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Working Paper

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Jena Economic Research Papers, No. 2008,081

Provided in Cooperation with:
Max Planck Institute of Economics

Suggested Citation: Cantner, Uwe; Meder, Andreas; Wolf, Tina (2008) : Intermediation, reciprocity and compatibility in regional innovation systems: an interregional comparison, Jena Economic Research Papers, No. 2008,081, Friedrich Schiller University Jena and Max Planck Institute of Economics, Jena

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JENA ECONOMIC RESEARCH PAPERS



2008 – 081

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by

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www.jenecon.de

ISSN 1864-7057

The JENA ECONOMIC RESEARCH PAPERS is a joint publication of the Friedrich Schiller University and the Max Planck Institute of Economics, Jena, Germany. For editorial correspondence please contact markus.pasche@uni-jena.de.

Impressum:

Friedrich Schiller University Jena
Carl-Zeiss-Str. 3
D-07743 Jena
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Intermediation, reciprocity and compatibility in regional innovation systems – an interregional comparison *

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November 3, 2008

Abstract

This paper investigates the possible presence of three problems in regional innovation systems (RIS): intermediation, reciprocity and compatibility. Based on firm data gathered for three different regions, Northern Hesse, Jena and Sophia Antipolis, we can show that a low propensity to cooperate in a RIS is related to poorly performing intermediaries and a low complementarity with the regional knowledge base. The issue of trust in cooperating tends to have no effect on the propensity to cooperate. However, it is a main determinant of failed cooperation projects.

JEL classification: D81; O18; P25

Keywords: regional innovation systems, reciprocity, intermediation, complementarity, cooperation

*We thank the Volkswagen Foundation for funding the research project "2nd order innovations". Especially, we would like to say a special thank you to our project partner Frank Beckenbach, Maria Daskalakis and Anne ter Wal for gathering the questionnaire data of Kassel and Sophia Antipolis and to Wolfgang Ziegler from the Jena patent information center for providing patent data. Furthermore, we want to thank the Hans-Boeckler-Stiftung and the for financing the scholarship of Tina Wolf and the German Science Foundation for funding the position of Andreas Meder within the RTG 1411 "The Economics of Innovative Change".

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1 Introduction

Empirically founded work by Allen (1983) on blast furnace production and von Hippel (1987) on US steel mini-mill industry initiated a line of research focussing on actors which work together and coordinate each other in order to generate new knowledge and, subsequently, collectively introduce innovations into the market. That cooperation in innovative activities may occur for different reasons (Bayona et al. 2001). A first argument relates to the complexity of technological development often requiring several specialized actors and a certain division of labor. Another is that uncertainty and risk involved in inventive and innovative processes bear the need of pooled activities. And often it is market access which is facilitated by cooperative agreements.

In addition to these arguments there is a perspective resting on the uneven spread of knowledge and competencies required to generate new ideas and, finally, to innovate. Consider innovations as bringing new combinations to the markets as Schumpeter (1912) put it. Hence, to generate them requires recombining existing knowledge (Cantner & Meder 2007). The appropriate knowledge, necessary to successfully innovate, may not be in the immediate reach of an actor but may rather lie outside (Cowan et al. 2006). Thus, access to that external knowledge may be an important prerequisite for innovative success. With this perspective invention and innovation activities rely on processes of collective or social learning and exchange of knowledge between actors (Lundvall 1992, Doloreux & Parto 2005). These considerations form the basis of the systemic view of innovative activities and the innovation process (Cantner 2000). Firms do usually not innovate in isolation, but in collaboration and interaction with other organizations (Fagerberg 2005). These other organizations may be other firms, universities, schools or ministries, whose behaviors are shaped by institutions (Edquist 2005). Organizations and institutions are components of systems aiming at the generation and diffusion of innovations, namely the systems of innovation (SIs) (Edquist 2005). The concept of SIs claims that certain combinations of organizations and institutions can enhance individuals's and system's ability to innovate and to compete (Cantner et al. 2003).

One of the fundamental modes of exchanging knowledge and new ideas within SI are network relationships. In the context of knowledge transfer and exchange they show certain advantages compared to market relationships on the one hand and to hierarchical relationships on the other. With respect to the former, market transactions require a well defined set of property rights which in case of knowledge is in most instances not possible. Regarding the latter, hierarchical relations may impair with incentives to generate new knowledge. In that view, network coordination does not require well defined property rights as the exchange of knowledge usually is not *uno actu* and rests much on trust and reciprocity instead of clearly defined and identifiable exchange values. From a perspective of hierarchies, networks just rely on deliberate exchange which - if appropriately reciprocated preserves incentives.

Despite these advantages, the establishment and continuation of network based knowledge exchange face their own problems affecting the generation of new ideas in a non-negligible way. Consider a number of potentially cooperating actors and after some time observe the level and intensity of network based exchanges to be considerably low. This may, firstly, indicate that actors failed to know of each other and getting into contact - the problem of intermediation. Secondly, it may be the case that lacking trust and reciprocity in the actors' relationships reduces their incentives to engage in network exchanges - the problem of reciprocity. And, thirdly, the knowledge pieces that might be exchanged do not fit to the network partners' knowledge requirements - the problem of complementarity.

In this paper we analyze the role these three problems play for the innovative performance of regional innovation systems. Since we have no benchmark at hand telling us the optimal performance of an SI we perform our analysis on a comparative basis. Consequently we investigate the observed differences between innovation systems measured in terms of actors engaged in cooperative innovation activities as well as in terms of successful cooperation projects. Hence, our analysis is actor based and controls for characteristics of the innovation system the actors are member of. The importance actors attach to intermediation, their relationship in terms of trust and reciprocity, and the complementarity among the knowledge stocks within a SI are used as explanatory variables. The observed SIs are the regions of Northern Hesse and of Jena in Germany and of Sophia Antipolis in France.

We find differences in the networking activities between these three regions. The majority of innovating actors located in Northern Hesse are isolated innovators, whereas the regional network of Sophia Antipolis is separated in numerous components. In case of Jena one large component is dominating the network activities. These observations correspond to the finding that in Northern Hesse the regional intermediation actors are evaluated worst and that here the regional knowledge base shows the lowest compatibility.

To achieve these conclusions, we proceed as follows. In section 2 we briefly introduce the SI concept and its core mechanism, network based exchange of knowledge and ideas. The following discussion of factors impeding the collective generation of new ideas and innovations allows us to derive appropriate hypotheses. Section 3 introduces our empirical approach, the three SIs under consideration as well as the data used. The empirical results obtained are presented and discussed in section 4. Section 5 summarizes our results and puts them into perspective.

2 Theoretical background

2.1 The systems approach to innovation

Over the last decades the concept of collective invention and innovation brought up by Allen (1983) and von Hippel (1987) has been developed to a system of innovation approach. Pioneering works here are Freeman (1987), Lundvall (1992) or Nelson (1992) which induced a stream of research on different levels and types of SI. Based on a rather general theory of systems Edquist (2005) refers to three main dimensions allowing to characterize systems, their components and the relationships among them (Carlsson et al. 2002), their demarcation (or attributes as Carlsson et al. (2002) puts it), and their objective. With respect to the first and third dimension Edquist defines an innovation system as *"all important economic, social, political, organizational, and other factors that influence the development, diffusion, and use of innovations."* (Edquist 1997, p.14). Following the interpretation of Asheim & Coenen (2005), the main concern of the SI approach is primarily to explain how innovations occur and not so much (as yet) to investigate how they do influence economic development. And with respect to the demarcation or attributes characterizing SIs, a wide range of different variants can be identified, be the demarcation the technology used (Edquist 2005), the industry of main activity (Malerba 2002), the region (Cooke 1992, 2001) or the country of location (Lundvall 1992, Nelson 2000, Freeman 1987).

