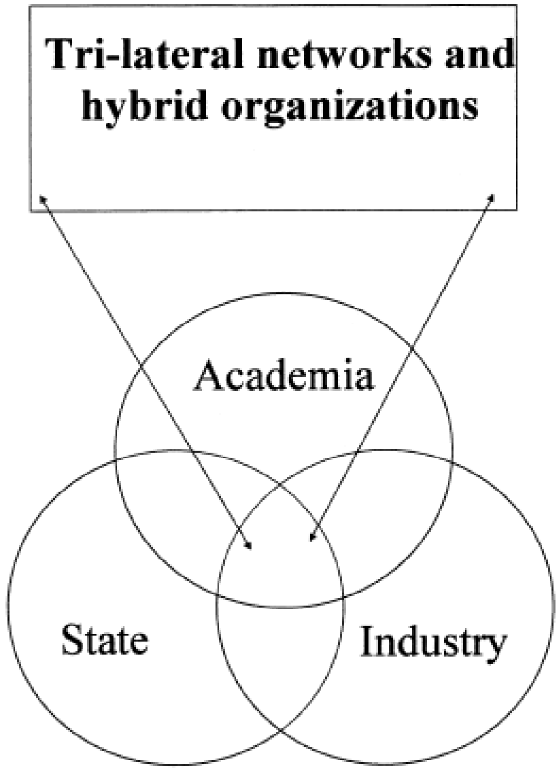

Figure 3: A Triple Helix Model of University-Industry-Government relations,

(Etzkowitz, Leydesdorff, 2000, p.111)

A different perception of the institutional proximity is that made by Ponds et al. (2007) that consider different kinds of institutional backgrounds and forms in terms of incentive structure distinguished between firms, universities and governments, according to the Triple Helix Model (Etzkowitz, Leydesdorff, 2000). This model attributes an increasing importance of more than just one dimension of institutional structure in improving innovation, given the increasing knowledge-base layout of societies. “This structure in which each strand may relate to the other two can be expected to develop an emerging overlay of communications, networks, and organizations among the helices”, (*ivi*, p. 112).

Therefore Ponds, van Oort and Frenken investigated the co-publication from collaborations in scientific research between different types of organizations: academic organizations, companies and government/no-profit entities. The results achieved by means of a negative binomial regression denoted that being close in terms of institutional structure and background enhances organizations to collaborate more. Instead, when divergences in the institutional structure are present, the geographic proximity seems to mediate in this sense, playing an important role in an indirect way overcoming the institutional differences.

Other empirical analyses were developed on the basis of this work such as the previously mentioned studies of Hardeman et al. (2015) and of Balland (2012). Both consider the collaboration as dependent variable and relate to some extent to the triple helix model. The first study proxies the institutional proximity using a dummy variable that considers whether or not two organizations belong to the same institutional sphere, which is considered at the macro-level as the equal set of norms and values. The second one instead accounts for the institutional proximity in terms of similar form but adding an extra component in the helix model, following the successive work of Leydesdorff and Etzkowitz (2003) that includes also the public structure as a fourth helix. Both researches find significant evidence for a positive influence of the institutional proximity on the cooperation of actors.

Interestingly, independently on how the institutional proximity is examined, it seems to be always an important requisite needed in order to stimulate an efficient innovation process.

Another work still based on the co-authored research publication is that of Hoekman et al. (2010) that however measure the institutional proximity in a way which is more close to Boschma's idea. In fact, in this case the institutional distance is taken into account as cross-border collaboration, considering the different institutional frameworks, norms, values, incentives and funding schemes existing in different regions. Institutional divergences are accounted at three spatial levels: the long-term collaborative contracts between institutions, the national boarders separating researchers and the importance of language in order to understand and efficiently communicate (*ivi*, p. 664). Using a sample of 313 regions in 33 European countries, the collaboration between regional pair *i* & *j* in a certain year revealed to occur with higher probability when belonging not only to the same sub-national region, but also to the same country and linguistic area.

Still considering the institutional framework at the macro level, Gallié (2009) considers as well the institutional distance, defined as the opposite of the institutional proximity identified by Boschma (2005). However, differently from before, the variable used to represent the innovation output is the number of patents registered by the 94 French departments used in the sample. In any case, this study revealed that knowledge spillovers within a cooperative technological network are more likely to diffuse among institutionally similar administrative units.

Also Marrocu, Paci and Usai (2013) consider the yearly average patents per capita (per million inhabitants). Differently, they measured the institutional proximity using a dummy variable, taking value equal to one in case of two regions belonging to the same country. Again, their finding revealed that the presence of a common institutional framework, concerning laws, norms, procedures and standards, may help an effective transmission of knowledge while eluding from possible inefficient behaviors.

The significant role played by this dimension of proximity holds even when changing the kind of innovation output. In fact, Li and Vanhaverbeke (2009), that examined whether or not a product innovation was pioneering or not, as already described in the Section concerning the cognitive proximity, still find evidence of positive and significant influence of the institutional closeness. Measuring the country differences in terms of institutions, language and culture, they found that it seems easier to come out with pioneer innovations when firms and their suppliers belong to similar countries in this sense.

However this is not always the case given that, as highlighted by Boschma (2005), there could also be situations in which such similarity becomes an obstacle, interfering with the innovation process itself.

2.2 Geographical proximity

In Boschma's work (2005) it has been claimed that 'geographical proximity per se is neither a necessary nor a sufficient condition for learning to take place: at most, it facilitates interactive learning, most likely by strengthening the other dimensions of proximity'. It is considered not necessary because in certain circumstances it can be substituted by the other dimensions of proximity, and not sufficient because of the major role played by the cognitive proximity in the implementation of the learning process. In fact, while the cognitive proximity is considered to be a prerequisite for interactive learning, the geographical dimension is not.

This is the motivation behind the choice of a restricted definition of geographical proximity, identified only by the physical distance between economic actors both in absolute terms (i.e. miles or kilometers) and in relative terms (i.e. travel time). For this reason appeared necessary to isolate this dimension from the other four in order to detect its real role without the involvement of the other forms identifying the 'pure' knowledge externalities that are geographically bounded.

Despite the increasing importance of the information and communication technologies that allow to exchange tacit knowledge also through longer distances by means of the other proximity forms, the spatial aspect still matters. This is because the transmission of tacit knowledge requires anyway some face-to-face interaction between actors, which is provided by a short geographical distance separating them that produces positive externalities.

In this sense the geographical proximity seems to enhance the interactive learning and innovation in an indirect way, stimulating the establishment of the other forms of proximity to which is related in a complementary way. It enforces the creation and strengthening of social, organizational, institutional and cognitive proximity that could turn out to be more important in the innovation process, but still facilitated by the spatial aspect itself.

Therefore, a 'too little' physical proximity results in no spatial externalities given the greater difficulty of actors to build up personal relationships, trust, common norms, habits and all those aspects that may enhance the interactive learning. Instead, 'too much' spatial proximity leads to a lack in geographical openness that, as always, may be detrimental for innovation. In fact the spatial 'lock-in' weakens the learning ability of regions, especially those that are highly specialized, because of their difficulties in the ability to adapt and respond to new developments and innovations. Nevertheless, this situation can be solved through a greater openness to the outside world, that is, through the establishment of also non-local relations that support the local ones in the supply of new impulses and ideas. However, as Boschma (2005) underlines, also the geographical openness is neither necessary nor sufficient as a solution for possible lock-in situations. It is not necessary given the alternative solutions provided 'in situ' by the other dimensions of proximity; it is not sufficient given the necessary presence of the other forms in order to be able to transfer tacit knowledge across longer distances. Therefore, the spatial openness may facilitate interactive learning and innovation more likely in an indirect way, 'realizing some distance with respect to the other dimensions'.

2.2.1 Principal measures used in empirical analyses

Most empirical analyses investigate not only the geographical proximity impact on innovation but consider also some other forms of proximity that could be responsible of such process. For this reason, many works have already been treated in the other Sections of this chapter for what regards the other components.

The already mentioned restricted definition of geographical proximity used by Boschma (2005) in both absolute and relative terms is used by many authors to investigate such dimension.

For what concern the latter, that is, the travel time or time distance separating firms or regions, positive results have been reached by MacPherson (1998) in his analysis on academic-industry linkages. Using a sample of 204 SMEs located in New York state and measuring the time-distance by car separating those firms from universities, he finds a inverse relation between distance and innovation, measured by the successful design, development and subsequent marketing of new or substantially new improved product over five years. Therefore the greater the time distance separating firms from major campuses, the smaller the proportion of links occurring between them. Similarly, even if at the regional level, Ponds et al. (2007) considered the collaboration intensity in science-based technologies and measured the average travel time between the regions where the collaborating organizations were located, finding as well a positive and significant impact of the geographical proximity for all the technologies considered.

The absolute measure of proximity has been adopted more widely in empirical analyses. At the regional level an important work was carried out by Bottazzi and Peri (2003) that considered the number of patents per squared kilometer of each region, out of the 86 included in the sample, filed with the EPO between 1977 and 1995, to capture those externalities that affect in a direct way the physical productivity of R&D in generating patents. Measuring the ‘shortest air distance’ separating two regions, they assigned a value equal to one to regions sharing a border, while the distance between those that do not have any common border has been measured in kilometers. They divided such distance into five classes, each with a span of 300 km, ranging from zero to 2.000 km. Using an OLS regression their findings suggest that the elasticity of innovation to R&D done in other regions is bounded within 300 km, after which becomes not significant. When increasing the accuracy of this measure through the use of intervals of 100 km, they found an even more rapid decrease of spillover with distance, with positive effects only within 200 km.

