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9 Do regional systems of innovation matter?

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The real questions

Scholars engaged in research in the field of regional economics or economic geography have little doubt that regions do matter for research and development (R&D). For these experts, the real questions are deeper and concern issues like the relative importance of the impact of location, the ways in which the influence of location comes into effect and how regional conditions for innovation activity can be improved. This chapter deals with these questions. Its starting point is a brief overview of empirical findings about the spatial distribution of innovation activity. The following sections represent an attempt to explain this evidence based on the notion of labor division in the field of innovation. The main characteristics of such a division of innovative labor have significant implications for the spatial organization of innovation activity as well as for the analysis. The concept of regional innovation systems and the role of different actors in such a regional system are explained followed by an overview of results of recent research concerning regional innovation systems. Finally, an exposition of basic policy options is given and some important issues for further research are specified.

Empirical evidence for the role of location for R&D

With regards to the "death of distance" that is implied by ongoing improvements of telecommunication techniques, the clustering of economic activity found in many empirical studies may be regarded as surprising.¹ These results clearly show that location matters for production, particularly for innovation. Moreover, it seems that under the conditions of globalization, the regional environment is becoming even more relevant. A simple reason for this tendency toward "glocalization" is that spatially-rooted factors gain in relative importance as the accessibility of other factors becomes easier or cheaper. Clustering suggests that there are agglomeration advantages at work that stimulate certain types of activity (Baptista 1998; Porter 1998). Among the most important of these

agglomeration advantages are a relatively high potential for face-to-face contacts, the presence of positive external effects, easy access to research institutions and differentiated input markets such as the labor market and the market for specialized innovation related services. All these factors may facilitate the generation and transfer of knowledge which constitutes a key element of innovation activity (Antonelli 2002: chapter 3).²

There are clear indications that the quality of regional innovation systems may differ considerably and that only some part of such differences can be attributed to the degree of agglomeration or clustering (Fritsch 2000, 2002, 2004). Agglomeration economies in clusters may stimulate the competitiveness of the firms involved. However, they explain only a fraction of the differences in the efficiency and the success of their R&D activity. Obviously, regional factors matter for innovation processes, but it is hard to make a more general judgment on the strength of the regional impact as compared to other causes like industry-specific factors or influences that are effective on the national level (Howells 1999). At least in some regions the impact of location appears to be rather strong. In this regard one might ask, for example, if the US computer industry would have gained the same strength and competitiveness if the Silicon Valley Cluster had not emerged. Regional factors have been rather important in this particular example. But is it not also true that the development of Silicon Valley was significantly stimulated by the characteristics of the industry and the national innovation system? Could the same phenomenon have occurred in other industries or in other countries such as Germany, for instance? Apparently, the different levels are not discrete but instead are mutually dependent (Scott 1996).

Problems of a division of innovative labor

Numerous studies on the genesis and development of certain innovations have shown that there are diverse actors involved (Jewkes *et al.* 1969). Many innovation processes are characterized by a high degree of labor division. Further, there are indications that the intensity of labor division has increased considerably in the last few decades (Arora and Gambardella 1994; Hagedoorn 2002). Yet, if the division of innovative labor plays such a prominent role, it would be inappropriate for this analysis to solely focus on a single actor, thereby neglecting the contributions of other actors. To take all relevant relationships into account, a more comprehensive approach to a system of innovation needs to be applied (see section on regional systems of innovation in a globalizing economy). There are some characteristics of innovation activity which imply a number of specific problems of labor division as compared to "normal" production processes. These special features can considerably affect the organization and the spatial distribution of R&D.

A first key problem that may severely impede a division of innovative labor is that, by its very nature, the result of an innovation process is unknown in advance and can not be predicted with certainty. Thus, it is not possible to completely specify a respective contract in advance. The resulting incomplete contracts leave room for opportunistic behavior by the contractual parties, i.e., self-serving interpretation of the terms of the contract to the disadvantage of other contract parties. Due to this danger of opportunistic behavior, economic actors may avoid contracting out certain tasks of the innovation process.