A system's *components* are the operating units. They can be either of physical nature such as firms,

actors or players or they show an intangible nature such as institutions in the form of legislative artifacts, traditions, and social norms. The systemic nature occurs as these components do not act in isolation, but they interact with each other as described by different types of *relationships*. A relationship does not necessarily predict a specific action but it implements a reaction of components to an action by an other component. So each component depends on the properties and behavior of all other system members. Consequently, a system cannot be divided into several subsystems that are independent of each other (Blanchard & Fabrycky 1990). According to Carlsson et al. (2002), the components of a system react if another component is removed from the system. Both the components and the relationship among them constitute the *whole system*.

In this paper the relationships among actors of an SI are our central concern. They indicate knowledge transfers and exchanges between related actors. Our further analysis rests on the assumption that the more relations we find among actors, the more knowledge and ideas are exchanged and depending on this the more new ideas are supposed to be generated. Consequently, factors influencing the cooperation intensity and innovative success are of interest to us. From an empirical point of view a main determinant promoting the transfer and exchange of knowledge is close spatial (often implying social) proximity among actors (Boschma 2005). This nicely coincides with observations of innovative activities being spatially not evenly spread but regionally a rather bounded phenomenon (Asheim & Isaksen 2002) quite regularly combined with an outstanding innovative performance of just those innovation clusters (e.g. Porter 1990, Jaffe et al. 1993). Consequently, one may ask whether and how spatial differences in innovative success and the functioning of the underlying processes of social learning and collective generation of new knowledge fit together. An SI approach taking up just these questions refers to so called Regional Innovation Systems (RIS).

2.2 Organizations, their relationships and the influence of institutions

Since the relationships among the components of an SI are at the core of our analysis some further considerations are required. According to Edquist & Johnson (1997) the components comprise organizations and institutions. The former "*... are formal structures that are consciously created and have an explicit purpose*" (Edquist & Johnson 1997, p.46-7). We distinguish here between firms, universities, venture capital organizations and public agencies, all of which are involved in innovative activities directly or indirectly. The latter "*... are sets of common habits, norms, routines, established practices, rules, or laws that regulate the relations and interactions between individuals, groups, and organizations*" (Edquist & Johnson 1997, p.46). An institution of considerable importance for the functioning of an SI is trust which governs and rules the network based exchange and transfer relationships among actors.

Organizations

Actors or organizations of an SI can be assigned mainly to three poles; some, however, are assigned to so-called intermediaries (Cantner & Graf 2003) to be discussed later. The poles to be distinguished are the market pole, the science pole and the technological-industrial pole. Networking relationships will show up within and between these poles. The market pole consists of actors engaged in introducing innovations directly or indirectly into a market. On the one hand the actors are related vertically to each other (up-stream to suppliers as well as down-stream to customers) and on the other hand horizontally with competition among them prevailing. Vertical relationships quite easily allow exchanging and transferring

knowledge in a network based way with the objective to better match (Karlsson 1997) technological opportunities and customer needs (Flaherty 1984). For competing firms to engage in this type of network relationships is less if at all viable. The actors of an SI's science pole are universities and public research institutes focussing on basic research. The exchange and transfer of knowledge among each other occurs on a rather regular basis finally leading to often close network type relations. The technological-industrial pole comprises different private research organizations such as firms' R&D laboratories. They concentrate on applied research and the development of prototypes. This applied R&D not seldom is performed in cooperations leading to network type relationships as rather frequently observed in technology parks or technology cities. In addition to knowledge exchange within poles networking activities between the actors of different poles can be observed. Market pole actors rather regularly collaborate with private research institutes as well as increasingly with public research organizations. The same holds for networking relations between private and public research organizations.

Relationships and the exchange of knowledge

The function of an SI to create, diffuse and exploit knowledge which then may lead to innovations (Liu & White 2001) is based on the exchange of knowledge and ideas among the SI's actors. For exchanges in rather general terms, different modes of coordination exist, markets, hierarchies and networks. In our context of exchanging knowledge and new ideas, networking appears to be better suited than the other two modes: In markets the exchange or transfer of knowledge always works when knowledge is protected by intellectual property rights and licensing or buying a patent works fine. It might even work in the case of tacit knowledge as one can acquire it by hiring human capital. Markets allow actors exchanging or trading knowledge to be quite distant from each other and being highly flexible in choosing trade partners. However, when appropriate intellectual property rights are absent and the value of a specific piece of knowledge is not known, market transactions usually fail. In those cases hierarchical relationships among actors may be a solution; here the proximity among the transfer partners becomes quite high and the choice of the partner quite inflexible. Remunerating scientists and researcher just as employees and pledging them to deliver the knowledge created reflects a high degree of control. Such arrangements for knowledge exchange and transfer are found in large firms running their own R&D laboratory. Of course, the flexibility required and the researchers incentives for exploring and exploiting external knowledge essential for further creative thinking are much reduced herein. This weakness of hierarchies leads us to a more flexible concept, network interaction. Here proximity of actors is at a medium level; it allows being flexible and switching rather easily from one cooperation partner to another on the one hand, but to be effective it requires some stability in the relations on the other. It is the reciprocity of exchanging knowledge which is not necessarily *uno actu* (as in markets) which provides for this stability. The control required is exerted by trust and reputation which in turn also provide for an appropriate incentive structure. Such network relations are suggested being the most appropriate mode of exchanging knowledge and they regularly are considered the core of innovation systems. Investigating one of the most successful SIs in the world, the Silicon Valley, one finds that networking (defined as a process in which knowledge is transferred (OECD 2002) is a key factor of its success.

Intermediaries

The emergence or setting up but partly also the continuation of knowledge exchange within as well as between the organizations of an SI require an initiator and/or mediator, a carrier and/or a medium.

Those entities are subsumed under the notion of intermediaries. Following Cantner & Graf (2003), among the intermediaries in this sense are offices devoted to technology transfer, public agencies (regional politicians, business development agencies), conferences and know-how markets, collaborative research ventures, patents, other sources of information like consultants and scientific journals, as well as employees' mobility. This principle function is to mediate contacts and to transfer knowledge between the actors of the SI (Karlsson 1997). Obviously the intermediaries mentioned are just different in their ability to fulfill both of these tasks. Some of them are deliberately installed and formal, others seem to work unconsciously and on more informal basis.

For the purpose of this paper we look at public agencies and technology transfer offices as they act as mediators between the pole of firms and the pole of research institutes (von Malmberg 2007). For realizing this function, their role could be a "teacher" or a "tutor". Acting as a teacher, the initiation and continuation of network projects relies on the knowledge and ideas hold by the intermediary. This results in strong ties between the SI actors and the intermediaries serving as sources and diffusion devices for information and knowledge exchange. Acting as a 'tutor' the intermediary's central position between the SI's actors is not based on their ability to hold, generate and diffuse knowledge but in enabling actors to get contact to other actors holding the searched for and required knowledge. Universities' transfer offices are just a point in case.

Institutions

Institutions are considered to be a second component of an SI. They can be defined as "*common habits, norms, routines, established practices, rules or laws that regulate the relations and interactions between individuals, groups and organizations*" (Edquist & Johnson 1997, p.46). Coriat & Weinstein (2002) define institutions as a set of formal and informal rules that shape behavior. They are used and required by individuals and organizations because they help reducing uncertainties (Coriat & Weinstein 2002) as they make others' actions predictable. Patent laws, rules and norms influencing the relations between universities and firms, are some examples for important institutions within SIs (Edquist 2005). Institutions in general cannot be considered as being fixed. In following their aims, organizations marginally influence them or create new institutions (North 1992). For the SI approach this implies that SI actors are considered being embedded in a system of institutions (Cantner & Graf 2003) where both system elements are mutually influencing each other. As an example, on the one hand the institution of trust initiates network based exchange of knowhow; and reciprocated knowledge transfer helps building up trust on the other hand.

2.3 Problems of intermediation, reciprocity and compatibility in systems of innovation

Having described the principle elements of an SI and their functioning, in the following we will discuss system failures, that prevent the emergence and the functioning of SI. The arguments we put forward are based on the assumption that SI's organizations are always willing to transfer and exchange knowledge. For that to take place they have to know where are possible partners or where to search for them; then partners have to fit together in the sense that the respective other's knowledge is relevant and complementary to one's own knowledge; last not least, the relationship has to be reciprocal in sense that the transfer of knowledge is not one way.

