Regional Technology Policy and Factors Shaping Local Innovation Networks in Small German Cities

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Abstract

Local innovation networks have been considered to be particularly important to innovation and technological change and to the growth prospects of regions and cities in Germany. Accordingly, innovation is a process that results from various (economic and social) interactions of different institutions located in a given region. When analysing the local (or regional) innovation system, one should consequently not only investigate the (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 in the context of the regional innovation system. However, the review of relevant theoretical and empirical investigations related to the German experience shows that such innovation and R&D cooperation networks appear to be less significant than expected. In particular those high-tech firms in small-sized German cities have direct access to the *international* innovation network, which quite often has made a more crucial contribution to their business performances than the regional and national ones have. 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 but failed to establish a significant intra-technological cooperation among partners in the rather less-developed areas which lack sufficient know-how, socio-cultural and institutional infrastructure and a certain degree of entrepreneurial tradition. 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 distinctive characteristics of the local innovation system, emphasising the experiences of two small cities, Landshut and Bochum.

Keywords: regional technology policy, local innovation network, Germany, Landshut, Bochum

JEL Classification: L52; O31; O38; R11; R58

Introduction

In the regional and local context, much attention has been devoted to technological development as well as product and process innovation as the necessary conditions for the stimulation of economic growth and the enhancement of competitiveness in the rapidly-changing international economic framework. In other words, local economies are now facing both inwards, in developing their own innovative capacities, and outwards, to compete in global markets (Porter 1990).

It has traditionally been argued that the basic innovation carried out by the entrepreneur leads to the creation of new industries, drives the business cycle and provides the basis for long-term economic growth (Schumpeter 1961). According to this logic, 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 decline stage. Additionally, the incidence of introducing new technology is likely to be lower in those regions that are already disadvantaged economically (Tödtling 1990). Apart from varied endowment with infrastructure, the differences in such economic and structural localities among regions are significant worldwide and do matter, for example, in a (multinational) firm's choice of location and its investment decisions (Simmie 1997).

Network characteristics are considered of particular importance to innovation and to the growth prospects of regions (Bergman et al. 1991). According to this idea, innovation is a process which results from various interactions among a number of actors in a given region. Such economic (and social) links can be considered 'intangible capital' that has durability, is created by means of an investment effort and deteriorates if not maintained (Karlsson 1995). Although firms (and entrepreneurs) generally play the central role in these interactions, a network with other scientific and public institutions contributes significantly to their R&D and innovation successes as well as to organisational change. Consequently, when analysing the regional innovation system, one should not only investigate the (horizontal and vertical) relations among firms (e.g. prime contractors, subcontractors, independent enterprises in similar and/or different industries) but also contacts with universities and other research institutions, as well as with technology centres (which make the diffusion of technological know-how possible). Furthermore, the role of government agencies (promotion), interest groups (commercial, technical and information support) and lending bodies (the provision of venture capital) should also be taken into account in the context of the regional innovation system.

Apart from providing a critical review of already-existing theoretical and empirical research under the particular consideration of the present regional technology and R&D promotion policies in Germany, this study examines the distinctive characteristics of the

local innovation systems while emphasising the interaction and networks among major actors mentioned above. For these purposes, the two German technology areas selected for the study are:

- the rapidly-growing Landshut area (near Munich in Bavaria), to emphasise the roles of high-tech-based small firms in local technological development and in co-operative links with big business in R&D, innovation and related activities,
- the Bochum area (in North Rhine-Westphalia) — one of several modern technology centres in the traditional industrial region of the Ruhr, to examine development alternatives to declining industries.

Major Characteristics of Regional Technology Policy in Germany

The arguments supporting technology as a crucial factor in local and regional economic development are essentially the translation down to the sub-national scale of the arguments expressed on national or global scales. The importance of technological innovation in a regional development context is its ability to provide a possible foundation for new industries; for the creation, broadening and deepening of markets for regional firms by substituting existing and competing goods by new economic goods. It can also affect cost, quality and reliability. A region in which industrial firms achieve substantial 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). Thus, the systematic activation and intensive utilisation of endogenous innovation resources in regional development constitutes a crucial challenge for a technology-oriented regional policy (Koschatzky 1994).

