Technische Universität Dresden
Fakultät Verkehrswissenschaften „Friedrich List"

Diskussionsbeiträge aus dem Institut für Wirtschaft und Verkehr

Nr. 5/2000

Klaus-Heiner Röhl

Saxony's Capital Dresden – on the Way to become Eastern Germany's first "Innovative Milieu"?

Dresden, November 2000

Herausgeber:
Die Professoren des
Instituts für Wirtschaft und Verkehr

ISSN 1433-626X
Internet: http://www.tu-dresden.de/vkiwv/VWL/home.htm

Saxony's Capital Dresden – on the Way to become Eastern Germany's first "Innovative Milieu"?

Klaus-Heiner Röhl*

In this paper, the chances of Saxony's capital city Dresden to become Eastern Germany's first high-tech-region is discussed. A presentation of the theoretical background of innovative milieux is followed by an overview of the region's universities, R&D institutes and other facilities relevant for milieu formation. Afterwards, the establishment of high-tech enterprises in the Dresden area is analyzed. The paper concludes giving a view of the region's further development potential.

1. Introduction

Ten years after unification the former socialist parts of Germany are still lagging behind considerably in their economic potential; subsidies of more than 60 billion euros p.a. are transferred from the west to the eastern Laender by the federal government. But in spite of the stagnation in the catching-up process that set in five years ago, some East German regions are showing signs of economic revival through clusters of highly productive manufacturing firms with rapidly growing output. These more successful regions are located in the southern parts of East Germany, where a concentration of machinery and electronics industries during the former centrally planned economy has left a reservoir of qualified personnel reemployable under market economic conditions, even though the "kombinate" with their anachronistic structures of vertically integrated production complexes had no chance to survive.

In the former industrial region of southwestern Saxony, a car-manufacturing-cluster is evolving centered on the Volkswagen plant near Zwickau, which forms East Germany's biggest industrial establishment with close to 5.000 employees. While the productivity of this investment surpasses Volkswagen's West German plants and a rising number of suppliers has been locating in the area in compliance with the just-in-time logistics concept, this is a mature industry with limited potential for further expansion. In addition, the one-sided orientation of economic development may cause a regional crisis in a downturn of the auto industry, as other manufacturing branches are still consisting of comparatively small scale operations.

The most promising cluster of technology-intensive industries in the New Laender is forming in the urban area of Saxony's capital Dresden, and it is this growing cluster of research facilities and high-tech establishments that is the focus of this paper. Regions able to attract or produce many innovative enterprises of growing industries and in addition have a variety of R&D and advanced educational institutions like universities strong in technical branches may be described as "innovative milieux", if certain conditions, especially strong intraregional linkages, are met. In eastern Germany, Dresden is well placed to become the first region to initiate a self-enforcing path of economic development, as will be discussed below.

The paper is structured into four main sections: A discussion of the theoretical background of innovative milieux is followed by an overview of the region's R&D institutes and other

* University of Technology Dresden, Faculty of Transportation Sciences, Institute for Economics and Traffic, D-01062 Dresden.

relevant facilities conditional for milieu formation. Afterwards, the establishment and development of high-tech enterprises in the Dresden region is analysed, followed by a conclusion giving a view of the further development potential of the region.

2. Theoretical Aspects of Regional Innovative Milieux

Regional clusters of innovative enterprises in conjunction with research and transfer institutions constitute an "innovative milieu", if certain conditions like network structures between firms, a reservoir of highly qualified labor, financial intermediaries offering risk capital, are met.[1] The relevance of the milieu concept results partly from its flexibility as the growing role of services in regional economies in addition to manufacturing is increasingly recognized (MARSHALL 1990).

The innovative milieu approach stresses the socio-economic conditions and a "culture of joint cooperative learning" at the regional level, that develops "through labor mobility, input-output-relations and face-to-face contacts, which are encouraged by spatial proximity" (STERNBERG 1995: 199). Despite the high importance of agglomeration economies, the innovative milieu is more of a cultural than geographical setting (CAMAGNI 1995: 319).[2] Core elements are a common basic understanding of socioeconomic problems and solution patterns and the coherence of production system, culture and main regional actors as well as the development of regional synergies (CREVOISIER and MAILLAT 1991: 19; PERRIN 1988).[3]

