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Regional dispersion of cooperation activities as success factor of innovation oriented SME

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Abstract

In this paper, we analyze the relationships between different types of innovation and collaboration, given the varying geographical distance of the latter. The study is based on the data of the research project "KompNet 2011 – Factors determining the success of regional innovation networks", which examines the innovation activities of small and medium-sized enterprises (SME) in and closely around Jena (Thuringia).

The aim of this paper is to explore to what extent spatial reach of collaboration linkages determines innovation orientation and innovative behavior. That means: Innovation performance could be positively related to (a) to a high intensity of local collaboration, (b) the intensity of international collaboration or (c) neither regional nor (inter)national collaborations.

In a first step we summarize the relevant literature which comprises aspects of our central subject under investigation. We additionally discuss the necessity of keeping in mind several control variables for theoretical and empirical reasons. In the following we present descriptive analyses relating to the regional reach of collaboration in general, the impact of collaboration on innovation and the links between the regional reach of cooperation and different forms of innovation, i.e. product, process, marketing and organizational innovation. In a final step we discuss the results of several regression models.

We observe that there is no significant influence of the geographical variables on the innovative performance of SME. Therefore our findings suggest that innovative firms rely on collaboration partners at a variety of spatial distances. The results also show a significant and positive influence of the intensity of competition on the innovativeness of firms in all models. Furthermore product- and process innovations are created by firms with intensive cooperative activities to scientific institutions, while a wide variety of cooperation partners and a strong focus on quality leadership turns out to be important for the development of marketing- and organizational innovations.

JEL classification: D85; L10; O31; R12

Key words: Cooperation, Geographical reach, Innovation, Intensity of competition, Marketing innovation, Organizational innovation, Process innovation, Product innovation, Quality leadership, Regional dispersion, SME, Spatial distance

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1 Introduction

The paper deals with the question how the innovation performance of small and medium enterprises (SME) is influenced by the regional localization of their cooperative activities. So far it is concerned with the interdependencies of firm organization and market structure as well as of size and spatial distributions of cooperation activity with the processes governing innovation behavior of SME.

The uneven spatial distribution of innovative behavior is a widely observed phenomenon. According to Gordon and McCann (2005a, 2005b) and Iammarino and McCann (2006) it is possible to distinguish between four alternative hypotheses explaining this finding.

1. The first one is the well known cluster approach of Michael Porter (2003). According to it the uneven spatial distribution of innovative behavior is the result of clusters of the currently more innovative sectors of the economy.

2. The second one is more concerned with the dynamics of industrial clusters in comparison to Porter's approach, such that the different phases of the product and profit cycles are reflected in terms of emergence, evolution and decline of innovative clusters (Vernon 1966; Markusen 1985). The focus here is on the relationship between space, value added, and production cost conditions at different stages in the product cycle (Gordon & McCann 2005a, 2005b; Iammarino & McCann 2006).

3. The third approach is concerned with the characteristics of different places. These could be the so called soft factors of regional economic performance (Kitson et al. 2004), as well as the regional university-industry linkages as the very core of regional innovation systems (Audretsch et al. 2003; Arvanitis et al. 2005; D'Este et al. 2005; Florax & Folmer 1992; Fritsch & Schwirten 1999; Frye 1993; Goldstein et al. 1995; Goldstein & Renault 2004; Lüder 1988; Peters & Becker 1999; Schamp & Spengler 1985; Smith 2003; Thanki 1999; Zucker et al. 1998).

4. The fourth hypothesis assumes that innovation is most likely to occur in clusters of small and medium-sized enterprises, whose spatial patterns happen to be uneven. From this point of view geographical proximity of SME is the key for the development of

mutual trust relations (Granovetter 1973) between them. These trust relations could be the result of shared experience of interaction with decision-making agents in different firms as well as of joint development of tacit knowledge in the course of cooperative innovation processes. The so-called 'new industrial districts' such as Silicon Valley (Saxenian 1996), and traditional industrial districts such as the Emilia-Romagna region in Italy (among others Brusco 1982; Castells & Hall 1994) have highlighted the role which social as well as purely instrumental business links may play in fostering localized growth.

Our own research combines elements of these hypotheses, starting with the observation that only little is known about how knowledge is actually transmitted, at what distance, and how this relates to the innovation outcome (Breschi & Lissoni 2001; Fritsch 2005; Döring & Schnellenbach 2006).

The remainder of the paper is organized as follows. Section 2 discusses the spatial dimension of innovation collaboration of SME. Section 3 presents the existing empirical literature on the influence of other control variables in the collaboration context. Section 4 summarizes the hypotheses and describes the data set. The descriptive and econometric results are presented in section 5 and section 6 concludes.

2 The spatial dimension of innovation collaboration

The analysis tries to shed light on the relationships between innovation and collaboration, given the varying geographical distance of the latter.

The relationship between innovation and location is one of the most influential ideas of the last twenty years. The inherent local concentration of innovation and thus a flourishing regional development is at the heart of a broad range of theoretical concepts from Porters´ famous clusters, the new industrial districts and the “innovative milieu” to the idea of regional learning or regional innovation systems (Moulaert & Sekia 2003). The relationship is often expressed as a paradox: Globalization and the accompanying strengthening of competitive pressures leads to innovation as the basis of economic success at all levels (from supra-national and regional to firm levels). But at the same time innovation processes tend to be locally concentrated and even to root in local innovation systems. This is illustrated by a lot of case studies and examples. The most prominent are Saxenians´ Silicon valley (Saxenian 1996) and the chapter 4 of Porters´ Competitive Advantage of Nations (1990, see also Porter 2003). In this vein geographical proximity is a necessary condition for innovation. Therefore, the spatial distribution of innovation and collaboration is an important part of empirical research and public regional development policy.

Two levels of innovation analyses are prevailing in the literature: First the macro-level, that is the regional level and second, the micro-level that is the firm level.

At the regional level many empirical studies estimate knowledge production functions (i.e. innovation production functions) using a diversity of inputs and outputs (Jaffe 1989, Audretsch & Feldman 2004; Lee et al. 2010). Here, the generation of innovation is seen as a black box because the process by which new knowledge is created at the local or regional level is left out of consideration. The interpretation of the findings grounds on “knowledge spillovers”, “creative atmosphere” and “local buzz”. These ideas tend to be vague or difficult to measure. In order to put these ideas into concrete terms the identification and separation of different forms of collaboration of firms (and public research institutions) at the regional level are necessary.

This leads to the idea that the key to understand local innovation systems has to found on a microeconomic approach. Innovation is not emerging out of an opaque regional bubble. Instead, firms innovate (not a region) and therefore the behavior of firms provides the explanation of the spatial concentration of innovation. Notwithstanding that the firms´ decisions depend on internal and external factors.

Thus, secondly, the firm level turns out to be important. In this respect, the analyses focus on the spatial dimension of firm related decisions. The literature of the geography of innovation relies on the idea that short spatial distances are beneficial for innovation due to the necessity of close interpersonal relationships and frequent face-to-face contacts. Both are necessary for the transfer of tacit knowledge. Many studies claim that this kind of knowledge is much more valuable in comparison to codified knowledge, given that innovation processes tends to base more on the transfer of external (new) knowledge in comparison to in-house development (Zucker et al. 1994; Morone & Taylor 2010).

This reasoning is challenged in several ways. As to the spatial implications Boschma (2005) puts forward the idea that several dimensions of proximity are relevant for collaboration, e.g. cognitive and social proximity. As to geographical proximity for analytical purposes it is necessary to isolate it from the other dimensions of proximity. Thus, only distance matters and this describes a situation where pure local knowledge externalities arise without any form of interaction or cooperation between local entities. As to empirical research it turns out that the isolation of pure spatial proximity makes no sense.

Boschma concludes that geographical proximity per se cannot be seen as neither a sufficient nor a necessary condition for the exchange of tacit (and all the more codified) knowledge. It is not sufficient because of other complementary forms of proximity like social and cognitive proximity. It is not necessary because of modern forms of communication, e.g. E-mail, Skype, videoconferencing and high personal mobility.

