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Regional Innovation Systems in Small & Medium-Sized Regions [1]

A Critical Review & Assessment

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Regional Innovation Systems in Small & Medium-Sized Regions

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Abstract

Continuous product and process innovations are prerequisites for sustainable competitiveness of both nations and regions. How such innovations are created and how successful innovation processes can be initiated are therefore extremely important questions. In recent years, it has been recognized that innovations are localized. They are now believed to be the result of ongoing and prolonged collaboration and interaction between firms and a variety of actors around them within what has been termed regional innovation systems. The actors in the regional innovation systems include customers, producers, subcontractors, consultants, governmental institutions, research institutes, universities, etc. Most of the research on regional innovation systems has focused on high-tech clusters in large metropolitan regions well equipped with a broad spectrum of all kinds of actors that are strategic in the innovation process. Much less interest has been devoted to regional innovation systems in small and medium-sized regions that are less diversified as regards strategic actors in the innovation process. The purpose of the current paper is to provide a critical state-of-the-art review of current research on regional innovation systems in small and medium-sized regions. In particular, we focus on what should be meant with a regional innovation system in this context and the possibilities to identify regional innovation systems that are typical for different types of industrial clusters and regions. Regional innovation policies in small and medium-sized regions are also discussed.

Keywords: cluster, innovation, innovation systems, knowledge, proximity, regional innovation systems

JEL **Classification:** R11, O31, O18

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1. Introduction

> *"…innovation is a ubiquitous phenomenon in the modern economy. In practically all parts of the economy, and at all times, we expect to find on-going processes of learning, searching and exploring, which result in new products, new techniques, new forms of organization, and new markets. In some parts of the economy, these activities might be slow, gradual and incremental, but they will still be there if we take a closer look"*, Lundvall (1995, p. 8).

Continuous product and process innovations are prerequisites for sustainable competitiveness of both nations and regions. How such innovations are created and how successful innovation processes can be initiated are therefore extremely important questions. In recent years, it has been recognized that innovations are normally the result of ongoing and prolonged collaboration and interaction between firms and a variety of actors around them. These actors include customers, producers, subcontractors, consultants, public organizations, research institutes and universities, etc. Also, institutions interpreted as normative structures and "rules of the game" are given an important role in promoting stable and efficient interaction and collaboration. Against this background, a systemic approach is argued to be most appropriate. An innovation system can in principle be described as the system in which the relevant factors (i.e. actors and institutions) in an innovation process interact.

The literature offers studies and conceptualizations of a number of different innovation systems. Four major types can be found in the literature; (i) *National Innovation Systems* (NIS), (ii) *Regional Innovation Systems* (RIS), (iii) *Sectoral Innovation Systems* (SIS) and (iv) *Technological Systems* (TS)[2]. In addition to these, there is Fischer, Revilla-Diez & Snickars (2001) on *Metropolitan Innovation Systems* and Malecki & Oinas (2002) on *Spatial Innovation Systems*. The NIS and RIS approach are similar in the sense that they do not focus on any particular industry or technology. Here, the whole set of industries in a nation or region with surrounding institutions are considered simultaneously, (Breschi & Malerba, 1997). These are the only types of innovation systems where, at least to some extent, the geographical boundaries are well defined. Both SIS and TS may or may not be spatially bounded. In the TS approach, the focus is on specific techno-industrial areas, (Carlsson & Stankiewicz, 1991). The main difference between TS and SIS is that the latter focus on the competitive elements between firms while the former stress the networks among firms, (see e.g. Breschi & Malerba, 1997).

RIS has recently gained increased attention. The emphasis on regions has many grounds. Most important among them is that innovation systems are most easily observed at the regional level, since distance tends to decrease the frequency of interaction among individuals. Of significance is also the acknowledgement by researchers of the role of the regional economic milieu and geographical proximity for the innovativeness of firms. Informal routines and norms that are specific to each region are argued to play an essential role in the behavior of firms and the form of collaboration between them. In addition, tacit and non-codified knowledge has been recognized as of importance in the innovation process while closeness and face-to-face contacts are prerequisites for the exchange of this kind of knowledge. Focusing mainly upon NIS, several important regional phenomena that facilitate innovation processes are ignored or not observed.

RIS have different characteristics in different regions depending on their industrial specialization. Innovation systems in high-technology regions are, for example, most likely different from the innovation systems in traditional regions specialized in, for example, wood and metal manufacturing. Moreover, due to regional specificities, such as routines and norms mentioned earlier, RIS can also possibly be very different between regions with similar industrial structures. One is also likely to observe substantial differences in the structure and functioning of RIS between large regions with many different economic activities and in small and medium-sized regions with a less diversified economic milieu.

Recognizing that innovations stem from co-operation between many different actors, it is reasonable to question the ability of smaller regions to generate innovations. Small and medium-sized regions that often are dominated by a limited number of industries and do not host actors such as universities and research institutes are naturally disadvantaged when it comes to innovations. What do

[2] Interested readers may consult *inter alia* Lundvall (1995) and Nelson (1993) on NIS, Cooke *et al* (1997, 1998) on RIS, Breschi & Malerba (1997) on SIS and Carlsson & Stankiewicz (1991) on TS.

RIS look like in regions that lack what is normally considered to be important actors in the innovation process? Can firms in such regions generate innovations in spite of the absence of certain regional strategic actors and lack of competence? What kind of innovations can they generate? These questions are of primary concern for smaller regions as well as national governments that actively try to harmonize regional disparities in innovation capacities. Acknowledging the role of RIS makes it natural to raise a question on whether they also need special regional innovation policies to function well. Of course, there are national innovation policies but these, probably in many cases, need to be complemented with regional innovation policies focusing on regional specificities. This question is particularly relevant to small and medium-sized regions lacking the diversified innovation infrastructure typical of larger regions.

The purpose of this paper is to provide a theoretical overview and a critical examination of the concept of and theories on RIS, in particular in relation to small and medium-sized regions, to discuss how the function of RIS differs between regions with different industrial specialization and size and to draw conclusions about how regional innovation policies can help to develop and to improve RIS. SIS and TS are beyond the scope of the paper.

The remainder of the paper falls into five parts. Section two describes the basic principles of the old linear and the modern interactive innovation model and explains the differences between them. Section three gives a theoretical overview of the concept of RIS, in which both a region and an innovation is defined. Particular emphasis is placed on the relationship between RIS and clustering of economic activities. A presentation of different types of RIS is also given. Section four discusses RIS in regions with different industrial specializations, focusing on small and medium-sized regions. Section five discusses what role regional innovation policy can and should play for the creation and development of RIS. A summary and conclusion of the paper is given in Section six.

2. The Linear vs. the Interactive (Non-linear) Model of Innovation

> *"..one of the key insights in modern innovation theory is that innovation is systemic, in the sense that firm-level innovation processes are generated and sustained by inter-firm relations, and by a wide variety of inter-institutional relationships"*, (Wiig & Wood, 1995, p.1)

As the statement above suggests, the modern interactive model of innovation, upon which the systemic approach to innovation is based, regards innovations as the outcome of an interactive process in which actors from a wide array of levels are involved. On the other hand, the traditional linear model of innovation, developed in the Fordist era, is based on the idea that R&D is the key to innovations. In this model, the innovation process is described as a chain that links different activities in a certain ordering, (see e.g. Halvorsen & Lacave, 1998; Fischer, 1999), as visualized in Figure 2.1. The chain starts with formal R&D activities followed by applied research and product development. The step after product development is commercialization. According to the linear model of innovation, more R&D would generate more innovations. Hence, low R&D capacity could explain low innovative activity, (Asheim & Isaksen, 1996). The policy implication to be drawn from the linear model is rather straightforward; innovations rely on R&D promotion.

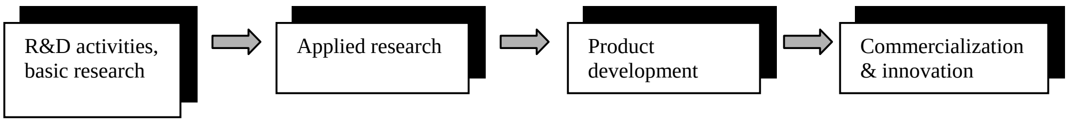

Figure 2.1. The linear model of innovation

Criticism against the linear model of innovation emerged in the post Fordist era when empirical studies showed that the innovation process did not work in such an order as described by the model, (Fischer, 1999). As far as the linear model of innovation can be considered as an "orthodox" model[3],

[3] Nelson & Winter (1982) do not mention the linear model of innovation explicitly.

the work by Nelson & Winter (1982) constitutes an important part of the criticism[4]. The main arguments by the critics was that innovation processes do not take place from left to right and "…the starting point does not have to be academia, the impulses and ideas could just as well have come from the markets, or the production spheres", (Halvorsen & Lancave, 1998, p.34). The model has also been criticized for its bias towards product innovations.

The criticism of the linear model spurred researchers to adopt the interactive model of innovation and "…today it is increasingly recognized that innovation extends beyond formal research and development (R&D) activities", (Mytelka & Farinelli, 2000, p.8). This model "…stresses feedback effects between upstream (technology-related) and downstream (market-related) phases of the innovation process, the many interactions of innovation-related activities, both within firms and in network agreements between them, and the central role of industrial design (in its widest sense) in the innovation process", (Fischer, 1999, p.14). According to the interactive model there is no such thing as a general order of how innovations come about. The ability of firms to innovate depends on their networks with other firms and actors. Massey et al (1992) have identified five differences between the linear and the interactive model of innovation;

1) There is not just one process of innovation from research to commercialization; rather, ideas are generated and developed at all stages of innovation, including production.

