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Abstract

Local innovation networks are considered to be important to innovation and technological change and to growth prospects of regions and cities in Germany. When analysing the local (or regional) innovation system, one should consequently not only investigate horizontal and vertical relations among firms but also the contacts with universities and other research institutions. Furthermore, the role of government agencies and interest groups that provide financial support as well as commercial and technical information should also be taken into account. However, the review of relevant theoretical and empirical investigations related to the German experience shows that such innovation and R&D co-operation networks appear to be less significant than expected. In general various regional technology policy measures adopted in German states (the provision of research infrastructure, establishment of technology centres, innovative SME support programmes, etc.) have been more successful in already economically better-off large cities than in the rural areas. Apart from offering a critical review of relevant theoretical and empirical research, this study introduces the present regional technology and R&D promotion policies in German states and examines the local innovation systems, taking Landshut and Bochum as examples.

Keywords: regional technology policy, local innovation network, Germany

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Introduction

Local or regional economies are presently directed both inwards, to develop their own innovative capacities, and outwards, to compete in global markets (Porter 1990). It is a generally acknowledged fact that the basic innovation carried out by firms creates new industries, drives the business cycle and provides the basis for long-term economic growth (Schumpeter 1961). More precisely, the growth of a region is stimulated by the presence of innovative industries and/or industries in the rapid-growth phase of the product life-cycle, and is retarded by the presence of industries in the slow-growth or declining stage. Additionally, the incidence of introducing new technology is likely to be lower in those regions that are already economically disadvantaged (Tödtling 1990). Apart from varied endowment with infrastructure, the differences in such economic and structural localities among regions do matter, for example, in a (multinational) firm's choice of location and its investment decisions (Simmie 1997).

Unlike science-pushed, linear processes that extend from basic scientific research at one end, through product development and production, to marketing at the other end, network characteristics are now widely considered to be particularly important for innovation and growth prospects of regions (Bergman et al. 1991; Storper 1992; Saxenian 1994; Anselin et al. 1997). Innovation is seen as an evolutionary, systemic process resulting from various, associational interactions among a number of actors in a given region (Cooke and Morgan 2000).[1] Such economic and social links can be considered 'intangible capital' with durability (Karlsson 1995). The establishment of such regional linkages can also be associated with huge sunk costs if the relationship is cancelled or no longer valid (Sternberg 2000). Such a network comprises

- horizontal and vertical relations among firms (e.g. prime contractors, subcontractors, independent enterprises in similar and/or different industries)
- firms' contacts with universities and other research institutions, as well as with technology centres, and
- the role of government agencies (promotion), interest groups (commercial, technical and information support) and lending bodies (the provision of venture capital).

According to Cooke (1998), the regional innovation-system-approach encompasses the concept of 'industrial district', 'innovative milieu' and 'regional learning' to the great extent.

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[1] New technology has also become more complicated. This requires "not only higher standards of knowledge, skills, and experience on the side of R&D [experts] but also forces all innovation actors to communicate [more] intensively" (Pleschak and Stummer 2000, 176).

In general it is said that SMEs profit the most from such an intra-regional co-operation among the different actors (Arndt and Sternberg 2000). Firms in traditional industries with comparatively low innovation intensities have only a minor need to be integrated in networks (Koschatzy and Sternberg 2000).

The regional innovation systems require regional-specific policies to achieve the collective learning among the participants in innovation (Lundvall and Borrás 1997).[2] In most European countries Laredo and Muster (2001) suggested that two main foci of regional innovation policies have been 'acting on the higher educational landscape' and 'SME innovation capabilities' through establishing proximity networks and intermediary structure (see also Turpin and Garrett-Jones 2002).

In addition to a critical review of already-existing theoretical and empirical research under the consideration of the present regional technology and R&D promotion policies in Germany, this study highlights the distinctive characteristics of local innovation systems in two selected German technology areas: the rapidly growing cities of Landshut in Bavaria and Bochum in North Rhine-Westphalia, representing one of several modern technology centres in the traditional industrial region of the Ruhr.

Major Characteristics of Regional Technology Policy in Germany

The importance of innovation in a regional development context is its ability to provide a foundation for new industries: for the creation, broadening and deepening of markets for regional firms by substituting existing goods by new ones. It can also affect costs, quality and reliability. A region in which industrial firms achieve technological progress through the generation, adaptation or adoption of new products is seen to have a competitive advantage over others making slower progress. (Wynarczyk, Thwaites and Wynarczyk 1997). Therefore, the activation and utilisation of endogenous innovation potentials for regional development has been a major challenge for a technology-oriented regional policy (Koschatzky 1994).

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[2] "Local innovation conditions and [...] patterns are determined by the general socio-cultural and economic [environment], the individual actors and their interactions, as well as the knowledge base, including codified and tacit [ones]. Consequently, no regional system [fully] resembles another; instead, each one has [more or less] specific characteristics, and thus follows its own development path" (Zenker 2000, 218).