Case studies covering regions of the so-called "third Italy" are precursors of the milieu approach. Here external effects of manufacturing in a marshallian atmosphere of co-operation lead to the sustainability of small-scale-enterprise structures in contrast to internal scale economies associated with mass production (GAROFOLI 1991). COURALT and ROMANI (1992: 206f) emphasize social contacts determining local production culture in Italian industrial districts. Basis of their success is an "entrepreneurial" culture of autonomous self-employed workers. Main characteristics of industrial districts also apply to innovative milieux: "Le district industriel est une entité socio-territoriale caractérisée par la présence active d'une communauté de personnes et d'une population d'entreprises dans un espace géographique et historique donné." (BECATTINI 1992: 36). But in contrast to the static nature of the district approach the milieu stresses the role of technological change. Innovations are seen as "the outcome of a collective and dynamic process of many actors" (STERNBERG 1995, 199).

In industrial districts as well as in other innovative regions small and medium enterprises (SME) with co-operative innovation activities are of special relevance. As big companies were faced with downsizing since the 1970s, SMEs were able to increase their share in overall

---

[1] The milieu concept was developed by French and Italian regional economists, who formed the "Groupe de Recherche Européen sur les Milieux Innovateurs" (GREMI) in the 1980s for empirical research and case studies (AYDALOT 1986; AYDALOT and KEEBLE 1988; CAMAGNI 1991, 1995; GORDON 1991; MAILAT 1991).

[2] This also constitutes the main distinction compared with SCOTTS (1988) "new industrial spaces", which often describe regions that were characterized as Innovative Milieux by GREMI authors.

[3] BRAMANTI and SENN (1991: 89f) stress the self organizing character of the regional innovation path, that does not follow the "classical" linear innovation model (MALECKI 1990) but evolves as an evolutionary process formed by explorative actions of decision makers in firms and institutions. A similar view of the innovative process with a rejection of the linear model follows from the work of DOSI (1988) and SILVERBERG (1990).

employment. While the innovation performance of small firms was seen rather critical for a long time (ANDERSSON 1985: 7), it is assessed much more positively in recent studies, which are not restricted to R&D-expenditures and personnel and patents but follow a more comprehensive definition of innovation with special emphasis on SMEs innovation's role in regional development (ACS and AUDRETSCH 1990; FRITSCH 1995).

TÖDTLING (1994: 80) stresses the important role public institutions[4] play in innovative milieux, especially as a complement to the internal potential of SMEs. Small firms " may … be more inclined than their larger counterparts to substitute internal research by using external sources of knowledge useful in their innovative or adoptive processes" (THWAITES and ALDERMAN 1990: 32). STERNBERG (1995) regards public institutions as essential actors in innovation networks. In his opinion the conditions given by regional policy are highly important for creative actions as necessary part of innovative milieux. In contrast to this view, CASTELLS (1991) expects only limited possibilities for political influence on milieu formation.

Networks of enterprises and regional institutions form an important element of innovative milieux, though the latter stress the socio-cultural aspects of regional development while the former describe the interaction of persons and institutions through formal and informal relations. "Through external networking, new forces for local development can be activated in the form of joint ventures between local … and external partners" (CAMAGNI 1995: 321). The interconnection of global networks and local embodiment in milieu structures is analyzed by TÖDTLING (1994) who sees the interaction between endogenous and exogenous influences on milieu-based innovations as a feature of flexible specialized regions.

The growing importance of the high technology sector and innovative enterprises for regional development triggered a multitude of empirical studies investigating the specific conditions prevailing in successful regions. Explicit "high-tech"-regions like Silicon Valley and Orange County in California, the Boston SMA (Route 128) and in Europe the „M4-Corridor" near London, Cambridge, Sophia Antipolis in southern France, the „Cité Scientifique" near Paris and the Munich area in Germany figure most prominently (PREER 1992; SAXENIAN 1994; SCOTT 1988, 1993; STERNBERG 1995, 1996a,b).

Metropolitan areas constitute a related type of milieu, which exhibit a leading role in technological development and a high diversity of economic activities. In the forefront are global nodes of the information age like New York, Tokyo, London and Paris (CASTELLS 1991). National metropolises like Milan, Amsterdam and Haifa also form urban innovative milieux, often specialized in high technology manufacturing or services in which they acquired a leading position (CAMAGNI 1995; DAVELAAR 1996; SHEFER and FRENKEL 1997).