Considering the firm level, the interval within which geographical proximity seems to have an influence on the innovation is narrower. Weterings and Koster (2007) used 50 km as limit of the distance to understand whether the location of a software firm near the founder previous workplace (in the same region and within this range) could impact on the introduction of new products or services to the market. In particular, this seems to be a pure geographical effect because when they account for the relations and interactions arising from this spatial closeness, the results show a negative impact of this kind of proximity on the innovation output.

Similarly, Orlando (2004) accounts for a radius of 50 miles around each firm within which spillovers from R&D can translate into innovative activity, characterized by a localized nature.

He uses a data panel of 515 firms from 1972 to 1995, belonging to 39 states and 29 four-digit SIC, linking the group identity of a firm to a specific four-digit sector (i.e. technological proximity) to the spatial dimension. In this way the results suggested that ‘an important share of the apparent geographical localization of R&D spillovers may be the result of other factors believed to facilitate industrial agglomeration’.

Very disparate outcomes have been achieved by Fafchamps and Söderbom (2013) that, beyond the already discussed social proximity, investigated the importance of the geographic space on different kinds of innovation in both Ethiopia and Sudan. The average distance between firms in kilometers, equal to 282 and 421 km respectively, seemed to have a greater impact on the conduction of R&D activity, while only in Ethiopia matters also for the development of new products.

Various works concerning different kinds of collaboration found it to be positively influenced by the geographical proximity either when calculated as kilometrical distance than when belonging to the same or contiguous spatial area. Among these, Autant-Bernard et al. (2007) at the firm level, Maggioni et al. (2007) and Hoekman et al. (2010) at the regional level, use almost the same method. They all account for physical distance in kilometers between partners in the first work, and regional central points/capitals in the other cases, using a continuous variable. At the same time, they also use a binary variable to identify respectively whether firms belong to neighboring countries, whether two regions belong to the same geographical area or whether they share a common border.

With this second measurement method of the geographical proximity, many other works find significant results. Among these, the previously mentioned studies of Agrawal et al. (2008) and Gallié (2009) find positive results for what concerns patenting activity. The first study uses a dummy variable for the co-location in the same Metropolitan Statistical Area (MSA) of the original and the cited/control inventors. The second one uses instead three different geographical levels to determine the extent to which the spatial closeness is significant: inside the department, bordering department and bordering departments of bordering departments of the analyzed area. The findings highlighted that only this last one had no impact on the innovation process and that R&D spillovers are in this case geographically localized.

More disparate results are reached when considering the geographical proximity to various types of actors. At the regional level, Fritsch (2001) analyzes the co-operative relationships with customers, manufacturing suppliers, other firms and publicly funded research institutions in relation to the spatial level, considering whether such partners are located within or outside the examined region. However, the results achieved showed to be very heterogeneous either for the type of partner that for the regression model used. Specifically, he considers three German regions: Saxony, which represent the control group, and Baden and Hanover. In general, considering the relationships between enterprises and actors located within the same region, the geographical dimension appears to play a more important role with respect to non-vertically related firms and public research institutions, with which seems to be more important the spatial closeness. Instead, the physical proximity assumes a lower relevance with respect to customers and suppliers.

Similarly but at the firm level, Doran et al. (2012) analyze both product and process innovations in SMEs at different spatial scale (regional, national and international) considering the interaction with five types of agents: suppliers, customers, competitors, higher education institutes (HEI) and agencies. When looking at the regional level, the only meaningful relations are those with HEI for the product innovation and with customers for process innovation, however with opposite impact: positive in the first case and negative in the second one. Instead, the relations with all the other actors seem to matter more at greater distance scales.

Still considering the product/process innovations at different geographical levels, Oerlemans and Meeus (2005) calculated the innovative ties with buyers and suppliers intra-regional, inter-regional and when both are present, and investigated also the impact of regional R&D spillovers. The effect of the geographical proximity showed a limited and specific impact on the relative outcomes, being not significant in case of inter-regional innovative ties and R&D spillovers.

No meaningful influence of the geographical proximity on new product innovation has been determined in the works of Fitjar and Rodríguez-Pose (2011) and Molina-Morales et al. (2014). The former uses the 'diversity of partners' as measure for the cooperation for the product innovation with different entities at various spatial levels. Given the peripheral and relatively isolated Norwegian region considered, the cooperation realized with partners on a regional scale seems to have no impact on the innovation itself, while is the international collaboration that matters in this case. The latter study, which measures the geographical proximity considering whether or not firms belong to a district, finds again no significant effects of this variable on the innovation performance of the 224 Spanish footwear firms analyzed. Nevertheless, they reached an important conclusion in line with Boschma's (2005) thought: while the geographical proximity itself could not be enough to act as an incentive for innovation, it operates in an indirect way, fostering the other dimensions of proximity, in this specific case the cognitive one. In fact the findings of this empirical study highlight the greater relevance of this second dimension in the explanation of both knowledge acquisition and results of innovation, given its already emphasized role of required precondition.

A fourth method used to measure the spatial proximity in empirical analysis contemplates the use of the geographical coordinates. Stuart and Sorenson (2003) analyzed the rate of founding of new high-tech companies in relation to the proximity of a geographical region to various actors, such as experts in biotechnologies, already established biotechnology firms, venture capital firms and leading universities. Considering 6.412 zip codes they calculated the distance considering the firms in the space according to their latitude and longitude and implemented a negative binomial regression which provided evidence for a meaningful and positive effect of the physical closeness on the dependent variable. At the enterprise level, analogous conclusions were achieved by Cunningham and Werker (2012) that geo-located each organization using Google Earth, collecting the latitude and longitude of each organization and relating it with the relative NUTS system.

2.2.2 The Spatial Econometric Techniques

A very different method, used only at the regional level and almost always when considering the patenting activity as measure of innovative output, is that based on spatial econometric techniques. As explained by Anselin (1988) "the collection of techniques that deal with the peculiarities caused by space in the statistical analysis of regional science models is considered to be the domain of spatial econometrics", (*ivi*, p.7). This author, that widely analyzed this subject, distinguished the spatial effects in two components: the spatial dependence and the spatial heterogeneity. The first one, also known as spatial autocorrelation, identifies the lack of independence commonly existing among the observations in cross-sectional data sets and is outlined by a concept of relative space or location, which emphasize the effect of distance.

It was firstly introduced by Moran (1948) that developed an index – the Moran's I index- measuring the degree of spatial dependence and testing the existence of spatial autocorrelation, defined as:

$$I = \frac{N}{\sum_i \sum_j wij} \frac{\sum_i \sum_j wij \ (Xi - \bar{X})(Xj - \bar{X})}{\sum_i (Xi - \bar{X})^2}$$

where N is the number of observations, w_{ij} is the weight between the observation i and j, Xi and Xj are the observations of the considered variable for regions i and j and $\bar{X}$ is the regional average.

The second component instead designates the heterogeneity in the data set directly related to the location in space, that is, the lack of stability over space of the relationships analyzed, implying that functional parameters vary with location.

In order to operationalize such spatial effects, statistical tools are used, precisely the spatial weight matrices and spatial lag operators.

The use of spatial weight matrices accounts for both the spatial dependence effect, expressed in the weights, and the spatial heterogeneity, considered in the specification of the model. The simplest kinds of matrix is the spatial contiguity matrix, that identifies whether or not two spatial units share a common border, by means of a binary measure taking values 0-1. Several orders of contiguity can be taken into account, resulting in a matrix where each spatial unit is represented both as a row and as a column and the non-zero elements are those contiguous. The most commonly used type is the spatial weight matrix which adds a measure of potential interaction between two spatial units. However, no agreements exists in regional science field on a general determination of the elements to be included in this matrix, hence on the right type of the matrix itself. However, it is often specified as:

$$wij = \frac{\widetilde{w}ij}{\sum_j \widetilde{w}ij}$$

where $\widetilde{w}_{ij}$ are the elements of a spatial neighbors matrix[23].

The spatial lag operators are instead used in order to achieve the goal of the spatial weight matrix: “to relate a variable at one point in space to the observations for that variable in other spatial units in the system”, (*ivi*, p.22). However, differently from a time series context, in the space shifts can occur in an infinite number of directions following an irregular pattern. This is the reason behind the use of lag operators that considers the weighted sum of all values belonging to a given contiguity class rather than the single values.

An important problem often encountered using this methodology is the so called ‘edge effect’ that occurs when the value of a considered variable measured for a spatial unit depends also on values of spatial units outside the sample, therefore not observed, going beyond the boundaries of the dataset. This result in a situation of spatial dependence where the observed variable is

[23] See Viton, 2010.

influenced but at the same time influences the values not included in the sample itself. This phenomenon can result in two different situations pertaining to the model: the case in which the regression model contains a spatially lagged dependent variable and when the spatial dependence is included in the error term only.

Among the spatial cross-sectional model, the most widely used and known are the Spatial Autoregressive Model (SAR), the Spatial Error Model (SEM) and the Spatial Durbin Model (SD).