According to Koschatzky and Gundrum (1997), public (regional)[3] technology and innovation promotion can have three major tasks:

- activation of potential regional resources for development and application of new technology,
- inter-linkage of region-specific resources in regional innovation networks that comprise all the relevant actors in industry, science and policy, and
- integration of regional networks into supra-regional technology co-operation systems.[4]

Public research infrastructure has been seen as a public good, which should preferably be provided by governments due to the market failure. Positive external effects are also expected from the endowment of research infrastructure and the promotion of basic R&D activities. Therefore, German states (*Länder*) have traditionally been responsible for establishing the public infrastructure of technology institutions that provide services for industry, especially through the technology-transfer centres linking universities and research centres with SMEs (Grotz and Braun 1997). In addition to the strategies like subsidising technological development and innovation activities of private firms and providing research centres publicly (especially for the so-called key-technologies), German regional governments have supported the flexible adaptation of basic research outcomes and rapid adjustment of SMEs to new challenges. These changes have been created by the 'technology-push' and 'demand-pull' in the market (Fischer 1995). Such a 'diffusion-oriented' aspect has gradually gained importance in the German regional technology policymaking (Sternberg 1995; Reinhard and Schmalholz 1996; Cooke and Morgan 1998). On the other hand, it is argued in line with the so-called subsidiarity principle that the regional government should withdraw from such types of innovation network promotion when these could be better organised by economic forces alone (Koschatzky 2000).

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[3] The German federal government also directly supports the establishment of regional/local innovation networks. The so-called BioRegio contest initiated in 1996 is an example. "Its major objective was to stimulate firm foundations and the location of foreign biotechnology companies in Germany, to accelerate growth in existing biotechnology enterprises and to ensure the supply of sufficient seed and venture capital to improve the competitive situation of Germany in biotechnology. In a competition procedure three regions with appropriate research potential were selected: Munich, the Rhine-Neckar Triangle (Heidelberg, Ludwigshafen, Mannheim) and the Rhineland (Cologne, Aachen, Düsseldorf, Wuppertal), each [was] subsidised with 50 million DM by the Federal Ministry of Education and Research (BMBF) until 2001" (Koschatzky 2000, 14).

[4] "The success or failure of innovation and technology policy measures supporting the network concept is decisively dependent on reaching a broad consensus of all relevant actors in policy, industry and science at an earlier stage ... It is also important to jointly identify priority areas and fields of action. Concrete policy measures for support should be defined on this basis as well" (Walter 2000, 119).

Apart from the generally acknowledged fact that SMEs suffer particularly from the rapid technological development processes and the consequent organisational changes, most regional policymakers in Germany also assume that the strong locational dependency of small firms leads to the 'bounded vision'. This is characterised, for example, by a lack of awareness of innovation possibilities caused by the limited resource and knowledge bases and expertise, etc. (Wiig and Wood 1997). However, Pavitt et al. (1987) suggest that small firms have also been able to introduce new products over time. Moreover Rothwell (1986) emphasises that SMEs are important agents in the technology diffusion where they take innovations made elsewhere and present them in various forms essential in meeting customers' needs. Therefore, small and innovative firms are often seen as a potentially powerful force in local economic change (Wynarczyk, Thwaites and Wynarczyk 1997).

However, there are also some disputes surrounding the technology promotion of SMEs as a long-term strategy for solving regional economic problems. Leaving aside the high insolvency rates in recent years among SMEs (Gray 1992; Plougmann 1994), the large firm size is generally acknowledged as a prerequisite for technological change and economic progress.[5] Large internationally-active companies have a greater ability to provide capital, information and experts. They can also well spread the innovation risks over a number of R&D projects.

Furthermore there are controversies in Germany surrounding the extent to which the state technology promotion system — aimed at supporting the new establishment of innovative firms and research institutions in economically less-developed areas — reduces the existing disparities among regions. The effects of local or regional co-operation depends on the concrete needs and the availability of partners that match these demands. Therefore, increasing the number of co-operative relationships or the share of partners within a region as well as supporting the formalisation of local clusters cannot always be recommended as a strategy (see also Grabher and Stark 1997).[6] In many cases the regional and local innovation systems are 'path dependent',[7] although in cases such as where a region is dominated by declining industries or agricultural production, radical government intervention may be required to modernise its economic structure (Turpin and Garrett-Jones 2002).

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[5] A variety of empirical studies suggest that large-scale companies are also at an advantage in comparison with SMEs regarding the access to external knowledge (Koschatzky and Zenker 1999).

[6] According to Herden (1992), networking between the different actors is particularly strong in regions that are economically highly developed.

There have been discussions in Germany about advantages and disadvantages of the regional technology development programme (see Box 1).

