THE SPAN OF R&D COLLABORATIVE NETWORKING AND INNOVATIONS: TOWARDS A CONDITIONAL FRAMEWORK

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Abstract

This paper presents a critical literature review on the academic debate around the issue of the relative importance of proximity against distant networking in determining companies' (SMEs) innovativeness. The review covers some ideas of the new economic geography and networks theories in the context of industrial clusters. We conclude with an identified research gap and a list of propositions for future research. The paper proposes that the relative importance and potential usefulness of distant inter-firm collaborative ties for R&D purposes increases when a number of moderating factors are present. These factors include: low spillover of knowledge into locations, high levels of internal technological diversity, R&D intensity, and high importance of foreign markets for firms.

Key words: R&D collaboration, network, knowledge spillover

JEL Code: O33, O32, O25

Introduction

This paper presents a critical analysis of the literature and a proposition of a research on the issue of technological knowledge acquisition by small and medium enterprises (SMEs) within and outside industrial clusters. The paper concludes with a research proposal which aims to show for the first time that SMEs that do not limit their research and development (R&D) collaborative ties to regional scope, but exploit technological opportunities in other regions and abroad, are likely to be more innovative and better performing than their region-focused counterparts. However, it is proposed that the relationship is conditioned by a number of knowledge-related factors, such as technological diversity of a firm, potential spillover pool of a region and others.

The theoretical background of this thesis is built mainly on the theories of new economic geography (e.g. Krugman, 1991) and the endogenous growth theory (e.g. Romer, 1986, 1990). However, a firm, rather than a region is considered as a unit of analysis. The firm-level analysis is preferred over the region-level analysis (which is more common for research in the domain of economic geography) in order to get deeper understanding of how SMEs satisfy their technological needs by the means of R&D collaboration, what are the incentives and obstacles for building collaborative ties, and what is the role of proximity in building these ties.

The context is limited to SMEs because they are known to be especially dependent on collaboration in their innovation activities due to their limited capabilities in terms of financial and knowledge-related resources, diseconomies of scale, and short-term management perspective (e.g. Bessant & Rush, 1995; Kaufmann & Todtling, 2002; Nooteboom, 1994). Despite the fact that SMEs have also some well-known advantages compared with large companies (e.g. less bureaucracy, quick decision making process), it is still difficult for the SMEs to innovate even within a collaborative network.

The contributions of the study proposed in this paper are mainly relevant for national and regional policy makers. The findings are expected to be able to shed light on the relative importance of the geography of inter-firm R&D collaboration for firm-level innovativeness, in particular the role of inter-regional and international networks to aid innovation in SMEs. Therefore, based on the findings of this study, it will be possible to discuss to which extent decentralization of national innovation systems (NIS) is a reasonable policy decision.

The rest of the document is organized as follows: the first chapter contains an overview of the academic literature on the importance of proximity for innovative capacity; the second chapter presents an overview of the literature on the importance of networking across distances for innovative capacity; in the third chapter an identified research gap and a suggested research question and propositions are presented.

1 On the importance of proximity for innovative capacity

According to the endogenous growth theory, regional and national disparities in terms of economic competitiveness, GDP growth rate and other macroeconomic indicators can be to a large extent attributed to the intensiveness of R&D activity of a region or a nation. The research within the domains of economic geography and regional economics has identified that both public and corporate R&D expenditures within regions have significant effect on the

regions' innovative performance (e.g. Giovanni & Santarelli, 2001). Many studies have identified strong correlation between corporate and university R&D expenditures and innovativeness (for example, measured as number of patent applications) at the regional level.

The research within the domain of economic geography and the new economic geography (NEG, the term strongly associated with Paul Krugman) during the last two decades has been focused on the role of geographic proximity between firms in innovation activity. This new approach is also known as the *geography of innovation* approach (Jaffe, 1989; Krugman, 1991). The notion of geography of innovation is theoretically grounded on the idea of "positive knowledge externalities" (see, for example, Antonelli, 1994), which states that not only the firms' own R&D activity determines the firms' innovativeness, but the overall business environment that is conducive for innovations. In other terms, knowledge and technologies are known to "spill over" within certain geographic areas. This local business environment conducive for innovations, due to the positive knowledge externalities effect, is often associated with the French term "milieu innovateur" coined by Aydalot (1986).