The Spatial Autoregressive Model (SAR) also called Spatial Lag Model, instead expresses spatial spillovers, stating that the level of the outcome variable y depends on the levels of y in neighboring regions. Formally:

$$y = \rho W y + X\beta + \varepsilon$$

where ρ is the spatial autoregressive parameter, *W* is an overall spatial weight matrix, X is a matrix of observations of explanatory variables and ε is a vector of random disturbance term.

The second model is the Spatial Error Model (SEM) in which no spatial interdependence is present in the outcome but only in the error term, therefore including in the model the influence of unobserved spatial autoregressive factors. Specifically:

$$y = X\beta + \varepsilon$$
$$\varepsilon = \lambda W \varepsilon + \mu$$

where ε is the vector of error terms, λ is the spatial autoregressive coefficient and μ is an error term that satisfies the assumptions of independent identical distribution (*i.i.d.*), with constant variance σ^2.

The spatial Durbin Model (SD) specification among the three mentioned is the less commonly used. It can be considered an extension of the SAR model, including both a spatially lagged dependent variable (*Wy*) and a spatially lagged explanatory variable (*WX*) and is illustrated as:

$$y = \lambda W y + X\beta - \lambda W X\beta + \mu$$

Most of the empirical analyses conducted using spatial econometric techniques conduct a Lagrange Multiplier (LM) test in order to disclose whether there is a generic spatial dependence in the error term (LM-err) or whether it is included in the omitted lagged dependent variable term

(LM-lag). Given the values obtained from these two tests is then possible to chose the preferred model, that would be the one with higher significant value.

For example, Fischer and Varga (2003) but also Cabrer-Borrás and Serrano-Domingo (2007) in their analysis based on 72 Austrian political districts and 17 Spanish regions respectively, make use of a spatial error model, given the higher value achieved in the LM-err test. Both find positive and significant values for the λ coefficient, meaning that the innovation in one region depends not only on its own innovative capacity, but also on the activity carried out in nearby regions, underling the relevance of the spatial localization of knowledge spillovers.

Contrarily, Moreno et al. (2005), Marrocu et al. (2013) and de Dominicis et al. (2013) found greater values for the LM-lag test. These three studies were all conducted considering various regions at the European level. In particular, the last mentioned implements a SARAR model that is a particular version of the SAR model with autoregressive disturbance, that allows for spatial spillovers in endogenous variables, and hence implicitly the exogenous variables, and the disturbances. The results achieved highlight the existence of spatial spillovers between neighboring regions, until the critical cut-off point of 300 km. In this study, the spatial relationship between regions *i* & *j* is measured considering the inverse of the squared distance between pairs of regions. Marrocu et al. (2013) instead make use of a general SAR model, measuring the distance between the centroids of two regions in kilometers and reaching as well a positive and significant value of the spatial autoregressive coefficient. Also Shang et al. (2012) in their analysis based on 30 Chinese provinces apply a SAR model but, differently from before, did not run a LM test. They calculated the geographical proximity by means of an inverse distance measure, stating that knowledge spillovers generated from region *i* are accessible to region *j* depending on the distance that separate them. However, their findings indicate that when a region is surrounded by innovative neighbors it seems to have higher levels of innovation thanks to knowledge spillovers.

Varga (2007) as well finds a higher value of the LM-lag but considered a first order contiguity matrix. However, most of the models developed indicate no presence of spatial autocorrelation, meaning that in the case of Hungary, knowledge spillovers from neighboring regions do not affect the country level of innovation.

It is therefore quite clear that also in this case both the type of model used and the context analyzed provide for different results.

2.3 Concluding remarks on the role of proximity

The conclusions reached by Boschma (2005) considering all the five dimensions of proximity can be summarized in two main points.

First of all, both situations of 'too much' and 'too little' proximity hamper the learning and innovation process that instead require a right balance between proximity and distance. Therefore, the proximity does not have an always positive acceptation, but can also negatively impact innovation.

Secondly, in order to put in place an effective interactive learning, the capacity to absorb new ideas becomes fundamental. This is the reason why the cognitive proximity (some but not too much) is identified as a prerequisite for learning. Given the uncertainty related to the innovation process, mechanisms able to transfer complementary pieces of knowledge between agents are essential. Boschma (*ivi*, p.71) states that, in theory, "geographical proximity, combined with some level of cognitive proximity, is sufficient for interactive learning to take place". Coordination and control mechanisms are also needed and usually provided by the other forms of proximity, specifically organizational, social, institutional and geographical proximity, acting either singularly but most likely in combination with each other, that are considered to be able to bring together actors either within and between organizations. Moreover, the non-geographical forms of proximity, other than the cognitive one, can also act as substitutes for the geographical dimension. This, in turn, may strengthen the other forms of proximity over time.

The characteristics that combine all the five dimensions of proximity are that, with the correct weight, they reduce uncertainty, solve the coordination problem and consequently promote the interactive learning and innovation.

	Key dimension	Too little proximity	Too much proximity	Possible solutions
1. Cognitive	Knowledge gap	Misunderstanding	Lack of sources of novelty	Common knowledge base with diverse but complementary capabilities
2. Organizational	Control	Opportunism	Bureaucracy	Loosely coupled system
3. Social	Trust (based on social relations)	Opportunism	No economic rationale	Mixture of embedded and market relations
4. Institutional	Trust (based on common institutions)	Opportunism	Lock-in and inertia	Institutional checks and balances
5. Geographical	Distance	No spatial externalities	Lack of geographical openness	Mix of local 'buzz' and extra-local linkages

Figure 4: forms of proximity - some features; Boschma (2005, p.71)

3. PROXIMITY AND INNOVATION: META-ANALYSIS

3.1 Data and Empirical Methodology

Given the variability existing among the results obtained in the literature concerning proximity and innovation, the meta-analysis is a useful instrument not only to summarize past researches, but also to allow comparability across studies. Considering that empirical analyses differ in terms of data sets, sample sizes, regression methodologies and other variables, this kind of analysis is a helpful framework to integrate, provide coherence and explain the disparate, and sometimes divergent, views related to a subject in empirical economic literature, allowing for a more objective review and the achievement of a general conclusion.

The aim of the meta-analysis developed is to shed light on those elements that drive the significance (or non significance) of core variables already existing in empirical analyses. In particular, the main goal is to understand whether or not, and in case which of the five dimensions of proximity outlined by Boschma (2005) are capable to produce some kind of innovation process.

In order to construct the database of empirical papers included in the meta-analysis, the starting point was the use of Scopus database, containing abstract and citations of peer-reviewed literature (scientific journals, books and conference proceedings) belonging to many fields.

To search for relevant documents, the key words used have been “Innovation” AND “Proximity”, present in the field type “Article Title, Abstract, Key Words”, published from “All Years” to “Present” and considering “ALL” document types. This search was then limited to the subject area “ECON”, relative to Economics, Econometrics and Finance and to the language “English”. This lead to a total of 175 articles presenting such characteristics.

Through the analysis of the abstracts it was possible to make a first screening and to exclude those articles not directly investigating the field of interest. Therefore, a first collection of 48 articles was made, which has been analyzed more deeply. Those papers which did not perform any empirical analysis were the first to be discarded, followed by those that did not perform the investigation of innovation as dependent variable and those that did not provide some kind of proximity measure through the independent variables. Moreover, also the articles not accounting for a direct relation between proximity measures and innovation were excluded.

Characteristics of the sample: inclusion of studies in which
→ *<u>Empirical Analyses</u> are performed by means of a Regression Method*
→ *Dependent Variable = <u>Innovation</u>*
→ *Independent Variable = <u>Proximity</u> (any kind)*
→ *Measurment of <u>direct relation</u> between innovation and proximity*

Figure 5: Characteristics of the sample

Given that only 22 empirical analyses respected such criteria, a further step has been implemented in order to construct a relevant sample. Therefore, the second round of research has been a deep investigation of each article's bibliography, to find articles that were not emerged through the Scopus research. This brought to a total of 249 articles selected, which have been searched in Scopus. Again, a first screening was made on the basis of the abstracts and also given the fact that some of the articles searched were not available in Scopus database. This brought to a second collection of 120 papers that have been analyzed in more detail. Among those, only 18 articles were in compliance with the conditions outlined above. Therefore, the final sample constructed constitutes a total of 40 empirical analyses extracted between October and December 2015. Appendix Table A1 lists the studies included in the analysis.

Among the analyses collected, the first focus was directed on the empirical models developed: in fact, all the studies considered were characterized by the use of innovation as dependent variable and by the presence of some kind of proximity as independent variable, displaying a direct relation with innovation, in order to specifically account for the straightforward impact it could have on such dependent variable.

Within the sample some level of heterogeneity was present: this brought to the decision not to simply include each article as a single estimate, but to split some analyses into as many estimates as were the different characteristics presented. This was made in order to introduce homogeneity and obtain a sample composed of elements perfectly comparable to each other.

Specifically, for what concerns this two principal aspects, because the 'basic' empirical researches considered only one kind of innovation (e.g. product innovations) and only one dimension of proximity (e.g. geographical), all the others that instead introduced more than one such elements had to be adapted. In other words, a research still focusing only on one innovation type, but concerned with the impact of multiple proximity dimensions, consequently accounted each dimension separately from the others, instead than considering the single research as a whole. Moreover, those studies developed with multiple empirical models accounting for more innovation types (e.g. product and process innovations accounted separately) in relation with more than one proximity dimension (e.g. geographical, cognitive and social), were disaggregated on both levels in order to produce many estimates, all containing a single characteristic of each aspect (in this example, six different estimates related to the same article). The same mechanism was applied also with respect to other relevant variables considered for the meta-analysis.