Box 1 **Research and Technology Policy in Bavaria: An Overview**

Technological progress and innovation are the basis of competitiveness. Bavarian industries can only overcome the existing competitive disadvantage caused by higher wages by continuously supplying high-quality products and services in world market. For this reason, promotion of research activities has been seen as one of the key strategies to guarantee the region's future development. Since the beginning of the 1980s, in order to support R&D, the Bavarian state government has placed strong political emphasis on:

- expansion of universities and research institutes carrying out urgently needed R&D activities and of future importance for the region (like micro-electronics, information and telecommunication, software development, media, biochemistry and environmental technology, etc.)
- establishment of technology-transfer centres to transmit the applicable advanced know-how (developed in universities and research institutes) to private firms,
- development of state government programmes to promote the innovation and research activities of SMEs, including:
  - the Bavarian innovation support programme to promote firms' development of new technologies for marketable products,
  - the Bavarian technology introduction programme to ease the market penetration of newly developed products,
  - the Bavarian subsidy programme for the promotion of rational energy production,
  - the Bavarian programme to support the establishment of technology-oriented companies,
  - the SME business technology advice programme to financially support the procurement of the external consulting services required in the application of new technologies to company-specific processes and products (Bayerisches Staatsministerium für Wirtschaft, Verkehr und Technologie 1998).

This Bavarian style of technology policy has functioned relatively well in the state-specific economic framework in which a few large leading industrial firms combined with a strong SME-base to serve as an engine for regional economic and technology development. In addition, this policy has provided favourable business circumstances for the success of innovative Bavarian SMEs and enhanced their competitiveness on the global market.

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[7] Innovation and technological development in a region is path dependent in the sense that a further step in their process is based on knowledge previously acquired or generated in the same region.

The major disadvantages of technology policy on the regional level include, for example:

- disturbance of the free market mechanism and allocation efficiency,
- creation of new jobs in a limited number of cases,
- generation of a culture of dependence, and
- R&D promotion in declining industrial sectors (e.g. coal mining, iron and steel, shipbuilding, etc.) that delays the necessary, immediate structural changes required for long-term growth.

On the other hand, these promotion measures have been positively assessed since they

- provide local firms an opportunity to enter new technology and production fields,
- financially support SMEs and create employment in high-tech sectors, and

enable co-operation and technology transfer between firms and research institutions, etc. (Kerlen 1995).

Brief Theoretical and Empirical Background on the Local Innovation System in Germany

In addition to the direct financial assistance and the quality and availability of regional and/or local R&D infrastructure, the success of innovation is generally seen as the outcome of durable interactions and networks among innovating firms and their partners, universities and technology-transfer centres for diffusing technologies, business service firms, etc., which create a sort of innovation system (OECD 1992; Wiig and Wood 1997; Fritsch and Lukas 1999; Arndt and Sternberg 2000). Apart from enhancing regional and/or local creativity, this type of co-operation system also acts as 'an uncertainty-reducing operator' (Grotz and Braun 1997) that reduces the risks related to rapid market development and increasing technological complexity and competition.[8]

Furthermore, the concept of agglomeration economies and the incubator hypothesis have been applied to explain why the local- and regional-level innovation performance of firms and economic growth are influenced by economies generated by the spatial proximity of the actors and associated externalities (Koschatzky and Sternberg 2000; Fritsch 2001). Such a geographical concentration allows for the better exploitation of the 'dynamic relative advantages' in developing the skills and know-how of a given

[8] Co-operation is also problematic: own strategies are revealed, independence is reduced and additional expenditures are necessary for co-ordination and communication with partners (Pleschak and Stummer 2000).

territory that arise from the synergetic relationship between actors in the innovation system and economies of scale in the provision of innovation services and support.[9] Large cities especially seem to provide excellent conditions for firms' innovation activities. Companies located in those central places have easy and speedy (low transport-costs) business and information access to other service and industrial firms (suppliers, distributors, etc.) or to government and research institutions. In addition, the denser the economic activity in an area surrounding a firm, the greater the probability of there being a large number of innovation suppliers. The recruitment of a specialised labour force is also convenient in such urban areas: modern industrial and (high-value) service firms "that are growing quickly need to be able to recruit specialised, experienced and skilled professionals who can meet specific requirements" (Mills and McDonald 1992, 42). It has quite often been suggested that a large number of innovations have emerged recently from the complex knowledge base embodied in the highly-educated professional workforce that has chosen to live in and around those large city areas. Moreover, technology information can be transmitted from one innovating firm to another as these skilled professionals switch jobs within a geographical enclave, a process described as the 'Marshall-Arrow-Romer externality of knowledge spill-overs between firms' (Glaeser et al. 1992). As a consequence, internationally competitive innovations seem mainly to have arisen in large metropolitan areas or their immediate surroundings. For this reason, some regional economists have attempted to apply an 'epidemic-hierarchical' model to describe the subsequent diffusion of innovations down through more minor nodes in international and national urban hierarchies (Simmie 1997; Fritsch 2000).