Possibility and inevitability of knowledge externalities are based on the intrinsic properties of knowledge. Thus, knowledge is considered as a public good that is non-rival and non-excludable (Arrow, 1962; Jaffe, 1986; Romer, 1986). Where non-rivalry basically means inexhaustibility due to replicability, and non-excludability means that possession of knowledge by one firm does not precludes other firms from using this knowledge. Therefore, the knowledge created by one firm or a university is supposed to be directly or indirectly available to other firms (fully or partly). This effect is practically explained by possibility to imitate innovations (Mansfield, 1977) as well as by circulation of skilled labor force and other mechanisms.

However, not any type of knowledge possesses the properties of non-rivalry and non-excludability. Thus, these two properties are mainly attributed to the type of knowledge known as tacit (non-codifiable) rather than to explicit (codifiable, embedded). As Romer (1986) argues, knowledge becomes rival and excludable if it is embodied into human capital. Moreover, technology, as an output of R&D process, is largely excludable by the means of intellectual property (Romer, 1986). Spence (1984) has introduced a dichotomy of perfect and imperfect appropriability of R&D. Perfect appropriability means that hundred percent of a firm's R&D output is appropriated by the firm, whereas imperfect appropriability means that R&D output becomes a public good to a certain extent. Therefore, knowledge spillover embraces the process of unintended leak-out of knowledge based on the knowledge

externality phenomenon, as well as intended interchange of knowledge through formal and informal interaction among firms.

However, the knowledge spillover does not happen equally smoothly in different contexts. Knowledge spillover is known to be inhibited by a number of factors, such as physical distance between firms, lack of trust among firms and unwillingness to share knowledge, unwillingness to discover and absorb new knowledge (e.g. Oakey & White, 1993), poor knowledge spillover pool available in a certain location (Jaffe, 1986) and other factors. Conversely, a large set of literature has been published on factors that promote knowledge spillover effect. Among these factors are innovation intermediaries and knowledge brokers, government initiatives, arrangement of industry actors in industrial clusters (Porter, 1990), and other factors.

These factors inhibiting and promoting knowledge spillovers and the postulates of the NEG in general have had significant influence in the second half of the 20th century on the policy makers around the world. Thus, one of the practical implementations of the idea of innovation as a geographical phenomenon has been the practical concept of industrial clusters (e.g. Porter, 1990). The governmental innovation policies promoting clusterization have been especially targeted toward high-tech (R&D intensive) industries. This is inline with the classical postulates of the NEG. Audretch and Feldman (1996) have discovered that companies of R&D intensive industries (industry R&D) with high proportion of highly skilled labor force tend to have higher propensity to cluster and, therefore, extract larger benefit from co-location.

Clusters are conventionally understood as a geographic concentration of collaborating and competing companies of one or several supplementary industries and supporting institutions. The term of cluster in its modern understanding was introduced by Michael Porter in his seminal work *The Competitive Advantage of Nations* (1990). Whereas the ideas of Michael Porter are in fact tracing back to the ideas of agglomeration economies, proposed by Alfred Marshall (1920) back in 1890.

Clusters are perceived by many theoreticians and policy makers as one of the main driving forces of economic development and also as one of the most effective ways of fostering innovations (e.g. Porter, 2000) on regional and national levels. Leaded by the ideas of geography of innovation, governments of many industrialized countries have focused their national innovation systems on regional and local levels. According to the Organization of

Economic Co-operation and Development (OECD) clusters should be understood by governments as manageable implementations of NIS in place.

However, not only co-location, but interaction among cluster members is important for knowledge-related benefits that eventually lead to increased innovative capacity of firms and competitiveness of regions. Geographical proximity between actors does not guarantee interaction, but it rather represents a potential of the interaction (Gilly et all, 2011). Moreover, not only internal, but also external (inter-regional and international) interaction of firms plays a significant role. The following chapter is focused on the issue of inter-organizational networking across distances as a crucial premise of knowledge spillovers and enhanced innovative capacity.