For this reason the actual final sample is composed of 95 different observations, based on 40 published articles.

Another important consideration related to the empirical models developed in the analyses concerns the way in which the dimensions of proximity have been treated.

As already said, only direct relations have been taken into account, excluding therefore those that were producing an indirect effect by means of another dimension of proximity (i.e. cases in which the geographic proximity has a direct impact on the development of cognitive proximity which in turn influences innovation, therefore affected by a geographic indirect effect and a cognitive direct effect).

Accordingly, only the analyses made at the firm or at the regional level were included in the sample, while those related to clusters have been excluded, given that within the cluster is not possible to identify the various proximity dimensions separately, because they are all interrelated, and therefore no direct relation can be established and investigated[24].

Moreover, as already explained throughout chapter 2, each dimension can be measured in a multitude of ways. As a consequence, some of the analyses used more than one measure to evaluate the impact of a proximity dimension. However, within the model developed for the meta-analysis, no distinction has been made with regard to the measure implemented to calculate the proximity effect. The focus was in fact directed at understanding whether any kind of proximity, irrespectively of the measurement method used to calculate it, showed a significant impact on the implementation of innovations.

Therefore, all such studies in which the measures utilized brought to the same results in terms of significance and direction of the effect has been considered in a uniform way. Instead, in case in which the results were divergent, because one measure proved to be significant while the other was not, the presence of a significant variable prevailed, given that at least in one case it was

[24] There exists a vast literature on clusters that has been analyzed also by means of meta-analysis (see Fang, 2015).

proved the existence of a direct impact exerted from proximity on innovation. No cases in which the divergence was related to the direction of the effect (positive *vs* negative) were found within the same study in relation to the same proximity dimension.

For what concerns the geographical proximity in particular, there are empirical analyses in which this dimension is measured only in one way but with respect to many different agents, such as firms, universities, suppliers, customers, and so on. Of course, not for all of them the physical closeness plays a role in determining the implementation of innovative processes. However, as long as the proximity variable presented significant results with at least one of such agents, it was considered significant for the meta-analysis purposes, without making any distinction on the type of agent, given that the presence of an effect of proximity was per se enough.

Another consideration also related to geographical proximity is that in some analyses it was not explicitly defined a proximity measure. This means that, for example, the data were divided into 'Regional, National and International' or considered 'within or outside' a certain region or distinguished between 'bordering and bordering of bordering' areas. In such situations, the smallest level of investigation was discretionary chosen as representative of the proximity variable.

Some analyses constructed multiple models with respect to the same dependent variable, different from each other only with respect to the introduction of some independent variables, other than proximity. However, the introduction or omission of such variables seemed not to have any influence on the significance or insignificance or on the direction of the proximity effect, which remained constant in all the different models developed. For this reason, despite the implementation of multiples models, the relative study was accounted only once (no split of articles was made for this reason).

In this model, independent variables other than proximity have been included for various reasons. Among those, one of the most important is the 'journal' of publication, considered in the analysis in order to detect the presence of a possible publication bias. The publication bias has been originally defined as "the publication or non-publication of studies depending on the direction and statistical significance of the results" (Rothstein et al. 2005, p. 3). In fact, it has been statistically proven that there is a tendency in the editorial policy to usually accept and publish studies with more highly significant results and to discourage the publication of researches that instead yield to statistically insignificant results.

However, there are numerous types of biases related to publication that go beyond such definition. Among those, the so-called ‘familiarity bias’ consists in the selective inclusion of studies only from one’s own discipline[25]. This could result in the possibility that some journals would be more inclined to publish only studies related to their field of interest: studies which would be instead rejected by other journals not directly related to the specific subject.

It must be specified that only published articles have been included in the meta-analysis sample, given the too vast literature on the subject treated and given the fact that the main interest was related to this second specific kind of publication bias. In fact the inclusion of the journal of publication of the articles among the independent variables has been made in order to detect the possible presence of a specific journal, or a group of journals, more prone to publish empirical analyses investigating the relation between proximity and innovation, or even to favor those studies demonstrating the existence of an impact exerted by proximity.

Another variable introduced in the model is that relative to the publication year. Considering the fact that the meta-analysis developed was performed with respect to all years to present, many different theories followed one another, as explained in the first chapter. Most of such theories are developed based on the implementation of various empirical analyses that could take years to be performed and then published. After a theory reaches a great consensus, becoming sediment, solid and characterized by a great number of citations, this could in turn lead to an increase in the number of empirical analyses performed toward the related subject. Therefore, the inclusion of this variable was made to detect possible changes occurred with respect to the main theories and approaches in literature.

Still related to existing literature, the area in which the theories develop could be related to the data used in the empirical studies. In fact many times the authors of main theories also implement a great number of analyses, often carried out in the same geographic area in which they are located, that means, using a sample of firms or sub-regions close to the authors’ research department. Therefore, variables representing the geographical areas of the analyses have been included in the model in order to account for this possibility and for a possible significant effect.

Also the ‘level’ of analysis was considered, examining whether a research has been carried out at the firm or at the regional level. This is also related to the number of observations that, accordingly, is usually greater for studies that employ a dataset of firms as unit of analysis, compared to those that account for regions or sub-regions that usually consider a smaller sample.

[25] See Rothstein et al. (2005).

Another important implication is that related to differences in the implementation of regressions by means of cross-sectional data or panel data. This because the former, even if it can be considered as less structured, is the most commonly used by the studies included in the meta-analyses while the use of panel data is less frequent, given the greater complexity it entails. However, the latter allows to deal with endogeneity, purifying the model from non-observed effects which are time-invariant, thanks to the fact that the regression is run over data which have been collected for the same entities over time. Therefore the kind of data used in the regression could show to have some effect on the results obtained in the meta-analysis.

For what concern the regression methodologies used in the different empirical researches, this varied widely both between, but sometimes also within, the single articles. In particular the difference depends on the kind of data available for the regression, which consequently leads to the application of different methods. In fact, the principal distinction is found in the nature of data collected, which could be continuous or dichotomous. In the former case, the most common regression method applied is usually an OLS – Ordinary Least Square – method, while in the latter many different methods pertaining to the class of the 'Discrete Choice Models' are almost equally implemented. This second class of models is composed of regression methods such as Logit, Probit, Negative Binomial, Poisson and many other that are amply used in the field of proximity and innovation research. Therefore, in the construction of the meta-analysis, also this aspect has been taken into consideration through the inclusion of a variable related to the methodology used, in order to detect a possible impact deriving from the different regression methodology applied in the studies included in the sample.

3.2 Econometric Analysis

The meta-analysis conducted was implemented by means of a random effect logit model. The choice of the logit model was due to the binary nature of the dependent variable considered, namely a dummy that is equal to 1 if the effect of proximity on innovation is found positive, and zero otherwise. The random effect model was chosen, in particular, for two reasons: first, this kind of models provides the opportunity to generalize findings by assuming that the selected empirical analyses are random samples from a larger population[26]; second, because it allows exploiting the panel structure of the data, while keeping also all the variables that do not vary

[26] See Cheung et al. (2012).

within each single article. In doing so, it is assumed that there is absence of any correlation between the article-specific fixed effects and the independent variables.

This meta-analysis has been accomplished as a kind of panel data analysis, where the single unit of observation is the single estimate, and it has been accounted for the presence of more than one estimate per article, as explained in the Section 3.1. In fact, the nature of the data considered in the sample is multidimensional, since it has been observed a set of articles and, by article, a subset of estimates.

Even if the basic data for a meta-analysis are usually the ‘effect size’, which measure the strength of the effect in individual studies, this is not the case for the meta-analysis here developed. The reason behind this depends on the nature of the variables utilized: in the empirical studies included, the proximity variables are usually calculated regardless of the intensity of their impact. In other words, all types of proximity are investigated only considering the existence (or significance) or not of an effect on innovation, but without paying attention to the magnitude of the effect.

Only few studies investigating the geographical proximity explicitly examined the strength of the proximity itself, for example dividing the kilometrical or mile distance into many classes and assessing until what limit the proximity was still able to drive innovative processes[27]. However, despite these exceptions, all the other articles were concerned only with the presence or not of an impact and on whether this was positive or negative.

The equation on which the meta-analysis is based is the following:

$$\Pr(Y_i = 1 \mid \mathbf{X}_i) = \Lambda(\beta_0 + \beta_1 x_{1i} + ... + \beta_n x_{ni})$$

where i is the single estimate, Y_i is the dummy variable capturing the effect of proximity on innovation, $\boldsymbol{X}_i$ is the vector of independent variables x, Λ is the logistic cumulative distribution, β_0 is the constant and $\beta_{1,}\dots,\beta_n$ are the coefficients to be estimated. With this equation, it is assessed the probability that proximity (in its various forms) affects innovation, while controlling for many characteristics of the studies under investigation.

The vector $\boldsymbol{X}i$ is composed of different independent variables, as mentioned in Section 3.1, which have been constructed as dichotomous variables with respect to the significant aspect that needed to be considered, with the only exception of the variables ‘number of observations’ and ‘age’ that are instead continuous. Table 1 provides the main summary statistics.

[27] See Bottazzi and Peri (2003); Weterings and Koster (2007); Orlando (2004).