In contrast to those pronounced theoretical arguments regarding the innovation network systems shown in Table 1, some empirical analyses suggest that the spatial proximity of firms to the technology-oriented partners (like research institutes or other private firms) does not always make a significant contribution to the firms' innovation and R&D activities (Wolff et al. 1991; Hahn et al. 1995). Furthermore, many small firms in Germany are so highly specialised that they can hardly find a regional partner suitable for co-operation (Grotz and Braun 1997). All this immediately indicates that although such regional and/or local networks enable indigenous firms to tap into local expertise and knowledge, they need to be linked to interregional and international networks if they are to remain innovative in the long-run and avoid the 'entropic death' especially in a global

[9] In particular spatial proximity plays a role in the transfer of implicit, non-codified knowledge. "It is argued that codified knowledge, e.g. embedded in standardised technologies, can be transferred over long distance costs, especially when the knowledge receiver is able to understand and read the code. Spatial proximity between user and producer is not necessary. Tacit knowledge, on the other hand, is only transferable through interpersonal contacts and verbal or non-verbal communication .... Spatial, social, and cultural proximity is a major precondition for this transmission process" (Koschatzky 2000, 7).

context (Camagni 1991).[10] Successful 'global regions' appear to be those whose networks incorporate an adequate supply of high-quality knowledge resources along with the ability and willingness on the part of local firms to make use of external sources of knowledge with a clear focus on innovation (Nelson 1994). Such types of global-national-regional innovation and technology networks are generally of different relevance to various local actors and, as Huggins (1997) suggests, it is SMEs that will have most to gain from the tight connection of regional systems to not only the national but also to the international actors.

Apart from providing for close co-operation with universities and research institutes, as well as for technology transfer and consulting services (see below), the German technology and innovation centres have also sought to play the role of incubator in the new establishment of SMEs. In other words, policies of such high-tech centres focus on the mobilisation and enhancement of local technological and industrial resources and are mainly targeted at creating small new technology-based firms. In the context of the public-private partnership, local authorities (i.e. city or municipal governments), private firms and the local Chamber of Commerce (IHK) are mostly the major sponsors in the development of these centres, and there is rather limited involvement from the universities (Sternberg 1995; Oh and Masser 1995). For a limited period of time (e.g. three to five years), these innovation centres usually provide offices and other commercial facilities at reasonable rents to make the setting-up of technology-oriented firms more convenient. There are presently around 100 such types of facilities (*Technologie- und Gründerzentrum*) in Germany with 1,800 firms and 15,000 employees. "For regions faced with a high concentration of older, declining ... industries [these innovation centres] have been viewed as a tool for facilitating economic restructuring through the incubation of new technology based ... [SMEs]. For other regions whose economies have been performing well, investment in the new innovation capacities of new technology in [these innovation] centres may represent a long-term insurance policy" (Oh and Masser 1995, 299). The many previous studies evaluating the effectiveness of German innovation centres as instruments of regional innovation policy and technology-led economic development have generally been positive about the support given to start-up firms, the value added to the local economy (especially in old industrial areas) and the so-called

[10] Among a number of global factors that have recently led to the emergence of international dimensions of innovation, "[t]he harmonisation of intellectual property legislation, driven by [WTO] and the agreement on trade-related aspects of intellectual property rights (TRIP), has been particularly significant. ... To the extent that intellectual property rights regulations are becoming indistinguishable and equally enforceable in all locations, national borders are becoming less important as boundaries to the production and diffusion of knowledge. Under these conditions the transnational corporations can develop strong alliances with firms or institutions, or innovation sub-systems (Edquist 1997) in the vari-

multiplier effects derived from the concentration of highly-qualified professional employment in those centres (Sternberg 1988 and 1990; Fiedler and Wodtke 1991).

Table 1 **Summary of Characteristics of Innovation Systems Theories**

Subject	Industrial district theory	Innovative milieu	Innovation systems
Concept of the actor	Actors are independent flexible organisations.	Actors are Schumpeterian entrepreneurs.	Actors are learning organisations.
Concept of the spatial environment	Environment consist of other actors to establish social links with.	Environment consists of resources which facilitate the economic process.	Environment is a macro- and meso-economic system of institutions.
Relations between innovation and environment	Through social links and networks of actors, information, knowledge, standards, etc. are communicated and distributed.	Depending on nature of innovations and technology, environment is a supply of resources or a supporting production system.	Institutions, proximity and diversity of resources stimulate or restrict interactive communication, learning and innovation in regions.
Spatial concentration mechanism	Districts are a way in which a production organisation can compete internationally.	Innovation milieus are an effect of the capacity of certain regions to better result of the learning processes and to realise lower information costs.	Spatial proximity stimulates interactive learning as a result of the characteristics of technological change. The meso-institutional system supports the emergence and the application of new forms of production.

Source: Mohannak and Turpin (2002), Contemporary Perspectives and Debates, in: Turpin et al. (Eds.), Innovation, Technology Policy and Regional Development, Cheltenham and Northampton.

On the other hand, with a few exceptions (for example Dortmund), the scale of German innovation centres is relatively small compared to the more spatially-concentrated ones in the US (i.e. Silicon Valley) and France (i.e. Sophia Antipolis). Nevertheless, many centres in the western part of Germany do not fully utilise the capacity of commercial sites for new firms. In addition, assessments have largely shown that the employment effects on the regional labour market led by incubator activities are less important than expected, partly because many of the centres dispersed all over the nation are relatively small. In other words, the German regions do not show the so-called Cambridge phe-

ous countries. Such alliances provide a bridge between the transnational system and innovation activities that would be *contained* by state boundaries" (Turpin and Garrett-Jones 2002).

nomenon, which describes the economic boom and technology-orientation of an entire region following the establishment of technology parks.