There are system level failures we are going to introduce, the problem of intermediation, of compatibility, and of reciprocity. Each and all of them may prevent the exchange of knowledge between actors to take place, albeit for different reasons.

Problem of intermediation

To understand the problem of intermediation in SIs it is useful to take a look at the asymmetrically informed borrowers and lenders in financial markets. Seeking for information about a potential finance partner causes high transaction costs for firms and private households (Williamson 1986). This can force the actors on the financial market to put up with the high costs, to make contracts without information, or to omit financial transactions (Diamond 1984). Financial intermediation, e.g. by a bank, can bear a net cost advantage in comparison to the direct financing.

The problem of intermediation in SIs is just similar. Searching for an appropriate collaboration partner may cause high transaction costs related to gathering information about the existence of potential partners, their knowledge features and their reputation. Actors may be aware of those costs or more reasonably they may anticipate but not exactly know their level. In both cases, if these costs are high or uncertain, actors may be reluctant and refrain from searching for potential partners. Applying this to the system level implies a kind of collective blindness. The function of intermediaries like 'public agencies' and 'transfer offices', but also of 'conferences and know-how markets', is just to overcome reluctance and blindness. Obviously, those intermediaries show a qualitative dimension with respect to their ability to connect actors in a most fitting way.

Hence, the problem of intermediation shows up as a situation, where the knowledge exchange of actors within or between system's poles does not take place at all or only on a rather low level of success. In this situation one may presume that intermediaries did not work in an sufficient way (Cantner 2000). Although actors are willing to collaborate in general it is either the inferior quality of the intermediaries or their alleged unimportance that prevents the emergence of appropriately fitting relationships. The discussion leads to our first hypothesis:

Hypothesis 1:

A comparably higher perceived importance of intermediaries as well as a higher quality of their services foster the initiation of collaborative R&D projects within the system of innovation.

Problem of reciprocity

Güth et al. (2002) sees the German proverb "*Wie Du mir, so ich Dir!*" ("*Tit for tat*") [p.6] as a suitable signpost to understand what reciprocity means for social interaction. Reciprocity can be defined as the inner tendency of individuals to answer to benevolent or harming behavior in the same sense (Gouldner 1960, Güth & Yaari 1992, Cialdini & Trost 1998). Reciprocity is the reaction, the answer, to the behavior of the others. Consequently, they react friendly and nice to friendly actions and they are nasty and even brutal in reaction to hostile actions (Fehr & Gächter 2000). These principles can be transferred to collective invention and innovation. There, cooperative activities in R&D, as one routine to develop new products or processes, "*are based on proven past performance and reliability of a co-operative relation, and thus has a rational basis even though it is no longer based on conscious deliberation.*" (Nooteboom 1999,

p.797f.). Hence, reciprocity to be effective relies heavily on the reliability and trust among cooperation partners.

Lacking reciprocity causes considerable problems for networking in SIs, it may even cause no networking activities to occur. Reciprocity in this context means that the transmission of knowledge by one actor is reciprocated by the other actor - not necessarily *uno actu*.¹ Fehr & Gächter (2000) describe cooperation as reciprocal because the partners have to open their own knowledge stock to get, simultaneously, access to the knowledge stock of the partner. Hence cooperation partners require to have reciprocal incentives (Cantner & Meder 2007). In case reciprocity is not given, the exchange of knowledge will not take place. In principle this can be related to a lack of trust on the level of bilateral relationships as well as on the system's level. Cooperation in R&D, as one routine to develop new products or processes, *"are based on proven past performance and reliability of a co-operative relation, and thus has a rational basis even though it is no longer based on conscious deliberation."* (Nooteboom 1999, p.797f.).

Accordingly, two types of reciprocity problems can be distinguished. First, there is an ex-ante problem of reciprocity, where the actors are not networking because they have prejudices on the potential cooperation partners. In this case the actors are doubtful about bi- or multilateral know-how streams (Cantner 2000). In order to avoid the danger of opening their knowledge stock without receiving an appropriate part of the partner's knowledge, actors attempt to go without networking. The result is that knowledge streams do not flow just because of a lack of trust in the potential partners reciprocation. Second, there is an ex-post problem of reciprocity, when tensions between currently cooperation partners occur. These tensions maybe related to one partner free riding on the others knowledge stock.² Thus, the cheated partner will react by withholding his knowledge stock or by breaking off the cooperation. Hence, if trust not being reinforced or being disappointed that causes actors not to be willing to collaborate anymore (Cantner & Graf 2003). This discussion allows us to formulate hypotheses on the effect of trust respectively lacking trust on collaborative activities:

Hypothesis 2:

- (a) The less trust the actors of the SI have to other actors of the system, the less collaboration emerges (ex-ante problem).
- (b) The less trust collaborative firms have to their partners, the more collaborations will fail (ex-post problem).

Problem of compatibility

Pfeiffer (1989) defines compatibility as *"the consistence of a system's elements with reference to that system's ultimate function"* [p.11]. Or conversely, a problem of compatibility prevails when the system's elements do not fit together in a consistent way. Applied to the theory of SIs, this problem occurs, when actors possess specific knowledge stocks which are not compatible so that opportunities for a fruitful exchange cannot be seen. In that case the exchange of knowledge and consequently the expected collective generation, diffusion and exploitation of new knowledge do not occur (Cantner & Graf 2003). The problem of compatibility occurs for different reasons.

¹Reciprocity by no means requires exchange in equal quantities or equally valuable "quantities" of knowledge - already for the reason that objective values for the "quantities" do not exist; otherwise market exchange would work efficiently.

²Here, it can also be the case that one partner only has the feeling, that the other is free riding on his knowledge.

The first one is related to the opportunities actors expect to generate by exchanging knowledge. This in turn depends on the one hand on the recombination potential of their knowledge stocks and on the other on the degree of mutual understanding. The former has to do with differences in knowledge or technological orientations and the second with the degree or level of knowledge or technological sophistication. To understand these two concepts we look at factors influencing an actor's choice of a cooperation partner. Rather generally the issue of compatibility requires an overlap of the actors' knowledge stocks (Cantner & Meder 2007). It is impossible, however, for that to find an exact degree. However, there are two conditions to be considered. The first one governs the potentials to create new knowledge. These are positively related to the heterogeneity of the potential partners' knowledge bases. Consequently, the overlap has to be small enough, implying the knowledge bases to be heterogeneous enough, so that a sufficient amount of new combination is possible. If the knowledge bases are too similar then the partners will not benefit much if at all from each other. The second condition governs mutual understanding, that is the partners' understanding of each other's knowledge base (Mowery et al. 1998). This mutual understanding is perfect if the knowledge bases are identical. There is no understanding if the knowledge bases differ too much. In this case the partners have to carry learning costs to understand each other (Cantner & Meder 2007) and to invest into their absorptive capacities (Cohen & Levinthal 1990).

Thus, the degree of technological overlap affects a trade-off relation. On the one hand the overlap has to be sufficiently small to allow for recombination effects and on the other hand it has to be sufficiently large to allow for appropriate mutual understanding (Nooteboom 2000). Combining both aspects suggests an inverted U-shaped relationship between the degree of technological overlap of two potential cooperation partners and the likelihood for them to engage in a collaboration. Mowery et al. (1998) identify just that kind of an inverted-U relationship.

Applied to an SI, the technological overlap between her actors governs the potential of fruitful collaboration and exchange of knowledge. Both, a too high as well as a too low degree of overlap may prevent exchange and consequently the well functioning of the SI. In case of an overlap too low, it should be in the interest of firms to invest in their absorptive capacities as this allows benefiting from a long lasting collaboration (Nooteboom 2000). If this does not happen, policy may intervene by supporting firms' efforts to build up absorptive capacities. To overcome an overlap being too high is less simple to cure. A policy option here would be focusing on the settlement of firms and research institutes that deviate from the SI's core of technological orientation. Hypothesis 3 summarizes our discussion of actors' compatibility in an SI:

Hypothesis 3:

The more differentiated the technological orientation or the technological levels of the SI's actors, the less cooperative relationships occur.