A third milieu variety are industrial districts that kept their innovation potential and flexibility inspite of technological change and the introduction of new production systems. Examples are the Italian textile regions Veneto, Emilia-Romagna and Tuscany, the Swiss Jura, Western Jutland in Denmark and parts of Baden-Wurttemberg in Germany (BECATTINI 1992;

[4] Important public institutions include Chambers of Industry and Commerce, technology transfer institutions, research and advanced education facilities and financial intermediaries supplying risk capital (TÖDTLING 1994).

GAROFOLI 1991). Fourth type of milieu are peripheral regions that were able to attract innovative industries like Scotland's "Silicon Glen", and the "Research Triangle" in North Carolina (MAIER and TÖDTLING 1995: 97) and some regions in southern France (HANSEN 1990). In this case the milieu is formed through growing intraregional connections and spillovers after enterprises external to the region established subsidiaries in the area.[5]

The role of the milieu approach for development and growth in peripheral regions and the revitalization of old industrialized areas is discussed by CAMAGNI (1995).[6] In his view the most important element of milieu generation is the utilization of local resources, synergies between local actors, external network, and a sustained process of innovation that not only comprises high technology, but involves all sectors of the economy. Collective learning enables technological and organizational creation as a "driving force" towards an innovative milieu. The main function of the milieu lies in the "reduction of (dynamic) uncertainty through information collection and transcoding" (CAMAGNI 1995: 322f).[7]

The milieu approach emphasizes the incubator function exerted on SMEs by local conditions and may be seen as a derivative of the "endogenous-development"-strategy of under-developed countries modified for regional economics. The establishment of technology-oriented business parks is a policy measure to improve the conditions for setting-up and growth of innovative businesses in a region (GOLDSTEIN 1991). In Germany, this goal is pursued through incubators called "Technologie- und Gründerzentren". Empirical studies show that incubation centers are only able to improve start up and growth of innovative enterprises if further conditions are met: „It can be seen that these centres are not bringing about substantial changes of the spatial pattern of innovation since … successful parks tend to be located either in large metropolitan or in more dynamic regions" (TÖDTLING 1994: 76).

Spillovers from R&D and educational institutions play an important role in the concept of innovative milieu. Despite new communication technologies, information-transfer-channels still exhibit mainly regionalized structures. Recent knowledge is often not yet well structured and cannot be codified because of its tacit nature (BAPTISTA and SWANN 1998). Its transmission requires co-operation, and spatial proximity is likely to reduce transaction costs.[8]

---

[5] Regrettably, case studies show that the internal networking in this type of milieu is often marginal and spin-offs occur only sporadically. The external establishments are dominated by subsidiaries of high-tech-enterprises containing their production steps with low human capital intensity (CASTELLS and HALL 1994: 139f).

[6] MAILLAT and VASSEROT (1988) examine the possibilities to mobilize the endogenous potential of old industrial regions. In their view the interconnection of existing enterprises, flexibilization of labor markets, linkages between industry and scientific institutions are most important for milieu generation. Chances for restructuring areas dominated by declining industries are also discussed by GRABHER (1991) and in STÖHRS (1986) analysis of "regional innovation complexes".

[7] In an overview of peripheral regions examined by GREMI researchers on the existence of innovative milieux, CAMAGNI (1995, 326f) ascertains a rather limited interconnection of external establishments with regional institutions and firms. He calls this a "potentially innovative" milieu, if local synergies have not (yet) led to higher innovation activities, or "innovations without milieu", if innovative activities are taking place in enterprises without regional linkages.

[8] HARHOFF (1995: 86) stresses the relevance of regional spillovers for high-tech start-ups from universities and R&D institutes. Entrepreneurs stay in the area to secure the continuity of their personal contacts as new knowledge is localized and contained in institutions and individuals (ANTONELLI 1998; VON HIPPEL 1998). Spatial proximity is not so much of importance because of its role in facilitating information exchange as it is

But empirical studies give no clear picture regarding the influence of the agglomeration grade on innovation spillovers (HARHOFF 1995: 89). PFIRRMANN (1994: 50f) denies a significant influence of the type of region on innovative performance when controlling for firms' characteristics like size, R&D staff and industry. According to his analysis, regional differences in innovation behavior can be traced back to differences in enterprises' spatial allocation. On the other hand, it can be argued that it is just the spatial structure that is influenced by agglomeration economies. In this view, regional differences in the allocation of innovative enterprises should become the focus of investigation (BRÖCKER 1995: 121).