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
Age	95	6,758	4,031	1	18
N. Obs	95	99095	398254	3	2044711
Journal	95	0,537	0,501	0	1
Data	95	0,284	0,453	0	1
Method	95	0,516	0,502	0	1
Level	95	0,653	0,479	0	1
Europe	89	0,730	0,446	0	1
North America	89	0,213	0,412	0	1
Other Area	89	0,056	0,232	0	1
Input - Output	95	0,726	0,448	0	1
Geo_prox	95	0,453	0,500	0	1
Geo_output	95	0,389	0,49	0	1
Cog_prox	95	0,189	0,394	0	1
Cog_output	95	0,084	0,279	0	1
Org_prox	95	0,126	0,334	0	1
Org_output	95	0,095	0,294	0	1
Soc_prox	95	0,147	0,356	0	1
Soc_output	95	0,116	0,322	0	1
Inst_prox	95	0,842	0,279	0	1
Inst_output	95	0,842	0,279	0	1
Output (A)	95	0,768	0,424	0	1
Output (B)	90	0,811	0,394	0	1
Output (C)	95	0,821	0,385	0	1

Table 1: Summary Statistics

The continuous variable ‘age’ has been constructed computing the difference between the current year 2016, and the year in which the study under consideration has been published. Therefore, this variable actually accounts for the age of the published articles, where the oldest are those that have been published less recently and vice versa. Additional summary statistics relative to this variable is presented in Table 2.

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
Year	95	2009,242	4,031	1998	2015
Age (2016 - year)	95	6,758	4,031	1	18

Table 2: continuous variables Year and Age - descriptive statistics

Among the binary variables, the 'journal' has been constructed considering whether or not the article examined was published in an urban/regional journal dealing with economic geography[28]. Therefore, this dummy variable takes value equal to 0 in such cases, representing the 46.32% over the total, and equal to 1 otherwise. This distinction has been made in order to account for possible publication bias deriving from the journal field of interest, which could constitute a category more prone to publish empirical researches carried out on this particular subject compared to other kinds of journals, but also to favor those studies demonstrating the existence of an impact exerted by proximity on innovation.

A second dummy variable developed is the 'level' which takes value equal to 1 when the level considered is micro and 0 when macro, corresponding to 65.26% and 34.74% of the cases respectively. The micro level identifies those studies conducted at the firm level, therefore those accounting in the number of observations the quantity of firms that have been included in the specific analysis. Few cases present instead the number of inventor pairs that collaborated on a specific innovation, which has been as well included in the micro group. On the other hand, the researches conducted at the macro level are those that utilized a sample composed of regions or sub-regions, where multiple firms and agents pertaining to various fields are present.

Also the geographical context in which the studies were carried out has been put under attention through the identification of three main areas: Europe, North America (including USA and Canada) and other. Therefore, distinct dummy variables have been created for these areas, all examining whether or not the studies were carried out in such contexts, assuming a value equal to 1 in such cases and 0 otherwise. However, this brought to the exclusion of the studies which were conducted in multiple locations (e.g. Europe, USA and Japan) that were not classifiable in either category, resulting in an overall of 89 cases considered.

Another dichotomous variable was created for the 'data', assigning a value equal to unity for panel data analyses, and equal to 0 for cross-section data analyses. This second type of analysis is the one that has been utilized more frequently, that is, in 71.58% of the cases.

For what concerns the methodology applied, considering the fact that in the empirical analyses examined regression methods such as Logit, Probit, Poisson, Negative Binomial and other belonging to the class of 'discrete choice models' were the most widely used, a dummy

[28] Six journals pertaining to the category of urban/regional have been included in this variable: Journal of Economic Geography; Papers of Regional Science; Entrepreneurship and Regional Development; The annals of Regional Science; Environmental and Planning and Journal of Urban economics.

variable was constructed accounting for the difference between continuous and discrete response choices. In this variable called 'method' a value equal to 1 was assigned to this kind of model, representing slightly more than 50% of the cases, and equal to zero for continuous models.

According to the type of innovation investigated as dependent variable in the different studies included in the analysis, it was possible to identify some distinct categories: the product/process innovations, the patents, the collaboration/cooperation and others.

However, it must be specified that while both product/process innovations and patents can be considered the result of an innovation process, the presence of some type of collaboration/cooperation between agents is not actually a real form of innovation, but can be considered as an important input able to put in place some innovation process that could lead to innovative outputs. For this reason, as reported in Table 3, a dummy variable has been introduced with respect to such distinction, differentiating innovation inputs with a value equal to 0, that is, the 27.37% of cases constituting in collaboration and cooperation, and innovation outputs, equal to 1, which includes the other innovation types considered (i.e. product/process; patents; other).

Input_Output	***Frequency***	***%***
0	26	27,37%
1	69	72,63%
Total	95	100%

Table 3: Innovation Input/Output

With respect to the proximity dimensions, more outcomes were found in relation of the various effect presented in the studies. In fact, in the empirical analyses included, the various dimensions showed both non-significant and significant results. In the latter case, the results achieved were either positive or negative. However, for the aim of the present analysis, no importance was given on the difference between non-significant and negative results: this because the focus was only pointed toward the presence or not of significantly positive impacts, therefore classifying the other options together.

Consequently, two dummy variables were constructed: one related to the 'proximity', taking value equal to 1 in the cases in which the relevant dimension was measured by the study considered and zero when instead it was not examined, and another related to the proximity ‘output’, resulting in a value equal to 1 in cases when the proximity effect turned out to have a positive influence on innovation and zero in the other situations.

Concerning the geographical proximity (see Table 4), this dimension has been measured in 43 cases over the total 95 taken into account, which consists of 85% of the studies included in the meta-analysis. This means that the geographical proximity has been measured in 34 empirical analyses over the total 40 and, for some of them, it has been examined more than once with respect to other relevant aspects such as, for example, different types of innovations, different models implemented, etc. The impact exerted showed to have a positive impact on innovation 38.95% of the times in complex.

		Overall		***Between***		***Within***
	GEO	***Freq.***	***Percent***	***Freq.***	***Percent***	***Percent***
prox	*0*	52	54,74	30	75,00	64,39
	1	43	45,26	34	85,00	60,83
	Total	95	100,00	64 (n = 40)	160,00	62,50
output	*0*	58	61,05	33	82,50	68,64
	1	37	38,95	30	75,00	57,83
	Total	95	100,00	63 (n = 40)	157,50	63,49

Table 4: Geographical proximity measurment and output - descriptive statistics

Compared to the geographical dimension, the organizational and social ones have been analyzed less frequently: in 12 and 14 cases respectively, as shown in the Tables 5 and 6. For the first one, positive results have been found in 9.47% of the total situations, while the second one presented a slightly better outcome, with positively significant effects detected in the 11.58% of the cases. Also in this circumstance, both dimensions present a certain level of variability both between and within the studies considered.

		Overall		*Between*		*Within*
	ORG	***Freq.***	***Percent***	***Freq.***	***Percent***	***Percent***
prox	*0*	83	87,37	40	100,00	91,62
	1	12	12,63	10	25,00	33,50
	Total	95	100,00	50 (n = 40)	125,00	80,00
output	*0*	86	90,53	40	100,00	93,50
	1	9	9,47	8	20,00	32,50
	Total	95	100,00	48 (n = 40)	120,00	83,33

Table 5: Organizational proximity measurment and output - descriptive statistics

		Overall		*Between*		*Within*
	SOC	***Freq.***	***Percent***	***Freq.***	***Percent***	***Percent***
prox	*0*	81	85,26	39	97,50	90,56
	1	14	14,74	11	27,50	42,58
	Total	95	100,00	50 (n = 40)	125,00	80,00
output	*0*	84	88,42	39	97,50	92,35
	1	11	11,58	9	22,50	44,26
	Total	95	100,00	48 (n = 40)	120,00	83,33

Table 6: Social proximity measurment and output - descriptive statistics

The institutional proximity is the dimension which has been measured the least, in only 8 cases over the total. Differently from the other dimensions, in all the studies included in the sample it always demonstrated to have positive and significant effect on innovation. This is the reason that renders the two dummies relative to institutional proximity perfectly equal to each other (see Table 7). Therefore, given the absence of heterogeneous results, and the consequence that only perfectly successful outputs are predicted, this variable was omitted from the estimates.

		Overall		Between		Within
	INST	***Freq.***	***Percent***	***Freq.***	***Percent***	***Percent***
prox	*0*	87	91,58	40	100,00	92,25
	1	8	8,42	8	20,00	38,75
	Total	95	100,00	48 (n = 40)	120,00	83,33
output	*0*	87	91,58	40	100,00	92,25
	1	8	8,42	8	20,00	38,75
	Total	95	100,00	48 (n = 40)	120,00	83,33

Table 7: institutional measurment and output - descriptive statistics

Only with respect to the cognitive dimension, a special condition was often detected, different from the other four: is the case of the inverted U-shape effect. In this situation the cognitive proximity exercises a positive impact on innovation in the beginning, until a certain point in which the impact becomes negative, as already emphasized in Section 2.1.1.

This dimension is the second most frequently investigated, following the geographical one, with 18 cases presenting the most disparate results, being the only to show also negative results in certain circumstances. Nevertheless, considering that also the inverted U-shape impact as well turns into negative effects after certain thresholds are reached, this represents an additional number of cases that could transform the direction of the influence exercised by proximity from positive into negative. Accordingly, only the 8.42% of the situations analyzed provided for a real and straightforward positive impact, all examined by distinct studies, as showed in Table 8.