3 Methodology and Data base

3.1 Regional setting

In our empirical analysis we test the hypotheses formulated with respect to three SIs problems. To do so we look at the cooperative behavior and attitude of actors considered being member of an SI. Our analysis is based on firm data as well as on data on regional level. The data for this research were on

the one hand obtained from a questionnaire survey conducted with firms in two German regions, Jena and Northern Hesse and one French region, Sophia Antipolis. On the other hand the data base contains patent application information between 1998 and 2003 of actors located in these three regions. We first briefly introduce the three regions under consideration.

Northern Hesse has been characterized as a region with largely missing or less developed regional innovation system (Gerstlberger 2004). On the national and the European level this region can be characterized as an old-industrialized location with a not too overwhelming economic performance and capability to innovate. Compared to averages on the country level, the federal level and the European level, the number of highly innovative firms and research institutes is comparatively low (Blume 2002). The economic structure of Northern Hesse is mainly characterized by machinery and heavy industry.

The region of Jena is often mentioned as one of the few success stories within the eastern part of Germany. Co-operations between Zeiss, Schott and Abbe at the end of the 19th century formed the basis for Jena's success, the close interaction between academic research and industrial production. Jena quickly developed to a technology oriented and innovative region, which persisted throughout the socialist period in the GDR. After the German unification Jena succeeded in keeping its core competencies in optics and extended into other fields such as biotechnology. The related economic success on individual as well as on firm level in form of catching up to comparable West German regions has not yet been achieved completely (see Cantner et al. 2003). In general Jena can be considered a grown, self-organizing SI.

The Sophia Antipolis science park is located in the South of France in the city of Vallebône (Provence-Alpes-Côte d'Azur), a region which does not have a specific scientific or industrial tradition. The science park which became operational by political will in 1972 is quite isolated in its immediate environment. Consequently the relationships of her actors are quite specific: first, there are a few actors running for innovation through local interactions and collective learning inside the park; second, most of the productive relationships are organized on the national, European and further international level. Since its start the science park hosts about 1000 firms offering an overall amount of 25,000 jobs. In this SI electronics and pharmacy are the two main fields of economic activity.

For our empirical analysis we rely on two databases. The first one contains firm level data, whereas the second one accounts for the patenting activity in the three SIs under consideration.

3.2 Firm level data base

The firm level data we use are drawn from a questionnaire based firm survey in 2006 which was embedded in the research project "2nd order innovations" financed by the Volkswagen Foundation. Firms active in manufacturing, IT and research services were asked about firm development, R&D effort, innovative and economic success and cooperative behavior for the period 2003-2006. Overall 832 firms answered to this questionnaire, whereof 55 are located in Sophia Antipolis, 248 in Jena and 529 in Northern Hesse. Table 1 shows the variables used in our analysis.

3.3 Regional patent data base

We use data from the "Deutsche Patentblatt" for both of German regions and data from the European Patent Office for the French region. The former data source includes all patents applied for at the German

Table 1: Variables - explanation and descriptive statistics

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
inno-suc	Binary variable with a value of 1 if this firm has successfully developed a new product or process within the last three years and 0 otherwise.	831	0.450	0.498	0	1
coop-suc	Binary variable with a value of 1 if this firm has successfully developed a new product or process together with a cooperation partner within the last three years and 0 otherwise.	827	0.244	0.430	0	1
coop	Binary variable with a value of 1 if this firm engaged in a research cooperation with the last three years and 0 otherwise.	832	0.445	0.509	0	1
coop-fai	Binary variable with a value of 1 if this firm engaged in a research cooperation with the last three years and this cooperation failed. Otherwise this value is 0.	827	0.036	0.187	0	1
int-imp	Binary variable with a value of 1 if this firm claimed that regional intermediate actors are important for the firm development and 0 otherwise.	764	0.191	0.393	0	1
int-qua	The firms were asked to evaluate the quality of regional intermediate actors on a 5-digit-Likert-scale. The higher the value the better the quality.	489	2.679	1.070	1	5
ex-ante-trust	Binary variable with a value of 1 if this firm has not cooperated because of missing trust to potential cooperation partner and 0 otherwise.	434	0.145	0.353	0	1
ex-post-trust	Average value from 3 5-digit-Likert-scales on trust to regional, national and international cooperation partner. The higher the value the higher the trust to partner.	318	3.909	0.733	1	5
je	Regional dummy with a value of 1 if this firm is located in Jena and 0 otherwise.	832	0.298	0.458	0	1
nh	Regional dummy with a value of 1 if this firm is located in Northern Hesse and 0 otherwise.	832	0.636	0.481	0	1
sa	Regional dummy with a value of 1 if this firm is located in Sophia Antipolis and 0 otherwise.	832	0.066	0.249	0	1
group	Binary variable with a value of 1 if this firm is a member of a firm group and 0 otherwise.	826	0.229	0.420	0	1
edu-r	Share of high-educated employees in total employees.	733	0.289	0.324	0	1
age	Firm age measured in years.	816	28.366	39.669	1	606
size	Firm size measured in natural logarithm of number of employees.	820	2.801	1.465	0	8.996

patent office and at the European patent office for Germany between 1998 and 2003. For the same period data from the EPO have been gathered for the region of Alpes-Maritimes. National French patents - usually more numerous than EPO patents, are not included. Hence, the total number of patents is inherently smaller for the French region. To assign a patent to a region we use the information about the inventors. If at least one inventor has his domicile in one of our regions the respective patent is assigned to this region.

The patent data base is used to test our hypothesis on compatibility problems in SI. We do so by concentrating on differences in the regional technological endowment characterized by the technologies pursued in the regions. Information about those technologies is drawn from the patents which are classified in accordance to international patent classification (IPC) using so-called IPC-codes. This classification, however, is much too detailed for our purposes. Therefore, we implement a concordance list developed by Schmoch et al. (2003) in order to reduce the widespread IPC classification to 43 technological fields that correspond with NACE industry codes on a 3-digit level. The registration procedure at the EPO or the

DPA allows to list more than one IPC class on a patent. Therefore, quite regularly a patent is classified for more than one technological field. We account for this by assigning patent respective weights for each technological field addressed.

Measuring here the technological endowment of a region on a yearly basis may lead to a rather poor measure as the changes from year to year may be rather abrupt. In order to smooth this we use four three-year periods with an overlapping year between the periods. By this procedure we achieve in the end four periods enabling us to make statements about the development of the three observed regional knowledge networks and to draw conclusions with respect to compatibility problems.

4 Intermediation Problem

The first problem of regional innovations systems analyzed is on the role of intermediaries whose task it is to get actors into contact. For being successful herein the existence of intermediaries has to be considered important or necessary and their service has to be of good quality. We test for both conditions. We suggested an intermediation problem to exist if regional politicians and business development agencies are not able to provide such a service. Consequently, either the probability of actors to cooperate should be lower or the quality of cooperation projects should be diminished. We also test for both of these possible effects.

Importance of intermediaries

In a first step we look at the importance of intermediaries as measured by $int - imp$ and analyze the effect on the cooperation probability and then on the cooperation success. For regressing on the actors' probability of being engaged in cooperative R&D projects we run logit regression models on the variable $coop$ indicating whether an actor is engaged in cooperative R&D projects or not. If intermediaries just fulfill their assumed role, the variable $int - imp$ representing the importance firms attach to regional politicians and business development agencies should have a positive coefficient, thus increasing the cooperation probability. The results for this estimation are presented in table 2. We look at the results of four models distinguished by the variables included in addition to the variable $int - imp$.

We find that in each of the four models the variable $int - imp$ (and the region specific variables $int - imp * sa$, $int - imp * jen$, $int - imp * nh$) shows no significant coefficient and, hence, has no impact on the cooperation propensity. The control variables show significantly positive coefficients, so larger firms ($size$), member of firm groups ($group$) and firms with a higher education level ($edu - r$) have a higher probability to cooperate. These results contribute to former empirical studies on cooperation propensity which find firm size (Dahlstrand 1999, Verspagen 1999, Miotti & Sachwald 2003), membership in a firm group (Baum et al. 2000), and the internal education level indicating the firm's absorptive capacities (Cohen & Levinthal 1990) to positively influence the cooperation propensity. The firm age (age) has no influence on the cooperation probability. As the regional dummies show no significant coefficients, we conclude that there are no regional differences in cooperation behavior per se.