2) Basic research is not the only initiator stage. This is not to imply that basic research pursued in laboratories is irrelevant to innovation.

3) Rather than just being used as the starting point of innovation, research results are used, in one form or another, at all stages of the innovation process.

4) The relationship between basic research and commercialization is too complex to be understood as a straight-line relationship. There are feedback loops at all stages.

5) The linear model reduces the contribution of the people involved in innovation, to only the first stages, while the interactive model makes it clear that innovation can take place in all stages and by different professions involved.

3. Understanding "Regional Innovation Systems"

The aim of this section is to define and discuss the concept of Regional Innovation Systems (RIS). Niosi (2000 p.8) states that "…any definition of RIS should start defining regions". This section starts by the region in the context of RIS and goes on to discuss innovations and innovation systems.

3.1 Basic Concepts: The Region – a Functional Entity

It is hard to find any explicit definition of the term region in the RIS literature. An attempt is made by Cooke *et al* (1997 p.480), who state that a region should be defined as "…a territory less than its sovereign state, possessing distinctive supralocal administrative, cultural, political, or economic power and cohesiveness, differentiating it from its state and other regions". We believe that a proper way to treat the concept of a region is to let it be synonymous with a functional region. This is because a functional region has characteristics germane to the mechanisms stressed to be important in the systemic approach. Specifically, a functional region is characterized by a high intensity of economic interaction (Johansson, 1998) and consists of nodes, such as municipalities, connected by economic

[4] However, their work amounts to much more than just criticism. They provide an alternative theoretical setting by, from an evolutionary perspective, stressing the role of search and selection processes for technological change and economic growth.

networks and networks of infrastructure, (Johansson, 1992). The borders of functional regions are determined by the frequency or intensity of economic interaction as shown in Figure 3.1.

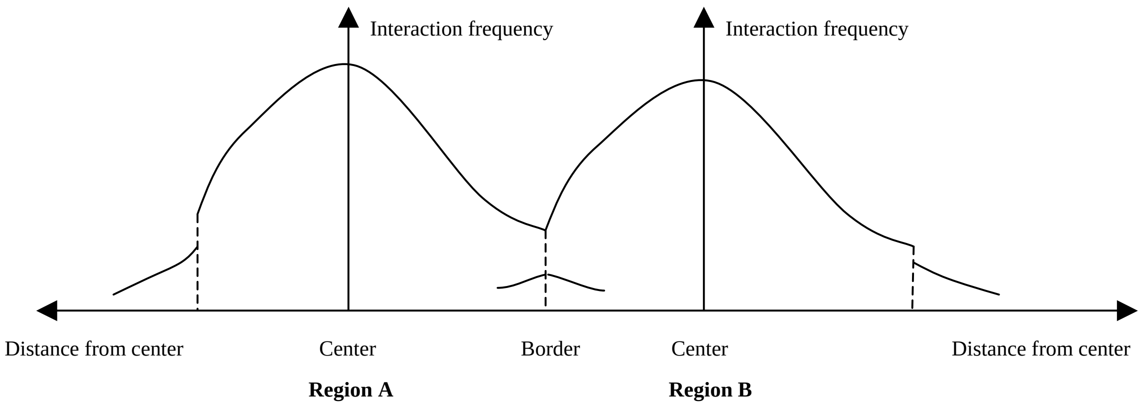

Figure 3.1. Demarcation of functional regions (based on Johansson, 1992)

Examples of economic interaction upon which the borders may be determined are intra-regional trade and labor commuting[5]. Commuting patterns is a common source for empirically identifying functional regions, (Karlsson & Olsson, 2000). The labor market is of special importance since the links between employers and employees create a rigid foundation of the economic network in a functional region, (Johansson, 1992). These links are one type of ties that form a regional economic system, (Johansson, 1992). The latter can be described as a structure that is formed by interactive elements, which can be classified by means of geographical patterns and/or organizational couplings, (Johansson, 1993). Almeida & Kogut (1999) also recognize the importance of the labor market and maintain that flows of knowledge is embedded in regional labor networks. For these reasons, commuting patterns can be regarded as the appropriate type of interaction to base the borders upon. A region then, can be defined as a territory in which the interaction between the market actors and flows of goods and services create a regional economic system whose borders are determined by the point at which the magnitude of these interactions and flows change from one direction to another.

3.2 The Concept of Innovation

The most fundamental feature of an innovation is that it is something new. It can be a new process, product or, following Schumpeter, a new combination. Straightforward definitions of innovations include, "…putting new products and services on the market or new means of producing them" (Bannock, 1992), "…the economic application of a new idea" (Black, 1997), "…the implementation of changes in production (…) [or] the introduction of new types of commodities on the market" (Suranyi-Unger, 1982). These definitions stress an important feature of an innovation, namely that it has to be used on the market to be classified as an innovation. Thus, it has to be involved in a commercial transaction. However, Freeman (1998) points out the twofold meaning of an innovation: "…the word is used both to indicate the date of the first introduction of a new product or process and to describe the whole process of taking an invention or set of inventions to the point of commercial introduction". Hence, it is important to distinguish between an innovation and an innovation process although it is emphasized that it is the innovation process that is important rather than the innovation as such, (Lundvall 1995; Edquist, 2000).

When market usage is imposed as a criterion for innovation, demand conditions will play an important role. Amendola & Bruno (1990) point out that what matters is not the environmental

[5] Since it is likely that the borders of a functional region depend on the type of interaction studied, the borders are fluid to some extent.

circumstances in which a innovation is created, but rather the ability and willingness of consumers to adopt and use the innovation. The importance of demand and early adopters for innovations have been emphasized by authors such as Porter (1990), Gregersen & Johnson (1996), Rothwell (1992), von Hippel, (1998 & 1988) and Sölvell *et al* (1991). These ideas can be related to the concept of the innovative milieu, (Maillat, 1993, 1995 & 1998).

Three different kinds of innovations are generally identified in the literature. These are (i) radical innovations, (ii) major (or adaptive) innovations and (iii) incremental innovations, (see e.g. Maillat, 1993; Jonsson *et al*, 2000; Asheim & Isaksen, 1996; Rothwell, 1992). A radical innovation implies that a totally new product is developed, which can create a new area of business. The second class of innovations, major (adaptive) innovations, constitutes improvements of already existing products or new products and processes within an established business. Incremental innovations are small and often stepwise improvements of existing products and processes. Hence, a broad view on innovations is taken.

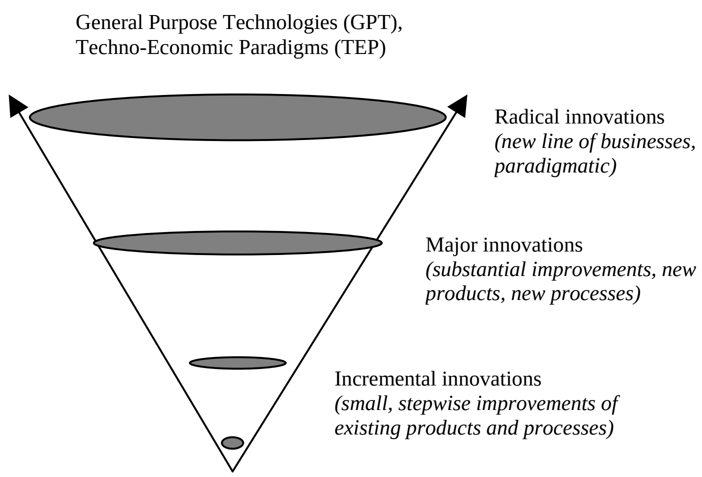

Figure 3.2. The scope of the innovation concept, (adapted from Jonsson et al, 2000)

In addition to the types of innovation mentioned above, yet another type can be found in the literature. Bresnahan & Trajtenberg (1995) introduce the concept of General Purpose Technologies (GPT) and Freeman & Perez (1988) discuss the concept of Techno-Economic Paradigms (TEP). These two concepts are in principle equivalent and refer to key technologies, such as the steam engine and electricity. Freeman & Perez (1998, p.47) write that a TEP has "…pervasive effects throughout the economy, i.e. it not only leads to the emergence of a new range of products, services, systems and industries in its own rights; it also affects directly or indirectly almost every other branch of the economy, i.e. it is a meta-paradigm". Figure 3.2 visualizes the scope of the innovation concept. The different types of innovation are ordered in descending order according to their pervasive force.

Diffusion processes are important since they "export" new ideas and foster imitations that may lead to major and/or incremental innovations. GPT and TEP have by their definition the most far-reaching diffusion process, followed by radical innovations. Thus, the penetration rate is stronger the more drastic the innovation is. Also, when it comes to new products, etc, it should be pointed out that established networks, such as links between customers and deliverers, both within and between firms are basic prerequisites for a smooth diffusion process, (Johansson, 1993). For example, Karlsson (1988) showed that firms in the Information Technology sector use intra-firm links to diffuse new applications. The generation of innovations can also be connected to the life cycle of a product, (Karlsson & Olsson, 1996). For example, in the later stages of a product's life when the product and the production routines are standardized, the innovations are most likely to be incremental, i.e. constituting marginal improvements of the product.

3.3 Innovation Systems

The concept of Innovation Systems (IS) is based upon the interactive model of innovation. The key feature of the concept is that an economy's (regional or national) ability to generate innovations does not only depend on how individual actors (firms, universities, organizations, research institutes, governmental institutions, etc) perform, but rather on how they interact as parts of a system, (Gregersen & Johnson, 1996; Eriksson, 2000). Meeus *et al* (1999) point out that a firm should be considered an actor that interacts with an actor set, which facilitates and contributes to the innovation process. The actor set contains actors such as buyers, sellers, suppliers, local and national authorities and intermediate organizations, etc. Similarly, Koschatzky (1998a) stresses the importance of co-operation between firms for the generation of innovations and Cooke (1996) points out that innovation networks are one of the most important types of business networks. Firms need external resources in the innovation and learning process and in order to access them, they need to be a part of a system that makes these external resources available, (Oerlemans *et al*, 1998). The following points can be seen as "foundations" of the concept of IS (de la Mothe & Paquet, 1998 p.105);

- It emphasizes that firms must be viewed as part of a network of public and private sector organizations whose activities and interactions initiate, import, modify and diffuse new technologies.