		Overall		Between		Within
	COG	***Freq.***	***Percent***	***Freq.***	***Percent***	***Percent***
prox	*0*	77	81,05	36	90,00	88,38
	1	18	18,95	15	37,50	54,56
	Total	95	100,00	51 (n = 40)	127,50	78,43
output	*0*	87	91,58	39	97,50	92,56
	1	8	8,42	8	20,00	48,75
	Total	95	100,00	47 (n = 40)	117,50	85,11

Table 8: Cognitive measurment and output - descriptive statistics

As a consequence of this peculiar situation, three distinct total outputs have been considered by means of different scenarios. The principal total output simply accounts for the presence or not of a positive effect exerted by any kind of proximity dimension on innovation, but also by the other independent variables included in the model. For this reason, the main focus is on whether the impact is positive or not. However, because of the characteristics of the inverted U-shape situation it was decided to include such results in the non-positive class, together with the negative and the non-significant results. Therefore, the total output takes value equal to 1 when the impact of proximity on innovation is positive, that is, in 76.84% of the situations, representing 90% of the studies included in the analysis, and 0 otherwise. This scenario will be referred to as the 'output A', reported in Table 9.

	Overall		Between	
Output (A)	***Freq.***	***%***	***Freq.***	***%***
0	22	23,16%	15	37,50%
1	73	76,84%	36	90,00%
Total	95	100,00%	51 (n = 40)	127,50%

Table 9: Total Output - Scenario A

A robustness check has been made in this respect, considering two additional scenarios: a more basic total output was constructed through the exclusion of the situation in which the results showed to have the inverted U-shape effect. This second scenario (i.e. 'output B') consequently contains a lower number of cases included in the sample, equal to 90 that, because were previously enclosed into the 'non-positive' results, consequently increased the percentage of positive outcomes to 81.11%. The third scenario developed (i.e. 'output C') instead included the inverted U-shape results among the positive outcomes, increasing even further the percentage of positive outcomes. Both scenarios are illustrated in Table 10.

		Overall		***Between***	
Total Output		***Freq.***	***Percent***	***Freq.***	***Percent***
Output (B)	*0*	17	18,89	13	32,50
	1	73	81,11	36	90,00
	Total	90	100,00	49 (n = 40)	122,50
Output (C)	*0*	17	17,89	13	32,50
	1	78	82,11	39	97,50
	Total	95	100,00	52 (n = 40)	130,00

Table 10: Total Output: Scenario B and C

This robustness check has been made in order to compare the three different outcomes and detect the presence of possible variables that maintain some level of significance in more than one model. Consequently, the finding of some coefficients that do not vary widely among the models implemented in terms of significance, but also with respect to their sign and magnitude, would be an evidence of the strength of such coefficients. The robustness of variables is a necessary condition in order to assert a valid causal inference, providing that, under appropriate conditions, the coefficients of such variables are insensitive to adding or dropping variables.

See Appendix Table A2 and A3 for further descriptive statistics.

3.3 Estimation Results

As already explained, the main model performed was based on the scenario A, while the other two scenarios have been taken into account for robustness checks. Therefore, these three outputs have been compared to each other in order to identify relevant variables exerting significant impact on the probability to obtain a positive outcome.

First of all, the three scenarios have been constructed with the inclusion of only proximity dimensions, introduced and investigated separately from each other (see Table 11). Therefore, the output A and C consisted of 40 groups composed of the single studies included in the meta-analysis, and of 95 observations, while the output B, because of the exclusion of the cases in which an inverted U-shape effect was disclosed, was consequently based on a smaller number of both observations and groups, equal to 90 and 38 cases respectively.

Both the geographical and the cognitive proximity showed to have a significant impact on the probability to obtain a positive outcome in the scenario A, persisting also in the scenario B only with respect to the latter dimension, which however decreased in its significance, passing from a 1% to a 10% level. The other two dimensions did not provide any significant results, as well as the last scenario.

Nevertheless, these two significant dimensions presented an opposite sign of their beta coefficient: positive for the geographical proximity and negative for the cognitive dimension. Since we are estimating a logit model, the estimated beta coefficient represents an odds ratio, i.e. the probability that proximity is related to a positive effect on innovation with respect to the probability that proximity has a zero, or negative, or inverted U-shaped effect.

Accordingly, the probability to obtain a positive outcome is 1.052 times greater than the probability to achieve a non-positive outcome when accounting for the geographical proximity. Instead, it turns out to be two times smaller in the scenario A and 1.260 times less in the scenario B whit respect to the cognitive dimension.

	OUTPUT A	*OUTPUT B*	*OUTPUT C*
Variable	**β *coeff.* *(s.e.)***	**β *coeff.* *(s.e.)***	**β *coeff.* *(s.e.)***
(1) Geo_prox	1.052* (0.623)	0.660 (0.587)	0.503 (0.556)
(2) Cog_prox	-2.002*** (0.681)	-1.260* (0.698)	-0.734 (0.613)
(3) Org_prox	-0.343 (0.864)	-0.492 (0.793)	-0.510 (0.749)
(4) Soc_prox	-0.009 (0.840)	-0.195 (0.757)	-0.268 (0.719)
N obs *n groups*	95 40	90 38	95 40

Note: every estimate includes a constant term;
****p<0.01; **p<0.05; *p<0.1*

Table 11: Proximity dimensions per Output

Table 12 shows five different models implemented for the outcome A: models 1-4 provide for the introduction of each dimension of proximity individually and one at time, as already showed in the first column of Table 11, while model 5 simultaneously includes all the proximity dimensions, together with the other independent variables considered. It must be specified that, because of the introduction of two dummy variables related to the geographical area, that are ‘Europe’ and ‘North America’, both the number of observations and the number of groups were reduced, for the reasons previously explained [29]. Therefore, this brought to a number of observations equal to 82, with respect to 38 groups in the scenario A and C, and 78 observations related to 37 groups for the output B.

[29] The number of observations is further reduced with respect to the 89 observations considered when including the dummies relative to the geographical areas because those pertaining to the category ‘other areas’ have not been included. The reason of this choice is based on the fact that they are already accounted for inside the other two dummies ‘Europe’ and ‘North America’, both investigating whether the analyses have been conducted in that specific territory, assuming a value equal to 1, or somewhere else (i.e. value equal to 0).

For all these models, the 'Log Likelihood' value is presented, allowing for comparability in their goodness of fit.

After the proximity dimensions have been all accounted for in the same model, together with the inclusion of the other independent variables, the significance of the geographical and cognitive proximity disappeared completely, resulting therefore in the presence of no significant effects exerted by any of the four proximity variables. Additionally, the social proximity variable was omitted by the model for collinearity reasons.

Among the other independent variables introduced, the 'journal', the 'method', the 'number of observations' and the 'level' of analysis showed a significant impact on the probability to obtain a positive outcome, with a negative beta coefficient for three of them.

Table 13 presents the final model, which includes all the independent variables, developed for all three scenarios, to allow for comparability and robustness checks.

The 'level' of analysis presented the most significant result among all, with a significance level of 1% and a negative beta coefficient equal to -3.292 in the 'output A'. This means that using firm-level data (with respect to macro-level data) decreases the probability to achieve a positive output of more than three times with respect to the probability to achieve a zero/negative/inverted U-shaped output. Accordingly, studies conducted at the macro level result in better a performance.

This result is in line with the findings of Beaudry and Schiffauerova (2009) that, when analyzing the level of geographical aggregation in order to find out whether different kinds of externalities are associated with different geographical classes, found evidence of the existence of a threshold at the medium classification level[30], more able to capture the presence externalities compared to more detailed levels of analysis.

This variable, together with the 'number of observations', turned out to be the most relevant, given that were proved to remain significant in all three different scenarios, with a small reduction of the beta coefficient values and changing only slightly their significance level.

Quite similarly, the other two important variables that emerged are the 'journal' of publication and the 'method' used in the analysis, however both turning non-significant with

[30] Beaudry and Schiffauerova (2009) identify five geographical classes, and found a threshold at the medium classification level, between Class 2 (composed of county - UK, province – Italy and Spain, prefecture - Japan, department - France, COROP - Netherlands, region - Israel, CSO region - UK, region NUTS 3) and Class 3 (labour zones: local labour systems - Italy, zones d'emploi - France, local labour market - Sweden).

respect to the scenario C. In the other two scenarios developed, the two variables maintain the same significance level, decreasing only moderately their beta coefficient in the output B.

The results reached show that, with respect to the ‘journal’, the publication of empirical analyses in urban/regional journals dealing with economic geography (with respect to other kind of journals that deal with different fields) increases a little more than two times the probability to obtain a positive outcome compared to the probability to achieve a non-positive outcome, precisely of 2.226 and 2.206 times in the output A and B respectively. This result provides for the existence of a small publication bias, highlighted by the propensity of urban/regional journals to favor the publication of empirical studies that demonstrate the existence of a positive impact on innovation exerted by the proximity dimensions.

Similarly, also for the value of the coefficient, studies carried out by means of continuous response models increase the positive outcome probability. In fact, when analyses are implemented through discrete choice models (rather than with continuous ones) this probability is reduced of more than 2 times with respect to the probability to obtain a non-positive outcome. Again, the beta coefficient exhibits a negative sign, with a value equal to -2.202 in the scenario A and -2.076 in scenario B. Hence, models constructed by means of discrete variables will result in a worse performance compared to those that account for continuous variables.