A second problem for a division of innovative labor may arise because R&D processes often require very special inputs that are not commonly traded in large markets. This rareness of suitable inputs is in many cases a result of the novelty inherent in innovation. Because of this novelty, markets for skills and resources that are important for an innovation process may not be readily available. In this case, the respective markets are rather "thin," i.e. there are only very few suppliers and transactions take place rather infrequently. Because suppliers are rare, this may require an immense amount of search costs to identify a suitable transaction partner. Moreover, if only few transactions take place, a clear market price may not exist so that negotiations about the price and further conditions of an exchange tend to be rather costly.

A third problem for a division of innovative labor is the potential of asymmetric information to severely hamper the trading of knowledge on markets. Because knowledge is the key input and output of innovation activity, a transfer of knowledge constitutes a necessary precondition for any division of labor in the field of R&D. Asymmetric information with regard to trading of knowledge means that the supplier possesses better information about the subject to be traded than his counterpart on the demand side. As a reaction to the risks involved in having this kind of incomplete information, rational customers will offer less than they would if they had been provided full information. For the supplier, describing the characteristics of the information offered may in many cases imply a more or less complete disclosure. Yet, once a potential customer possesses the information, he has no reason to purchase it. Therefore, information that is intended to be sold cannot be completely disclosed. Due to this asymmetry, the level of transactions on the market may be rather low and adverse selection processes may result in a poor quality of supply.

A fourth possible difficulty concerns the transfer of information or knowledge as such.³ One obstacle to the transmission may be that the knowledge is "tacit," i.e., it is not completely codified so that it can only be communicated face-to-face or through a transfer of the person that possesses that knowledge. Moreover, the identification and the use of relevant information may require a certain "absorptive capacity" (Cohen and Levinthal 1989). This means that the recipient must already possess some knowledge – such as basic skills or a shared language – in order to be able

to assess the economic value of new information and to assimilate and then apply it to his own commercial ends. Another potential problem in regard to information transfer is the danger of uncontrolled knowledge flows, i.e., the possibility of the transaction partner obtaining valuable information without adequate compensation.

As a result of these problems, many contributions to innovation processes cannot be easily traded on anonymous "spot markets." A division of innovative labor between different organizations may, therefore, require incompletely specified, long-term agreements ("relational contracting") that imply a considerable degree of cooperative spirit and trust.⁴ Thus, a cooperative relationship may be regarded as one of the main characteristics of a division of labor in innovation processes. In addition to the role of cooperative relationships in the division of innovative labor, the literature suggests some further potential benefits of cooperation on R&D. One of these issues is that, as far as cooperative relationships are characterized by relatively "open" exchange of information, such flows of knowledge or information may be stimulating for innovation activity.⁵ Many authors emphasize that not only formal cooperative relationships, such as joint ventures or contract research, are important for knowledge flows, but that informal relationships like "information trading" (reciprocal exchanges of information between personnel of competing firms) may also play a significant stimulating role for innovation activity (e.g. von Hippel 1987; Saxenian 1994).

In a division of innovative labor, spatial proximity can be conducive for at least two reasons. First, if the establishment and management of incomplete contracts as well as the transfer of knowledge require face-to-face contact, large geographic distance between partners may act as a severe impediment. Second, spatial proximity to other establishments in the same industry can constitute a prerequisite for benefiting from certain resources in the region. These include the labor market, research institutes, infrastructure and the presence of specialized suppliers. These issues may at least partly explain why innovation activity tends to be clustered in space and why flows of new knowledge are concentrated within the environment close to the source.

Regional systems of innovation in a globalizing economy

The concept

One great advantage of the "system of innovation" approach is that the analysis can explicitly account for division of innovative labor between individuals and organizations (Freeman 1987; Lundvall 1992a; Nelson 1993; for an overview Edquist 1997). The important issue of labor division is largely neglected when the innovation activity of particular individuals or organizations lies, more or less exclusively, at the center of attention.