In addition, geographical proximity may cause a lock-in effect. So, spatial concentration of industries with strong ties, close networks and permanent collaboration may very well lead to a myopic view as to the inherently open, unknown and uncertain process of innovation. If this is true (geographical) proximity may cause a negative influence on innovation. A possible solution could be a mixture of local and extra-local linkages (local buzz and global pipelines).

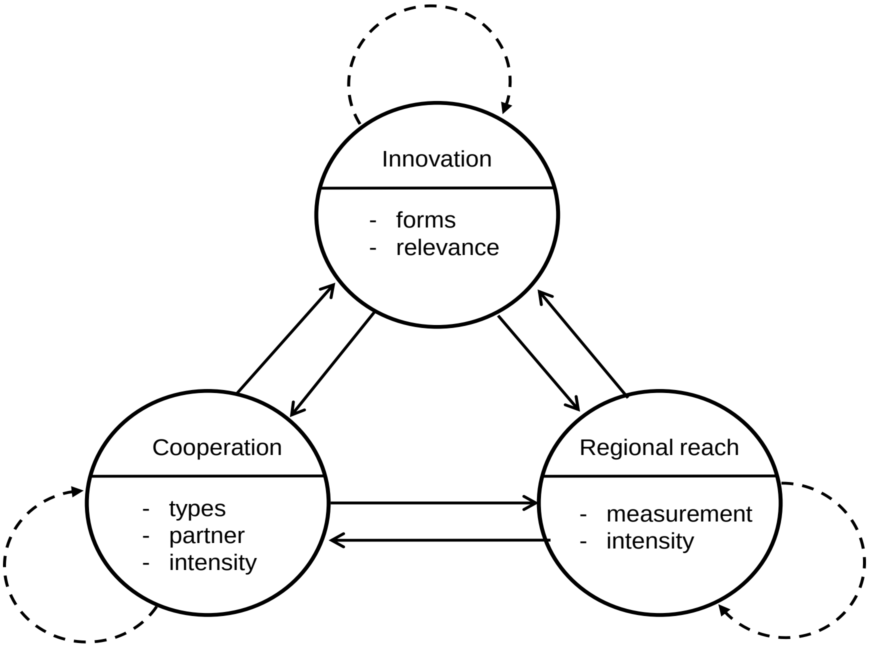
As to innovation most of the authors agree that the transfer of tacit knowledge is important. But this knowledge transfer predominantly is related to cooperation, i.e. bases on intended interactions of firms. From this point of view pure spill-over of tacit knowledge is a phenomenon contradictory in itself. This argument corroborates the idea to focus on the cooperation and collaboration behavior of firms. Therefore, we found our analysis on the idea that these – in addition to the innovation capabilities internal to a firm – are the fundamentals of innovation at the firm level.

But collaboration in itself is a vague concept, either. Various forms of collaboration and different types of collaboration partners exist and in addition the intensity of transfer channels fluctuates.

The notion of innovation itself adds to these ambiguities with respect to different forms of innovation and their relevance. Product and process innovations are not very well defined concepts. A basic problem is that it is very difficult to define the degree of innovation founding on measurable criteria. Thus it remains an open question whether the term innovation refers to a marginal improvement or to a block-buster global scale market innovation. Even the Oslo-manual does not solve this problem. Furthermore, organizational, marketing and financial innovations have to be considered.

The relationships between the three aspects of innovation, collaboration and geographical distance have to be disentangled in order to analyze the spatial dimension of innovation so much discussed in the literature. A first step is to separate the three basic linkages of first, innovation and collaboration, second, innovation and physical distance and third, collaboration and geographical proximity. Chart 1 illustrates this reasoning.

Chart 1 **The holy trinity of regional innovation**



A number of studies deal with the impact of cooperation on firms´ innovative activities. Robin and Schubert (2010) use the data set of the CIS4[1] survey 2002-2004 and find positive effects of cooperation on product and process innovation. Their paper focuses on formal collaboration between firms and public research institutions and relates to France and Germany. Their results confirm the findings of Mohnen et al. (2007), Belderbos et al. (2004), Nieto and Santamaria (2007). In addition Antonelli and Fassio (2011) reveal a positive impact of vertical knowledge flows on process innovations and horizontal knowledge flows on product innovation. Unfortunately these papers do not consider the influence of geographical distance.

Several authors deal with the influence of geographical distance on innovation. In his seminal article Jaffe (1989) using patents tries to shed light on the meaning of geographical proximity. He relies on patents assigned to firms as an indicator of innovation and relates this to industry R&D and university research at the state level in the US. His outcome is that there is only weak evidence of spillovers from university research within the state.

[1] Fourth Community Innovation Survey (CIS4) of the European Union.

In general as to the influence of distance previous studies arrive to different outcomes. The maximum geographical distance of knowledge spillovers varies between at least 75 miles (Anselin et al. 2000), 300 km (Bottazi & Peri 2003) and up to 400 km (Greunz 2005). Most of these spillover-type studies link some indicator of innovation and some measure of distance but fail to consider the mechanisms of knowledge transfer. That means they do not model the form of collaboration resulting in innovation.

Based on data of the 6th Framework Program of the European Union concerning R&D cooperation Autant-Bernard et al. (2007) show that geographical distance plays no role, at least at the European level. They conclude that geographical distance can no longer be considered as the main determinant of collaboration. Instead social distance (network effects) matters. Interestingly this outcome does not hold at the national level. Relying on a subset of 75 French firms geographical and network effects both influence firms´ decision to cooperate. Here local clustering turns out to be important as to the probability of R&D cooperation.

The spatial dimension and different types of collaboration play a dominant role in Isaksen and Onsagers (2010) article as to knowledge-intensive industries in Norway. Their sample consists of 1380 firms and they find that with regard to the firms´ innovation partners 20-30 percent are located in spatial proximity (municipality or neighboring municipalities), 40-60 percent are extra-local networks within Norway, and 20-26 percent show an international reach. As to innovation – contradicting conventional reasoning - they reveal that firms in small urban regions and rural regions exhibit larger product and process innovation rates in comparison to large urban regions. But their descriptive analysis does not tackle the question of any links between innovation rates and reach of cooperation. According to their empirical results - 32.6 percent of the firms in small urban regions (10.000-199.000 inhabitants) find collaboration partners in their own local area compared to 19.6 percent in rural regions and 23.3 percent in large urban areas - their seems to be no link between innovativeness and regional reach of collaboration.

De Jong and Freel (2010) explore the geographical distance of innovation collaborations in Dutch high tech small firms. They selected 316 firms that successfully collaborated for innovation (i.e. had new technology-based products in the past three years). As dependent variable they use the geographical distance. About 72 percent of partners were within 150 km and the median distance to partners was 82 km.

Furthermore, nearly 79 percent of partners were located in the Netherlands. As to the interdependence of innovation and reach of collaboration they do not consider differences with regard to innovation performance (all of the firms of their sample are innovators) but conclude that geographical distance per se has no influence and can be compensated by other forms of proximity.

Drejer and Vinding (2007) concentrate on the propensity of innovative firms to collaborate across geographical distance in two regions of Denmark. They distinguish regional, national and international reach of collaboration. 32.6 percent of the collaboration partners are located in the region, 35.4 percent on the national level and 32.0 percent abroad (Drejer & Vinding 2007). Thus, their data do not point to a clear spatial profile of collaboration. But as to firms in the two regions of East Jutland and North Jutland there are significant differences with regard to the location of their collaboration partners. They conclude that this difference is due to the peripheral and less developed situation in North Jutland.

The spatial reach of successful knowledge transfer is one hypothesis tested by Cummings and Teng (2003). Their survey is based on US high-technology companies with sales greater than US $ 10 million and includes sixty-nine usable responses. Their dependent variable is transfer success and is measured using a 22-item scale that includes a broad range of aspects to provide a reliable measure of transfer success. The spatial distance is measured using the number of miles between the cooperation partners. Their sample shows a mean of 1433 miles (Cummings & Teng 2003). An interesting outcome is that the spatial distance variable has no significant influence and this result holds as to different specifications of their regression analysis.