Regional knowledge spillovers of university R&D are analyzed by JAFFE (1989), who shows a positive influence of university R&D expenditures on the number of firms' patents in the same US states.[9] Most important spillovers are new ideas for products and competitive advantages. In a comparison of technology-intensive and other industries, AUDRETSCH and FELDMAN (1996) discover stronger regional clusters of innovation activities for high-tech firms indicating more intensive spillovers in knowledge-based industries. The creation of spillovers is an important aim of regional innovation policy.

The milieu approach is criticized for its "definitorial ambiguity" and lack of operationalism constricting empirical work mostly to purely descriptive case studies (MAIER and TÖDTLING 1995: 99). "… the fundamental question of what are the necessary and sufficient conditions that constitute an innovative milieu has not been answered satisfactorily" (BERGMAN et al. 1991: 289). This point is emphasized by the structural differences of regions in which GREMI authors claim to have identified innovative milieux. These include regions in southern Italy, Spain and Greece not usually regarded as innovative. Also criticized is the omission of external impulses for innovation and milieu formation (BERGMAN et al. 1991: 290).

3. Institutional and Industrial R&D and Technology Potential in Saxony

Beside East-Berlin Saxony's agglomerations already were the leading centers of R&D in industrial and public institutions in the economy of the GDR (OSTWALD 1990: 60f), but many of these R&D units were not able to survive after 1989. The current situation of R&D in Saxony is characterized by a strong dominance of public and state-subsidized institutes after the R&D units of the former "kombinate" experienced a decline to less than 20% of their former personnel following the end of the centrally planned economy (MESKE 1996: 167). The extreme decline of industrial R&D in Eastern Germany is a problem up to now unsolved by public programs like incubators and research parks or subsidies. In contrast to this the public R&D institutes as well as university research were stabilized and rebuilt for the most part. The technology and science policy of the state of saxony aims at the build-up of

important for personal relations forming a precondition for incentive and sanction mechanisms necessary in implicit cooperation treaties (BRÖCKER 1995: 120).

[9] But no subregional spillovers were shown, and it is questionable if US states are adequate geographical areas for this type of analysis (ACS et al. 1992). A controversy also remains about patents' suitability as a measure of innovation activity. FELDMAN (1994: 42f) is able to show that JAFFE's conclusions also hold with innovation citations in industry journals instead of patent data.

networks between public and private R&D units to set free synergies for the state's economic development (SMWA 1992; SMWK 1997: 8).

Universities and Technical Colleges

The universities and technical colleges constitute the core elements of the research and higher educational facilities in Saxony with more than 26.000 employees and 78.000 students at the beginning of 2000. While the enterprise sector was forced to reduce its R&D personnel by about 80% after 1989, universities and colleges were able to retain the strength of their scientific workforce, in a growing part funded through industry contracts. The number of students has grown by 40% since 1992. Every year, about 15.000 young people begin their studies at the state's universities and colleges.

In 1996, the state budget for universities and colleges amounted to 1.46 billion euros, with universities claiming by far the biggest share with 84%. (Statistisches Jahrbuch Sachsen 1998).[10] Personnel expenses claimed 870 million euros or almost 60% of the budget, 240 million (16.5%) was available for investments. By far the biggest share of the university and college budget was spent in the regions where the educational institutions are located. The importance of the university for long-term productivity growth and educational spillovers into the regional labor market is stressed by PFÄHLER et al. (1997) in an analysis of the effects of Hamburg university. Universities and technical colleges are an important factor in the regional economy determining firms' decisions about the location of establishments and investments and facilitating agglomeration economies.

Saxony's four universities form the core of the state's educational and research landscape. With technical universities at Dresden, Freiberg, Chemnitz and Leipzig university, there is a well-balanced distribution on Saxony's three main regions; a fifth small universitarial facility is located in Eastern Saxony at Zittau.

Dresden University of Technology is the biggest of the four with about 25,000 students and 9,000 employees, including 600 lecturers. It can be seen as the core of the region's research and education potential. Its origins can be traced back to a technical college founded 1828. In 1890 it reached university status. After German unification, parts of the former college for transportation sciences and the medical academy were integrated into the university. As the departments for economics and law were newly established, the former technical university now offers a complete curriculum. The research and co-operation potential of Dresden university is shown by the high number of external R&D projects. In 1997, there were 2,422 projects worth about 67 million euros. In 1998 the number reached 2,626 with a similar financial volume; 711 projects were contracted by public entities like the federal state, Laender and the European union, 433 were research projects by the German research foundation (DFG) and 898 were industry contracts (Technische Universität Dresden 1999).