- It emphasizes the linkages (both formal and informal) between organizations.

- It emphasizes the flows of intellectual resources that exist between organizations.

- It emphasizes learning as a key economic resource.

Lundvall (1995) stresses that an IS should primarily be thought of as a social system, since learning is the most central activity in the innovation process and involves interaction between people. As Meeus *et al* (1999, p 6) put it, "…markets do not accumulate knowledge, they connect knowledgeable actors"[6].

IS can be approached in a narrow or in a broad way, (Gregersen & Johnson 1996). The narrow approach makes it possible to identify specific sectors that generate and distribute innovations when supported by specific institutions. In this context, an innovation system would have clear boundaries. With the broader approach, innovations can be generated by ordinary economic activities, such as procurement, production and marketing, in every part of an economy. The broader view is generally argued to be more appropriate to use when approaching IS, (see e.g. Gregersen & Johnson, 1996; Lundvall & Lindgaard-Christensen, 1999). The narrow approach can be associated with the old linear model of innovation, (Asheim & Isaksen, 1996). Definitions of IS when the broad view is taken include the following;

> *"…a system of innovation is constituted by the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge.."*, (Lundvall, 1995, p.2)
>
> *"…a system of actors (firms, organizations and government agencies) who interact in ways which influence the innovation performance.."*, (Gregersen & Johnson, 1996, p.484)
>
> *"…we will specify system as including all important determinants of innovation"*, (Edquist, 2000, p.15)
>
> *"…a set of institutional actors that, together, plays the major role in influencing innovative performance"*, (Nelson & Rosenberg, 1993, p.4)

[6] However, it is important to keep in mind that ordinary goods also contain and diffuse knowledge, such as technical know-how. Eli Heckscher stated that imports of goods could stimulate local production that substitutes imports, (Johansson, 1992). Thus, a new imported product stimulates imitation, which may result in incremental (or perhaps major) innovations.

Edquist (2000) emphasizes that the systemic approach to innovation is to a large extent holistic. The aim is to include all the important determinants of innovation. Gregersen & Johnson (1996) point out that the holistic approach should not be interpreted as if the innovation process depends on everything. The main point is that it provides a new perspective and understanding of the determinants in an innovation performance. Lundvall (1995) stresses that specific definitions must be adjusted to the processes studied, but emphasizes that the institutional set-up and the structure of production are universal components in all innovation systems.

The rather vague definitions of IS reflect the need for further research. Particularly, it is necessary to try to specify what factors are included in everything and what factors are more or less important. Thus, identifying necessary and sufficient requirements for innovation systems to function is a central research question, not least to be able to formulate regional innovation policies.

3.4 Regional Innovation Systems

Innovation systems are most often referred to as national systems, (Asheim & Isaksen, 1996; Freeman, 1995). The definitions of innovation systems provided in the previous section are also originally given in connection to discussions of National Innovation Systems (NIS). As far as the processes maintained to be important are concerned, the basics of a RIS are in principle the same as for a NIS. For example, Meeus *et al* (1999 p.9) define a RIS as "…the innovating firms surrounded by a number of actors who are all in one way or another linked to the innovation process of a focal firm and to each actor". However, Wiig (1996) stresses that a RIS should be looked upon as analogous to definitions of NIS, but that they should not be considered only "micro-national systems". One can relate the NIS concept to regional institutions and actors but must at the same time recognize that regional systems may differ from the national standard. This in turn makes RIS different from each other[7].

Asheim & Isaksen (2001) designate RIS as regional clusters that are supported by surrounding organizations. They argue that a RIS has two key features. These are (1) firms in the regional core cluster and (2) an institutional infrastructure. The most obvious reason to focus on clusters is that they (as well as geographical proximity in general) tend to facilitate the key points made in the systemic approach, namely learning through interaction.

3.5 Clusters & Regional Innovation Systems

> *"…the main argument for territorial agglomeration of economic activity in a contemporary capitalist economy is that it provides the best context for an innovation based economy",* (Asheim & Isaksen, 1996, p.6)

A cluster can be defined as a number of firms (within the same industry) that share the same location in space, (Karlsson, 2001). In each cluster, it is possible to observe a common labor market, a common market for input-deliveries to the firms and/or information- and technology-transfers between the firms. Many firms can, for example, together provide a large demand for specialized labor and create a pooled labor market, which secures the supply of labor for the firms as well as the supply of jobs for workers. When motivating the role of clusters, most of the literature emphasizes that clusters facilitate knowledge spillovers and knowledge transfers. The former is considered to be of special importance for the innovation process (see e.g. Breschi, 1998; Koschatzky, 1998b). In general, knowledge spillovers is referred to as a kind of informal diffusion of knowledge which takes place most effectively when firms are located close to each other. As Feldman & Audretsch (1998, p.2) put it, "…knowledge may spill over, but the geographic extent of such knowledge spillovers is bounded". Knowledge transfers refer to more explicit and planned transmission of knowledge between economic agents. Transfers often involve a regular commercial transaction. These are obviously facilitated by proximity, but are not interchangeable with knowledge spillovers, (Karlsson & Manduchi, 2001).

In the context of innovation it is usually maintained that much of the knowledge relevant for innovation processes is tacit. Tacit knowledge can be defined as semi- and unconscious knowledge that does not exist in explicit printed forms, (Leonard & Sensiper, 1998). Skills and routines are

[7] Radosevic (2000) maintains that RIS develops from interaction between determinants from different levels, e.g. national, sectoral and region-specific determinants.

examples of tacit knowledge, (Lorenzen, 1998). Its formation and use depend, to a large extent, on the social and institutional context in a region, (Lam, 1998). Several studies have also shown that informal oral sources of information are keys to successful innovations, (Karlsson, 2001). The main communication channels for tacit knowledge are employee mobility, informal personal relations and supervision, (Lorenzen, 1996). Hence, the transmission of tacit knowledge necessitates face-to-face (FTF) contacts. Since firms and individuals in a cluster are by definition located in proximity to each other, it is evident that clusters facilitate both knowledge spillovers and knowledge transfers.

In addition, not only geographical proximity but also *relational* proximity has a role to play in improving the ease by which knowledge is transmitted, (Capello, 2001). The latter encompasses relations developed by integration of firms and socio-cultural homogeneity. Also, Wiig & Wood (1995) stress that the presence of mutual trust and collective tacit knowledge in a region tend to stimulate innovative activities. Mutual trust facilitates exchange of knowledge and diminishes uncertainties while collective tacit knowledge eases exchange of technological know-how, etc. Both these elements are likely to be developed in clusters if anywhere. For example, Storper (1995) emphasizes that every cluster develops its own specific rules, i.e. local institutions, which may include conventions and rules for developing, communicating and interpreting knowledge. Storper refers to these relationships as untraded interdependencies between actors. This concept is equivalent to Maillat's (1995) concept of atmospheric externalities. It basically means that each cluster in a region has its own norms that "..stem from a shared technical culture, from interaction between, and mobility of, individuals on the labor market…", (Maillat, 1995, p.161), which in turn "…facilitates the exchange of knowledge and makes it easier also to establish contacts and exchange information between persons and firms within an area", (Wiig & Wood, 1995, p.3). Within this context one can talk about a localized learning processes in which the learning takes place locally with few external actors involved.

Furthermore, it should be noted that individuals must have relevant training to be able to absorb the knowledge they acquire, (Karlsson & Manduchi, 2000; Fischer, 1999). To be able to make sense of high-level knowledge in engineering, an education in engineering is generally a prerequisite. Maurseth & Verspagen (1998 p.16) study knowledge spillovers in Europe and conclude that "…technology diffusion is in no sense automatic, but demands a certain level of economic development, in addition to innovative efforts and favorable institutional settings". Moreover, Bottazzi & Peri (1999) find that knowledge spillovers between European regions are especially strong between technologically similar and geographically close regions. This suggests, not surprisingly, that the ability for a region/cluster (or rather the individuals residing in it) to adopt and use new knowledge partly depends on the education of the workforce in the region.

Having discussed the reasons for the emphasis on clusters for RIS, it is natural to ask if all clusters can be characterized as RIS. The answer is no even if clusters, as shown, play a key role for a RIS. A regional cluster is not a sufficient condition for RIS. Asheim & Isaksen (2001) emphasize the importance of more explicit co-operation and Mytelka & Farinelli (2000) state that it may be necessary to link the firms in clusters to new knowledge bases and deepening the intensity of tacit knowledge, especially in clusters in traditional industries. Cooke *et al* (1997, p.484) list the requirements for a RIS explicitly:

> "An innovative regional cluster is likely to have firms with: access to other firms in their sector as customers, suppliers or partners, perhaps operating in formal or informal networks; knowledge-centers such as universities, research institutes, contract or research organizations and technology transfer agencies of consequence to the sectors in question; and a governance structure of private business associations, chambers of commerce and public economic development, training and promotion agencies and government departments. Where these are available in a region and crucially, the organizations noted are *associative* (Cooke & Morgan, 1998), meaning there is systemic, i.e. regular two-way, interchange on matters of importance to innovation and the competitiveness of firms, we may consider this to be a regional learning system. Where to this added the financial capacity, through the existence of the financial infrastructure needed to enable firms to gain the necessary venturing finance and invest the necessary qualities of capital to generate endogenous innovation, we may speak of a regional innovation system".