Fritsch (2000) refers to the manufacturing sector in the three German regions: Baden, Saxony and Hanover-Brunswick-Göttingen. His survey studies the propensity of firms to cooperate with customers, suppliers, other firms and public research institutions. The dependent variables of his regression models are the existence and the number of cooperative relations. There are significant differences as to the cooperation behavior in his three regions, confirming the idea that the spatial reach of cooperation depends on characteristics of the region at hand. Furthermore, about 30 percent of cooperative links with customers and suppliers are located in the same region. As to other firms (i.e. competitors) nearly 50 percent of all cooperative relationships refer to the regional level and about 55 percent of the cooperative links with public research institutes are regional collaborations. He concludes that there is a high importance of geographical proximity and that this is especially true as to links with public research institutions. With regard to collaboration with suppliers and customers spatial proximity turns out to be much less important. Overall, the influence of the spatial reach of collaboration on the innovation success remains open. At the level of the three regions under scrutiny the highest propensity to cooperate locally was found in Saxony but the firms in Baden are leading with regard to innovation.

Krätke's (2010) survey for the metropolitan region of Hanover-Brunswick-Göttingen bases on 1138 regional economic actors (453 public research establishments, 613 firms and 72 other establishments). The survey distinguishes different forms of collaboration as to intensity from formal collaboration (high intensity) to education and qualification (low intensity). His outcomes are as follows: 34 percent of all network collaborations are regional links, 43 percent have partners in the national economic territory of Germany and international connections have a share of 23 percent.

With regard to a subsample of 412 firms reporting patent applications he investigates the influence of the reach of collaboration on the innovation output of firms (number of patents). Regional connectivity, that is the number and intensity of links to regional partners, has a highly significant positive impact on innovation output. The same result holds as to supra-regional links, i.e. national and international partners, outside the metropolitan area under scrutiny. A specification of a negative binomial regression including regional and international links and omitting the national reach does not alter the results: both regional and international collaboration has a significant and positive influence.

A comparison of the different studies turns out to be rather difficult. The main reason is the diversity of concepts and indicator variables to be found in the literature as to collaboration, innovation and spatial distance.

As to collaboration some papers assume the existence of links – the so called spillovers - without any further specification as to the precise meaning of this term (Jaffe 1989; Anselin et al. 2000). Other authors focus on formal collaboration between firms and public research institutions (Robin & Schubert 2010) or joint EU funded research projects (Autant-Bernard et al. 2007). Some use joint patents as an indicator of collaboration (Canter & Graf 2008, Broekel et al. 2011) and Cummings and Teng (2003: 49) define three interdependent types of knowledge transfer activities. Drejer and Vinding (2007) in their survey asked for the main partner of innovation collaboration, but did not specify the type of collaboration (similar: Fritsch 2000). To the contrast Isaksen and Onsager (2010) distinguish nine knowledge transfer channels.

With respect to innovation many studies rely on patents as indicator of innovation (Jaffe 1989; Krätke 2010) or only include product innovation (Anselin et al. 2000, Drejer & Vinding 2007). Cummings and Teng (2003) ask for successful knowledge transfer and Antonelli and Fassio (2011) refer to product and process innovations. Isaksen and Onsager (2010) include product- and process-innovations and in addition patents.

As to spatial distance the indicators refer to administrative boundaries (Jaffe 1989, Fritsch 2000), functional delineations (Anselin et al. 2000, Broekel & Meder 2010), more or less precisely defined local/regional, national and international spatial levels (Drejer & Vinding 2007, Krätke 2010) or precise definitions as to miles or kilometers (Cummings & Teng 2003, Autant-Bernard et al. 2007, De Jong & Freel 2010).

With regard to the populations and control variables these studies ground on different sets of data. Some studies cover only a certain group of firms: Manufacturing and services with 20 employees and more (Robin & Schubert 2010), manufacturing (Fritsch 2000; Antonelli & Fassio 2011), micro and nanotechnologies (Autant-Bernard et al. 2007), biotechnology (Audretsch & Stephan 1996), science-based firms (Krätke 2010), high-technology corporations (Cummings & Teng 2003), certain two-digit industries (Anselin et al. 2000). As to control regressors, variables such as size of firms, R&D capacity, factors hampering innovation, management strategies, degree of competition and many more play a role.

Last not least, the analysis of regional innovation systems has to cope with problems of causality and internal relationships of innovation, cooperation and regional reach. Chart 1 depicts the idea that as to any of the three poles both directions of influence are possible (Cassiman & Veuglers 2002, Okamuro et al. 2011). Besides, the dashed arrows illustrate that substitution and complementarity of different forms of innovation, collaboration and regional reach have to be considered.

To sum up, the empirical literature covers a tremendous diversity of indicator variables, populations and in addition methods. Even so some generalizations with regard to the spatial reach of collaboration for innovation are possible.

First, as to the spatial reach the descriptive results are to some extent similar. About 30 percent of all collaborations can be found at the local and regional level. National cooperation relationships amount to about 40 to 50 percent and international linkages have a share of more or less 20 percent.

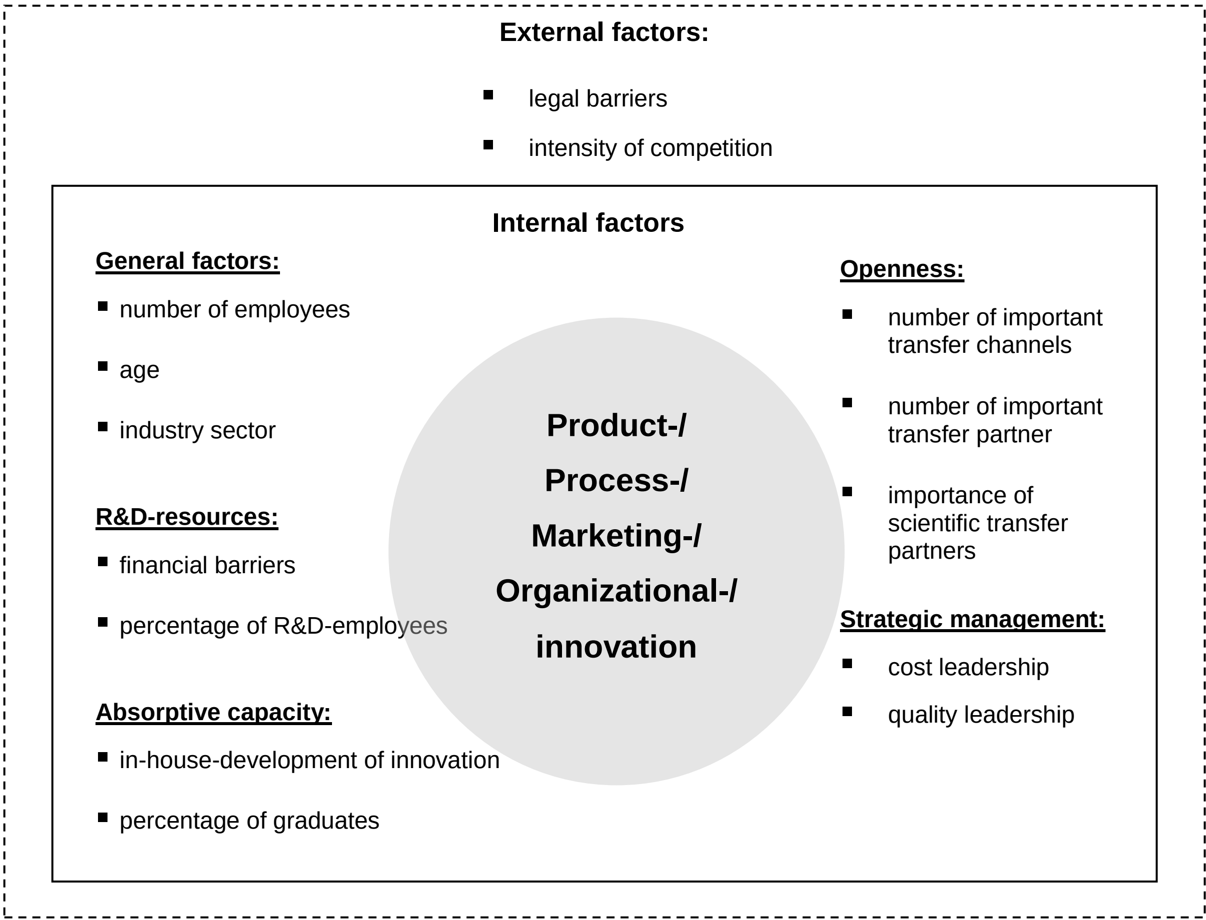
Second, the results of several empirical investigations do not indicate a negative or positive influence of a local spatial reach of cooperative links per se as to innovation (Fritsch 2000; Cummings & Teng 2003; Drejer & Vinding 2007; De Jong & Freel 2010; Isaksen & Onsager 2010; in addition see Freel et al. 2009). There is only on study directly dealing with the question of the influence of the spatial reach of collaboration on innovation (Krätke 2010). But his results show no difference as to regional or supra-regional collaborative relationships, either. Both have a positive influence on the number of patents of an establishment.