Looking next alternatively at the success of collaborative projects we use the corresponding dependent variable $coop - suc$ which is also binary. Hence, we use just the same model specification as before and run logit regressions on the effect the importance of regional politicians and business development agencies

Table 2: Impact of the importance of intermediate actors on cooperation behavior

	model 1	model 2	model 3	model 4
	Logit	Logit	Logit	Logit
	coop	coop	coop	coop
int-imp	0.243 (1.32)	0.229 (1.13)	0.246 (1.19)	
int-imp * sa				0.689 (0.84)
int-imp * je				0.146 (0.43)
int-imp * nh				0.268 (0.97)
je			-0.114 (0.51)	-0.079 (0.32)
sa			-0.010 (0.02)	-0.072 (0.16)
size		0.185 (2.63)***	0.182 (2.57)**	0.182 (2.56)**
age		-0.001 (-0.41)	-0.002 (0.46)	-0.002 (0.46)
group		0.874 (4.05)***	0.882 (4.08)***	0.888 (4.10)***
edu-r		1.296 (4.54)***	1.339 (4.16)***	1.326 (4.10)***
Constant	-0.353 (4.32)***	-1.366 (5.61)***	-1.333 (5.30)***	-1.335 (5.26)***
Observations	764	661	661	661
Robust z statistics in parentheses				
* significant at 10%; ** significant at 5%; *** significant at 1%				

(*int - imp*) has on the success of collaboration projects. The regression results are presented in table 3. We run five models distinguished by the use of control variables and by the use of the overall or region specific variables (*int - imp * je*, *int - imp * nh* and *int - imp * sa*).

Our results show a significantly positive influence of (the overall) *int - imp* in models 1-3. Hence, the importance of intermediate actors increases the success probability of cooperation in research and development. Using the region specific *int - imp* variables in models 4 and 5 this result remains stable. There are, however, regional differences since in model 4 the presence of intermediaries shows a much higher influence in the region of Sophia Antipolis (2.292) than in the two other regions, Jena (0.737) and Northern Hesse (0.460). In model 5 this order does not change except the coefficient for Jena becomes insignificant. Here again, the control variables *size*, *group* and *edu - r* show significantly positive coefficients.

In view of these results we conclude that the assumed role of politicians and business development agencies in regional innovation systems as initiator of R&D cooperations is reflected in our data with respect to the probability for cooperation success. Hence, on these terms hypothesis 1 cannot be rejected. Furthermore a ranking of the intermediation impact is identified where the region characterized by a less developed SI (Northern Hesse) shows up with the lowest effect.

Quality of intermediaries In the second step of analyzing the presence of intermediary problems we look at the quality of intermediaries as evaluated by the regional firms. As we have just found, the intermediary actors in regional innovation systems positively influence the cooperation success probability. We assume that this effect increases with an increasing quality of such actors. For this analysis the depen-

Table 3: Impact of the importance of intermediate actors on the cooperation success probability

	model 1	model 2	model 3	model 4	model 5
	Logit	Logit	Logit	Logit	Logit
	coop-suc	coop-suc	coop-suc	coop-suc	coop-suc
int-imp	0.662 (3.26)***	0.771 (3.40)***	0.732 (3.09)***		
int-imp * sa				2.292 (2.72)***	1.670 (2.36)**
int-imp * je				0.737 (2.45)**	0.461 (1.41)
int-imp * nh				0.460 (1.76)*	0.926 (3.01)***
size		0.341 (4.20)***	0.352 (4.40)***		0.340 (4.15)***
age		-0.006 (-1.69)*	-0.005 (-1.39)		-0.007 (-1.79)*
group		0.490 (2.04)**	0.495 (2.04)**		0.520 (2.17)**
edu-r		1.440 (4.25)***	1.529 (4.17)***		1.413 (4.07)***
Constant	-1.376 (-13.68)***	-2.793 (-8.60)***	-2.903 (-8.54)***	-1.376 (-13.68)***	-2.768 (-8.50)***
Observations	761	659	659	761	659

Robust z statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

dent variable is *int – qua* which is measured on a 5-digit-Likert-scale where higher values indicate better evaluations. This type of dependent variable requires running ordered logistic regressions (OLogit).³ Using this method we attempt to identify intermediation problems by introducing regional dummy variables.

The results of our analysis are presented in table 4. We run five models, where the first one looks only at the control variables and the last one only at the importance of intermediaries. Models 2-4 test for each region separately. Here, regional dummies are included separately in order to test whether a region differs significantly from the mean effect.

Model 1 delivers that the control variables have no influence on the evaluation of intermediaries at all. In model 2 the dummy variable for Jena (*je*) has a significantly positive sign. This implies that firms located in this region are more content with the work of regional intermediaries than actors located in the two other regions. In model 3 a regional dummy for Northern Hesse (*nh*) is included which shows a weakly significant, negative coefficient. Hence, the evaluation of intermediaries of this region is below the average. Finally, model 4 shows for Sophia Antipolis (*sa*) that the evaluation does not differ significantly from the average. Finally, we find firms claiming that the regional intermediaries are important tend to give a better evaluation of these actors. This finding strengthens our argument for combining both steps of analysis (relationship between *int – qua* and *int – imp*).

In view of the regression results in table 4, we conclude that the region with the strongest indication of an intermediary problem is the region of Northern Hesse, in comparison to the other two observed regions. Combining this with the results found in the step before we conclude for Northern Hesse a major intermediation problem: firms there attribute the lowest importance to the regional background actors and give them an evaluation worse than the average of all firms.

³Here the actual values taken on by the dependent variable are irrelevant, except that larger values are assumed to correspond to "higher" outcomes. This is due to the fact that this evaluation method has clear cut definitions for each scale.

Table 4: Testing for intermediary problems

	model 1	model 2	model 3	model 4	model 5
	OLogit	OLogit	OLogit	OLogit	OLogit
	int-qua	int-qua	int-qua	int-qua	int-qua
je		0.384 (1.81)*			
nh			-0.403 (1.87)*		
sa				-0.021 (0.06)	
int-imp					0.641 (2.56)**
size	0.067 (1.00)	0.079 (1.16)	0.074 (1.11)	0.067 (1.00)	0.067 (0.99)
age	0.000 (0.10)	0.002 (0.53)	0.002 (0.61)	0.000 (0.10)	0.002 (0.56)
group	-0.018 (0.08)	-0.060 (0.28)	-0.074 (0.34)	-0.017 (0.08)	0.004 (0.02)
edu-r	0.506 (1.71)*	0.409 (1.36)	0.287 (0.94)	0.512 (1.72)*	0.359 (1.16)
Observations	430	430	430	430	427
Robust z statistics in parentheses					
* significant at 10%; ** significant at 5%; *** significant at 1%					

5 Reciprocity problems in regional innovation systems

Our next step is concerned with the issue of reciprocity governing cooperative activities within SIs. We operationalize reciprocity with the firms' evaluation of the trust they have in potential and in concurrent cooperation partners respectively. The analyses we pursue follow two directions. We first ask whether a low intensity to cooperate in an SI can be explained by missing trust towards potential cooperation partners. Hence, we here look at an ex-ante reciprocity problem. Secondly, we investigate whether the failure of cooperative ventures in an SI is related to missing trust towards partners involved herein. This relation points to an ex-post reciprocity problem.

Analyzing the ex-ante reciprocity problem we use the binary variable *ex – ante – trust* as dependent variable. It takes the value of 1 when a firm not engaging in cooperative innovation does so because of missing trust to potential partners. As explanatory variables we use regional dummies in order to identify regional differences as well as the control variables *size*, *age*, *group* and *edu – r*.