Against such a description, few clusters would probably qualify as RIS. Hence, despite cluster constituting a suitable regional industrial structure upon which a RIS can be based, a RIS has properties not shared by clusters in general. In particular, as stressed by the authors, it is not only necessary that the firms have access to a complete "actor set" they must also be engaged in reciprocal co-operation with the actor-set in the innovation process.

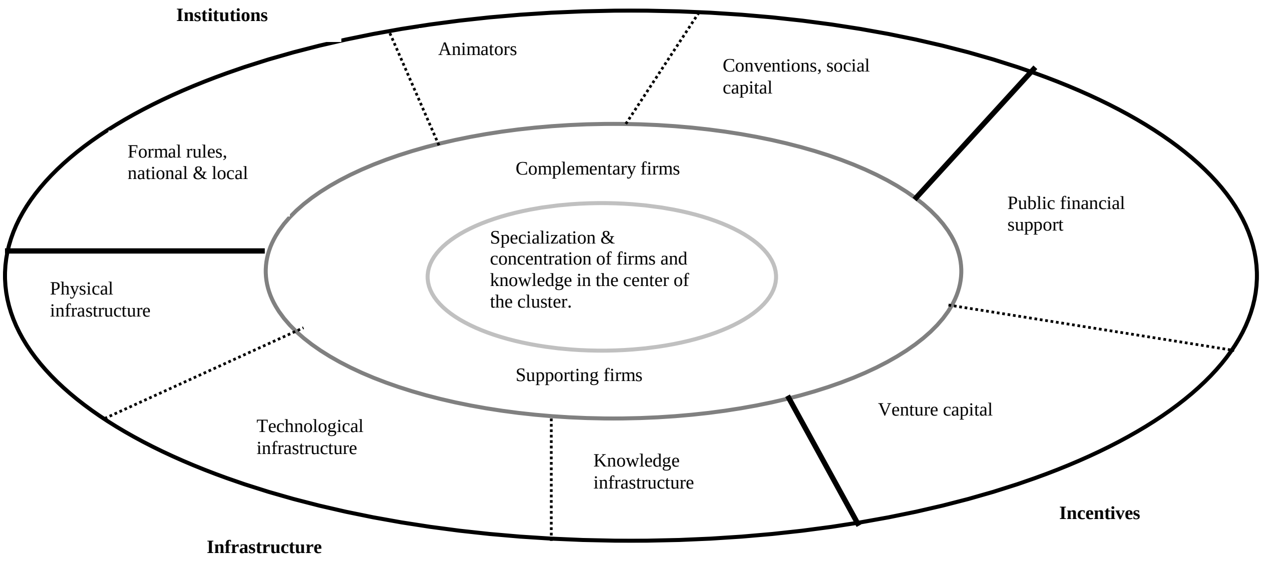

Figure 3.3. Components of a complete Regional Innovation System, (adapted from Eriksson, 2000).

Figure 3.3 describes what may be called a "complete" RIS. The core is constituted by the firms in the regional cluster, surrounded by supporting as well as complementary firms. Institutions, as normative structures and "rules of the game", are present which facilitate co-operation and knowledge spillovers and transfers. Using the concepts earlier defined, untraded interdependencies (or atmospheric externalities) are developed. Likewise, an infrastructure of knowledge and technology as well as financial resources surrounds the firms.

Figure 3.3 suggests that the university-industry-government relationship have a key role to play in the functioning of a RIS. Etzkowitz & Leydesdorff (2000 p.111) refer to this relation as the *Triple Helix*. In their view, the Triple Helix generates "…a knowledge infrastructure in terms of overlapping institutional spheres, with each taking the role of the other with hybrid organizations emerging at the interfaces". Universities are maintained to play an essential role for the functioning of RIS. Of course, universities are not the only relevant knowledge provider. Application-oriented and non-university research institutes are also important in forming the knowledge infrastructure in a RIS. Koschatzky (2001, p.3) stresses that Higher Research Institutes (HEIs) generally fulfill two main functions in a region:

- to manage the common knowledge base of a region by producing and diffusing knowledge through education, by distributing scientific and technological information and by demonstrating and transferring technological or scientific solutions.

- to provide expertise knowledge by training, consulting, contract research and development, or by the transfer of services, taking into account the specific needs of single actors.

Since HEI's keep regional firms up to date regarding scientific solutions, etc, they facilitate necessary industrial transformations when new technologies are introduced. In that sense, they counteract lock-in situations. In addition, Koschatzky (2001) maintains that HEIs do not only act as knowledge providers, they are also incubators for new firms since they qualify and support potential entrepreneurs. HEIs thus help transform new scientific knowledge into commercialized products and create new businesses. Their presence also affects the location-choice of firms, at least high-technology firms, since they tend to regard them as a source for new knowledge and technologies, (Varga, 1998). Anselin *et al* (1996) provide empirical evidence for that university research in a region has a significant positive impact on the innovative activities of the high-technology firms in that region.

3.6 Different Types of Regional Innovation Systems

The previous section focused on what may be called complete RIS. However, it is important to recognize that a RIS may be more or less complete. A region (or cluster) that has not all the characteristics listed in Figure 3.2 may still be referred to as a RIS. Thus, there are different types of RIS. Asheim & Isaksen (1996, 2001) distinguish between three broad groups of RIS, (1) territorially embedded regional innovation networks, (2) regional networked innovation systems and (3) regionalized national innovation systems. These differ mainly in terms of their connection to knowledge-providers and actors outside the region as well as the form of co-operation in the innovation process. Table 3.1 lists the characteristics of each type of RIS in Asheim & Isaksen (2001).

For the first type of RIS, territorially embedded regional innovation networks, proximity (both geographical and relational), is the main stimulus for firms' innovative activities. Interaction with knowledge providers and their presence tends to be very modest. Probably the best examples of this kind of systems are "…networking SMEs [small and medium-sized enterprises] in industrial districts, which build their competitive advantage on localized learning processes", (Asheim & Isaksen, 1996, p.14). Firms in territorially embedded regional innovation networks rely upon locally developed knowledge and the untraded interdependencies discussed above tend to be strong. It seems therefore natural to suggest that learning-by-doing and learning-by-using are the key knowledge-generating mechanisms in these systems and that the innovations achieved are mainly incremental innovations. But these systems hold different types of knowledge, (Asheim & Isaksen, 1996). While learning-by-doing and learning-by-using are primarily based on informal, practical and tacit knowledge, there is also a specific kind of knowledge that stems from "disembodied technical knowledge", which is mastered by firm-groupings through untraded interdependencies as well as formal exchange with other firms, (Asheim & Isaksen, 1996). This kind of knowledge is not mainly based on tacit knowledge. It is instead referred to as localized, codified knowledge. It may constitute the basis for interactive learning. Furthermore, "…according to modern innovation theory, interactive learning has the potential to produce radical innovations in addition to incremental ones", (Asheim & Isaksen, 1996, p.15). However, the probability for these systems to produce radical innovations is low due to the lack of knowledge providers.

Table 3.1. Some characteristics of the three main types of RIS.

Main type of RIS	**The location of knowledge organizations**	**Knowledge flow**	**Important stimulus of co-operation**
Territorially embedded regional innovation networks	Locally, however, few relevant knowledge organizations	Interactive	Geographical, social and cultural proximity
Regional networked innovation systems	Locally, a strengthening of (the co-operation with) knowledge providers	Interactive	Planned systemic networking
Regionalized national innovation systems	Mainly outside the region	More linear	Individuals with the same education and common experiences

Source; Asheim & Isaksen (2001, p. 11)

A danger with territorially embedded regional innovation networks concerns its ability to sustain the competitiveness of the firms in the system/region. For example, Asheim & Isaksen (1996) maintain that it is doubtful whether a territorially embedded regional innovation network is capable of avoiding lock-in situations by breaking path dependency and changing technological trajectory. Lack of co-operation with knowledge organizations may result in that firms are unable to catch up with new technologies and new knowledge. Close co-operation with research universities facilitates necessary industrial transformations when new technologies, etc, are introduced. Similarly, Asheim & Isaksen (2001) stress that the majority of firms do need access to universal knowledge (from e.g. national systems of innovation). This is especially true for SMEs. Thus, it is not possible to fully rely on localized learning and tacit knowledge (as well as localized, codified knowledge) must in many cases be complemented with formal R&D-competence, (Asheim & Isaksen, 2001). This suggests that for this type of RIS, it is important that the regional actors develop external linkages and not only co-operate intraregionally.

The second type of RIS, regional networked innovation systems, can be seen as an extension of the first type of RIS where the needs described above are satisfied. Asheim & Isaksen (2001) write that the basic features are the same as for the first type, but in this case the networking is better planned and more systemic. According to the authors, this is achieved by means of a strengthened regional infrastructure, such as having more local organizations, e.g. R&D institutes and vocational training organizations, participating in the firms' innovative activities, (Asheim & Isaksen, 2001). Thus, in regional networked innovation systems the firms have access to local competence making the likelihood of lock-in situations lower (and the probability of radical innovations higher). Asheim & Isaksen (2001 p.10) argue that "…the networked system is more or less regarded as the ideal-typical RIS; a regional cluster of firms surrounded by a local supporting institutional infrastructure". Hence, this type of RIS is synonymous with the type presented in Figure 3.2.