This points to a remarkable difference in comparison to the whole body of literature as to the importance of clustering of innovations at the regional level. The empirical fact of regional clustering in general is explained by reference to local and regional networking, i.e. collaboration. Therefore the outcomes at the firm level contradict to some extent the results at the regional level. The reasons may be special circumstances as to specific forms of collaboration and innovation (e.g. patents and patent related collaborations) or collaboration partners (e.g. public research institutions with a predominantly regional reach of collaboration activities).

3 Control variables

According to the literature a range of controls exist. In our study several control variables have been integrated, which are selected based on theoretical and empirical reasons. Thereby we distinguish two kinds of factors: internal and external to the firm (chart 2).

Chart 2 Research model of control variables



General factors:

- **Firm size**

With regard to the firm size as a factor of the innovation performance the literature shows different results. On one hand it is mentioned that the process of innovation is driven by large established companies with a high market share. This idea of Schumpeter (1946) led to an ongoing discussion. The following aspects corroborate a lower innovative activity of SME: the internal financing out of profits is difficult due to lower production capacity. Beside of this SME mostly exhibit only a small or less diverse R&D base (R&D department), so that R&D capacity is correspondingly low (Nelson 1959). In addition, the access to external financing sources for the implementation of innovation projects is very difficult, especially for smaller firms (Rottmann 1995). On the other hand, SME have shorter decision paths, they focus more on market niches and because of their flexibility and specialization, especially in terms of customer needs, they often develop new products and processes (see also De Jong & Vermeulen 2006).

For this reason the relationship between firm size and innovation activity is amply discussed in the literature, which shows different results (Hausman 2005, Freel 2005, Shefer & Frenkel 2005, Wagner et al. 2005, Avermaete et al. 2004, Bhattacharya & Bloch 2004, Rogers 2004). For example a positive relationship between firm size and the number of product innovations was found by Kang and Kang (2009), Tether (2002) and Griffith et al. (2006). But Garcia-Torres and Hollanders (2009), De Jong and Freel (2010) and Hanson (1992) revealed a negative significant coefficient for firm size (Kang et. al. 2009). In addition, Kuemmerles´ (1998) results indicate a concave relationship between laboratory size of multinational companies and research performance. Also Chang and Robin (2006) show an “inverted-U” pattern between the size of Taiwan firms and R&D intensity and/or technology import intensity.

- **Age of firm**

The theoretical background and the empirical results of this control variable are manifold. For example Audretsch (1995) deals with the relationships among entry, post-entry growth, the role of incumbents and innovation. On one hand there is the proposal that incumbents have more experience, e.g. substantial R&D knowledge, and the firm performance will improve over time due to organizational learning (Kuemmerle 1998). On the other hand start-up firms tend to innovate more quickly than incumbents due to the fact that in the stage of entry, firms have to explore the value of new ideas in an uncertain context (Kang & Kang 2009).

The influence of firm age on innovation performance has been investigated in several studies, which showed different results. Agarwal (1998: 215) relates small firms´ survival to innovative performance. But Kang and Kang (2009) could not detect this positive significant influence of a "start-up" variable on the number of product and process innovations. Hanson (1992) discovered that both firm size and firm age tend to be inversely related to innovative output. Huergo and Jaumandreu (2004) find that the probability of innovation varies as to entry, post-entry and advanced-ages. Their results are that entrant firms tend to present the highest probability of innovation while the oldest firms tend to present lower probabilities. But there are also empirical studies, that the firm age has no significant influence on product and process innovations (Freel 2005, De Jong & Vermeulen 2006).

- **Industry dummies**

Already Malerba und Orsengio (1997) discussed the existence of differences across sectors in the patterns of innovation and similarities across countries in the patterns of innovation for a specific technology. They proposed "that the specific pattern of innovative activity of a sector can be explained as the outcome of different technological regimes that are implied by the nature of technology and knowledge. The notion of technological regime provides a synthetic representation of some of the most important economic properties of technologies and of the characteristics of the learning processes that are involved in innovative activities" (Malerba & Orsengio 1997). On closer examination of the literature it turns out, that most of the studies cover only a certain group of firms: Manufacturing and services with 20 employees and more (Robin & Schubert 2010), manufacturing (Antonelli & Fassio 2011), micro and nanotechnologies (Autant-Bernard et al. 2007), biotechnology (Audretsch & Stephan 1996), science-based firms (Krätke 2010), high-technology corporations (Cummings & Teng 2003), certain two-digit industries (Anselin et al. 2000). To detect the possible variations across sectors in the determinants of innovation performance, numerous studies include industry dummies as control variables. The delineation of the industry variable and also the findings of these studies are heterogeneous. For example Mohnen, Mairesse and Dagenais (2007), based on the micro-aggregated firm data from CIS1, compare manufacturing industries in seven European countries. They select a number of explanatory variables for the propensity to innovate and the intensity of innovation. They conclude that their "innovation framework already accounts for sizeable differences in country innovation intensity, more so in the high-tech than in the low-tech sectors" (Mohnen et al. 2002).

Upon a database of 1250 small firms De Jong and Vermeulen (2006) analyse the determinants of product innovation across seven industries (manufacturing, construction, wholesale and transport, retail, hotel and catering, knowledge-intensive service and financial service firms). They detect that "firms from manufacturing, knowledge-intensive services and financial service industries scored better on most innovative practices and realised new product introductions more often compared to firms from construction, wholesale and transport, retail services and hotel and catering services" (De Jong & Vermeulen 2006).

R&D Resources:

The degree of available R&D resources is one of the most relevant aspects for innovation performance. The literature and studies show a broad range of indicators, which in general include the R&D expenditure and R&D personnel. Cohen and Levinthal present that the level of internal R&D investment is an important parameter of the absorptive capacity of a firm (Cohen & Levinthal 1990, Faems 2010). For example, Robin and Schubert reveal that a higher level of innovation expenditures (per employee) is associated with a higher probability to innovate and this is consistent with the framework of an "innovation production function". Here the main inputs are innovation expenditures, containing above all R&D expenditures (Robin & Schubert 2010).

- **Financial barriers**

A lack of internal financial resources can limit the firms´ capacity to support its R&D activities and consequently the development of new products and processes. In addition, these companies are forced to compensate this deficit by being closer to the innovation activity of other firms in the same sector and therefore to the diffusion of informal knowledge in the sector (Garcia-Torres et al. 2009). But surprisingly the outcome of Garcia-Torres and Hollanders is that firms which are hampered by high innovation costs or financial barriers tend to innovate more (Garcia-Torres et al. 2009).

- **Percentage of R&D- employees**

Another possible indicator, mentioned in the literature, is the number of R&D employees. In this context Broekel and Brenner (2009) conclude that “professional R&D employees are the innovative entity in industrial innovation processes. They search for and recombine existing knowledge in order to generate innovative products”. Several empirical studies use this kind of variable (for example Broekel & Brenner 2009, Faems 2010) and detect predominantly a positive influence on innovation performance.

Faems (2010) uses the relative number of R&D employees as a proxy for the internal innovation efforts of the firm (Faems 2010). He observes a positive significant interaction effect between competitor collaboration and the internal R&D efforts in terms of a new-to-the-market innovation performance. Also Broekel and Brenner (2009) confirm that R&D employment is a necessary component in innovation processes. But concerning new-to-the-firm innovation performance this positive effect could not be detected. Relating to firm cooperation in innovation, Lenz-Cesar and Heshmati (2009) identified that the variable R&D intensity (measured as the proportion of employees involved in innovation activities) is highly significant for cooperation with customers, suppliers, institutions and competitors (Lenz-Cesar & Heshmati 2009).