Innovation systems consist of innovative agents, the relationships between these agents, as well as the rules and institutions influencing the generation of innovation and the relevant selection mechanisms.⁶

With regard to the spatial definition of an innovation system, many authors deal with whole nations. They thus, implicitly or explicitly, assume that the similarities of institutions, language and culture form a "natural" geographical frontier (Lundvall 1992a: 3). However, there is no need to limit the innovation-system approach to nations. While for some issues (e.g., markets for goods in global technological competition) it may be more suitable to choose a higher level of aggregation and to investigate the international division of innovative labor on a world-wide scale (Lundvall 1992a: 3f.), other questions may be analyzed more appropriately on a lower aggregation level, e.g., regions within nations. Such a regional focus is particularly appropriate when the local environment is important and short-distance interaction plays a significant role (Cooke *et al.* 1997: 488f.; Cooke 1998; Howells 1999; Lagendijk 2001).

In this context, the regional system should not only be regarded as a down-scaled sub-category of the national innovation system where certain characteristics deviate from the national average. Rather, such a top-down perspective may be quite inappropriate when the regional dimension is dominant and location-specific factors are much more important than issues at the national level. Empirical research has indeed provided considerable evidence for the significance of face-to-face contact, localized patterns of communication, knowledge sharing and searching, etc. that may well result in diverging innovation performance.⁷ Therefore, the national innovation system can also be regarded as the aggregate of rather different regional systems in the sense of a bottom-up approach. According to this view, the region-specific factors have a stronger impact than they do in a top-down approach. In any case, the different dimensions of the innovation system – region, nation, world, industry – are connected and interact (Scott 1996).

A role model of regional innovation systems

Our knowledge about how regional innovation systems work is still rather limited. The simple role model illustrated in Figure 9.1 may be helpful as a conceptual framework for assessing the main issues of our current understanding. This model includes three types of actors in a region:

- *Public institutions for research, education and other forms of knowledge transfer* generate, accumulate and distribute information. Included under this heading are mainly universities, other public research institutions as well as transfer agencies. One of the main tasks of these institutions is to absorb and store the relevant knowledge that has been generated elsewhere in order to be able to spread

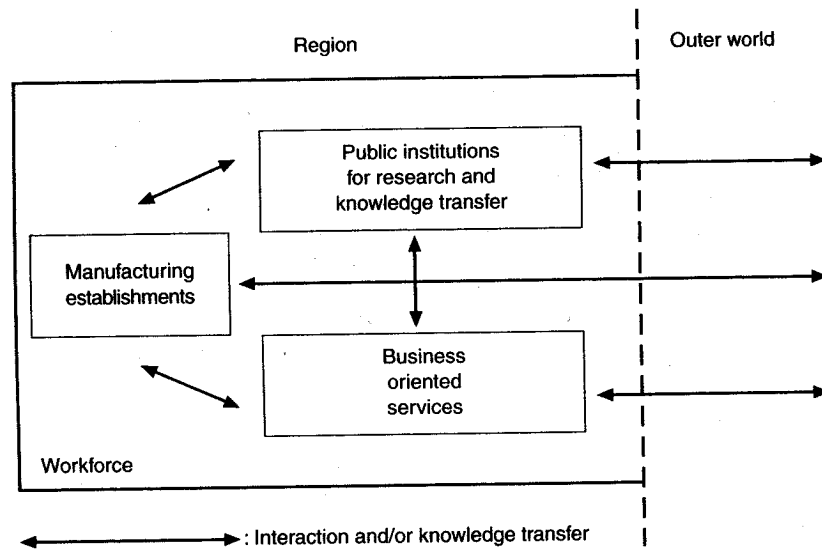


Figure 9.1 Main actors in a regional innovation system.

it to other actors in the region. In this sense, the public research institutes take on the role of an “antenna” for innovation activity in a region (Fritsch and Schwirten 1999, 2002). Particularly through the provision of education and by collaborating with private sector firms they supply the regional system with important inputs for innovation activity (Varga 2000).