States (Länder) in Germany have traditionally adopted an interventionist approach by creating the public infrastructure of technology institutions providing a range of services for industry, particularly via the technology-transfer centres which act as the linkage-points between universities, research centres and SMEs (Grotz and Braun 1997). In the theoretical discussion, (public) research infrastructure has generally been considered a type of public good which should be provided by governments, due to the market failure characterised by non-rivalry and non-exclusive use. Positive external and spin-off aspects are expected to result from the endowment of these public goods and the promotion of (basic) R&D activities.

In addition to common strategies such as subsidising technological development and innovation activities of private firms and providing research centres publicly (especially for the so-called key-technologies), there have also been remarkable efforts made by regional governments to support the flexible adaptation of generated research outcomes and rapid

adjustment of SMEs to new challenges caused by the ‘technology-push’ and ‘demand-pull’ in the market (Fischer 1995). In recent years such a ‘diffusion-oriented’ aspect has gradually gained importance in the context of the regional technology policy in Germany (Reinhard and Schmalholz 1996; Sternberg 1995).

Apart from the fact that SMEs suffer particularly from the rapid technological development processes and the consequent organisational changes, most regional policymakers additionally assume that the strong locational dependency of small firms leads to so-called ‘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). Pavitt et al. (1987) show that small firms have also been able to introduce new products over time. Moreover Rothwell (1986) has suggested that small firms are vital agents in the diffusion of technology where they take generic innovations developed elsewhere and present them in the wide variety of forms essential in meeting the expressed or latent needs of a broader range of users. “SMEs are important also in introducing those incremental innovations which surround generic technologies and existing applications which broaden and deepen markets ... In technological and market terms, the small and innovative firm could be seen as a potentially powerful force in local economic change. As most small firms, once established, continue to produce in the same locality, their technological activities could increase the vitality of the host economy by adding to its strength and competitiveness” (Wynarczyk, Thwaites and Wynarczyk 1997, p. 34).

However, there are also some doubts surrounding the SMEs and their technology promotion as a long-term solution to regional economic problems. Leaving aside the high rates of insolvency and business failure occurring in recent years among SMEs (Gray 1992; Plougmann 1994), large firm size is quite often seen as a prerequisite for economic progress via technological change. Especially stress is placed on the leading innovative role of large internationally-active companies which have a greater ability to provide capital, information as well as managerial and technical specialists and to spread related risks over a portfolio of innovation projects carried out by large R&D departments.

There have been lively discussions in Germany as to the advantages and disadvantages of publicly-promoted innovation and R&D activities engaged in the context of the regional economic and technology-development programme mentioned above. To sum up, the major disadvantages of technology policy are considered to be:

- disturbing the free market mechanism, hindering allocation efficiency and generating a culture of dependence,
- creating new jobs in only a limited number of cases,
- sometimes delaying the necessary structural changes required immediately for long-term regional growth, as it can also promote R&D activities in traditional, declining industries like coal-mining, iron and steel, shipbuilding, etc.

On the other hand, these promotion measures:

- offer firms a chances to enter new technology and production fields, thereby accelerating regional growth and structural change,
- provide support for SMEs and create employment in high-tech sectors,
- encourage co-operation and technology transfer between firms and research institutions, etc. (Kerlen 1995).

Box 1
Research and Technology Policy in Bavaria: An Overview

Technological progress and innovation are the basis of competitiveness. As is widely acknowledged, Bavarian industries can 'only' compensate for the existing competitive disadvantage in the world market due to higher wages by continuously supplying high-quality (innovative) products and services. For this reason, the improvement, assurance and promotion of research activities has been seen as one of the major determinants in the region's future economic development. Since the beginning of the 1980s, in order to promote R&D the Bavarian state government has placed strong political emphasis on:

- the selective expansion of universities and research institutes under the consideration of the R&D activities in urgent need and of future importance for the region,
- the establishment of a large number of technology-transfer centres to transmit the applicable advanced know-how (developed in universities and research institutes) to private firms (operating in areas like micro-electronics, information and telecommunication, software development, media, biochemistry and environmental technology, etc.),
- the development of state government programmes to promote the innovation and research activities of SMEs, including, for example:
  - 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).