Absorptive capacity:

According to Cohen and Levinthal (1990: 128) the absorptive capacity requires the "ability to recognize the value of new information, assimilate it, and apply it to commercial ends". Therefore it determines the company's ability to internalize external knowledge for economic use in the development of product and process innovations. One has to bear in mind that this absorptive capacity also indicates the internal innovation capacity of a firm. Empirical studies refer to different measures of absorptive capacity, among others:

- **In-House Development**

In this aspect an enterprise which creates its innovation through in-house development should have sufficient absorptive capacity as a critical factor for a successful cooperation performance. In-house development might affect innovation outcomes positively by enabling firms to absorb and develop knowledge and skills related to the innovation in greater depth than might be possible though outsourcing. Due to this it provides a higher potential for capabilities, which can be extended or redirected into new products and processes. Moreover, firms with in-house development fully exploit their capabilities within the organization, because an integration of existing with new technology and capabilities is easier and crucial in order for firms to fully leverage their potential (Weigelt 2005). "Substantial in-house capacity is needed to recognize, evaluate, negotiate, and finally adapt the technology potentially available from others" (Dosi 1988: 1132). Aside in-house development involves higher resource allocation costs in comparison to outsourcing and therefore these firms are expected to be more committed to innovation, which results in a broader scope of implementation of innovations (Weigelt 2005).

Another important factor, which supports a positive influence of the in-house development of firms, is the degree of prior innovation-related experiences. Firms with routines within the innovation process and past innovation experience should easier adopt advanced innovations.

- **Percentage of graduates**

A larger stock of higher educated human capital within the firm allows a higher knowledge production and contributes to a faster diffusion of knowledge. These two aspects are important requirements of the innovation process (Soete et al. 2002). Therefore human capital is seen as a crucial input factor for R&D and thus for the innovation performance. Following these considerations, an innovative company has to dispose of higher qualified staff. Furthermore a high percentage of graduates might promote the absorption and diffusion of informal knowledge (Garcia-Torres et al. 2009).

Openness:

An important activity in the innovation process is the search for new ideas that have commercial potential. Firms invest extensive amounts of resources like money and time in order to increase the ability to create, use, and recombine new and existing knowledge. Innovative firms have changed the way they search for new ideas and knowledge, adopting open search strategies that involve the use of a wide range of external actors and sources to help them achieve and sustain new products and processes. In this context knowledge sources especially networks, communities, linkages and cooperation have become important for innovative performance. Different studies suggest that the network of relationships between the firm and its external environment can play an important role in shaping performance (Laursen & Salter 2006).

- **Number of important transfer-channels**

Firms are searching for ways to connect their internal with external knowledge resources. The knowledge and technology transfer activities between firms and other enterprises or scientific institutions is conducted in various forms. They range from joint research to the support of PhD-theses as well as the participation in workshops or the establishment of a new company. According to the diversity of individual transfer forms there is also a variety of systematizations.

The literature uses classifications based on the nature of the transfer object (e.g. personnel, technology and research, basic transfer) or on the intensity of personal contacts (e.g. infrastructure, indirect and direct transfer).

With regard to knowledge transfer processes many studies adopt the transfer model of Bozemann (2000) (e.g. Schmoch et al. 2000, Hilliger 2006, Timm & Gundrum 2007). Based on a comprehensive review of the literature Bozemann developed an aggregated model of knowledge and technology transfer. The model incorporates important parameters of the transfer process such as transfer donor, transfer recipient, transfer objects, transfer media and demand environment in context with each other.

- **Number of important transfer partners**

Cooperative relationships can help to overcome innovation barriers, such as cost barriers and legal restrictions. The motivation for cooperation is justified for instance by: the reduction of innovation costs through economies of scale and specialization benefits, the dispersion of innovation risk by participating partners as well as access to material, such as capital and intangible resources, e.g. external knowledge (Henke 2003, Rammer & Bethmann 2009). However, there are also some negative aspects of cooperation, e.g. an unintentional drain of knowledge, transaction and monitoring costs (Rammer & Bethmann 2009). These arguments hold with regard to a number of partners involved.

Some studies deal with the effect of R&D cooperation on innovation performance depending on the different partner types. The studies show confusing results (Belderbos et al. 2004, Fritsch & Franke 2004). For instance Belderbos, Carree and Lokshin (2004) analyse that R&D collaboration with competitors has a positive effect on product innovation. In contrast, Aschhoff and Schmidt (2008) could not confirm this positive effect in their study, Nieto and Santamaria (2007) report a negative relationship and Kang et al. (2009) show an inverted-U shape relationship. Faems (2010: 16) observes that "firms can benefit from competitor collaboration in terms of new-to-the-market innovation performance only if they implement such external innovation activities with internal innovation efforts". Garcia-Torres and Hollanders (2009) find that suppliers are the relevant sources of information for product innovation.

- **Importance of scientific transfer partners**

The advantage of a firm`s cooperation with scientific institutions is the access to the results of research that is cutting edge of contemporary knowledge and technology. The majority of studies deal with university-firm linkages and conclude that this kind of collaboration positively influences firm´s innovation performance (Kang & Kang 2009). For example, Belderbos et al. observe a positive impact of firm`s university cooperations and the growth of new-to-the-market sales (Belderbos et al. 2004). In the field of collaboration with research institutes, Robin and Schubert (2010) observe a positive effect of cooperation with public research on the intensity of product innovation (measured by the share of innovative sales) in France and Germany. Faems (2010) integrates the variable “explorative collaboration” in his examination, which takes the value of 1, if the respondents had collaborated with universities, consultants or other knowledge institutes. On the contrary, his result shows no impact of this variable on firm`s innovation performance.

Strategic Management:

- **cost leadership/quality leadership**

The strategy of any business establishment is a crucial setting, because it defines how the long-term objectives of a company should be reached. Cost and quality leadership are two basic strategies. Both strategies, irrespective of their focus on potential savings as to operations, raw materials and intermediate goods or the quality of the products can only be realized successfully through the development of innovations (Disselkamp 2005).

External Factors:

In addition to the different internal factors, the performance of an enterprise depends on general economic trends and political regulations. The literature underlines that the degree of competition within a market is an important determinant of the innovation activity (Zimmermann 2003) and that especially legal regulations are important impediments to innovation.

- **intensity of competition**

An important driver of firm innovation is the intensity of competition. On the one hand, companies, which are subject to a high competitive pressure and high speed of innovation, are forced to continuously improve processes and products. The same effects can occur when a threat of substitution by other goods exists. Also suppliers or customers with a high bargaining power can act as a driver of innovation.

- **legal barriers**

Not only global markets, but also the increasing number of existing regulations and requirements confronts the enterprises with new challenges. So the development and launch of new products and processes is connected with a higher investment of time and money. Thus an enterprise facing strong regulations may decrease its innovation activities. However, the opposite effect could also be the case. If, for example, already existing products and processes of a firm have to be replaced because of new regulations, this results in more innovations.

4 Hypotheses and data set

The aim of this paper is to explore to what extent spatial reach of collaboration linkages determines innovation orientation and innovative behavior. Therefore we use descriptive and explorative approaches. Having in mind the findings of the last two sections we want to analyse if these concomitant intra- and interregional links are a precondition for innovation. In contrast, given a successful regional innovation system, local links could be a substitute for more far reaching collaboration activities.

That means: Innovation performance could be positively related to (a) to a high intensity of local collaboration; (b) the intensity of international collaboration, or (c) neither regional nor (inter)national collaborations.

We build our analysis on a data set collected from a sample of firms in the district of the city of Jena and the adjacent counties (Landkreise) with a maximum distance of 25 kilometers. The information was collected during the time period August 2009 to March 2010. The sample includes several different industries and service sectors from manufacturing to trade and IT-services. In comparison to several studies quoted in sections 2 and 3 we cover a broad range of industries and services.