Regionalized national innovation systems, the last category, are different from the other two in many aspects. Outside actors are involved in the firms' innovative activities and in the regional industry as a whole. The institutional infrastructure is also partly integrated with the national or even international innovation system. Therefore, it is close to a "micro-national system". Regional clusters in which the knowledge providers are first and foremost located outside the region are good examples, (Asheim & Isaksen, 2001). Relevant examples also include R&D institutes and science parks with only some degree of linkages to the local industry. Asheim & Isaksen (2001) argue that co-operation between firms and knowledge organizations in regionalized national innovation systems are often related to specific projects with the aim of developing more radical innovations. They also point out that the innovation process is, to a greater extent, of the linear nature. The knowledge used is more formal and "…co-operation may be stimulated when people have the same kind of education (e.g. as engineers) and sharing the same formal knowledge, rather than belonging to the same local community", (Asheim & Isaksen, 2001). Hence, the interaction between knowledge organizations and the firms appears to be primarily based on commissioned research work rather than on integration and continuous involvement.

The discussion above can be summarized in the following points:

- Interaction between agents is a necessary condition for a RIS to function.
- Such interaction is achieved through clustering. Thus, there is a specific production structure that is important for RIS.
- Existence of knowledge-providers is not a prerequisite for a RIS.
- A necessary but not sufficient condition is that the actors within a RIS produce and diffuse knowledge among each other. It is not sufficient because it is the degree to which knowledge is produced and diffused that is relevant question [8].
- Different kinds of RIS can be identified based on the following:
    - How knowledge is produced.
    - The kind of knowledge produced.
    - How the interaction is organized.
    - The boundaries of the system, i.e. how "regional" is the RIS?

[8] Here it is possible to talk about a minimum degree of knowledge creation and diffusion, below which one cannot talk about a RIS.

- The nature of the knowledge available and produced partly determines the kind of innovations a RIS is able to produce. Hence, different RIS produce different kinds of innovations.

4. Regional Innovation Systems in Different Industries & Regions with different Industrial Specializations

In this section, the focus is on Small and Medium-Sized Regions (SMRs) dominated by traditional manufacturing industries. There is an evident lack of general theories in the literature regarding how the function of RIS differs between regions with different industrial specializations. For many authors, the theory seems to be the arrival point and there is no real application of it. However, the different types of RIS based on Asheim & Isaksen (1996 & 2001) discussed in section 3.2.2 provide an overall idea. For example, it is sensible to assume that the innovation system in small and peripheral regions, that are likely to be without a research university, etc, are best described as territorially embedded regional networks, while the innovation systems in larger regions, with research universities and other knowledge providers/organizations, are likely to be synonymous with regional networked innovation systems. However, an examination of some empirical findings is necessary here due to the lack of general theories.

4.1 Theories & Empirical Findings

Breschi & Malerba (1997) point out that the technological knowledge in different sectors has different characteristics. They emphasize that the technological knowledge can be characterized according to the degree of:

1) Specificity: (the knowledge can be specific, i.e. connected to certain applications, or generic)

2) Tacitness: (the knowledge can be tacit and local or codified and easily transferable)

3) Complexity: (e.g. the knowledge may stem from different disciplines to different extents)

4) Independence: (the knowledge can be identified easily or be embedded within a larger system)

They further provide examples of different sectors in which the knowledge is of a different character, constituting what they call different sectoral innovation system (SIS). They argue that the knowledge base of the innovative activities in the traditional (non-knowledge intensive) sector has a low degree of complexity and is easily codified and transferred. This implies that geographical proximity is not important for the actors and the authors argue that there is likely to be a high degree of geographical dispersion of the innovators. Mechanical industries and industrial districts make up another sector. Here, Breschi & Malerba (1997) maintain that the knowledge base for the innovative activities is characterized by a high degree of tacitness and specificity. There are many innovators and the boundaries of knowledge are local. Hence, geographical proximity is important for the firms in this sector. The authors identify two other sectors, the computer (hardware) industry and the software (microelectronics, biotech) industry. Knowledge is highly complex in both sectors and they are generally considered to be knowledge-intensive. The hardware industry, which according to the authors has few innovators, is geographically concentrated and knowledge has global boundaries. The software industry, on the other hand, has many innovators, where a mixture of both tacit and codified knowledge makes geographical proximity very important. Knowledge boundaries are both local and global since they have both tacit and codified properties.

Similar ideas are put forward by Meeus *et al* (1999 p.10), who discuss how interaction with the actor set varies from one firm to another. For them, it is likely that "…supplier dominated and scale intensive focal firms interact less frequently with the actor set than focal firms in science based industries and specialized suppliers". They also state that "…radical innovations are associated with a higher frequency of interaction between the actor set and the focal firm than incremental innovations".

In this sense, traditional industries, including many manufacturing industries, are less dependent upon the regional "milieu" for their innovative activities. This view is shared by Breschi & Malerba (1997).

Audretsch & Feldman (1996) make use of the Industry Life Cycle Theory[9], to analyze and explain spatial dimensions of innovative activity. Like Breschi & Malerba (1997), they argue that the nature of the knowledge is important for the spatial location of innovative activities. Their main hypothesis is that the tendency of innovative activity to cluster is strongest during the early stages of the industry life cycle. They state (p.259) that "…innovative activity should take place in those regions where the direct knowledge-generating inputs are greatest, and where knowledge spillovers are the most prevalent", an argument that concurs with the discussion above. The authors also argue that tacit knowledge is likely to play an especially important role in the innovation process in the early stage of the industry life cycle, since "…there are no widely accepted standards with respect to product specifications, so that obtaining information about what consumers want and how it can be produced demands proximity to knowledge sources". Since exchange of tacit knowledge demands geographical proximity and face-to-face contacts, one can draw the conclusion that the tendency for innovative activities to spatially cluster is strongest in the early stages of the cycle. Based on data for 210 U.S industries, which were classified into four stages of the industry life cycle, Audretsch & Feldman (1996) find evidence that the propensity of innovative activities to cluster is greatest in the early stages, while it is more dispersed in the mature and declining stages of the cycle.

Other empirical studies include Jonsson *et al* (2000), who study the Swedish medicine-technology sector and find that the innovative activity is highly concentrated. They discover that five metropolitan and urban areas (Stockholm, Göteborg, Malmö, Uppsala and Halmstad) account for 80 % of the creation of new products and processes. However, some degree of dispersion was observed with respect to improvements of existing products. Moreover, the manufacturing industry was found to be less concentrated than other industries within the sector. Similar core-periphery patterns are found for the manufacturing industry in Norway. For example, Wiig & Isaksen (1998) find a clear center-periphery pattern when measuring different Norwegian regions' share of firms with innovation costs and share of firms producing new or significantly altered products. Peripheral regions had a substantial lower share of both. Moreover, Asheim & Isaksen (1996) show that the costs associated with innovation of firms in central areas are mainly made up by (or are related to) R&D, while the same costs of firms in peripheral areas are, on the other hand, mostly constituted by trial production and production start-ups. This suggests that firms in central areas are more concerned with radical innovations while firms in peripheral regions are skewed towards incremental innovations and tend to "…import and alter innovations from outside", (Asheim & Isaksen, 1996 p. 23). Likewise, based on data from 100 manufacturing firms in a Norwegian peripheral region (Finnmark), Wiig (1996) finds that the typical innovative firm is larger than the average firm and that these sell the largest share of their total sales outside the region. That the innovative firm is larger than the average firm is in line with the reasoning by Audrestch & Feldman (1996 p.256). They write that "…during the early stages of the industry life cycle, there is a high amount of innovative activity and new and smaller enterprises tend to have the relative innovative advantage (..) during the mature stages of the industry life cycle, there tends to be less (product) innovative activity (..) [and] the established incumbent enterprises tend to have the innovative advantage and the new entrants are confronted by an inherent innovative disadvantage". Hence, the role of learning and developed experience is likely to be strong for incumbent firms in the mature phases.

From the discussion above, it is clear that high-technology industries using highly complex knowledge, such as computer hardware and software industries are in the greatest need of a rich regional milieu. These industries also interact most frequently with the regional milieu in the innovation process and the Triple Helix tends to be of special importance. As Breschi & Malerba (1997) point out, these industries are also dependent upon global knowledge, which implies that linkages to innovation systems in other domestic regions and abroad are likely to be important. It seems therefore sensible to suggest that RIS in these industries can be linked to what Asheim & Isaksen (1996) refer to as regionalized national innovation systems and regional networked innovation systems. For example, these industries tend to be located close to research universities and the high complexity of the knowledge involved is likely to result in limited linkages to the local industry in the

[9] Synonymous with the Product Life Cycle theory.

region. This depends, however, on the level of education in the region. It is also apparent that this type of industries tends to cluster in larger regions. Against this background, high-technology industries seem to constitute the best basis for RIS.

In traditional sectors, on the other hand, a typical firm interacts less with different actors. Firms in these industries do not seem to need such a rich regional economic milieu. It has been shown empirically that the innovative activities of traditional industries are more geographically dispersed than in other industries. It has also been shown that the innovative activities of manufacturing firms in peripheral regions are less associated with formal knowledge compared to central regions, suggesting that peripheral firms are mainly concerned with incremental innovations and the import of novelties from other regions.

4.2 RIS in Small & Medium-Sized Regions Dominated by Manufacturing within Traditional Industries – an elaboration

Empirical studies point out that large and central regions with a large knowledge base in relative terms are mostly involved with radical innovations. Moreover, knowledge-intensive (central) regions are also likely to be the first to adopt new techniques and new knowledge. Tödtling (1993) states that regions with large agglomerations of economic activity and knowledge providers tend to have the location requirements to constitute the earliest adopters of new techniques. Also, these regions tend to act as import nodes, from which novelties diffuse to other regions, Johansson & Westin (1987). In the subsequent discussion, SMRs dominated by manufacturing industries will be treated as receivers in such a diffusion process.