The dummy variables are used to identify region specific problems of ex-ante reciprocity. We run logit regression with always only one regional dummy. For an ex-ante reciprocity problem to exist in a region, the probability of being a non-cooperative actor because of lacking trust in that region has to be higher compared to the average of our sample (the control group comprises again all firms located in the other two regions). Specific to our sample is that firms located in Sophia Antipolis never stated missing trust to be responsible for non-cooperating. Hence for Sophia Antipolis an ex-ante reciprocity problem seems not to be existent. Consequently we run respective Logit-models only for Northern Hesse and Jena. Our results are presented in table 5 where model 1 tests the control variables and models 2 and 3 look at the regional ex-ante reciprocity problems.

In model 1 none of the control variables shows a significant influence on *ex – ante – trust*. The inclusion of the regional dummies in model 2 and model 3 also does not lead to significant coefficients. Hence,

Table 5: Logit model on ex-ante reciprocity problems

	model 1	model 2	model 3
	Logit	Logit	Logit
	ex-ante-trust	ex-ante-trust	ex-ante-trust
je		-0.431 (1.05)	
nh			0.564 (1.31)
size	0.075 (0.62)	0.064 (0.52)	0.058 (0.46)
age	0.002 (0.44)	0.001 (0.15)	0.000 (0.08)
group	-0.437 (0.86)	-0.424 (0.83)	-0.404 (0.80)
edu-r	0.274 (0.47)	0.406 (0.69)	0.501 (0.83)
Constant	-2.010 (4.89)***	-1.888 (4.34)***	-2.417 (4.64)***
Observations	364	364	364
Robust z statistics in parentheses			
* significant at 10%; ** significant at 5%; *** significant at 1%			

we conclude that in neither of the three regions ex-ante reciprocity problems are prevalent. Hypothesis 2a therefore has to be rejected.

Turning to the second step of testing for ex-post reciprocity problems we use as dependent variables first the cooperation success represented by the binary variable *coop - fai* which takes the value of 1 if the cooperation failed. We complement this analysis by using next the ex-post reciprocity variable *ex - post - trust* which is constructed from three 5-digit-Likert scales on trust to regional, national and international cooperation partners. A higher value of *ex - post - trust* indicates a higher level of trust.

The Logit regression results on *coop - fai* are presented in models 1-3 of table 6. The explanatory variables are the ex-post reciprocity variable *ex - post - trust*, her region specific values (*ex - post - trust * nh*, *ex - post - trust * sa*, *ex - post - trust * je*), as well as the control variables *size*, *age*, *group* and *edu - r*.

Model 1 test for the control variables. Only firm size shows a weakly significant positive influence ($p < 10\%$) on the probability of a cooperation failure. Hence, for larger firms the failure probability is higher. We suggest that with an increasing size the number of cooperation projects tends to be higher and thus the probability of one failed cooperation project increases too. In model 2 we test for the impact of trust in general. The variable *ex - post - trust* is included and shows a significantly negative coefficient (-1.130). We conclude that a higher level of trust is related to a lower probability of failure. To account for regional differences in model 3 we include region specific trust variables. For all three regions we find negative coefficients which are significant except for Sophia Antipolis. Hence, the general positive relationship between missing trust and the probability of a failed cooperation can be observed for the region of Jena as well as for Northern Hesse. The insignificant result for Sophia Antipolis might be caused by the small number of failed cooperations there.

Next we look at interregional differences in the level of trust expressed in *ex - post - trust*. For that we run ordered Logit regressions on *ex - post - trust*. The results are presented in models 4-7 of table 6. To test for regional differences regional dummies are used. Additionally, the control variables are tested which according to model 4 do not show any significant impact on trust. The separate inclusion of the

Table 6: Logit model on ex-post reciprocity problems

	model 1	model 2	model 3	model 4	model 5	model 6	OLogit
	Logit	Logit	Logit	OLogit	OLogit	OLogit	OLogit
	coop-fai	coop-fai	coop-fai	ex-post-gen	ex-post-gen	ex-post-gen	ex-post-gen
ex-post-trust		-1.130 (2.71)***					
ex-post-trust * je			-1.454 (3.54)***				
ex-post-trust * nh			-1.114 (2.87)***				
ex-post-trust * sa			-0.985 (1.62)				
je					-0.460 (1.65)*		
nh						0.475 (1.62)	
sa							0.152 (0.26)
size	0.308 (1.80)*	-0.072 (0.29)	-0.080 (0.31)	0.019 (0.24)	0.001 (0.02)	0.009 (0.12)	0.016 (0.20)
age	-0.008 (0.88)	-0.004 (0.62)	-0.008 (0.94)	0.000 (0.25)	-0.000 (0.34)	-0.001 (0.42)	0.000 (0.27)
group	0.605 (1.13)	0.586 (0.89)	0.620 (0.97)	0.122 (0.45)	0.146 (0.55)	0.149 (0.56)	0.121 (0.45)
edu-r	0.419 (0.58)	-0.784 (0.69)	-0.513 (0.41)	0.904 (2.66)***	1.117 (3.03)***	1.267 (3.19)***	0.859 (2.39)**
Constant	-4.544 (6.94)***	1.458 (1.01)	1.637 (1.18)				
Observations	716	279	279	280	280	280	280
Robust z statistics in parentheses							
* significant at 10%; ** significant at 5%; *** significant at 1%							

regional dummies in models 5,6 and 7 delivers a negative coefficient for Jena (model 5) and insignificant estimates for the two other regions. Hence, actors from Northern Hesse and Sophia Antipolis do not differ significantly in their trust evaluation compared to the average. For Jena, however, there is a weak evidence that this region faces a problem with ex-post reciprocity. This result is surprising because of the much higher cooperation level in Jena compared to the other regions as will be shown in the next section.

6 Compatibility problems

Hypothesis 3 refers to compatibility problems in SI. This malfunctioning of an SI shows up if the actors within the system do not cooperate in research and development, because of a mismatch of their knowledge stocks. Information on that are unfortunately not available in our data base on firm level. Therefore, we have to switch to the available patent data base.

In order to bridge the gap between the firm data base and the patent data base we look at the interregional differences in cooperative activities. Table 7 shows that the differences are the same for both data bases. In our firm database we find 35.48% of the firms located in Jena have been involved in a research cooperation during the last three years which is nearly twice the share of Northern Hesse (18.34%). The cooperation propensity of actors located in Sophia Antipolis is in between (30.91%). In the patent data base cooperation is indicated by the number of co-application ties per actor. What we find here is that

the number of innovative actors does not differ that much between Jena and Northern Hesse, although the difference is increasing over time. For Sophia Antipolis we find the highest number of innovative actors and an increase of this value over time. Looking at the number of patents in cooperation (co-applications) the number for Jena in the first period is about 5 times higher than the number for Northern Hesse and Sophia Antipolis; this factor is increasing over time and reaches about 8 in the fourth period with respect to the value for Northern Hesse. The relation to Sophia Antipolis remains constant over time. Looking finally at the ties per actor we find for actors in Jena a rather stable average number of co-application of patents of about 0.6 for all four periods. For actors located in Northern Hesse and Sophia Antipolis this number is much lower and declines from 0.14 for Northern Hesse respectively 0.11 for Sophia Antipolis in the first period to 0.1 for both regions in the last period. Summarizing these three observations it becomes evident that the cooperation intensity in Jena is much higher than those in Northern Hesse and Sophia Antipolis. In sum one can conclude that the descriptive results of both data bases based on firm and on patent data show the same results in comparing the three regions. Although the cooperation propensity of actors located in Sophia Antipolis lies in between Jena and Northern Hesse, the firm data base offers an obvious higher cooperation value than the patent data for Sophia Antipolis.