The focus of the engineering and economics curricula lies with civil and process engineering, electrical engineering, computer sciences, transportation economics and engineering and –

[10] With close to 500 million euros each, Dresden and Leipzig universities have by far the biggest budgets. Most costly, with more than 500 million euros combined, were the medical departments of these two universities.

besides business administration and political economics – also economically applied computer sciences and business oriented engineering. Medical and biomedical sciences are main research fields (SMWK 1997, 17). Because of the growing concentration of the semiconductor industry in the Dresden area, which will be discussed in more detail below, the departments for electrical engineering and computational sciences play a decisive role in the supply of a qualified workforce. The electrical engineering department counted almost 3,200 students in 1990, but in 1997, this number had fallen to below 1,000. In 1996, the department had about 40 lecturers, 115 scientific and 100 technical employees. Since 1998, the number of students in engineering courses and computer sciences has been rising sharply. This trend may be caused by the brighter perspectives on the labor market (DIW, IfW, IWH 1998: 121). In computer sciences, only 10 to 15 students finish their studies every year, but this number is likely to rise again in the future. Co-operative research with industry is conducted by the institute for semiconductor and microsystems technologies (IHM).[11]

A transfer office called "TUDtransfer" was created for faster industrial adoption of innovations from university research. One of its aims is to help SMEs in R&D activities, but also in participation at trade fairs and in marketing activities. Because of the high share of small firms in Eastern Germany these points are of special relevance for the creation of innovative milieu conditions. Joint R&D is facilitated through a "technology alliance" with transfer offices in Kiel, Hanover, Berlin, Cologne, Karlsruhe, Stuttgart and Munich.

Table 1: Staff[1] and students at Saxony's universities

Year	**Dresden[3]**		**Leipzig**		**Chemnitz[2]**		**Freiberg**		**Zittau**		**Saxony**	
	Staff	Students	Staff	Students	Staff	Students	Staff	Students	Staff	Students	Staff	Students
1992	5,470	18,892	–	15,613	–	5,516	1,347	2,080	–	–	–	42,101
1993	5,090	18,860	3,078	16,688	1,974	5,437	1,233	1,995	–	19	–	42,999
1994	5,508	19,648	2,918	17,646	1,833	5,350	1,183	1,941	18	83	–	44,668
1995	5,644	20,283	4,942	18,921	2,121	4,998	1,536	2,027	22	137	14,265	46,366
1996	5,496	21,577	5,361	20,044	2,157	5,112	1,547	2,174	27	165	14,588	49,072
1997	5,391	22,003	5,094	21,563	2,141	4,969	1,519	2,422	35	190	14,180	51,147
1998	4,803	22,646	4,790	22,452	1,974	5,138	1,505	2,657	35	197	13,107	53,243

– = not available or not existent. 1. Up to 1994 for Leipzig, Chemnitz, Freiberg planning data. Diverging data due to differences between staff plans and actual employment . Staff of Dresden and Leipzig universities without medical departments, medical staff 1997: 3,615 at Leipzig (scientific personnel: 1.017) and 4,110 at Dresden (scientific personnel: 954). 2. Until 1997 Chemnitz-Zwickau. 3. Integration of college of education and College of transportation sciences 1992/93, of medical academy 1993.

Sources: Saxony Statistical Yearbooks 1996 - 1998, Saxony Statistical State Office 1998, 1999 (Statistische Berichte B III); Information of the universities.

In the district of Southwest Saxony two technical universities are located, that are rather small, with less than 8,000 students combined. As Freiberg's distance is only 30 kilometers and Chemnitz' 60 kilometers from Dresden, both universities can be counted as part of the educational potential of the greater area. Especially, education and research at the electrical engineering and computational sciences department of Chemnitz university is of importance for milieu formation in the semiconductor industry of the Elbe valley. The university's micro-

[11] The IHM employs a staff of 80, it is conducting a joint research project in IC-assembly technologies with Siemens/Infineon (DIW 1997: S. 28).

technologies center, a joint establishment with the Dresden center for microelectronics dating back to before 1990, is conducting research in the field of co-integration of microelectronics and micromechanical applications. Process technologies for highly integrated circuits are developed in co-operation with Infineon's Dresden plant and regional R&D institutes.