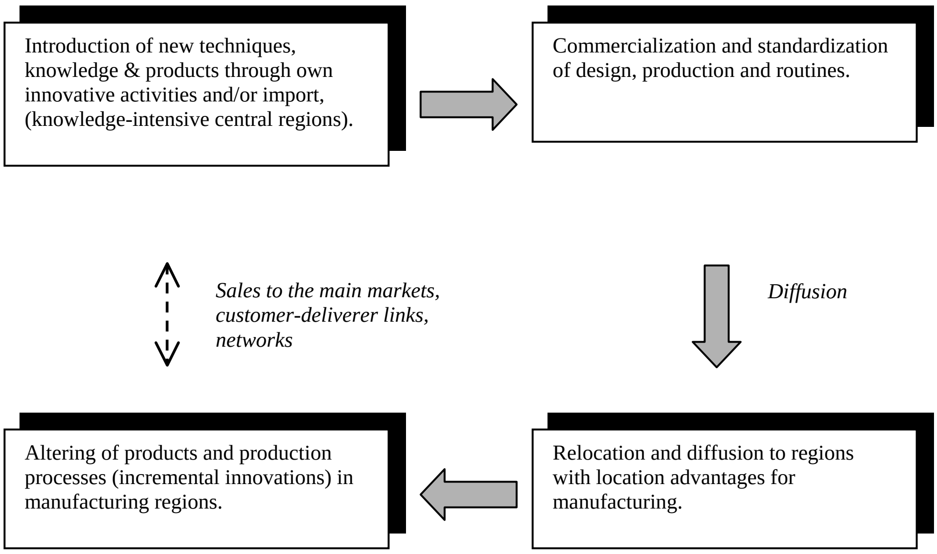

Figure 4.1 Diffusion and re-location of production of novelties

Based on the Spatial Product Cycle (SPC) theory, Figure 4.1 provides a schematic picture of the diffusion and re-location of the production of novelties. A central idea in the SPC theory is that knowledge-intensive regions (import nodes) generate and import innovations, of which the production is then subsequently re-located to manufacturing regions with cost advantages when the products are standardized and certain routines are established, (Johansson & Westin, 1987). Thus, in the mature phases of a product's life, SMRs (as defined above) usually have a location advantage. For the most part, such production is located in SMRs in order to produce more cheaply for other larger markets. Thus, the majority of the goods are shipped to large regions or exported abroad. Therefore, it may be assumed that the manufacturing firms in SMRs dominated by manufacturing are linked to larger regions via established networks, e.g. customer-deliverer links[10]. These links are likely to be of major importance for the innovative activities of firms in SMRs. Customer-deliverer links may, for example,

[10] One may also consider that larger firms sometimes out-locate the manufacturing division(s) to SMRs

work as channels through which demand for improvements of existing goods and new ideas diffuse from larger regions to firms in smaller regions. This may in turn stimulate improvements of products. As mentioned previously, a number of authors have stressed that a “demanding demand” functions as an innovation-trigger, (see e.g. Porter, 1990). This type of demand structure, though rarely an endogenous phenomenon within SMRs, may thus be “imported” via networks. Hence, external linkages exist and should be of special importance for the innovation processes of firms in SMRs.

Based on this framework, how then can an innovation system in these regions be described? In principle, one is able to identify three types of manufacturing SMRs. Firstly, there are SMRs with many manufacturing SMEs that form a cluster. An example of this type of SMRs is the Gnosjö region in Sweden, (see e.g. Karlsson & Klaesson, 2000). Secondly, there are SMRs with one (or a few) large manufacturing firm(s) surrounded by smaller local suppliers that together may form a cluster. Thirdly, one finds manufacturing regions in which there is one large manufacturing firm with a few or non local subcontractors. Peripheral regions in the north of Sweden with a manufacturing division of a larger company are good examples, (see e.g. SNA, 1995). These three types are, in principle, identical to Markusen’s (1996) industrial districts, namely Marshallian, Hub-and-Spoke and Satellite Platform industrial districts, respectively. It is questionable to talk about an innovation system in regions characterized by Satellite Platform industrial districts. Asheim & Isaksen (2001) argue that it is not appropriate to talk about RIS in regions that are dominated by branch activities of, for example, trans-national corporations and in regions having too few firms within the same sector to form a regional cluster. The reason is that there is generally no base to form regional innovation networks upon, such as trust and collective tacit knowledge, etc, (see e.g. Asheim & Isaksen, 2001). Therefore, it is natural to focus upon the first two categories of SMRs.

The innovation system in this type of regions (Marshallian and Hub-and-Spoke) may best be described as territorially embedded. That is, knowledge providers play a minor (or no) role in the innovation process and knowledge is primarily developed through learning-by-doing and learning-by-using. Exchange of knowledge is mostly informal and tacit, where untraded interdependencies are likely to play a key role. Both theories and empirical findings suggest that incremental innovations are the main type of innovations made. But in the light of the discussion above, some points need to be added to Asheim’s & Isaksen’s (2001) characterization. Firstly, information and demand, etc, transferred to the firms through external linkages are important stimulus for the innovative activities, in addition to social, cultural and geographical proximity. Secondly, firms do get access to universal knowledge and novelties through the process in which the production of novelties is out-located to these regions. As stressed earlier, one must keep in mind that new goods carry information about new techniques and technical solutions, etc. Relocation of the production novelties then implies that this new know-how is accessible to the firms in the manufacturing region and stimulates imitation, etc. Hence, these innovation systems are not as closed as it may be perceived. How they perform also depends on the innovative activities in larger regions and the import activity of import nodes since these activities have a strong influence on SMRs specialized in manufacturing.

Manufacturing SMRs that are characterized by Marshallian industrial districts are different from those characterized by Hub-and-Spoke industrial districts. The latter is obviously more dependent upon certain firms, i.e. the large manufacturing firm(s) in a region, than regions characterized as Marshallian industrial districts. The innovation process in the Hub-and-Spoke type of region is, for example, likely to be more dependent upon large firms’/the larger firm’s ability to absorb new knowledge and recognize demands for improvements of products, etc.

Based on the above discussion, the conclusions drawn about RIS in manufacturing SMRs can be summarized in the following points:

- Clustering of manufacturing firms is the underlying mechanism that facilitates interaction and exchange of technical know-how.
- Endogenous knowledge-generating mechanisms are primarily learning-by-doing and learning-by-using.
- New knowledge and technical know-how are gradually introduced to the system by diffusion and relocation processes from larger regions to small and medium-sized regions specialized in manufacturing.

- Customer-deliverer links to other regions help to convey ideas about how to improve and alter existing products/production processes.
- The innovative activities mainly concern incremental innovations that stem from imitations and various improvements of existing products.

5. Regional Policy & Regional Innovation Systems

> *"..regions, networks and information technologies are not entities that can learn or innovate. What is required above all are persons who can recognize the significance of information and knowledge and use them to innovate successfully. This in turn requires high standards of education as a basis both for entrepreneurship and for the quality of the labor force"*, (Hansen, 2000 p.18)

To reduce uncertainty by providing information, to regulate conflicts and co-operation and to provide incentives are basic functions of governmental institutions, (Edquist, 1997). These can be seen as universal missions for policy makers. They are, of course, also important for innovation systems, but what policies are more specific for RIS? In principle, regional innovation policies should take all elements in Figure 3.3 into account. For example, access to venture capital and a good physical infrastructure are always important. However, some elements are more important than others. As the quotation above emphasizes, education should be one of the primary concerns for regional policy makers. To be able to absorb and develop new knowledge and new technical solutions a good education is of paramount importance. A regional innovation policy should therefore always aim to attract skilled labor and establish regional knowledge providers such as, universities and research institutes. This is especially important for SMRs specialized in manufacturing that have a workforce with a low knowledge-intensity. To develop the ideal type of RIS (regional networked innovation systems), tacit and local knowledge must be complemented with more formal knowledge, such as R&D-competence. A strengthening of the regional infrastructure should be a focal aim. But many regions are too small to be able to host a research institute or local research university. In such regions, it is important to develop linkages to new knowledge bases and knowledge providers in other regions, i.e. external linkages, (Echeverri-Carroll & Brennan, 1999; Mytelka & Farinelli, 2000). Having studied the innovation system in a Norwegian peripheral region (Finnmark), Wiig (1996 p.39) concludes that firms need:

1) contact with relevant research milieux.

2) technical institutions for innovation support.

3) financial support for innovation.

4) young educated people to start in industry.

5) new subjects at the technical colleges in the region.

6) to overcome network bottlenecks.

These findings support the fact that knowledge providers and skilled labor are the most important factors to consider. They also suggest that the needs of regional firms should be taken into account when formulating and implementing education policies. It is important that universities and policy makers recognize what kind of education and knowledge institutions that the firms in the region demand.

The existence of knowledge providers is, however, not enough for a successful regional innovation process. As stressed throughout the paper, the systemic approach to innovation emphasizes the importance of interaction and collaboration between knowledge providers and the business sector. Regional policy makers should therefore try to establish networks between research universities and firms, and also try to integrate the regional public sector in the innovation process. That is, establish a well-functioning university-industry-government relation. This can, for example, include attempts to initiate different research projects that involve actors from all three sectors. Another important aspect is that businessmen, etc, need places to meet in order to exchange knowledge. It has, for example, been stressed that knowledge spillovers, especially in the context of tacit knowledge, are strongly facilitated by frequent face-to-face contacts. Establishing communities, arenas and other arrangements that create a base and possibility for recurrent face-to-face contacts can therefore be effective tools to encourage such spillovers. By such arrangements it might also be possible to overcome network bottlenecks, such as found by Wiig (1996). Recall that one difference between territorially embedded regional innovation systems and regional networked innovation system (the ideal) is that the networking in the latter type of RIS is more planned and systemic.