- *Manufacturing establishments* act as final producers in the regional innovation system. Their role is to commercialize the available knowledge by incorporating it into marketable goods and then selling these goods to customers inside and outside the region. In fulfilling this role they need to be able to absorb the relevant knowledge – in most cases this will require them to perform some R&D activity as well (Cohen and Levinthal 1989). The competitiveness of the manufacturing establishments in an innovation system is of crucial importance for its economic success. If the manufacturing establishments do not perform well and are not competitive on a world wide scale, the public institutions for research, education and other forms of knowledge transfer may remain largely ineffective. This is, for example, a problem in many eastern European regions that were governed by a socialist regime, an example being the states of the former German Democratic Republic.
- *Suppliers of business-oriented services* support innovation activities in public research institutions and manufacturing establishments.

Business-oriented services include support in the fields of engineering and planning, tax preparation and legal services, market research, advertising, engineering and planning as well as business consulting and financial services, such as the provision of venture capital.⁸ The presence of high-quality specialized services may allow for a relatively high degree of labor division that in turn results in a high efficiency of regional innovation activity.

The regional workforce with its qualification and knowledge constitutes an additional main element of a regional innovation system. In particular, it is an important source for all kinds of entrepreneurship in both long established and newly founded firms.

It is important to recognize that these elements only constitute a framework for regional innovation activity. Because of the dynamic character of innovation processes, the elements of the innovation system are subject to permanent change. Innovation systems are “learning systems” in which communication among agents is one of the main sources of the creation of new knowledge (Antonelli 2002: chapter 3). Accordingly, diverse empirical examples show that the interaction of the elements in a regional innovation system and their relationships to the outer world are of key importance for the system’s performance. This is a principal hypothesis in the literature on industrial districts (Porter 1998 and the contributions in Pyke *et al.* 1990), of the network approach to the analysis of innovation activity (Camagni 1991a; Saxenian 1994) as well as of the concept of “innovative milieux” (Aydalot and Keeble 1988; Crevoisier and Maillat 1991). The emphasis on the interaction of an innovation system’s elements corresponds to a basic hypothesis in economic science, which states that division of labor will result in efficiency gains. One may therefore expect a relatively high regional level of interaction on R&D to lead to correspondingly high productivity in innovation processes. These relationships, particularly if they are cooperative in nature, are also frequently regarded as an important medium of transferring relevant knowledge.

Because a significant part of the knowledge that is relevant for innovation processes is not codified but tacit, it remains with the respective individuals. It is, therefore, localized. Moreover, this knowledge may be specific to the conditions in a particular market, establishment or region. Path-dependencies, indivisibilities and external effects (e.g. agglomeration economies) in the creation of knowledge lead to a regional embeddedness of innovation activity. For this reason, each regional innovation system is characterized by a specific knowledge stock that makes the system unique and distinguishes it from that of other regions (Antonelli 2002: chapter 3; Maskell and Malmberg 1999).

In many well-functioning regional innovation systems, new innovative firms and entrepreneurship play an important role.⁹ The regional dimension is of considerable relevance for new firm formation processes because

most founders of new businesses are regionally embedded and come from the same region in which they start their businesses (Johnson and Cathcart 1979). Entrepreneurs tend to “spin-off” from regional firms and research institutions. Their entry into the market presents a challenge to the incumbent firms, which may induce them to change their product program and their general economic behavior. This is particularly true for innovative entry. The example of the “new economy” shows that new innovative firms can be important agents of change. To the founder, setting up a new firm presents a way of commercializing his knowledge. To set up a new firm can be understood as a means for the founder to commercialize his knowledge (Audretsch 1995: 47–55).

One main reason for this is that innovative ideas as such can hardly be traded on a market – be it because of their vagueness, because of market imperfections (see the section on problems of a division of innovative labor) or because incumbent firms are focused on drawing profits from their established product program and are not interested in implementing new ideas that may require radical changes. Moreover, in quite a number of cases starting a firm may represent the one and only chance of putting an idea into practice (Audretsch 1995: 54f.).

As the section on problems of a division of innovative labor showed, a division of innovative labor requires transfer of knowledge between the parties involved. Such transfers of knowledge are termed “spillovers” (Breschi and Lissoni 2001; Feldman 1999; Karlsson and Manduchi 2001). There are diverse ways in which such knowledge spillovers may become effective. These include market transactions, cooperative relationship, publication of R&D results, flow of innovative goods and mobility of personnel including spin-offs from private-sector firms and public research institutions. Independent of the specific means of such knowledge transfers, one can expect that intensive division of labor and interaction is associated with a correspondingly high level of spillovers. Thus, due to the efficiency gains of labor division, pronounced spillovers should be one of the chief characteristics of an efficiently functioning innovation system.