The basic population comprises 811 firms with at least 5 employees. This population data set relies on information provided by the firm registers of two renowned commercial private data banks (Creditreform and Hoppenstedt). All these firms were contacted by phone in order to identify partners for “face-to-face” interviews with a sound knowledge as to the firm innovation behavior and economic conditions. Finally we conducted personal interviews lasting 40-60 minutes with 280 enterprises, representing a response rate of 35%. Due to a lack of any innovative behavior of firms on the one hand and other data collecting problems (e.g. incomplete answers, interview cut-offs) on the other hand this finally resulted in a sample size of 216 interviews with SME, which pursued innovation projects within the last three years.

SME are defined according with EU policy as firms with up to 250 employees. As to large firms the reach of collaboration without exception covers the national and very often the international dimension (Fritsch 2000, Freel et al. 2009). Hence differences with regard to the spatial reach of collaboration are likely to be particularly revealing with regard to small and medium enterprises.

The concentration on innovators is possible, because our aim is not to distinguish innovators and non-innovators but we are interested in explaining the interdependence of innovation success on the one hand and the geographical reach of collaboration on the other hand.

In order to cope with self-selection problems the contacts by phone always included a question as to the reason of the refusal to participate. The answers corroborate the idea that there is no systematic and non-random influence as to the non-participators. Given the efforts devoted to the data collection process, the survey is only to a limited extent plagued by the self-selection bias problem found in so many empirical studies.

The questionnaire used closed-ended but nonetheless detailed questions designed to catch the supposed inherent complexity and various meanings of first, the term innovation, second, the collaboration channels (i.e. the knowledge transfer processes) and third the spatial reach of collaboration.

As to innovation the questions ground on the Oslo-manual definitions of innovative behavior. We distinguish product innovation, process innovation, organizational innovation and marketing innovation. With regard to the first two forms of innovation the questionnaire includes innovations new to the market or new to the firm as well as improvements of existing products or processes.

Concerning cooperation as an instrument to promote innovation, the transfer of knowledge becomes particularly relevant. Innovation always has its roots in new knowledge. Thus we pay special attention to the diverse aspects of knowledge transfer processes. Therefore, 16 different collaboration and knowledge transfer options were identified and requested. The types of different channels vary from formal cooperation (personal contract based work, test jobs, etc.) to informal cooperation (workshops, attending of fairs, personal non-contract based work, etc.). By means of this detailed range of transfer channels we should be able to identify differences in the variety of possible collaboration behaviors.

In order to investigate the importance of these different types of knowledge transfer possibilities more precisely, the questions measure the intensity of use of these channels on a 6-point scale (Likert-scale-type).

In addition we ask for the innovation relevance as well as the sectoral and spatial dispersion of collaboration activities. With regard to the latter we distinguish four geographical dimensions: local, regional, national and international linkages.

Besides we include all control variables discussed in section 3:

- The variable SIZE is defined as the total number of full-time equivalent employees in 2009 to control a linear effect on the innovation performance. Furthermore we add the square term of SIZE to allow for a curvilinear relationship ($SIZE^2$).
- The independent variable AGE is simply the age of the firm, i.e. years since founding.
- Based on the classification of economic activities (Federal Statistical Office Germany, Edition 2008) we aggregated the following twelve industry sectors (see table 1):

Table 1 Industry dummies and classification

Variable	Acronym by the classification of economic activities	Industry sector(s)
BR_1	C.24 – C.25	Manufacture of basic metal, fabricated metal products, processing and working
BR_2	**C.26**	**Manufacture of computer, electric and optical products**
BR_3	**C.27**	**Manufacture of electrical equipment**
BR_4	**C.28**	**Manufacture of machinery and equipment**
BR_5	C.10 – C.23, C.29 – C.33	Other manufacturing
BR_6	F.41 – F.43	Construction
BR_7	G.45 – G.47	Wholesale and retail
BR_8	J.62 – J.63	Information services
BR_9	K.64 – K.65	Financial/insurance services
BR_10	M.69 – M.71 M.73 – M.74	Professional, scientific and technical services
BR_11	M.72	Scientific research and development
BR_12	H + N	Other services

Source Federal Statistical Office Germany Edition 2008

- To capture sectoral patterns in the innovation performance we control for significant effects of *BR_2*, *BR_3* and *BR_4*. The value of these industry dummies takes 1, when the firm belongs to the corresponding sector; otherwise it takes 0.

- The independent variable *HOUSE* measures if a firm claims in-house development to be the most important type of innovation development (value = 1). This dummy variable allows us to look for the influence of absorptive capacity on the innovation performance.

- We asked the respondents to what extent different cost factors, including equity financing and debt financing of innovation projects as well as too high innovation costs, have inhibited their innovation activities. We sum up the individual evaluations of the three cost barriers to calculate the variable *FINA*.

- Moreover, we include the share of graduates on the total number of employees by the variable *GRAD* and the share of research and development employees by the variable *RND*. Both have a continuous index with a range between 0 and 1.

- We control the variety of transfer relations in two different ways: we are able to analyze the number of transfer channels (*N_CHAN*) and the number of transfer partners (*N_PART*) used. Therefore we compile a list of 16 transfer channels and seven partners. In both cases the collaboration intensity is evaluated on a 6-point Likert-scale from “0 – not important” till “5 – very important”. We count the number of channels and partners evaluated with 4 or 5.

- In addition we analyze the impact of relationships with scientific partners measured by the variable *SCIEN,* which sums up the intensity of collaboration with universities, universities of applied sciences and research institutes.

- In order to identify the influence of the strategic performance on the innovation activities, we determine the relevance of cost leadership (*COST*) as well as quality leadership (*QUAL*) on a 6-point Likert-scale from “0 – not important” till “5 – very important”.

- To control for the impact of the intensity of competition, often mentioned as a relevant determinant on the innovation activity, we asked for the importance of Porter’s five competitive forces on a 6-point Likert-scale from “0 – not important” till

"5 – very important". Simply adding these numbers for suppliers, substitutes, customers, potential and current competitors (Porter 2004) we build an index of intensity of competition named *COMP*.

- In order to identify the relevance of legal regulations (*LEGA*) as barriers to innovation, the questionnaire included the relevance on a 6-point Likert-Scale from "0 – not important" till "5 – very important".

5 Descriptive findings and econometric results

In this section a first step summarizes the relevant variables and presents several descriptive analyses. In this respect we first examine the regional reach of collaboration in general. Second, we focus on the collaboration relevant for innovation and its geographical pattern. Third, the links of different forms of innovation and their regional reach are under scrutiny. In a final step we discuss the results of a basic regression model.

Table 2 Descriptive statistics of dependent and independent variables

Variable	Typology and value range	Acronym	Mean value	Minimum; Maximum
Dependent Variables				
Product innovations	Likert-Scale	PROD	2.66	0; 5
Process innovations	Likert-Scale	PROC	2.00	0; 5
Marketing innovations	Likert-Scale	MARK	3.40	0; 5
Organizational innovations	Likert-Scale	ORGA	3.31	0; 5
Independent Variables				
Local cooperations	Continuous	LOCAL	31.60	0; 100
Regional cooperations	Continuous	REGIO	25.61	0; 100
National cooperations	Continuous	NATIO	36.71	0; 100
Controls				
- general factors				
Number of employees	Continuous	SIZE	31.95	5; 220
Age	Natural number	AGE	18.25	1; 162
Industry Sector	Dummy	BR_XX		0; 1
- R&D resources				
Financial barriers	Natural number	FINA	6.08	0; 15
R&D-employees	Continuous Index (0-1)	RND	0.25	0; 1
- absorptive capacity				
In-House-Development	Dummy	HOUSE	0.70	0; 1
Graduation rate	Continuous Index (0-1)	GRAD	0.31	0; 1
- openness				
Used transfer channels	Natural number	N_CHAN	1.97	0; 9
Used transfer partners	Natural number	N_PART	1.41	0; 6
Scientific partners	Natural number	SCIEN	3.92	0; 15
- strategic management				
Cost leadership	Likert-Scale	COST	3.27	0; 5
Quality leadership	Likert-Scale	QUAL	4.04	0; 5
- external factors				
Intensity of competition	Natural number	COMP	14.69	4; 25
Legal barriers	Likert-Scale	LEGA	2.32	0; 5

Table 2 provides a brief overview on the variables included in the analyses, their value ranges, acronyms and descriptive location parameters.