Even if the theory emphasizes the importance of knowledge spillovers, it is important that policy makers pay attention to the balance between private and public dimensions of novelties and knowledge, i.e. the free-rider problem. Based on a postal survey from 121 manufacturing firms in two Norwegian regions (More and Romsdal), Wiig & Wood (1995) found that the "fear of imitation/risk associated with being first to innovate" was the most restrictive factor to product and process innovations. This implies that too effective policies to generate spillovers can have negative effects on firms' incentives to innovate. If newly created knowledge goes public after a short time, i.e. becomes freely accessible to everyone, which firm will be willing to bear the cost of developing it? Various rules for patent-regulations and property rights, etc, which prevent from too effective spillovers are most often determined at the national level, but an awareness of the issue at the regional level is nevertheless important.

In sum, a regional innovation policy directed towards the development and improvement of regional innovation systems should include measures that:

- develop regional knowledge providers and/or link the firms to external knowledge sources.
- attract skilled labor and promote the education of labor.
- develop an institution responsible for scanning markets and technologies for regionally important clusters.
- promote interaction and collaboration between firms, knowledge institutions and governmental institutions.
- promote recurrent contact between businessmen, i.e. develop more formal and planned networking.
- secure the supply of venture capital.

A final point to be made is that policies for regional innovation systems demand an extensive study of the regional economy. As mentioned earlier, each cluster in a region develops its own norms and informal routines. This implies that forms of collaboration and interaction are likely to be different between different clusters within and between regions. Careful considerations and studies must therefore be made before establishing a general regional innovation policy. Even if the aims should in many cases be the same, this may not be true for the instruments.

6. Summary & Conclusions

The purpose of this paper was to present a state-of-the-art review and a critical assessment of current research about RIS with special focus on their role in small and medium-sized regions. We were particularly interested in finding out what policy conclusions could be drawn for regional innovation policies in small and medium-sized regions.

The results are partly disappointing. Current research on RIS suffers from a number of deficiencies. The theoretical base is not well developed and much of what has been written lacks the clarity that is necessary to really evaluate the research and formulate strong policy conclusions. It is inadequate to define a RIS as all those factors that influence the innovation process. Such definitions are not operational. For this reason, more and better research on RIS is necessary to be able to formulate guidelines for regional innovation policies, in particular, in small and medium-sized regions.

However, a number of conclusions can be drawn in the light of the review and assessment. Firstly, it seems clear that for regional innovation policies to be meaningful the regions in question must already have either one or several clusters of SMEs or one or several larger leading companies surrounded by clusters of suppliers and/or customers. Secondly, since most small and medium-sized regions do not have public research institutions, developing strong links to research universities in other regions are of paramount importance. Thirdly, for those small and medium-sized regions that have one or several institutions of higher education it is important to take special measures to adapt the educational profile to fit with the needs of the regional innovation networks. Fourthly, problems to recruit qualified personnel seem to hamper the regional innovation systems in many small and medium-sized regions. Special measures may often be needed to facilitate the recruitment of qualified personnel. Fifthly, since RIS to a large extent function via collective learning it is necessary to improve existing arenas and meeting places and also create new arenas and meeting places. Sixthly, because many innovations are best realized within new firms it is vital for the regional innovation systems to offer broad support to new entrepreneurial ventures. Seventhly, as conditions in each region have unique traits, it is necessary to base all regional innovation policies upon careful studies of the existing regional innovation systems, the way they function as well as their weaknesses. Eighthly, administrative and functional regions normally do not coincide. Since the functional region is the relevant region from an economic point of view, it is therefore of great importance to see to it that regional innovation policies are formulated and executed for functional regions.

References

Almeida, P. & Kogut, B. (1999), "Localization of Knowledge and the Mobility of Engineers in Regional Networks", *Management Science*, 905-917

Amendola, M. & Bruno, S. (1990), "The Behavior of the Innovative Firm: Relations to the Environment", ?-?

Anselin, L., Varga, A. & Acs, Z. (1996), "Local Geographic Spillovers between University Research and High Technology Innovations", *Journal of Urban Economics*, 42, 422-448

Asheim, B. & Isaksen, A. (1996), *Location, Agglomeration and Innovation: Towards Regional Innovation Systems in Norway*, STEP Report R-13, Oslo

Asheim, B. & Isaksen, A. (2001), "Regional Innovation Systems: the Integration of Local Sticky and Global Ubiquitous Knowledge", Forthcoming in *Journal of Technology Transfer*

Audretsch, D. & Feldman, M. (1996), "Innovative Clusters and the Industry Life Cycle", *Review of the Industrial Organization*, 11, 253-273

Bannock, G. *et al.* (1992), *The Penguin dictionary of Economics 5^{ed}*, Penguin Books, London

Bergman, E., Maier, G. & Tödtling, F. (eds) (1993), *Regions Reconsidered*, Ipswich Book Co Ltd, Suffolk

Black, J. (1997), *A Dictionary of Economics*, Oxford University Press, Oxford

Bottazzi, L. & Peri, G. (1999), *Innovation, Demand and Knowledge Spillovers: Theory and Evidence from European Regions*, CEPR Discussion Paper Series No. 2279

Breschi, S. (1998), *Agglomeration Economies, Knowledge Spillovers, Technological Diversity and Spatial Clustering of Innovations*, LIUC Papers in Economics, N.57

Breschi, S. & Malerba. (1997), "Sectoral Innovation Systems: Technological Regimes, Schumpeterian Dynamics and Spatial Boundaries", in Edquist, C (ed). 1997, *Systems of Innovation: Technologies, Institutions and Organizations*, Pinter, London

Bresnahan, T. & Trajtenberg, M. (1995), "General purpose technologies – engines of growth?", *Journal of Econometrics*, 65, 83-108

Capello, R. (2001), "Urban Innovation and Collective Learning: Theory and Evidence from Five Metropolitan Cities in Europe", in Fischer, M. & Fröhlich, J. (2001), *Knowledge, Complexity and Innovation Systems*, Springer-Verlag, Berlin

Carlson, B. & Stankiewicz, R. (1991), "On the nature, function and composition of technological systems", *Journal of Evolutionary Economics*, 1, 93-118

Cooke, P., Uranga M. J. & Etxebarria, G. (1998), "Regional systems of Innovation: an Evolutionary Perspective", *Environment and Planning*, vol. 30, 1563-1584

Cooke, P., Uranga M. J. & Etxebarria, G. (1997), "Regional Innovation Systems: Institutional and Organizational Dimensions", *Research Policy*, 26, 475-491

de la Mothe, J. & Paquet, G. (1998), "National Innovation Systems, Real Economies and Instituted Processes", *Small Business Economics*, 11, 101-111

Dosi, G. *et al*. (eds) (1988), *Technical Change and Economic Theory*, Pinter Publishers, London

Echeverri-Carroll, E. & Brennan, W. (1999), "Are Innovation Networks Bounded by Proximity?", in Fischer, M., Suarez-Villa, L. & Steiner, M. (eds) (1999), *Innovation Networks and Localities*, Springer-Verlag, Berlin

Edquist, C. (2000), "Systems of Innovations – Their Emergence and Characteristics", in Edquist, C. & McKelvey, M. (eds) (2000), *Systems of Innovations: Growth, Competitiveness and Employment Volume 1*, MPG Books Ltd, Cornwall

Edquist, C (ed). 1997, *Systems of Innovation: Technologies, Institutions and Organizations*, Pinter, London

Edquist, C. (1997), *Institutions and Organizations in Systems of Innovation: the State of the Art*, Working Paper No. 182, TEMA-T AN

Edquist, C. & McKelvey, M. (eds) (2000), *Systems of Innovations: Growth, Competitiveness and Employment Volume 1*, MPG Books Ltd, Cornwall

Eriksson, A. (2000), *Regionala Innovationssystem – Från Teori till Genomförande* (Regional Innovation Systems – from theory to accomplishment), Swedish Office of Science and Technology, Stockholm

Etkzkowitz, H. & Leydesdorff, L. (2000), ”The dynamics of Innovation: from National Systems and Mode 2 to a Triple Helix of University-Industry-Government Relations”, *Research Policy*, 29, 109-123

Feldman, M. & Audretsch, D. (1999), “Innovation in Cities: Science-Based Diversity, Specialization and Localized Competition“, *European Economic Review*, 43, 409-429

Fischer, M. & Johansson, B. (1994), “Networks for Process Innovations by firms: Conjectures from Observations in Three Countries”, in Johansson, B., Karlsson, C. & Westin, L. (eds) (1994), *Patterns of a Network Economy*, Springer-Verlag, Berlin

Fischer, M. (1999), “The Innovation Process and Network Activities of Manufacturing Firms”, in Fischer, M., Suarez-Villa, L. & Steiner, M (eds) (1999), *Innovation, Networks and Localities*, Springer-Verlag, Berlin

Fischer, M., Suarez-Villa, L. & Steiner, M (eds) (1999), *Innovation, Networks and Localities*, Springer-Verlag, Berlin

Fischer, M. & Fröhlich, J. (2001), *Knowledge, Complexity and Innovation Systems*, Springer-Verlag, Berlin

Fischer, M., Revilla-Diez, J. & Snickars, F. (2001), *Metropolitan innovation system: theory and evidence from three metropolitan regions in Europe*, Springer-Verlag, New York

Freeman, C. & Perez, C. (1988), “Structural crises of adjustment: business cycles and investment behavior”, in Dosi, G. *et al*, (1988), *Technical Change and Economic Theory*, Pinter Publishers, London

Freeman, C. (1995), ”The National System of Innovation in Historical Perspective”, *Cambridge Journal of Economics*, 19, 5-24