How regional innovation systems work: evidence from recent research

Reviewing the recent empirical research on the regional dimension of innovation activity, four main topics can be identified:

- regional differences in the extent of R&D activity and innovation performance;
- the significance of regional knowledge spillovers, their role in innovation processes and the way in which these spillovers become effective;
- the role of R&D cooperation in regional innovation systems;
- the formation of new innovative firms in a regional context.

With regard to the first topic, there can be no doubt that innovation activity is not spread evenly but instead is clustered in space (see the section on empirical evidence for the role of location for R&D). However, attempts to empirically detect a clear impact of location on the innovation behavior of economic actors have been largely unsuccessful (see Fritsch 2000, for a brief review of the evidence). Recent empirical analyses of innovation activity in a number of European regions (for the project design, see Sternberg 2000) have been successful in identifying such inter-regional differences of innovation behavior (Fritsch 2000). Taking the efficiency of R&D expenditure as a measure of the quality of a regional innovation system (Fritsch 2002), there is significant variation showing some correspondence to a center-periphery hypothesis that suggests better conditions for innovation activity in the center as compared to more remote areas or regions that are characterized by a relatively low degree of agglomeration (the periphery). An analysis of the German regions in the sample shows that the interregional differences in the efficiency of their respective innovation activity can, to a considerable degree, be explained by the differences in the amount of regional knowledge spillovers (Fritsch and Franke 2003). This result supports the hypothesis that the interaction of the elements of a regional innovation system is of crucial importance for its performance.

Empirical research has found that the spread of new knowledge tends to be heavily concentrated around its source.¹⁰ Obviously, spatial proximity is of significant importance for such information flows. However, the relative importance of the different spillover channels is unclear. A quite popular hypothesis suggests that R&D cooperation may play an important role in this respect, particularly for the flow of “tacit” knowledge, which is not completely codified. Analyses of R&D cooperation in the European regions mentioned above have shown that R&D cooperation is a rather widespread phenomenon (Fritsch and Schwirten 1999, 2002; Fritsch 2001, 2003). A particular regional focus could be found for R&D cooperation between manufacturing establishments and public research institutes as well as for horizontal cooperation among manufacturing establishment in the same industry and for relationships with providers of business services. This highlights the importance of spatial proximity for these types of interaction.

The spatial pattern of the R&D cooperation with suppliers and customers seems to correspond largely to the regional dimension of the respective markets. Cooperative relationships between research institutes tended to be interregional on a world wide scale (Fritsch and Schwirten 2002). The analysis of this data also revealed significant differences in cooperation behavior between regions (Fritsch 2001, 2003, 2004). Quite surprisingly, the propensity to cooperate on R&D was below average in establishments located in highly urbanized areas with a rich supply of cooperation partners. Contrary to the popular assumption, R&D

cooperation was not found to be a strong medium for knowledge spillovers. Additionally, there was no significant positive relationship between the propensity for R&D cooperation and the efficiency of regional innovation activity.

A number of examples clearly demonstrated that new firms and entrepreneurship can constitute a powerful driving force for the specific regional innovation system (Bresnahan *et al.* 2001; Feldman 2001). They are a particularly important explanatory factor for cluster formation (Klepper 2001; Cooke 2002). The empirical evidence suggests that once new firm formation processes in a cluster have taken off and passed a certain threshold, the development of the cluster benefits from self-reinforcing effects. Therefore, studying well-developed clusters with a rich supply of supporting services and institutions may not tell us about the beginning stages of new firms' cluster building processes. Thus, one important question that remains to be answered is: "What are the important factors in the initial stage of cluster formation?" The answer to this question is particularly relevant for a policy designed to stimulate the development of regional innovation systems.