The primarily R&D-, SME- and infrastructure-oriented regional policy measures have contributed to the establishment of new (small) firms and job creation, to the modernisation of industrial structure as well as to rapid economic growth in Bavaria. This Bavarian style of 'loosely' defined decentralised (industrial and) technology policy has functioned relatively well in the state-specific economic framework, in which a few large leading (internationally well-known) 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 firms and enhanced their competitiveness on the global market.

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

Apart from the direct public assistance and the endowment of R&D infrastructure provided by regional and/or local governments, the success of innovation is generally seen as the outcome of mutual, consistent and long-lasting interactions, co-operation and networks among innovating firms and their partners, universities and technology-transfer centres for diffusing knowledge and technologies, business service firms, etc., which create a sort of innovation system (Arndt and Sternberg, 2000; Fritsch and Lukas 1999; Wiig and Wood 1997; OECD 1992). Apart from enhancing local creativity, this type of regional co-operation system also acts as 'an uncertainty-reducing operator' (Grotz and Braun 1997, p. 546), which reduces the risks related to rapid market development and increasing technological complexity and competition.

Furthermore, the concept of agglomeration economies and the incubator hypothesis have often 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 (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 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. Large cities especially seem to provide excellent conditions for firms' innovation activities. Companies located in those central places have easy and speedy (low transport-cost) 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 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, p. 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).

In contrast to those theoretical arguments that emphasise the advantages of the so-called 'local milieu' (Sternberg, 2000), 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 (Hahn et al. 1995; Wolff et al. 1991). Furthermore, many small firms in Germany are so 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 context (Camagni 1991). 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 one but also to the international.

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 1800 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, p. 299). The many previous studies evaluating the effectiveness of German innovation centres as instruments of regional inno-

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

On the other hand, with a few exceptions (for example, Dortmund), the scale of the German centres is relatively small when compared to those 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 significant 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 phenomenon, 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, p. 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 afore- mentioned 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 which 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 well in modern high-tech industries such as information technology, biotechnology, materials engineering and the automobile industry (Reinhard and Schmalholz 1996; Mytelka 1991; Hagedoorn 1995). 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-cycle forcing firms to establish rapid and 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 technology. 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 1 summarises the typical channels of exchange 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 significant in Germany and its regions (Hahn et al. 1995; Wolff et al. 1991; 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 2). 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). Ac-

cording 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 requests from firms.

Table 1 **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 ...
Actors	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 (expenses and sources) for further development and innovation	Information about • products for future market (strategies and plans) • 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 (expenses and sources) 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 (project management or co-operation) • Transfer-oriented training	Information about economic and technological success in the new production system and/or related firms' specific problems	• Consulting services for firms' on 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 2 **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

The Local Innovation System in Landshut[1]

The Landshut region of Bavaria 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 large 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 large extent, SMEs located in Landshut are (directly or indirectly) forced to supply high-quality intermediate products and parts that correspond in quality to the end-products of these large firms (customers). In addition, these large firms often act as the major providers of information and/or new technology which these SMEs need to enhance the quality of their supply.

Although most high-tech firms located in Landshut are SMEs, many also 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 reflects in equal measure the advantages of achieving a market presence and the cost savings that can be achieved. 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 flexible in production processes and product modification. To guarantee such flexibility and reduce business risks, these firms have established a sort of vertical (supply) network with their intact sub-contractors. This is not only defensive in character but also has mutual complementary effects.

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

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 techno-

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[1] 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.

logical 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 polytechnical 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 professors of the *Fachhochschule* when recruiting new, qualified personnel.[2]

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 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 technology in the production process. Furthermore, SMEs in Landshut generally wish that the Chamber of Industry and Trade *(IHK für Niederbayern)* and the regional government in Lower Bavaria were 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.

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, at the same time, 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.

Bavaria's SME-oriented technology policy aiming to support 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 worldwide 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 concen-

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[2] 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 technicians employed in these firms are also involved in the *Fachhochschule's* education programme as adjunct faculty, and/or invited research and thesis supervisors.

tration of financial means at a reduced number of already-established large technology poles such as Munich and Nuremberg (with better future prospects). This would eventually make Landshut's position weaker. 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 Local Innovation System in Bochum

The innovation-related activities of firms located in Bochum have generally been stimulated, and also led by increasingly fierce international competition. The quality regulations which are set by the European Commission for example, (such as regulations on machinery products and CE — the Conformity to Europe) have also continuously forced a number of high-tech firms to enhance product quality. Yet this, in turn, increased production costs significantly, as several local SMEs complained when surveyed.