As innovation depends significantly upon information and knowledge; these 'invisible' elements have emerged as important determinants of regional development (Nijikamp et al. 1994). "Interactions across industrial networks appear to be particularly rich in information and knowledge, with synergies creating further knowledge and often resulting in dynamic technical accumulation and production improvement..." (Huggins 1997, 103). Although co-operation in innovation activities and the establishment of common R&D networks among (particularly small-sized) firms (with partners, suppliers, etc.) seem to achieve economies of scale, firms in Germany tend to avoid close contacts with others when developing new technologies, products and processes. The so-called horizontal co-operation between industrial firms in similar fields seems to occur in a limited way in Germany, despite the gradual recent increase in the role played by large German industrial firms as 'technology suppliers' (Wolff et al. 1991). Apart from the aforementioned fact that a high degree of specialisation leaves many innovative firms almost unable to find suitable partners in a region, this type of 'egoistic behaviour' can also be justified by, for example:

- the achievement of a leading position in the innovation competition with other firms, and the further maintenance of competence in the market,
- the emergence of problems in co-operation with other partners reflecting differences in the setting of major R&D objectives and related solution systems.

However, in practice it is quite common for those firms that prefer internal means of technology development to recruit (external) R&D experts from research institutions and/or other (particularly large) firms with successful innovation experiences.

In Germany, the external procurement of technological knowledge and the results of R&D — from other firms and (private and public) research institutions, via technology-transfer centres and business-service companies — has gradually gained importance since the beginning of the 1980s. This trend can be observed in modern high-tech industries such as information technology, biotechnology, materials engineering and the automobile industry (Mytelka 1991; Hagedoorn 1995; Reinhard and Schmalholz 1996). Major reasons for the preference of this type of innovation-oriented co-operation among individual firms include:

- the increasing complexity and inter-sectoral character of new technologies,
- the reduction of product life-cycles forcing firms to establish rapid, just-time connections to the new technology required for production,

- the efforts to reduce costs and to avoid risks related to technological development and consequently the constraints on R&D capacity,
- the easy observation of complementary and/or substitutive technologies and product markets, etc.

The major services provided by external suppliers of technology also include the related information, consulting services and company-specific assistance required for in-house adaptation of new production technologies. Technology transfer is generally said to be efficient when there are simultaneous exchanges of information between those supplying and demanding technology within the innovation network. Table 2 summarises the typical exchange channels of technology know-how and information, as well as related consulting advice among these actors. It also suggests the functions played in the technology transfer system by (technology) suppliers and demanders, as well as mediators.

As mentioned before, technological co-operation and innovation-oriented linkage between suppliers and customers has been quite relevant in Germany and its regions (Wolff et al. 1991; Hahn et al. 1995; Grotz and Braun 1997). The establishment of such co-operation links has recently been triggered by restructuring and the move of large firms towards 'lean production', prompting the externalisation of certain production processes and service activities (Malecki and Tödtling 1995). In many cases, suppliers (i.e. generally SMEs) are forced by their customers (i.e. mainly large international firms) to integrate new technological developments as well as to adjust their products and marketing strategies (Table 3). This, in turn, increased the need for SMEs to innovate and to gain flexibility in their operation. In this context, these large firms appear to play the leading role in the innovation process of the economy of region in which those suppliers are located.

Although SMEs generally benefit more than large firms from the technology information and advice provided by the local technology-transfer centres, a number of experts in Germany criticise the centres for their inadequate integration into the innovation process of those local SMEs and the regional technology network (Staudt et al., 1993). In addition, the quality of their consultancy is often assessed as needing improvement, because the services do not adequately meet the urgent needs of SMEs in many cases (Staudt et al. 1996). According to such discontented opinions, the transfer centres are not familiar with the R&D activities and specialisation of SMEs in the region, partly because of the lack of long-standing formal and informal communication between these two actors. Furthermore, the centres are asked to take the first steps towards actively determining the innovation and technology needs and demands of firms, instead of confining themselves to responding passively to specific firms' requests.

Table 2 **The Innovation and Technology Transfer Network and the Different Tasks of the Individual Actors**

Functions	Tasks of ...		Business services for firms and for research institutes by ...
	technology supplier	technology demander	external technology mediator
Technology and information transfer	New technology and other results of research and active dissemination of knowledge Information on: • technology application, potential markets, branches and firms, • financial aspects for further development and innovation	Information about • products for future markets • technology needs • existing technological knowledge in firm • financial constraints for further development and innovation Innovation management and organisation in firms	Provision of information about • technology application, potential markets, branches and firms • existing technological knowledge in firms, branches, markets and also in research institutions • financial aspects for further development and innovation
Consulting services and further support in implementation	• Patent registration • Efficient application and implementation of technology in firms' specific production systems • Agreement on further co-operation in the fields of technology application • Assistance in the establishment of firms or within projects • Transfer-oriented training	Information about economic and technological success in the new production system and/or related firms' specific problems	• Consulting services for firms' regarding innovation management, new establishment, etc. • Advice for technology suppliers about the market-oriented technology management • Assistance for firms related to patent registration, the efficient application and implementation of technology in firms' specific production systems, problem-solving within projects and transfer-oriented training