Policy options

As this analysis has shown, innovation processes are characterized by an intensive division of labor that has a pronounced spatial dimension. The available empirical evidence clearly demonstrates that regional conditions are highly relevant for innovation processes. Further, there is good reason to assume that the quality of the regional innovation system is of particular importance for relatively new industries like the "new economy" (Audretsch and Feldman 1996b; Cooke 2002: chapter 6). If the current trend continues, we should expect a further increase in labor division, regional specialization and clustering of innovation activity in the future. The emerging spatial pattern will then be characterized by only a few regional centers of excellence throughout the world for each technological field in which the main market players have to be present in order to monitor technological developments and absorb relevant knowledge (Patel and Vega 1999; Pearce 1999). There are two general conclusions that can be drawn from the recognition that regions do matter for R&D activity. First, innovation policy should take into account the spatial dimension of innovation processes and the importance of regional conditions. This implies that regional institutions should at least participate in the design and operation of technology policy measures by contributing their expertise about local conditions. Second, the local level could be an appropriate starting point for a policy designed to initiate and stimulate innovation activity. In many cases, innovation policy at the regional level may well prove to be more promising than on a national scale.

When outlining possible strategies of a regional innovation policy, it is

helpful to distinguish between different types of regions. One category comprises regions where the innovation system is underdeveloped or largely missing as is the case in many peripheral, sparsely-populated areas or in less-developed countries. Under these conditions, the main task for innovation policy is to create the basic prerequisites for R&D and initiate innovation processes. A second category comprises regions that possess a well-developed innovation system that is equipped with public research institutions, a supply of innovation-related services and qualified labor. If the innovation system in such a region is well functioning, policy may try to safeguard this development and keep the system intact. In case the regional innovation system is not working satisfactorily, the problem is how to revitalize it.

The regional endowment with public institutions for research and education is obviously a well suited means for building up a new innovation system because it is subject to direct political control. The existence of public research facilities may constitute an important source and necessary precondition for private-sector R&D. However, while the lack of public research institutions can be a severe impediment for regional innovation activity, the presence of appropriate public institutions as such constitutes only a necessary condition of a well-functioning regional innovation system. With regards to complementary private sector activity, experience shows that attempts to directly create certain technological clusters or to steer innovation activity in a certain field are quite likely to fail. Thus, policy should abstain from such endeavors (Cooke 2002). Additionally, it is rather difficult to promote interaction among the actors both within and outside the regional innovation system and to stimulate the emergence of an "innovation culture." Empirical examples show that many of the well-functioning high-tech innovation systems benefited from massive external impulses during their early stages and that development required considerable time, often several decades (Bresnahan *et al.* 2001; Sternberg 1996).

Theoretical concepts as well as empirical evidence suggest that once the development of an innovation system has "taken off," the main bottleneck for the system's performance tends to be deficient interaction, a lack of absorptive capacity and the absence of a productive innovation culture. This may particularly hold true for "older" innovation systems with a well-developed institutional infrastructure. There are a number of well-documented examples in which the performance of such mature innovation systems is severely blocked by the "lock-in" effects of long-established ties as well as by inadequate institutions (Grabher 1993).¹¹ In these cases, the main task for policy is to re-launch the system, in order to overcome the existing impediments and spur new development.

Whatever the circumstance, a productive innovation culture constitutes an important ingredient of a successful regional innovation system. There are, however, no simple recipes for the creation of a culture that leads to guaranteed success. Nevertheless, one can provide some guidelines.

Generally, a policy of stimulating interaction and division of innovative labor should provide sufficient opportunities and incentives for contact and information exchange in a region. It may also be helpful and promising to publicly provide information about potential partners for R&D cooperation as well as management advice with regard to organizing such cooperative relationships. In order to ensure appropriate interaction between public research and private-sector firms, the institutional setting should provide incentives for public research institutions and pay attention to the needs of the region's private economy. Additionally, policy should not hamper labor mobility between institutions as this is an important medium for knowledge transfer. This particularly pertains to spin-offs from public research institutions and private-sector firms.