2 On the importance of networking for innovative capacity

There have been published many academic studies that have shown that knowledge spillovers are happening both within and across regions. Such studies have been conducted for the US, as well as in Europe. Thus, many studies have shown that R&D undertaken in a certain region effects innovative capacity of firms in nearby regions. This implies than not only the pure spillover of tacit knowledge via frequent social interaction and collaboration with neighbours effects innovative capacity of firms and regions, but intentional interaction across distances as well. However, the geographical proximity is still an important factor determining knowledge diffusion in so far as many studies have revealed a tendency of the knowledge diffusion phenomenon to decay with distance.

The extant theory supports this idea. Knowledge diffusion process is known to have different forms: either as an unintentional "diffusive" form based on "spatial contiguity", or as an intentional form based on "a-spatial networks" (Maggioni et al, 2007, p.472). The intentional (also known as relational) knowledge diffusion tends to be happening among so called "crucial nodes" of knowledge. Maggioni et al (2007) have analyzed the data on 109 European regions and have suggested that both the spatial knowledge spillover as well as relational networking of companies across regions is needed to produce innovations. However, the effect of relational networking across regions was found to be of lesser importance than the effect of spatial knowledge spillover.

The links of local companies (for example, cluster-based) to the companies and institutions located in other regions and countries bring new knowledge into the region or cluster and therefore sustains its knowledge heterogeneity and growth (e.g. Menzel &

Fornahl, 2009). According to another perspective, external (inter-regional and international) inter-firm cooperation can compensate for weaknesses of regional or national innovation systems and to span the so-called "structural holes" (Sapsed et al, 2007) of such systems (e.g. lack of domestic suppliers, poor research capabilities etc). In other words, the roles of local/regional, national and global systems of innovation are known to be complementary in enhancing firms' innovation performance. For example, there is some empirical evidence that sectors which are more advanced in terms of innovations tend to rely on knowledge network within the regional innovation system, whereas less advanced sectors rely more on external knowledge networks within national and global innovation systems. This means that firms are able to compensate the weaknesses of regional innovation infrastructure by establishing collaborative relationships with organizations located abroad or in other regions of a country.

The distinction between the relational networking and spatial knowledge spillovers recently has transformed into discussion on the opposition of the "local buzz" and "global pipeline" phenomena (e.g. Albino et al, 1999; Bathelt et al, 2004). According to this framework, the innovative capacity of a cluster or a region depends on two premises: (a) active inter-exchange of knowledge within a geographic location via formal and informal inter-organizational interaction ("local buzz") as well as on (b) connectivity of the global sources of technological knowledge ("global pipelines"). The role of a "global pipeline" can be played for example by a leader firm (often a multinational enterprise), by a hub-firm or by a university (Albino et al, 1999; Bathelt et al, 2004; Gilly et al, 2011) that act as knowledge gatekeepers - acquiring knowledge from the world leading locations an facilitating its diffusion in the home region.

Therefore, as it has been illustrated, not only the concentration and intensiveness, but also the span (extensiveness) of networks leads to increased innovative capacity of firms and regions. In the following chapter we conclude the academic debate on the relative importance of proximity and distant networking in determining firms' innovativeness and indentify a research gap. A research question and a list of propositions for future research are also presented and justified.

3 Conclusions of the literature review and propositions

Innovation activity is often viewed as a territorial phenomenon and policy makers around the world are implementing innovation policies on regional and local levels. However, as numerous studies have shown, SMEs in regional and local clusters also rely on exogenous

competences in conducting their innovations. As it was illustrated in the previous chapter, not only the intensiveness and proximity, but also the diversity of inter-organizational relations influences companies' innovativeness. However, although a lot has been published on the link between networking and innovations, very little has been said so far on the relation between the span of networking activity and innovations. Nevertheless, some publications contain indirect evidence that the span and the diversity of networking activity enhances firms' knowledge base and innovative capacity.

Therefore, this paper points out an important gap in the knowledge which still has to be fulfilled. The following ***questions*** need to be investigated: (a) *to what extent the span of knowledge exploration effects innovativeness of SMEs*? And (b) *what factors moderate the importance of the span of knowledge exploration?* In order to answer these questions, below we present a list of theory-based propositions that would be beneficial to test against large samples of data.