Source: Reinhard and Schmalholz (1996), Technologietransfer in Deutschland. Stand und Bedarf, Munich; Kerlen (1994), Experience with Technology Transfer in Highly Industrialized Regions. The Case of North Rhine-Westphalia, Hanover

Table 3 **Inter-firm Research, Technology Co-operation Agreements and the R&D, Production and Marketing Spectrum**

Research and development co-operation			Technological co-operation			Manufacturing and marketing co-operation		
Type 1	Type 2	Type 3	Type a	Type b	Type c	Type i	Type ii	Type iii
University based co-operative research financed by associated firms (with or without public support)	Government-industry co-operative R&D projects with universities and public research institutes	Establishment of R&D corporations on a private joint-venture basis	Corporate venture capital in small high-tech firms (by one or several firms)	Non-equity co-operative R&D agreements between two firms in selected areas	Technical agreements between firms concerning completed technology, incl. technology sharing, two-way- and/or cross-licensing in separate product markets	Industrial joint venture firms and comprehensive R&D, manufacturing and marketing consortia	Customer-supplier agreements notably partnership	One-way licensing and/or marketing agreements
Many partners		Several partners	Few or very few partners			Few or very few partners		

Sources: OECD (1986), Technical Cooperation Agreements Between Firms: Some Initial Data and Analyses, Paris

Local Innovation System in Small German Cities — Landshut and Bochum[11]

The Landshut region has experienced a rapid structural change from an agricultural to a modern industrial region. Many firms in this area have traditionally been suppliers of intermediate goods to large internationally-known Bavarian firms like Siemens, BMW, MAN, MBB and Audi, which are located in the larger surrounding city regions of Regensburg, Nuremberg, Ingolstadt and Munich. As a consequence, firms in Landshut have quite well-established (formal and informal) co-operation with these large firms in technology development and transfer. To a great extent, SMEs located in Landshut are forced to supply high-quality intermediate products and parts that correspond in quality to the end-products of these large firms.

Large firms like Opel and Nokia in Bochum have also been playing the leading role in the local innovation system. Their position has become stronger in recent years as they have gradually outsourced production activities within the city region. In particular, they expect, from their local suppliers, the 'just-in-time' delivery of high-quality parts (see also below). Such large firms not only gain innovation ideas and new technology from their headquarters but also utilise their own R&D capacities to develop new products, parts, design, etc., which better satisfy the specific needs of consumers in their major market segments. After successful in-house innovation, managers of these large firms examine whether new products (or assembly parts) can be produced (at lower costs but the same quality) by suppliers in the region or other parts of Germany. In the affirmative case, they give sub-contracts to small-scale suppliers. However, such types of 'vertical' business relationship with suppliers have been based on projects in many cases.

Many high-tech SMEs located in Landshut act as global players. These technology-based firms acquire innovative ideas, for example from firms and research institutions in the US, and compete against European and Asian firms on the world market by adopting these ideas in product development. Although these modern SMEs have usually carried out the development of new products (or intermediates) 'in-house', the final assembly has increasingly been outsourced, for example to partners in the same or related industries in neighbouring countries like the Czech Republic. This business strategy aims at achieving market presence and cost savings at the same time. Also, because of their limited production capacity, SMEs in Landshut often produce a small number of high-quality products 'just-in-time' on an order basis; a fact which forces them to be

[11] Analyses of the local innovation system in Landshut and Bochum are carried out mainly on the basis of expert interviews conducted among ten selected high-tech-oriented SMEs as well as in the large firms mentioned in the text, in research institutions and among local policy-makers and interest groups in the individual city-regions.

flexible in production processes and product modification. To guarantee such flexibility and reduce business risks, these firms have also established a sort of vertical (supply) network with their intact sub-contractors.

As regards firms' horizontal co-operative relationship within a group of similar industries in Landshut, relatively active exchanges of experience have recently taken place in the field of innovation management and organisation, etc. However there has been only limited direct, true transmission of technology between indigenous firms, with the exception of, for example, the between-company mobility of high-tech experts.

The economic development of Landshut has largely been determined by the fact that Munich, Nuremberg, Regensburg and Ingolstadt have more modern economic structures and are better endowed with basic R&D infrastructure in the form of universities, research institutions, etc. Furthermore, as a consequence of the short travel time to these technology and modern industrial centres in Bavaria, firms in Landshut have always had easy interregional access to the required information about technology development.