Stimulating entrepreneurship can be an effective means for promoting further development and overcoming blockages. As mentioned earlier, the connection of a regional innovation system to the outer world is of immense importance for its performance. Policy should, therefore, avoid everything that might hinder this connection and instead seek to stimulate external contact.¹² Because a large part of relevant new knowledge is tacit in its nature and can only be communicated face-to-face, the exchange of personnel with outside institutions is of particular importance. Promoting such exchanges may be an important line of action for regional innovation policy. Policy could also safeguard a sufficient level of absorptive capacity for external knowledge in the region. This may be a matter of providing basic skills or the creation and support of institutions which monitor technological developments and make the results available to the actors in the innovation system.

The main issues for further research

This chapter has discussed how regions matter for R&D and the opportunities for policy to improve the quality of regional innovation systems. There are, however, numerous open questions that deserve further investigation. The following three areas of research about regional innovation systems are more or less direct results of the analysis:

- One set of questions concerns the ways in which knowledge spillovers become effective (Breschi and Lissoni 2001). What is the role of cooperation, labor mobility, trade of goods and other forms of interaction for the transfer of knowledge? How could and should policy stimulate such spillovers? If absorptive capacity is a bottleneck for knowledge spillovers, in what way can policy lead to improved capabilities?
- Little is known about the early development stages of regional innovation systems (Bresnahan *et al.* 2001). Why do some regions experience a quick acceleration that leads to rapid development while others remain static? Which factors spur self-enforcing growth processes and

what are the main impediments for such a development? What is the role of public research institutions in initiating self-reinforced development?

- Furthermore, we should know more about promising policy options, in particular, what kind of policies might be used to stimulate the division of innovative labor and the emergence of a productive innovation culture? What instruments could help to build up productive innovation networks? In which way could the regional system be appropriately linked to the outer world? How can obstacles in old systems be overcome?

For all three research areas, new firm formation processes and entrepreneurship may play an important role. Given the large contribution of R&D to economic growth, regional innovation policy may be a highly effective strategy for promoting development. It is therefore of great importance to learn more about the regional dimension of innovation activity and the possibilities for improving the efficiency of regional innovation systems. One should, however, not forget that regions are embedded in national systems. Thus, nation-wide regulations and conditions may have severe implications for regional innovation activity. Finally, if one considers the relationship between the regional and the national system as an appropriate starting point for policy measures, this may constitute the subject of important further research.

Notes

- 1 For empirical evidence see Audretsch and Feldman (1996a), Cooke (2002: 130–156), Baptista and Swann (1998), Feldman (1994), Porter (1998), Prevezer (1998), Scott (1996), Shohet (1998), and Swann (1998).
- 2 The body of literature does not provide a standard definition of knowledge. Knowledge is more than just information because it also comprises the ability to assess its usefulness as well as to interpret and to apply it. In contrast to information, knowledge is often context-dependent. "Information is the medium in which knowledge is processed, stored and communicated. Knowledge is the content." (Chichilnisky 1999, 9).
- 3 For a comprehensive treatment of problems of information transfer see von Hippel (1994).
- 4 See MacNeil (1978) for a detailed characterization of the different types of agreements.
- 5 See, for example, Axelsson (1992), Lundvall (1992b) and Powell (1990).
- 6 "A [...] system of innovation is that set of distinct institutions which jointly and individually contributes to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artifacts which define new technologies" (Metcalfe 1995: 462f.).
- 7 For an overview see Howells (1999: 77–84).
- 8 These kinds of activities are often summarized as "knowledge intensive business services" (KIBS).

- 9 Examples are the Silicon Valley (Saxenian 1994), the US Capitol region (Feldman 2001), Munich (Sternberg and Tamasy 1999), Cambridge (Wicksteed 1985) and many others. For an overview see Bresnahan *et al.* (2001).
- 10 Acs *et al.* (1992), Jaffe *et al.* (1993), Anselin *et al.* (1997). For an overview see Karlsson and Manduchi (2001).
- 11 Examples can be found in many old-industrialized regions of North America and western Europe as well as in many parts of the former socialist countries of eastern Europe (see the contributions in Fritsch and Brezinski 1999).
- 12 This concerns, for example, any rules (e.g. in public policy programs) that discriminate against cooperation with partners that are located outside the region or abroad.

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