The survey comprises information with regard to the importance of several innovation types (evaluated on a 6-point Likert-scale). We include product and process innovations both new to the market as well as marketing and organizational innovations. Hence we are able to provide a more detailed analysis of innovations in comparison to previous studies. As to the spatial distance of collaboration we measure the percentage of transfer partners at the same place of location (LOCAL), in the remaining federal state (REGIO), in the rest of the country (NATIO) and abroad (INTER).

On a general level, that means considering all the 16 knowledge transfer channels of our questionnaire, we identify four different patterns of spatial reach (see Pfeil et al. 2011 and table 3):

I. Collaboration with dominant role of local relationships, e.g. student trainees
II. Collaboration with dominant role of supraregional relationships, e.g. advanced training of firm members
III. Collaboration with uniform distribution over the local, regional and national distance, e.g. economic consulting
IV. Collaboration with distance paradox, e.g. research contracts

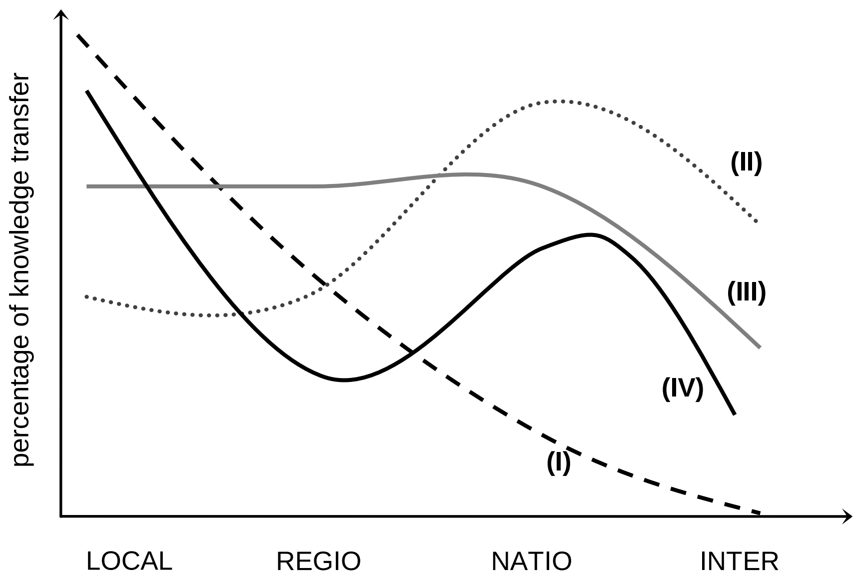
The expression distance paradox refers to the fact, that there is first no smooth decline with increasing spatial distance and second no uniform spatial distribution of collaboration activities (Rosenfeld & Roth 2004). To the contrary, a clear dip at the regional distance level emerges.

Table 3 Geographical reach of transfer channels (by transfer channel)

			LOCAL	REGIO	NATIO	INTER
I.	Student trainees	(N=104)	76%	17%	7%	0%
II.	Advanced training	(N=176)	28%	26%	41%	5%
III.	Economic consulting	(N=89)	32%	30%	33%	5%
IV.	Research contracts	(N=75)	40%	24%	27%	8%

Chart 3 illustrates the patterns of collaboration with regard to the four geographical areas and underlines the differences between the transfer channels examined.

Chart 3 Spatial patterns of collaboration



In the following analyses we do not explore the geographical dispersion of all of the transfer channels, but concentrate on those channels which are highly relevant for the innovation projects of a specific firm.

55 firms evaluate none of the transfer channels as very innovation relevant and 50 enterprises practice only one transfer channel to speed up the development of innovations. At the maximum nine important transfer channels are identified. The specific collaboration channels, which are rated as highly relevant for innovation projects, also vary from firm to firm. The number of firms, which declare the relevant transfer channel as highly innovation relevant, ranges from advanced training (N=85) and workshops (N=68) to doctoral thesis (N=4) and lectureships (N=3).

In order to examine the relevance of the four cooperation regions we calculate the mean spatial concentration of those transfer channels, which are evaluated as highly relevant for the firm's innovation projects at the level of each firm. Table 4 presents the results with regard to the four geographical regions. Overall about one-third of the innovation-relevant collaborative activities are aimed at the local level and the same holds as to the national level. Only 6% of all cooperations are international oriented, while the remaining 22% are allocated to regional collaborations. Thus, when we examine the cooperative relationships relevant for innovation on an aggregated level, we find the spatial pattern of collaboration called "distance paradox".

Table 4 Geographical reach of transfer activities (by industry sector)

		LOCAL	REGIO	NATIO	INTER
Total	(N=159)	36%	22%	35%	6%
Manufacturing (BR_1 – BR_5)	(N=71)	33%	23%	34%	9%
High-Tec (BR_2 – BR_4)	(N=28)	40%	16%	33%	11%
Services (BR_6 – BR_12)	(N=88)	39%	22%	36%	4%

In comparison with most of the studies cited in chapter 2 and 3 our data reveal a higher geographical concentration of the cooperation activities within the local level, i.e. the region of Jena. This might result out of the broad range of industry sectors we included in our analysis. To check this we separately look for the geographical reach of collaboration of the manufacturing and service sectors (see table 4). Services possess a slightly higher percentage of local and national cooperations, while manufacturing enterprises cooperate more than twice as much on the international level. Focusing on the high-tech sectors, e.g. optics, reveals a considerably different pattern. High-tech industries exhibit a more accentuated distance paradox on the one hand and more international collaborations on the other hand.

Different types of collaboration go in hand with different forms of innovation. Thus, we verify the relations between the importance of different forms of innovation activities and spatial reach of collaboration. The results of the descriptive analyses are shown in table 5.

All of the firms ascribing high importance to one of the four types of innovation tend to possess fewer cooperation partners at the regional level. In addition, as to product and process innovations these firms exhibit more international collaboration activities.

Table 5 Innovation and the reach of collaboration

			LOCAL	REGIO	NATIO	INTER
Product innovations	Less important (0 – 2)	(N=59)	35%	30%	32%	3%
	Very important (3 – 5)	(N=100)	37%	18%	37%	8%
Process innovations	Less important (0 – 2)	(N=88)	36%	24%	36%	4%
	Very important (3 – 5)	(N=71)	36%	21%	34%	9%
Marketing innovations	Less important (0 – 2)	(N=29)	28%	32%	32%	7%
	Very important (3 – 5)	(N=129)	38%	20%	36%	6%
Organizational innovations	Less important (0 – 2)	(N=41)	30%	28%	34%	8%
	Very important (3 – 5)	(N=117)	39%	20%	35%	6%

To sum up, the descriptive analyses reveal a heterogeneous distribution of geographical reach of collaboration. In comparison to other empirical studies of spatial reach a strong local orientation emerges, accompanied in most cases by a distance paradox with regard to the regional level of collaboration. In addition, the international level always turns out to play a clear less important role. The latter is true as to the other regions at hand but also as to the outcomes of other empirical studies. These two findings of a strong local and a weak international reach are almost independent of first the industries or sectors and second the form of innovation. But the data also indicate that the types of collaboration, the forms of innovation and the industry under scrutiny influence the geographical reach of collaboration.

The very different empirical approaches and outcomes summarized in chapter 2 and 3 point to a complex relationship of innovation and regional reach of collaboration and besides reveal a number of other factors that might influence this relationship. Hence the necessity to add a multivariate approach. In this respect we use a binary-choice model distinguishing less important (coded 0) and very important (coded 1) innovations.

We rely on four logistic regression models – one for each of the forms of innovation. We focus our analysis on factors influencing innovation. So innovation is our dependent variable. As to the factors relevant for innovation we concentrate on spatial distance of collaboration (measured by LOCAL, REGIO and NATIO - INTER is used as reference group). Furthermore we implement several control variables described in section 3 (see table 2).

Table 6 below shows the regression results.