The two technology-transfer institutions located in Landshut — *Fachhochschule Landshut* and *Landesgewerbeanstalt (LGA)* — are to some extent in competition with each other. The former additionally provides various courses related to innovation and technological development but its education schedule appears to be concentrated on the basic training of the engineers required by large Bavarian firms. Some rapidly-growing modern SMEs in Landshut complain that graduates of this polytechnic university are often less creative in practice, when generating new products and implementing innovative ideas. A few relatively-large firms in Landshut (including Hitachi) benefit from close contacts with teaching staff of the *Fachhochschule* when recruiting new, qualified personnel.[12]

The large firms interviewed are satisfied with the endowment of technology and research infrastructure in Bochum. However, in regard to the direct transmission of new technology know-how and innovation ideas, it is quite often suggested that these large firms have rather loose contacts with universities, *Fachhochschule* and technology-transfer centres located in the region and in the surrounding cities. In Bochum, research activities are often carried out in the form of closed-shops. Large ones carry out their own applied research, which is of immediate need in product development or modifica-

[12] Instructors and students of this polytechnic are often present in local firms to conduct laboratory sessions scheduled in the corresponding teaching and learning programmes. Highly qualified managers and technical experts employed in these firms are also involved in the *Fachhochschule's* education programme as adjunct faculty, and/or invited research and thesis supervisors.

tion, while universities do basic research separately. Unfortunately, there has been insufficient mutual exchange of research results between these two actors, unlike the usual cases in the US where the mutual co-operation in R&D activities and the application of results have been better established between firms and universities.[13]

Most SMEs interviewed in the Bochum city region produce highly sophisticated intermediate goods and complain about the very time-consuming nature of co-operation with universities in the fields of product development. They find universities less flexible and slow to react to immediate problems the firms are facing. It is partly for this reason that some (well-established) small firms in Bochum also carry out innovation activities 'in-house'. Nevertheless, in many cases, these SMEs share basic testing and measuring instruments with universities because of the expense of such modern R&D equipment.

Bochum's technology-transfer centres with an incubator function (like the *Cooperationsgesellschaft Hochschulen und Industrielle Praxis:* CHIP[14]) generally enjoy a good reputation as major external mediators, especially for new entrepreneurs in the region, and provide the following advantages, which reflect the proximity to the university:

- easy implementation for the potential market of product ideas from the university,
- efficient division of tasks and effective co-operation through the research network,
- common usage of laboratories in the university, personal contacts, exchange of information and experiences as well as feed-back among researchers, businessmen, etc.,
- easy access to bank credits for new entrepreneurs,
- easy recruitment of young, well-qualified R&D staff directly from the university, which particularly provides incentives for the location in the technology centre, etc.

However, the activities of high-tech SMEs located in the centre have generally taken place independently from one company to another, following the specific interest of individual firms. The synergy effects which were originally expected from tackling common innovative projects by several SMEs within a centre and in co-operation with universities have unfortunately been quite scant in previous years.

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[13] Moreover, these large firms also have little experience with the external (private) providers of business services. Closer co-operation is expected in the future, however.

[14] The CHIP, established in 1991 and financed by indigenous industrial firms and the Bochum IHK, also sees its role as being the mediation of information exchange and personal contacts. This institution organises regular seminars on the latest research results from the university.

In addition, a number of private business service firms in and around Landshut play the role of local technology mediator. Many SMEs in the industrial sector that have experience with these business service firms on a project basis seem generally satisfied with their expertise and plan to co-operate intensively in the future. However, when interviewed, local high-tech firms quite often complain that the services provided by these private technology mediators in previous years made little contribution to solving firm-specific problems related to the application of new technologies in the production process.

The Bochum Chamber of Industry and Trade (IHK) provides the service of examining the applicability of new ideas to the marketable products and the eligibility of potential new entrepreneurs (regarding the possessed state of technology, target markets, business experiences, qualifications, etc.). In the case of a positive judgement, the Bochum IHK and state government of North Rhine-Westphalia promote (the latter financially) the development of products and the establishment of eligible firms. However, in the experience of the interviewed SMEs, the practical introduction of a new development onto the market generally takes more than one-and-a half years after product innovation (or the establishment of a new firm). In some cases, large firms with R&D facilities could adopt these innovation ideas for practical application more rapidly and, as a consequence, shorten the time required for market penetration. Furthermore, SMEs in Landshut generally want the Chamber of Industry and Trade *(IHK für Niederbayern)* and the regional government in Lower Bavaria to be more active in providing relevant information and promoting technology development, although most investigated SMEs are quite satisfied with the flexibility previously shown by the Chamber in managing those activities.

Bavaria's SME-oriented technology policy aimed at supporting R&D activities and the implementation of new technologies in the production and commercialisation process appears to have been quite helpful for the promoted firms in Landshut, though the latter consider that it needs to be more transparent and project-oriented. Since the collection of specific information about new technology, changes in market needs and regulations world-wide is time-consuming and very costly, many SMEs in Landshut want the different (federal, state and local) levels of German governments to join other local industrial and commercial associations in partly relieving them of these tasks. As an extra way of raising the efficiency of current Bavarian technology policy, experts favouring the concept of central place and economies of scale argue for a stronger concentration of financial means at a reduced number of already-established large technology poles such as Munich and Nuremberg (with better future prospects). From the point of view of the few existing local firms, Landshut has no urgent need to be equipped with new R&D

infrastructure, since firms located in this area have direct access to the technology centres in the larger surrounding agglomerations named above.
The general assessment from the large firms and investigated SMEs in Bochum is that the general investment and technology-promotion schemes provided by the state government of North Rhine-Westphalia have been quite helpful for their business activities, albeit the effects of the latter has been less important than those of the former. The technology-related information a large firm needs is generally collected by the firm itself. In the opinion of several high-tech SMEs in Bochum, some basic institutional changes are necessary if German regions wish to develop a well-functioning technology and information transfer network between the regional government, universities, research institutes and private firms, as it is the case in the US and Japan.