Table 7: Cooperation behavior

Survey data analysis		No. of cooperative actors	Number of actors		Ratio (03-05)
	Jena	88	248		35,48%
	Northern Hesse	97	529		18,34%
	Sophia Antipolis	17	55		30,91%
Patent data analysis		period 1	period 2	period 3	period 4
year		98-00	99-01	00-02	01-03
Number of actors					
	Jena	254	277	257	249
	Northern Hesse	212	224	185	174
	Sophia Antipolis	318	324	323	358
Number of cooperation					
	Jena	161	158	153	152
	Northern Hesse	30	28	20	18
	Sophia Antipolis	36	41	45	36
Cooperation ties per actor					
	Jena	0.634	0.574	0.595	0.610
	Northern Hesse	0.141	0.125	0.108	0.103
	Sophia Antipolis	0.113	0.126	0.139	0.100

On this basis we are now interested in whether the specificities of the regional knowledge bases are related to the differences in cooperation intensity. What we expect here is that the knowledge base of Jena should show a higher compatibility among the various knowledge stocks than the knowledge bases of Northern Hesse and Sophia Antipolis. To test for this we use three indicators, the number of technological fields, the share of patent filed for in the top five technological fields and, finally, the Herfindahl index. The respective figures are presented in table 8.

First, looking at the technological fields the regional actors are filing patents for we would expect a low number for Jena and comparable numbers for Sophia Antipolis and Northern Hesse. We find the

Table 8: Compatibility in regional systems

period		period 1	period 2	period 3	period 4
year		98-00	99-01	00-02	01-03
Number of patents	Jena	730	814	772	810
	Northern Hesse	590	574	463	440
	Sophia Antipolis	356	389	460	662
Number of technological fields	Jena	39	38	38	37
	Northern Hesse	38	37	36	36
	Sophia Antipolis	32	33	35	36
Share of top 5 techn. fields	Jena	77.26%	78.37%	77.59%	79.38%
	Northern Hesse	50.51%	54.18%	52.70%	52.73%
	Sophia Antipolis	51.69%	54.76%	57.39%	62.23%
Herfindahl Index	Jena	0.087	0.087	0.088	0.093
	Northern Hesse	0.068	0.068	0.069	0.063
	Sophia Antipolis	0.079	0.090	0.090	0.101

number of fields to be quite similar between Jena and Sophia Antipolis and remaining roughly constant over time.⁴ Surprisingly, the number of technological fields is lowest in Sophia Antipolis, but it is increasing over time which corresponds to the declining cooperation propensity. Taking into account that the number of patents in Jena is higher than in Northern Hesse and Sophia Antipolis, we conclude that this is a first, but rather weak, hint on the compatibility differences between the regional knowledge bases.

The second indicator is the share of patents that have been filed for in the top 5 technological fields where those 5 most frequented fields represent the core of the regional knowledge base. The share of patents filed for in these top five indicates the strength of the regional knowledge core. The respective third rows of table 8 show the results. Quite obviously, the top five technological fields in Jena are more likely to be frequented than those in Northern Hesse and Sophia Antipolis. Three out of four patents are classified into the top 5 technological fields in Jena, whereas only every second patent in Northern Hesse and in Sophia Antipolis. This share is increasing over time for Sophia Antipolis and, although much less, for Jena; it remains constant for Northern Hesse. Hence, especially of Sophia Antipolis and also for Jena this development indicates a pattern of specialization. In case of Jena this observation complements nicely to our conclusion above of a higher compatibility of this regional stock of knowledge. For Sophia Antipolis the specialization goes hand in hand with a decreasing cooperativeness. With respect to our compatibility argument this seems to be counterintuitive.

In order avoid the shortcomings related to arbitrarily choosing 5 core technology fields we compute the Herfindahl index for all technology fields. Assuming that the technological fields are independent of each other, this index measures the homogeneity of the regional knowledge base over all technological fields. For Sophia Antipolis, here again, we find counterintuitive results. Increasing Herfindahl values (from 0.079 to 0.101) go hand in hand with the declining cooperation propensity. In contrast to this and

⁴Following Schmoch et al. (2003), the total number of technological fields is restricted to 43. Hence both regions patent in almost all of the technology fields.

in a line with the results of the two other indicators, the Herfindahl index shows a higher homogeneity of the regional knowledge base in Jena of about 0.089 compared to Northern Hesse about 0.068. Applying a Wilcoxon-Mann-Whitney test for assessing whether the two vectors of Herfindahl indexes (one vector for each region comprising four observations) come from the same distribution we find significant differences ($p < 0.01$) between both region. We conclude from that a more homogeneous regional knowledge base in Jena compared to Northern Hesse. As the cooperation behavior is higher for Jena too, hypothesis 3 on the relationship between the compatibility of the regional knowledge base and cooperation behavior in regional innovation systems cannot be rejected at least for the comparison of Jena and Northern Hesse.

7 Conclusion

This paper investigates whether differences in the cooperative innovative activities between regions can be explained by certain characteristics of the respective regional innovation systems. More precisely, we attempt to relate a weaker performance in cooperative innovation to malfunctions of the respective regional innovation system. Those malfunction are related to intermediation, reciprocity and compatibility of the actors in an RIS.

Hypotheses formulated for effects of these three SIs features on cooperative innovation are tested for three regions, Northern Hesse and Jena in Germany and Sophia Antipolis in France. Firm questionnaire and patent data for three regions are used. For all three regions we find that firms which consider intermediaries important have a higher probability of success in cooperating; there is however no effect on the likelihood to form a cooperation. Furthermore, the evaluation of intermediaries' services is significantly different between the three regions with the region weakest in terms of cooperative innovation assigning the lowest grade. As to the problem of reciprocity in knowledge exchange we find no evidence for an *ex ante* trust problem. However, with respect to failing cooperation projects we find an *ex post* reciprocity problem. Finally, with respect the compatibility of the actors' knowledge stocks we find for Jena a much more homogeneous knowledge base indicating a higher compatibility compared to Northern Hesse or Sophia Antipolis. Interestingly, over time increasing homogeneity of the knowledge bases in Jena and Sophia Antipolis is combined with an increasing tendency to cooperate in the former and a decreasing one for the latter. This somewhat surprising result for Sophia Antipolis may originated from date base we used for this region. While we used patent data from the German patent office for Jena and Northern Hesse, we have to revert to information from the European Patent office for Sophia Antipolis.

In this paper we figure out that differences in the cooperation propensity and, thus, in the networking within RIS might be due to problems of intermediation, reciprocity or compatibility. While there exists manifold literature dealing with the consequences of a malfunctioning SI (Buesa et al. 2004, Doloreux 2004, Ronde & Hussler 2005) there are no empirical studies on where these differences come from exist so far. Especially the impact of intermediation and reciprocity on networking is a sparsely analyzed issue on the systemic level. We find evidence that the major problem for intermediation actors is rather communication than programmatic work.