Large firms in the city region, like Opel and Nokia, have been playing the leading role in the regional innovation system. Their position has become stronger in recent years as they have gradually outsourced production activities within the city region. They expect, from their local suppliers, the 'just-in-time' delivery of high-quality (or assembly) parts which guarantee the quality of their final products and as global (or European) players, they generally gain innovation ideas and new technology from their headquarters in Japan and the US. In many cases, they also exploit and utilise their own R&D capacities to develop new products, parts, design etc., which better satisfy the specific needs of customers 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 low cost 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 are by no means permanent and institutionalised, but rather mainly based on projects.

In their general assessment of location determinants, 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 modification, 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 has been better established between firms and universities. 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.

Most SMEs interviewed in the 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. While these companies are strongly customer-oriented and should as mentioned deliver their high-quality products to large firms just-in-time, 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' by themselves. Nevertheless, in many cases, these SMEs share basic testing and measuring instruments in universities because they can hardly afford such modern R&D equipment.

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.

Bochum's technology-transfer centres with an incubator function (like the *Cooperationsgesellschaft Hochschulen und Industrielle Praxis:* CHIP[3]) 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,

[3] 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.

- easy recruitment of a young well-qualified R&D labour forces 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 of common innovative projects by several SMEs within the centre and in co-operation with the universities have unfortunately been quite scant in previous years.

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 with the effects of the latter less significant 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 Germany is to develop a well-functioning technology and information transfer network between the regional government, universities, research institutes and private firms, as is the case in the US and Japan.

Conclusions

According to the review of relevant theoretical and empirical investigations and the case studies of Landshut in Bavaria and Bochum in North Rhine-Westphalia, the role of the local innovation and technology co-operation network between the regional public body, private firms, technology-transfer centres and research institutions appears less significant than expected in these surveyed areas, although a well-established network is a recognised prerequisite for continuous regional economic development (Anselin et al, 1997; Saxenian 1994; Storper 1992). This concluding assessment is quite 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. (Koschatzky and Sternberg, 2000; Hahn et al. 1995; Staudt et al. 1996; Grotz and Braun 1997). Consequently, the following findings of the present study seem more or less universally applicable to small German city regions:

- Local co-operation in innovation activities and the establishment of common R&D networks among firms to realise economies of scale are generally limited. Such egoistic behaviour from firms is also dominant in the collection of the latest technology information; although the external procurement of technological know-how and R&D results are gradually gaining in importance.

- The existing innovation-oriented inter-firm linkages are mainly based on the vertical 'supplier and customer relationship', particularly that between large (international) high-tech firms and local SMEs. In particular, the technological success of such a network in the local context is widely determined and triggered by quality standards and norms set by large leading companies. In the future the intensification of such vertical technological co-operation and joint product development is expected, 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 to collect innovation- and technology-oriented information.
- Technology transfer institutions and universities, as well as private technology consulting firms, appear to be playing a less significant role as solvers of the specific problems that local firms have when developing new products or adopting new technologies in the production process. The benefits of making co-operative innovation and technology development on the basis of cost- and know-how-sharing between research institutions and firms seem to be underestimated. Nevertheless, 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 as positive. Technology and innovation centres with the incubator function seem to be important for new local entrepreneurs but the synergy effects initially expected from tackling of common large-scale innovation projects by several SMEs within the centre, in co-operation with neighbouring universities, have unfortunately been less significant.

As generally assessed by firms, and as many economists also argue, the different types of (primarily R&D-, SME- and modern infrastructure-oriented) industrial and technology policy measures implemented in German states seem to have improved the region's 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). In spite of these overall positive effects of regional (economic and) technology policy, the extent to which this type of promotion system — aimed at supporting the new establishment of innovative firms and research institutions in less-developed areas, reducing the existing disparities among regions in German states, has not yet been assessed systematically. It is likely that the growth poles (respectively '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 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 (Sternberg 1995; Grotz and Braun 1997; Amin and Thrift 1994). 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, p.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 (incl. the easy access to data banks of existing patents), also in co-operation with universities and technological-transfer centres as well as industrial organisations like IHK.

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