Conclusions

The role of the local innovation and technology co-operation network seems to be less significant than expected in the investigated city regions of Landshut and Bochum, although a well-established network is a recognised prerequisite for continuous regional economic development in Germany. This concluding assessment is comparable with the major outcomes of similar research carried out recently for several different German city regions such as the surroundings of the Lake Constance and Neckar-Alb (Baden-Württemberg), Aachen (North Rhine-Westphalia), Lüneburg-Celle (Lower Saxony), etc. (Hahn et al. 1995; Staudt et al. 1996; Grotz and Braun 1997; Koschatzky and Sternberg 2000). In these areas a 'fragmented innovation system' is still persistent, which means that, although individual actors largely exist, their co-operation with each other is insufficient (see also Zenker 2000). Consequently, the following findings of the present study appear to be more or less universally applicable to small German city regions:

- The establishment of common R&D networks among firms to realise economies of scale is generally limited. In many cases even the collection of the latest technology information is also carried out by firms; although firms' external procurement of technological know-how and R&D results are gradually gaining importance.
- The existing, relative stable innovation-linkages are mainly the 'customer and supplier relationship' between large (international) high-tech firms and local SMEs. Yet the spatial proximity appears to be less important in this case (see also Fritsch, 2001). In the future such vertical technological co-operation and joint product development is expected to be intensified, but this will increasingly be of a national and international character.

- The local milieu appears to be important for exchanges of information about management and organisation as well as marketing strategies, while innovative firms (also SMEs) more commonly look for interregional or international contacts. This fact again asserts that knowledge-intensive firms need not only local but also trans-territorial networks (Capello 1996).
- Technology transfer centres, universities and private technology consulting firms have been playing a less crucial role as solvers of the local firms' specific problems related to the development of new products or adoption of new technologies. The benefits of making co-operative innovation and technology development based on cost- and know-how-sharing between research institutions and firms are underestimated (see also Arndt and Sternberg 2000). The contribution of universities as the basic local R&D infrastructure and the provider of high-quality workforces to technical progress in the regional economy is assessed positive. Technology and innovation centres have been judged to be crucial for new local entrepreneurs but the synergy effects initially anticipated from tackling of common large-scale innovation projects by several SMEs within the centre, in co-operation with neighbouring universities, have unfortunately been less remarkable.

The different types of — primarily R&D-, SME- and modern infrastructure-oriented industrial and — technology policy measures implemented in German states appear to have improved the regions' competitiveness and contributed to the establishment of new, small-scale innovative firms and job creation, the stimulation of SMEs' innovation activities and application of technologies and the modernisation of industrial structure, as well as economic and technology development in these states (see also Maier 1989; Grabow, Heuer and Kühn 1990; Semlinger 1993; Shams 1995).

It is likely that the growth poles (or 'islands of innovation', e.g. the city regions of Munich and Nuremberg in Bavaria, Stuttgart in Baden-Württemberg, Berlin, Hamburg, etc.) on which high-tech firms with better 'absorptive capacity of knowledge' (Cooke and Morgan 1998, 16) and research facilities are concentrated, benefit continuously from those regional (as well as national) R&D promotion programmes. This suggests that those technology policy measures have been more successful in the regions already better-off economically. On the other hand, the so-called 'innovation-oriented' regional policy measures in Germany designed to stimulate the rapid establishment of local technology networks (incl. the establishment of new innovative SMEs) in those less-developed (peripheral rural) areas have remained less successful, because in many cases they lack a sufficient mass of know-how, skills and finance, a socio-cultural and institutional infrastructure and a certain degree of entrepreneurial tradition which can not easily be generated by public intervention within a short period of time (Amin and Thrift

1994; Sternberg 1995; Grotz and Braun 1997). Furthermore, the structural transformation of an old industrial region like the Ruhr area to a modern high-tech one through intensive promotion of technology appears to require a much longer time than initially anticipated in Germany, although "Ruhr-based firms spawned large numbers of innovation activities themselves, and in their suppliers, as they diversified into innovative technologies after the 1980s steel crisis" (Cooke 1996, 162).

Additionally, in order to promote the innovation activities of firms and to better exploit technological potentials, the following proposals have been made and should be considered thoroughly in future R&D and technology policy-making:

- efficiency enhancement of technology-transfer centres and their services through greater transparency of activities and structure,
- stronger, project-oriented promotion of innovation and R&D activities of SMEs which particularly produces applicable results for the market,
- simplification of administrative and bureaucratic procedures required for the approval of the projects to be promoted,
- stimulation of more positive public attitude towards rapid technological development and innovative SMEs,
- more intensive support for the development of human capital required for firms' innovation management by focusing on the direct institutional links between universities/technical schools and companies, and
- more-systematic public provision of specific information on the latest technological developments especially for SMEs (including the easy access to databanks of existing patents), also in co-operation with universities and technological-transfer centres as well as industrial organisations like the IHK.

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