Table 6 Determinants of different innovation types

Dependent variable		PROD	PROC	MARK	ORGA
Number of cases		216	216	215	215
Chi²-Omnibus-Test		53.807***	41.329***	44.171***	44.643***
Nagelkerkes R^2		29.7%	23.4%	28.4%	27.4%
Hit Ratio		72.7%	70.4%	80.5%	78.1%
Chi²-Hosmer-Lemeshow-Test (Significance level)		2.824 (0.945)	4.326 (0.827)	3.882 (0.868)	4.583 (0.801)
(constant)		-2.226	-2.166	-2.420	-3.758**
Local coop	LOCAL	-0.017	-0.018	0.011	0.009
Regional coop	REGIO	-0.029*	-0.019	-0.009	-0.006
National coop	NATIO	-0.006	-0.016	0.010	0.008
Computer/Optic	BR_2	1.489**	0.155	0.082	0.449
Electric	BR_3	-0.270	-0.782	-1.279	-0.629
Machinery	BR_4	-0.037	-0.078	0.250	-1.038
Firm Size	SIZE	0.010	0.024*	-0.003	-0.001
Square of SIZE	$SIZE^2$	0.000	-0.0001*	0.000	0.000
Age	AGE	0.016	0.005	0.020	-0.002
Financial barriers	FINA	0.012	-0.007	-0.016	0.011
R&D-employees	RND	1.229	0.603	0.656	0.447
In-House-Develop	HOUSE	0.569	0.330	-0.242	0.119
Graduates	GRAD	-0.374	-1.433*	-0.930	-1.028
Transfer channels	N_CHAN	0.255**	0.012	0.122	0.009
Transfer partners	N_PART	-0.169	-0.208	0.431**	0.444**
Scientific partners	SCIEN	0.108**	0.164***	-0.016	0.022
Cost leadership	COST	0.112	0.188	-0.173	0.163
Quality leadership	QUAL	-0.013	0.200	0.442***	0.435***
Competition	COMP	0.105**	0.072*	0.151***	0.116**
Legal barriers	LEGA	0.159	0.069	-0.254**	0.037

Significance level: *** = 1%-; ** = 5%-; * = 10%-level

Looking at the statistics of the logistic regressions all four models have a relative high model chi-square (omnibus test) and correspondingly are significant on the 1 % level. Nagelkerkes R^2 presented for each model as a pseudo R-square value has to be interpreted with caution but a value above 20 % indicates an acceptable level of explanation. The same caveat and conclusion applies as to the hit ratios (percentage of correctly classified cases) ranging from 70.4 % to 80.5 %. Finally, the Hosmer-Lemeshow-statistic tests the null hypothesis of no significant difference of predicted and observed classifications. For all four regressions the null cannot be rejected. Thus, the statistics point out that all four models fit the data adequately and allow an economic interpretation.

Our central question refers to the influence of the geographic reach of collaboration on the innovation at the firm level. Here the outcome is clear cut. There is no influence of local, regional and national cooperation in comparison to international cooperation. The single exception is the product innovation model. In this case cooperative relationships within the same federal state, i.e. REGIO, turn out to have a significant (but only at the 10% level) and negative influence on the probability of the development of process innovations.

This result of a missing influence of the geographical reach of collaboration is very robust with regard to various specifications of the binary response model. It holds as to other geographical reference groups as well as other definitions of the geographical variables. We also included more detailed industry sectors as well as some additional control variables, e.g. incentives for innovation at the firm level, control for non-linear relationships and test for several interaction effects, e.g. sector specific influences of in-house development, or interdependencies between our geographic variables and percentage of graduates. However there were no reliable relationships with our dependent variables.

Furthermore, the use of an ordered logit regression does not change our findings. This estimation method seems appropriate, given the ordered scale of the dependent variable with a range from “0 – not important” to “5 – very important”.

For the development of product and process innovations new to the market completely new knowledge is important, so that collaborative links to universities or research institutes are of high importance. In fact, cooperation with scientific partners positively affects the importance of product and process innovations (significant at the 5% and 1% level). This result confirms the findings of a lot of other empirical studies. In comparison marketing and organizational innovations does not depend on scientific partners but are influenced by the openness of a firm measured by the number of transfer partners.

A significant effect of the firm size could only be confirmed for the process innovation model. In accordance with Kuemmerle (1998) and Chang et al. (2006) we detect a weak evidence (significance level 10%) for an “inverted-U” pattern between the firm size and the innovative behavior.

Looking at all the four categories of innovation one variable always has a significant and positive influence. The degree of competition turns out to be of general importance. This corroborates our hypotheses that the determinants of innovative behavior have to be analyzed on the firm level because intensity of competition as the main driver of innovation cannot be measured at the macro-level. In addition, strategic management objectives are relevant: Quality leadership has a significant positive influence on marketing and organizational innovations. This finding confirms the idea that improvements in the product quality require the implementation of adequate management approaches.

6 Conclusions

Our paper deals with the relationships between different types of innovation and collaboration, given the varying geographical distance of the latter. Based on a survey at the firm level we incorporate a broad range of control variables, which were not accounted for by other comparable studies at the regional level. Nevertheless, given the contradicting results of theoretical reasoning and existing empirical outcomes our analysis has an exploratory character.

To sum up the descriptive analyses, we reveal a heterogeneous distribution of geographical reach of collaboration. Cooperation activities can be characterized by a strong local orientation, hardly important international links and a pattern called distance paradox. The expression distance paradox refers to the fact, that there is first no smooth decline with increasing spatial distance and second no uniform spatial distribution of collaboration activities. To the contrary, a clear dip at the regional distance level emerges.

All of the firms ascribing high importance to one of the four types of innovation tend to possess fewer cooperation partners at the regional level. In addition, as to product and process innovations these firms exhibit more international collaboration activities. Comparing firms with a high respectively low relevance of product innovations we observe the most obvious differences.

The main finding is that the results show no influence of the geographical variables. But we confirm a significant and positive influence of the intensity of competition in all models. This aspect underlines the importance of an existing competitive pressure within a market for the innovation performance of SME. Moreover it corroborates the relevance of an analysis of this issue not on the macro-level (regional level), but on the firm level (micro-level). In particular, two different patterns could be identified by the regression results: On one hand, product- and process innovations of SME depend on cooperative activities with scientific institutions. On the other hand, the results show that especially marketing- and organizational innovations are generated by firms with a wide variety of cooperation partners and by firms whose strategy focuses on quality leadership. Therefore, strategic management decisions play also an important role for the innovation performance.

As to the econometrics other approaches and extensions are possible. A two part (i.e. hurdle) model allows to distinguish the innovators and non-innovators in a first step and to explain the innovators´ behavior in a second step. Thus, allowing for dissimilar effects of the explanatory variables in the first and second step.

The possibility of the endogeneity of collaboration is a second point of concern. Cooperation makes sense for firms innovating more. So, the causal relationship is far from being clear. This would lead to a Heckit-model with endogenous explanatory variables and a simultaneous equation system.

Overall our findings suggest that innovative firms rely on collaboration partners at a variety of spatial distances. Policy interventions in favor of regional and local networking based on the cluster literature are probably misleading. Some evidence as to this argument is provided with the distance paradox. The descriptive analysis reveals that collaboration at the regional level has a pronounced dip in comparison to the local and national reach. This relates to the weak evidence of a negative influence of regional collaboration activities with regard to product innovations.

But at least with regard to the regional innovation system of Jena a local focus of collaboration does not seem to be harmful. These outcomes as to a strong local bias of collaboration activities are in line with evidence pointing out that Jena is an efficient regional innovation system with a location specific collaboration spirit (Cantner et al. 2008, Fritsch et al. 2010).

Probably, following Nelson and Winter (1982), collaboration for innovation is a kind of search process with risks and uncertainties where a great deal of mistake is inevitable. A broad search strategy with a multitude of collaboration activities and in addition a geographical reach depending on the firm specific needs will lead to more technological and market opportunities discovered.

Given the importance of scientific partners for product and process innovations, innovation policy should concentrate on the funding of public research. In addition, the public funding of openness of firms might be helpful due to the positive effects of the number of partners and transfer channels. Thus, fostering networking without imposing a spatial reach is reasonable.

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