Freeman, C. (1998), “Innovation”, in Newman, P. (1998), *The New Palgrave Dictionary of Economics and Law*, Macmillian, London

Gregersen, B. & Johnson, B. (1996), “Learning Economies, Innovation Systems and European Integration”, *Regional Studies*, Vol. 31, 479-490

Greenwald, D. (1982), *Encyclopedia of Economics*, McGraw Hill, New York

Griliches, Z. (1979), “Issues in Assessing the Contribution of Research and Development to Productivity Growth”, *Bell Journal of Economics*, 10, 92-116

Halvorsen, K. & Lacave, M. (1998), *Innovation Systems in Urban Areas*, NIBR Working Paper 1998:110

Hansen, N. (2000), *The New Economy – Implications for Peripheral Regions*, Mimeograph, University of Texas

Hauknes, J. (1999), *Innovation Systems and Capabilities*, STEP Working Paper A-10, Oslo

Johansson, B. & Westin, L. (1987), “Technical Change, Location and Trade”, *Papers of the Regional Science Association*, vol. 62, 13-25

Johansson, B. (1992), *Ekonomisk Dynamik i Europa*, Liber-Hermods, Malmö

Johansson, B. (1993), “Economic Networks and Self-Organization”, in Bergman, E., Maier, G. & Tödtling, F. (eds) (1993), *Regions Reconsidered*, Ipswich Book Co Ltd, Suffolk

Johansson, B., Karlsson, C. & Westin, L. (eds) (1994), *Patterns of a Network Economy*, Springer-Verlag, Berlin

Johansson, B. (1998), *Infrastructure, Market Potential and Endogenous Growth*, JIBS, Jönköping

Jonsson, O., Persson, H. & Silbersky, U. (2000), *Innovativitet och Regionen – Företag, Processer och Politik* (Innovativeness and the region – firms, processes and politics), Rapport 121, Swedish Institute for Regional Research, Östersund

Karlsson, C. (1988), “Innovation Adoption and the Product Life Cycle”. *Umeå Economic Studies*, No. 185, University of Umeå

Karlsson, C. & Westin, L. (1994), “Patterns of a Network Economy – an Introduction”, in Johansson, B., Karlsson, C. & Westin, L. (eds) (1994), *Patterns of a Network Economy*, Springer-Verlag, Berlin

Karlsson, C. & Olsson, O. (1996), “Product Innovation in Small and Large Enterprises”, *Small Business Economics*, 10, 31-46

Karlsson, C. & Olsson, M. (2000), *Methods for Identifying Functional Regions – Theory and Applications*, JIBS Working Paper Series No 2000-3, Jönköping

Karlsson, C. & Manduchi, A. (2001), "Knowledge Spillovers in a Spatial Context", in Fischer, M. & Fröhlich, J. (2001), *Knowledge, Complexity and Innovation Systems*, Springer-Verlag, Berlin

Karlsson, C. & Klaesson, J. (2000), "Success in Manufacturing Employment in an Industrial District: Higher Productivity or Lower Wages?", *Investigaciones Europeas de Dirección y Economía de la Empresa*, vol. 6 No. 2, 65-90

Karlsson, C. (2001), *Klusters Betydelse för Industriell & Regional Utveckling* (The Role of Clusters for Industrial & Regional Economic Development), Mimeograph, JIBS

Koschatzky, K. (1998a), "Innovation Networks of Industry and Business-Related Services – Relations between Innovation Intensity of Firms and Regional Inter-firm Cooperation", *European Planning Studies*, 7 , 737-757

Koschatzky, K. (1998b), "Firm Innovation and Region: the Role of Space in Innovation Processes", *International Journal of Innovation Management*, Vol. 2 No. 4, 383-408

Koschatzky, K. (2001), *Regional Development through Entrepreneurship Promotion? The Role of Higher Education Institutes for Stimulating Firm Foundations*, Paper presented at the 41st Congress of the ERSA, Zagreb, Croatia

Lam, A. (1998), *Tacit Knowledge, Organizational Learning and Innovation: a Societal Perspective,* DRUID Working Paper No. 98-22

Leonard, D. & Sensiper, S. (1998), "The Role of Tacit Knowledge in Group Innovation", *California Management Review*, 40, 112-131

Lorenzen, M. (1996), *Communicating Trust in Industrial Districts*, Paper presented in the Erasmus Intensive Seminar, Turin

Lorenzen, M. (1998), *Localized Learning – Why are Inter-Firm Learning Patterns Institutionalized within Particular Localities?*, Mimeograph

Lundvall, B. (1995), "Introduction", in Lundvall, B. (ed) (1995), *National Systems of Innovation – Towards a Theory of Innovation and Interactive Learning*, Biddles Ltd, London

Lundvall, B. (ed) (1995), *National Systems of Innovation – Towards a Theory of Innovation and Interactive Learning*, Biddles Ltd, London

Lundvall, B. & Lindgaard-Christensen, J. (1999), *Extending and Deepening the Analysis of Innovation Systems – With Empirical Illustrations from the DISKO-project"* , DRUID Working Papers No. 99-12

Maillat, D. (1993), "The Innovation Process and the Role of the Milieu", in Bergman, E., Maier, G. & Tödtling, F. (eds) (1993), *Regions Reconsidered*, Ipswich Book Co Ltd, Suffolk

Maillat, D. (1995), "Territorial Dynamic, Innovative Milieus and Regional Policy", *Entrepreneurship & Regional Development*, 7, 157-165

Maillat, D. (1998), "Interactions Between Urban Systems and Localized Productive Systems: an Approach to Endogenous Regional Development in Terms of Innovative Milieu", *European Planning Studies*, 6, 117-129

Malecki, E. & Oinas, P. (2002), "The Evolution of Technologies in Time and Space: From National and Regional to Spatial Innovation Systems", *International Regional Science Review*, 25, 102-131

Markusen, A. (1996), "Sticky Places in Slippery Space: a Typology of Industrial Districts", *Economic Geography*, 72, 293-313

Massey, D., Quintas, P. & Wield, D. (1992), *High Tech Fantasies: Science Parks in society, Science and Space*, Routledge, London

Maurseth, P. & Verspagen, B. (1998), *Knowledge Spillovers in Europe and its Consequences for Systems of Innovation*, ECIS Working Paper No. 98.1

Meeus, M., Oerlemans, L. & van Dijck, J. (1999), *Regional Systems of Innovation from within – an Empirical Specification of the Relation Between Technological Dynamics and Interaction Between Multiple Actors in a Dutch Region*, ECIS Working Paper No. 99.1

Mytelka, L. & Farinelli, F. (2000), *Local Clusters, Innovation Systems and Sustained Competitiveness,* UNU/INTECH Discussion Paper Series

Nelson, R. & Winter, S. (1982), *An evolutionary theory of economic change*, Harvard University Press, Cambridge, Massachusetts

Nelson, R. & Rosenberg, N. (1993), “Technical Innovation and National Systems”, in Nelson, R. (ed) (1993), *National Innovation Systems – a Comparative Analysis*, Oxford University Press, New York

Nelson, R. (ed) (1993), *National Innovation Systems – a Comparative Analysis*, Oxford University Press, New York

Noisi, J. (2000), *Regional Systems of Innovations – Market Pull and Government Push*, Paper presented at the annual meeting of the Canadian Research Network on Regional Innovation Systems 2000, Montreal

Oerlemans, L., Meeus, M. & Boekema, F. (1998), ”Does Networks Matter for Innovation? – the Usefulness of the Economic Network Approach in Analyzing Innovation”, *Tijdschrift voor Economische en Sociale Geografie*, vol. 89 No. 3, 289-309

Porter, M. (1990), *The Competitive Advantage of Nations*, Macmillian, London

Rothwell, R. (1992), “Successful Industrial Innovation: Critical Factors for the 1990s”, *R&D Management*, 22, 3, 221-239

Radosevic, S. (2000), *Regional Innovation Systems in Central and Eastern Europe: Determinants, Organizers and Alignments*, Mimeograph

Storper, M. (1995), “The Resurgence of Regional Economies, Ten Years Later: the Region as a Nexus of Untraded Interdependencies”, *European Urban and Regional Studies*, 2, 191-215

Suranyi-Unger, T. (1982), ”Innovation”, in Greenwald, D. (1982), *Encyclopedia of Economics*, McGraw Hill, New York

Sveriges National Atlas (SNA). (1995), *Industri och Service* (Industry and Services), Italy

Sölvell, Ö., Zander, I. & Porter, M. (1991), *Advantage Sweden*, Nordstedts, Stockholm

Tödtling, F. (1993), “Spatial Differentiation of Innovation – Locational and Structural Factors: Results from an Austrian Study”, in Bergman, E., Maier, G. & Tödtling, F. (eds) (1993), *Regions Reconsidered*, Ipswich Book Co Ltd, Suffolk

Varga, A. (1998), *University Research and Regional Innovation – a Spatial Econometric Analysis of Academic Technology Transfers*, Kluwer Academic Publishers, Massachusetts

von Hippel, E. (1988), *The Sources of Innovation*, Oxford University Press, New York

von Hippel, E. (1998), “Economics of Product Development by Users: the Impact of Sticky Local Information”, *Management Science*, Vol. 44 No.5, 629-644

Wiig, H. (1996), *An Empirical Study of the Innovation System in Finnmark*, STEP Working Paper R-09, Oslo

Wiig, H. & Wood, M. (1995), *What Comprises a Regional Innovation System? – An Empirical Study*, STEP Working Paper R-01, Oslo

Wiig, H. & Isaksen, A. (1998), *Innovation in Ultra-Peripheral Regions: the Case of Finnmark and Rural Areas in Norway*, STEP Report R-02, Oslo