OUTPUT A	***(1)***	***(2)***	***(3)***	***(4)***	***(5)***
Variable	***β coeff. (s.e.)***	***β coeff. (s.e.)***	***β coeff. (s.e.)***	***β coeff. (s.e.)***	***β coeff. (s.e.)***
Geo_prox	1.052* (0.623)				0.515 (0.978)
Cog_prox		-2.002*** (0.681)			-0.747 (1.233)
Org_prox			-0.343 (0.864)		-0.546 (1.176)
Soc_prox				-0.009 (0.840)	(omitted)
Age					-0,001 (-0.133)
Journal					-2.226* (-1.267)
Data					-0,051 (-0.98)
Method					-2.202** (1.040)
N. Obs					0.005** (0.002)
Level					-3.292*** (-1.264)
Europe					1.866 (1.357)
North America					2.052 (2.393)
Input - Output					-1.381 (1.123)
N obs	95	95	95	95	82
n groups	40	40	40	40	38
Log Likelihood	-47,999	-45,200	-49,433	-49,511	-27,939

Note: every estimate includes a constant term;
variable "Soc_prox" was omitted for collinearity reasons;
****p<0.01; **p<0.05; *p<0.1*

Table 12: Final model per Output (A)

	OUTPUT A	***OUTPUT B***	***OUTPUT C***
Variable	**β *coeff.* *(s.e.)***	**β *coeff.* *(s.e.)***	**β *coeff.* *(s.e.)***
Geo_prox	0.515 (0.978)	0.525 (0.974)	0.348 (0.928)
Cog_prox	-0.747 (1.233)	-0.429 (1.278)	0.033 (1.216)
Org_prox	-0.546 (1.176)	-0.533 (1.166)	-0.372 (1.127)
Soc_prox	(omitted)	(omitted)	(omitted)
Age	-0,001 (-0.133)	-0.002 (0.133)	0.018 (0.126)
Journal	-2.226* (-1.267)	-2.206* (1.284)	-1.347 (1.131)
Data	-0,051 (-0.98)	-0.226 (0.999)	0.159 (0.925)
Method	-2.202** (1.040)	-2.076** (1.060)	-1.124 (0.965)
N. Obs	0.005** (0.002)	0.005** (0.002)	0.003* (0.002)
Level	-3.292*** (-1.264)	-3.261** (1.288)	-2.543** (1.106)
Europe	1.866 (1.357)	1.720 (1.358)	1.207 (1.308)
North America	2.052 (2.393)	1.869 (2.392)	2.513 (2.426)
Input - Output	-1.381 (1.123)	-1.540 (1.196)	-0.806 (1.088)
N obs	82	78	82
n groups	38	37	38
Log Likelihood	-27,939	-27,269	-32,369

Note: every estimate includes a constant term;
variable "Soc_prox" was omitted for collinearity reasons;
****p<0.01; **p<0.05; *p<0.1*

Table 13: Estimation Results per Output

Another set of models was then developed with respect to the five different proximity dimensions (see Table 14): instead than accounting for the probability to obtain a positive outcome in general, in this case, for each model it was investigated the probability to obtain a positive outcome related to the single proximity measure. This means that, for example, the first model that deals with the geographical proximity, examines the probability that the impact exerted by such dimension is positive, and the same is worth for the other four.

All the models, with the exception of the geographical proximity, were developed on the total number of observations included in the meta-analysis, because the variables related to the geographical area were being omitted when included in the models, save for the first model in which the variable 'Europe' results to be significant at the 10% level. Such variable is a dummy that takes value equal to 1 when the studies have been conducted in a country belonging to Europe, and zero otherwise. Therefore, given the negative coefficient displayed, the probability that the geographical proximity exercises a positive impact is about two times lower than the probability of a non-positive effect, for the studies conducted in Europe, rather than somewhere else. However, the variable 'North America' did not provide any significant results, meaning that probably the most performing studies are those conducted in geographical contexts other than North America and Europe.

The first model, investigating the geographical proximity, is the one that provides the highest number of significant variables, compared to the others. In fact, an additional significant variable found is the variable 'age', relative to the publication of the article that, given its positive sign, suggests that better results are achieved by publications carried out less recently. The reason behind this finding could be related to the development of the geography of innovation literature, which was originally more concerned with the investigation of the geographical aspect of proximity, and the strong and diffuse conviction that this was one of the main driver of innovative processes, compared to more recent theories that provide many different views, as depicted in the first chapter.

A third significant variable, also, and even more, strongly identified in the fifth model concerning the institutional proximity, and already found in the general models as well, is the 'level' of analysis. This again shows a negative sign in both models, strengthening the importance of empirical analyses conducted at the macro level. For the institutional proximity the relevance of such dimension is greater than for the geographical proximity, both in terms of significance than in terms of impact, given its value of -2.520 against a -1.007 for the latter.

With respect to the results achieved in the general models, also the ‘journal’ of publication turned out again to have a significant impact, but only with respect to the social proximity, maintaining a negative sign but slightly decreasing the value of the beta coefficient.

Another important outcome, though achieved only in the development of the proximity models, concerns the cognitive dimension: a significant impact at the 10% level is obtained by the variable ‘input-output’. Given the negative sign of such variable, the probability of a positive cognitive proximity outcome is 2.789 times more than that of a non-positive effect in cases of innovative inputs: this means that, when cognitive proximity exerts a positive impact, it is much more probable to be related with some kind of cooperation and collaboration between agents, rather than with innovative outputs.

Lastly, for what concern the organizational proximity, no significant variables were identified. The variables ‘data’, ‘method’ and ‘number of observations’ did not provide significant results in any of the models concerning the proximity dimensions.

	(1) Geo_Prox	*(2) Cog_Prox*	*(3) Org_Prox*	*(4) Soc_Prox*	*(5) Inst_Prox*
Variable	***β coeff. (s.e.)***	***β coeff. (s.e.)***	***β coeff. (s.e.)***	***β coeff. (s.e.)***	***β coeff. (s.e.)***
Age	0.131* (0.074)	0.054 (0.098)	-0.113 (0.122)	-0.161 (0.131)	-0.209 (0.143)
Journal	-0.499 (0.513)	1.180 (0.970)	-0.336 (0.767)	-1.262* (0.764)	0.614 (0.945)
Data	-0.237 (0.547)	-0.628 (1.143)	-0.108 (0.908)	0.673 (1.022)	-0.311 (0.945)
Method	0.144 (0.576)	-2.320 (1.481)	0.542 (0.862)	-0.622 (0.908)	1.826 (1.234)
N. Obs	7.85e-07 (6.32e-07)	-1.74e-05 (8.99e-05)	-2.08e-5 (5.65e-05)	7.28e-07 (7.05e-07)	1.78e-07 (7.48e-07)
Level	-1.007* (0.582)	-0.580 (0.956)	-0.025 (0.834)	0.867 (0.904)	-2.520** (1.133)
Europe	-2.120* (1.106)	-	-	-	-
North America	-1.988 (1.228)	-	-	-	-
Input - Output	-0.284 (0.705)	-2.789* (1.466)	0.657 (1.053)	0.645 (1.229)	-0.769 (1.156)
N obs	89	95	95	95	95
n groups	38	40	40	40	40
Log Likelihood	-53,867	-22,073	-27,948	-29,789	-22,326

Note: every estimate includes a constant term;
variables "Europe" and "North America" were omitted for collinearity reasons.
****p<0.01; **p<0.05; *p<0.1*

Table 14: Total Output per Proximity Dimension

CONCLUSIONS

The importance of the proximity concept is not recent, but conversely, founds its origins and its first theoretical developments many decades ago. During this time, different theories and strands of thought followed one other, with a strong initial attention directed on the role of geographical closeness between actors, hence investigating the function played by the space.

Over time, other kinds of proximity beyond the geographical one emerged, each considered distinctly as the cause of the interaction among actors, able to produce knowledge and consequently innovation. Many different empirical analyses were consequently developed by the economists in order to provide confirms to the hypotheses on which such theories were based.

A recent strand of literature, the 'Evolutionary Economic Geography', moved a step further in the analysis of proximity, evolving to a multi-dimensional concept, in which all the various proximity dimensions play a role toward the implementation of innovative processes. In particular, one of the most known studies elaborated on this position was published by Ron Boschma in 2005, entitled *Proximity and Innovation: A Critical Assessment*, in which five proximity dimensions were delineated: geographical, cognitive, organizational, social and institutional.

Despite these recent developments, the literature concerning the causal effect existing between proximity and innovation is very wide and debates on the importance of the different dimensions are still open.

For this reason, in the present study a meta-analysis was conducted with the aim to shed light on this miscellaneous field in which different, and sometimes also opposite views and empirical results are present. In particular, even though proximity has been extensively analyzed also with respect to other factors, such as productivity, the attention was pointed towards innovation, given its crucial role for the creation of long-term economic growth.

This kind of analysis is indeed a useful instrument not only to summarize past researches, but also to allow comparability across studies that not only differs in the results achieved, but also in their models' construction and development.

The meta-analysis here developed was based on 40 empirical studies conducted on the causal relation between proximity and innovation, and was implemented through a random effect logit model. The five dimensions of proximity identified by Boschma were taken as guideline to assess a possible univocal result and other relevant independent variables were included in the model.