Proposition 1: *SMEs' span of collaborative ties for R&D purposes is positively associated with the SMEs' innovativeness.*

However, one of the main questions raised in this study, as it is stated above, is to identify conditions under which exploration of distant technological knowledge becomes beneficial for SMEs. To begin with, presumably, SMEs vary substantially in their market strategies, that implies that their networking behaviour varies as well. For example, Mort and Weerawardena (2002) have identified that the firms that compete globally from the very beginning of their business operations (i.e. so called "born global") tend to build networks proactively both on local and global levels. Therefore, the next proposition concerns the moderating effect of the location of business operations (i.e. sales destination) of SMEs.

Proposition 2: *The relation between SMEs' span of collaborative ties for R&D purposes and innovativeness is moderated by the sales destination of the SMEs.*

Jaffe (1986, p.986) argues that a firm benefits from R&D spillovers within the same "technology space" with its neighbors. In other words, in order to benefit from R&D spillover a firm's research activity has to be relevant to the research activity of its neighbors. The total measure of the technological relevance is named "potential spillover pool" by Jaffe (1986, p.986) and is calculated as a function of a firm's *technological proximity* to its neighbors. The measure of technological proximity is based on the estimation of the degree to which two firms' research interests, approximated by patent categories, overlap (Jaffe, 1986). Therefore,

we propose that an SME that can not satisfy its technological needs locally due to poor potential spillover pool of a cluster or a region should benefit more from exploration of technological knowledge elsewhere.

However, in the proposed model the measure of potential spillover pool is suggested to be measured as subjective to (perceived by) firms. The rationale behind the preference for subjective rather than objective patent-based measure is the following. First, the choice of subjective measure allows avoiding some limitations peculiar to patent-based measures. For example, the fact that patent classification is technology-based rather than product- or service-based undermines its economic usefulness (Jaffe, 1986). This means that some products or services can be based on formally different technological categories, whereas some technological categories can include technologies of different industries and of very diverse practical application, which undermines validity of this measure.

Second, the use of subjective rather than patent-based measure of the potential spillover pool allows enriching the measure. By operationalizing the concept of potential spillover pool into a list of specific items, the measure would embrace not only availability of relevant research activities in a given geographic area, but also accessibility to such activities. Presence of relevant research activity within a geographic area does not assumes its perfect accessibility due to a number of reasons. First of all, lack of formal and informal interaction among organizations in a geographic area can make the knowledge locked within a few key knowledge producing organizations. Second, lack of trust among companies can undermined the companies willingness to share knowledge among another.

Proposition 3: *The relation between SMEs' span of collaborative ties for R&D purposes and innovativeness is moderated by the potential spillover pool of the SMEs' home location.*

According to some literature (e.g. Hassink, 1996) presence of R&D department and intensity of internal R&D activity increases firms' propensity to be involved into inter-organizational R&D cooperation. Although this literature does not relate R&D intensity to the span of cooperative links, but only considers the number of links, we make an assumption that span of cooperative ties is also a function of internal R&D activity. Conversely, there exists some empirical evidence that firms can successfully substitute lack of internal R&D activity with more intensive collaborative networking. Therefore, the moderating effect of internal R&D intensity is expected to be non-linear.

Proposition 4: *The relation between SMEs' span of collaborative ties for R&D purposes and innovativeness is moderated by the R&D intensity an SME.*

The final factor, which we propose as having moderating effect on the relation between the span of knowledge exploration and innovativeness is the internal technological diversity. Technological diversity is conventionally understood as a variety of patent categories a firm holds, which in other terms can be interpreted as breadth of a firm's technological portfolio (Srivastava & Gnyawali, 2011). By introducing this moderating variable we rely on the idea, formulated by Srivastava and Gnyawali (2011, p.799), that "breadth of portfolio resources helps a focal firm engage in a greater degree of exploration". Therefore, it is proposed that the higher a firm's internal technological diversity is, the more likely it is to engage itself into distant R&D collaborative relations.

Proposition 5: *The relation between SMEs' span of collaborative ties for R&D purposes and innovativeness is moderated by the internal technological diversity of an SME.*

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