References

- Allen, R. (1983), 'Collective invention', *Journal of Economic Behavior and Organization* **4**, 1–24.
- Asheim, B. & Coenen, L. (2005), 'Knowledge bases and regional innovation systems: Comparing nordic clusters', *Research Policy* **34**, 1173–1190.
- Asheim, B. & Isaksen, A. (2002), 'Regional innovation systems: the integration of local sticky and global ubiquitous knowledge', *Journal of Technology Transfer* .
- Baum, J., Calabrese, T. & Silverman, B. (2000), 'Don't go it alone: Alliance network composition and startups' performance in canadian biotechnology', *Strategic Management Journal* **21**, 267–294.
- Bayona, C., Garcia-Marco, T. & Huerta, E. (2001), 'Firms' motivation for cooperative r&d: an empirical analysis of spanish firms.', *Research Policy* **30**(8), 1289 – 1307.
- Blanchard, B. & Fabrycky, W. (1990), *Systems Engineering and Analysis*, Prentice-Hall.
- Blume, L. e. a. (2002), Die regionalreform in stadt und landkreis kassel. Ökonomische aspekte, kostensenkungspotentiale, fiskalische konsequenzen.
- Boschma, R. (2005), 'Proximity and innovation: A critical assessment', *Regional Studies* **39**, 61–74.
- Buesa, M., Heijs, J., Pellitero, M. & Baumert, T. (2004), 'Regional systems of innovation and the knowledge production function: the spanisch case', *Technovation* pp. 1–10.
- Cantner, U. (2000), Die Bedeutung von Innovationssystemen für die internationale Wettbewerbsfähigkeit, in U. Staroske, M. Wiegand-Kottisch & K. Wohlmuth, eds, 'Innovation als Schlüsselfaktor eines erfolgreichen Wirtschaftsstandortes', Lit Verlag.
- Cantner, U. & Graf, H. (2003), Innovationssysteme und kollektive Innovationsprozesse: Einige theoretische Grundlagen, in U. Cantner, R. Helm & R. Meckl, eds, 'Strukturen und Strategien in einem Innovationssystem - Das Beispiel Jena', Verlag Wissenschaft & Praxis.
- Cantner, U., Helm, R. & Meckl, R. (2003), Innovationssysteme aus volks- und betriebswirtschaftlicher Perspektive: Bedeutung und Strukturen, in U. Cantner, R. Helm & R. Meckl, eds, 'Strukturen und Strategien in einem Innovationssystem - Das Beispiel Jena', Verlag Wissenschaft & Praxis.
- Cantner, U. & Meder, A. (2007), 'Technological proximity and the choice of cooperation partner', *Journal of Economic Interaction and Cooperation* **2**, 45–65.
- Carlsson, B., Jacobson, S., Holmen, M. & Rickne, A. (2002), 'Innovation systems: analytical and methodological issues', *Research Policy* **31**, 233–245.
- Cialdini, R. & Trost, M. (1998), Social influence: Social norms, conformity and compliance, in G. Gilbert, S. Fiske & G. Lindzey, eds, 'The Handbook of Social Psychology, Volume II', Oxford University Press.
- Cohen, W. & Levinthal, D. (1990), 'Absorptive capacity: a new perspective on learning and innovation', *Administrative Science Quarterly* **35**(1), 128–152.
- Cooke, P. (1992), 'Regional innovation systems: Competitive regulation in the new europe', *Geoforum* **23**, 365–382.
- Cooke, P. (2001), 'Regional innovation systems, clusters, and the knowledge economy', *Industrial Corporate and Change* **10**(4), 945–974.
- Coriat, B. & Weinstein, O. (2002), 'Organisations, firms and institutions in the generation of innovation', *Research Policy* **31**, 273–290.

- Cowan, R., Jonard, N. & Zimmermann, J.-B. (2006), 'Evolving networks of inventors', *Journal of Evolutionary Economics* **16**, 155–174.
- Dahlstrand, A. (1999), 'Technology-based smes in the göteborg region: their origin and interaction with universities and large firms', *Regional Studies* **33**(4), 379–389.
- Diamond, D. (1984), 'Financial intermediation and delegated monitoring', *Review of Economic Studies* **51**, 393–414.
- Doloreux, D. (2004), 'Regional innovation systems in canada: A comparative study', *Regional Studies* **38**, 481–494.
- Doloreux, D. & Parto, S. (2005), 'Regional innovation systems: current discourse and unresolved issues', *Technology in Society* **27**(2), 133–153.
- Edquist, C. (1997), *Systems of Innovation: Technologies, Institutions and Organizations*, Pinter/Castell.
- Edquist, C. (2005), Systems of innovation - perspectives and challenges, in J. Fagerberg, D. Mowery & R. Nelson, eds, 'The Oxford Handbook of Innovation', Oxford University Press.
- Edquist, C. & Johnson, B. (1997), Institutions and organizations in systems of innovation, in C. Edquist, ed., 'Systems of Innovation: Technologies, Institutions and Organizations', Pinter/Castell.
- Fagerberg, J. (2005), Innovation: A guide to the literature, in J. Fagerberg, D. Mowery & R. Nelson, eds, 'The Oxford Handbook of Innovation', Oxford University Press.
- Fehr, E. & Gächter, S. (2000), 'Fairness and retaliation: The economics of reciprocity', *Journal of Economic Perspectives* **14**(3), 159.
- Flaherty, M. (1984), 'Field research on the link between technological innovation and growth: Evidence from the international semiconductor industry', *American Economic Review* **72**(2), 67–72.
- Freeman, C. (1987), *Technology policy and economic performance: lessons from Japan.*, Pinter, London.
- Gerstlberger, W. (2004), 'Regional innovation systems and sustainability—selected examples of international discussion.', *Technovation* **24**(9), 749 – 758.
- Gouldner, A. (1960), 'The norm of reciprocity: A preliminary statement', *American Sociological Review* **25**(2), 161–178.
- Güth, W., Kliemt, H. & Napel, S. (2002), 'Wie du mir, so ich dir! - Ökonomische theorie und experiment am beispiel der reziprozität', *Papers on Strategic Interaction, Max-Planck-Gesellschaft* **19**.
- Güth, W. & Yaari, M. (1992), Explaining reciprocal behavior in simple strategic games: An evolutionary approach, in U. Witt, ed., 'Explaining Process and Change, Approaches to Evolutionary Economics', The University of Michigan Press.
- Jaffe, A., Trajtenberg, M. & Henderson, R. (1993), 'Geographic localization of knowledge spillovers as evidenced by patent citations', *The Quarterly Journal of Economics* .
- Karlsson, C. (1997), 'Product development, innovation networks, infrastructure and agglomeration economies', *The Annals of Regional Science* **31**, 235–258.
- Liu, X. & White, S. (2001), 'Comparing innovation systems: A framework and application to china's traditional context', *Research Policy* **30**, 1091–1114.
- Lundvall, B. (1992), *National Systems of Innovation: Towards a theory of innovation and interactive learning*, Pinter.

- Malerba, F. (2002), New challenges for sectoral systems of innovation in europe, Technical report, DRUID Summer Conference.
- Miotti, L. & Sachwald, F. (2003), 'Co-operative R&D: why and with whom? an integrated framework of analysis', *Research Policy* **32**(8), 1481–1499.
- Mowery, D., Oxley, J. & Silverman, B. (1998), 'Technological overlap and interfirm cooperation: implications for the ressource-based view of the firm', *Research Policy* **27**(5), 507–523.
- Nelson, R. (1992), 'National innovation systems: A retrospective on a study', *Industrial and Corporate Change* **2**, 347–374.
- Nelson, R. (2000), National innovation systems, in Z. Acs, ed., 'Regional Innovation, Knowledge and Global Change', Pinter.
- Nooteboom, B. (1999), 'Innovation and inter-firm linkages: new implications for policy', *Research Policy* **28**, 793–805.
- Nooteboom, B. (2000), 'Learning by interaction: Absorptive capacity, cognitive distance and governance', *Journal of Management and Governance* **4**, 69–92.
- North, D. (1992), *Institutionen, institutioneller Wandel und Wirtschaftsleistung*, J.B.C. Mohr.
- OECD (2002), *Dynamising National Innovation Systems*, OECD, Paris.
- Pfeiffer, G. (1989), *Kompatibilität und Markt, Ansätze einer ökonomischen Theorie der Standardisierung*, Nomos Verlagsgesellschaft.
- Porter, M. (1990), *The Competitive Advantage of Nations*, Harvard Business Review.
- Ronde, P. & Hussler, C. (2005), 'Innovation in regions: What does really matter?', *Research Policy* **34**, 1150–1172.
- Schmoch, U., Laville, F., Patel, P. & Frietsch, R. (2003), 'Linking technology areas to industrial sectors', *Final Report to the European Commision DG Research*.
- Schumpeter, J. (1912), *Theorie der wirtschaftlichen Entwicklung. Eine Untersuchung über Unternehmergeinn, Kapital, Kredit, Zins und den Konjunkturzyklus*, Duncker & Humblot, Berlin.
- Verspagen, B. (1999), 'Large firms and knowledge flows in the dutch R&D system: A case study of philips electronics', *Technology Analysis and Strategic Management* **11**(2), 221–233.
- von Hippel, E. (1987), 'Cooperation between rivals: informal know-how trading', *Research Policy* **16**(5), 291–302.
- von Malmberg, F. (2007), 'Stimulating learning and innovation in networks for regional sustainable development: the role of local authorities', *Journal of Cleaner Production* **15**, 1730–1741.
- Williamson, S. (1986), 'Costly monitoring, financial intermediation and equilibrium credit rationing', *Journal of Monetary Economics* **18**, 159–179.