The results achieved provide for a neutral and impartial outcome: in fact, all the five proximity dimensions investigated turn out to be non-significant in the general model implemented (i.e. output A). Moreover, this result has been further demonstrated by the development of two additional robustness checks carried out by the outputs B and C. Consequently, the proximity dimensions did not appear to have any effect.

Instead, other variables turned out to be important drivers of the positive outcome found: among those, primarily the number of observations, resulting in better performance the greater the number used in the analyses, and the macro level of investigation, dealing with studies carried out at the regional or sub-regional level, were confirmed to be significant by all three outputs elaborated. Furthermore, the latter variable additionally proved its significance in the models constructed for the single proximity measures. In fact, when accounting for the positive outcome deriving from the individual proximity dimensions, both for the geographical and the institutional proximity the macro level of analysis produced significant results, against those studies that used firms as units of observation.

Other two important variables indentified, even though slightly less relevant given their lack of significance in the third output, were the use of continuous response models in the execution of the empirical analyses and the publication of the articles in urban/regional journals. This second variable also found validation in the model dealing with the positive outcomes of social proximity, finding a significant result. Therefore, this provides for the existence of a small publication bias, highlighted by the propensity of urban/regional journal to favor the publication of empirical studies that demonstrate the existence of a positive impact on innovation exerted by the proximity dimensions.

In this second set of models developed with respect to the single proximity outcomes, other variables presented a significant result. For the geographical proximity both the analyses conducted in countries other than Europe and North America and the publication year turned out to play a role. This second variable suggests that better results are achieved by publications carried out less recently and the reason behind this outcome could be intrinsic in the development experienced by the literature on the geography of innovation, originally more concerned with, and more in favor of the impact exerted by the geographical aspect of proximity.

Last but not least important finding is the significant impact revealed by the innovative inputs when examining the cognitive proximity outcome. This result explains the importance of cooperation and collaboration between agents in relation to the cognitive dimension of proximity, going back to the idea of the cognitive proximity as a prerequisite for learning. In fact, as emphasized by Boschma (2005), this dimension is considered the sole able to allow an interactive learning process to take place. Therefore, what the results of this meta-analysis highlight are that cooperation and collaboration between actors, that in an optimum situation share a common knowledge base with diverse but complementary capabilities, give the capacity to identify, interpret, exploit and absorb knowledge, consequently allowing innovative processes to take place and positive outcomes to be obtained.

APPENDIX

Table A1: Studies included in the meta-analysis

#	AUTHORS	PUBLICATION YEAR	JOURNAL
1	MacPherson	1998	Entrepreneurship & Regional Development
2	Autant-Bernard	2001	Research Policy
3	Fritsch	2001	Regional Studies
4	Bottazzi, Peri	2003	European Economic Review
5	Fischer, Varga	2003	The Annals of Regional Science
6	Greunz	2003	The Annals of Regional Science
7	Stuart, Sorenson	2003	Research Policy
8	Orlando	2004	RAND Journal of Economics
9	Capello, Faggian	2005	Regional Studies
10	Moreno, Paci, Usai	2005	Environment and Planning
11	Oerlemans, Meeus	2005	Regional Studies
12	Wuyts, Colombo, Dutta, Nooteboom	2005	Journal of Economic Behavior & Organization
13	Autant-Bernard, Billand, Franchisse, Massard	2007	Papers in Regional Science
14	Cabrer-Borràs, Serrano-Domingo	2007	Research Policy
15	Cantner, Meder	2007	Journal of Economic Interaction and Coordination
16	Maggioni, Nosvelli, Uberti	2007	Papers in Regional Science
17	Nooteboom, Van Haverbeke, Duysters, Gilsing, Van den Oord	2007	Research Policy
18	Ponds, van Oort, Frenken	2007	Papers in Regional Science
19	Varga	2007	Acta Oeconomica
20	Weterings, Koster	2007	Research Policy
21	Agrawal, Kapur, McHale	2008	Journal of Urban Economics
22	Gilsing, Nooteboom, Vanhaverbeke, Duysters, van den Oord	2008	Research Policy
23	Cusmano, Mancusi, Morrison	2009	Structural Change and Economic Dynamics
24	Gallié	2009	Regional Studies
25	Li, Vanhaverbeke	2009	Technovation
26	Hoekman, Frenken, Tijssen	2010	Research Policy
27	Ponds, Van Oort, Frenken	2010	Journal of Economic Geography
28	Fitjar, Rodríguez-Pose	2011	European Planning Studies
29	Balland	2012	Regional Studies
30	Broekel, Boschma	2012	Journal of Economic Geography
31	Cunningham, Werker	2012	Papers in Regional Science
32	Doran, Jordan, O'Leary	2012	Entrepreneurship & Regional Development
33	Shang, Poon, Yue	2012	China Economic Review
34	de Dominicis, Florax, de Groot	2013	Applied Economics
35	Fafchamps, Söderbom	2013	The World Bank Economic Review
36	Marrocu, Paci, Usai	2013	Technological Forecasting & Social Change
37	Molina-Morales, García-Villaverde, Parra-Requena	2014	International Entrepreneurship and Management Journal
38	Ter Wal	2014	Journal of Economic Geography
39	Hardeman, Frenken, Nomaler, Ter Wal	2015	Science and Public Policy
40	Lander	2015	Industry and Innovation

Table A2: descriptive statistics – Output A

OUTPUT (A) = 1										
Dummy Var	***GEO output***		***COG output***		***ORG output***		***SOC output***		***INST output***	
	Freq.	***%***	***Freq.***	***%***	***Freq.***	***%***	***Freq.***	***%***	***Freq.***	***%***
0	36	49,32%	35	81,40%	64	87,67%	62	84,93%	65	89,04%
1	37	50,68%	8	18,60%	9	12,33%	11	15,07%	8	10,96%
Total	73	100%	43	100%	73	100%	73	100%	73	100%
Dummy var	***Journal***		***Data***		***Method***		***Level***		***Input - Output***	
	Freq.	***%***	***Freq.***	***%***	***Freq.***	***%***	***Freq.***	***%***	***Freq.***	***%***
0	36	49,32%	55	75,34%	38	52,05%	42	57,53%	22	30,14%
1	37	50,68%	18	24,66%	35	47,95%	31	42,47%	51	69,86%
Total	73	100%	73	100%	73	100%	73	100%	73	100%
Continuous Var	***Year***		***N. Obs***							
Min	1998		3							
Max	2015		2044711							
Mean	2009,164		128886							
St. Dev	4,252		450759							

Table A3: Descriptive statistics – proximity measures

Var	GEO = 1	Freq.	%	COG = 1	Freq.	%	ORG = 1	Freq.	%	SOC = 1	Freq.	%	INST = 1	Freq.	%
Journal	*0*	20	54,05%	*0*	2	25,00%	*0*	4	44,44%	*0*	7	63,64%	*0*	3	37,50%
	1	17	45,95%	*1*	6	75,00%	*1*	5	55,56%	*1*	4	36,36%	*1*	5	62,50%
	Total	37	100%	***Total***	8	100%	***Total***	9	100%	***Total***	11	100%	***Total***	8	100%
Data	*0*	27	72,97%	*0*	6	75,00%	*0*	7	77,78%	*0*	9	81,82%	*0*	6	75,00%
	1	10	27,03%	*1*	2	25,00%	*1*	2	22,22%	*1*	2	18,18%	*1*	2	25,00%
	Total	37	100%	***Total***	8	100%	***Total***	9	100%	***Total***	11	100%	***Total***	8	100%
Method	*0*	20	54,05%	*0*	6	75,00%	*0*	4	44,44%	*0*	6	54,55%	*0*	2	25,00%
	1	17	45,95%	*1*	2	25,00%	*1*	5	55,56%	*1*	5	45,45%	*1*	6	75,00%
	Total	37	100%	***Total***	8	100%	***Total***	9	100%	***Total***	11	100%	***Total***	8	100%
Level	*0*	19	51,35%	*0*	4	50,00%	*0*	6	66,67%	*0*	9	81,82%	*0*	4	50,00%
	1	18	48,65%	*1*	4	50,00%	*1*	3	33,33%	*1*	2	18,18%	*1*	4	50,00%
	Total	37	100%	***Total***	8	100%	***Total***	9	100%	***Total***	11	100%	***Total***	8	100%
input/output	*0*	10	27,03%	*0*	3	37,50%	*0*	2	22,22%	*0*	3	27,27%	*0*	4	50,00%
	1	27	72,97%	*1*	5	62,50%	*1*	7	77,78%	*1*	8	72,73%	*1*	4	50,00%
	Total	37	100%	***Total***	8	100%	***Total***	9	100%	***Total***	11	100%	***Total***	8	100%
	Min/Max	***Mean***	***St. Dev.***	***Min/Max***	***Mean***	***St. Dev.***	***Min/Max***	***Mean***	***St. Dev.***	***Min/Max***	***Mean***	***St. Dev.***	***Min/Max***	***Mean***	***St. Dev.***
Year	1998/2015	2008,2	4,553	2003/2015	2008	5,155	2005/2015	2010,1	3,059	2005/2015	2010,9	3,360	2007/2015	2011,3	2,964
Nobs	3/2044711	127180	451002	86/1218	426,5	390,34	40/1218	538,22	491,93	42/2044711	255368	604761	40/1883142	235717	665660

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