Freiberg technical university was founded in 1765 as a mining school. Today exploration and exploitation sciences and energy oriented technologies are still important fields of research and education, but these were complemented by economics of resources, business administration and environmental sciences. Fields of research include new materials, sensor technologies, automation engineering, recycling technologies.

In addition to its universities Saxony has a comprehensive system of technical colleges (Hochschulen für Technik und Wirtschaft) with facilities at Dresden, Leipzig, Mittweida, Zwickau and Zittau. Most of the colleges were engineering schools in the former GDR. The educational focus of the technical colleges is on engineering and business administration. Dresden technical college offers courses in architecture and construction engineering, electrical engineering, computational sciences, civil engineering and process engineering, agriculture and economics. In 1999 it had 4.500 students. The college's institute for motor vehicle engineering is strong in R&D co-operation with industry to develop more energy efficient engines (SMWK 1997: 35f; HTW Dresden 1998).

Non-university R&D Institutes in Saxony

After the elimination of the former centralized system of institutional R&D in the GDR which showed a strong hierarchy with facilities of the „academy of sciences" at the top, the institutional structures of Western Germany were transferred to the New Laender, though not without difficulties (MESKE 1996: 168). In Saxony there are 22 non-university R&D facilities and parts of institutes based in West Germany belonging to the country's main public research societies. Together they have about 3.200 employees, funded mainly by the federal and state governments but also through industry contracts (SMWK 1997).

An important element of co-operative federal and state research activities are the institutes of the so-called "blue list" funded equally by the Berlin government and the Laender. In Dresden the institute for polymerization research with 166 employees, the institute for solid materials research (235 employees) and the institute for ecological spatial development with 78 employees belong to this grouping. In the Rossendorf research center, which evolved from the nuclear research program of the GDR, five blue-list-facilities are located. Their research focus is new materials, nuclear physics and safety, and bio-organic sciences. Counting 600 employees, Rossendorf is Saxony's biggest non-university research facility. As the state's remaining three blue-list-institutes are located in Leipzig, all facilities of this type are concentrated in the state's two main cities.

The " Max-Planck-Gesellschaft" comprises Germany's main institutes for basic research, e.g. in medical sciences. Eight facilities belonging to this society are located in Saxony, as well as another nine of the Fraunhofer-society. These are engaged in more application-oriented research, and are partly funded by industry contracts. Max-Planck-institutes are located in Dresden, Leipzig and Freiberg. Fraunhofer-facilities exist in Dresden and Chemnitz, showing a concentration in agglomerations and university cities.

Table 2: Research institutes in Saxony's agglomerations

	Dresden[2]		Leipzig		Chemnitz		Saxony	
	institute	staff	institute	staff	institute	staff	institute	staff
Main research center	-	-	1	280	-	-	1	280
blue list	8	914	3	141	-	-	11	1,055
state institutes[3]	1	121	1	130	-	-	2	251
Max-Planck-society	4	71	3	79	1[4]	3[4]	8	153
Fraunhofer-society	8	486	-	-	1	103	9	589
all institutes	21	1,592	8	630	2	106	31	2,328

1. Including parts of institutes. 2. Including Rossendorf. 3. Only institutes with research in engineering or economics. 4. In Freiberg.

Source: SMWK 1997: 67f.

The Max-Planck-society maintains eight facilities in Saxony, five institutes and three working groups at universities. In Dresden there are institutes for physics of complex systems and chemical physics of solid materials as well as working groups for the theory of complex and of correlated electron systems based at the university. A division of the Berlin institute for colloid research is located at Freiberg (SMWK 1997: 126). The Dresden Fraunhofer-institutes cover the following research fields: microelectronic circuits and systems, electron beams and plasma sciences, ceramic engineering and powder materials, physics of new materials and lamination technology. In addition there are four divisions of institutes located in Dresden.

Being the site of more than 20 research facilities and divisions of institutes, the Dresden area surpasses the rest of Saxony taken together; its employment share reaches almost 69%.

A feature distinctive to the East German R&D landscape are its independent research companies, which originated from research divisions of the former "kombinate". Saxony has 42 of these R&D providers employing about 2,000 persons. They are subsidized by the state government with the aim of preserving the industrial R&D capacity. In the long run, the research companies are thought to pay for themselves through industry contracts, and the public funding is reduced accordingly (SMWA 1997; SMWK 1997). About half of these R&D companies are clustered in the greater Dresden area.

A further expansion of the already substantial research and technology potential of Saxony's three main agglomerations, including four universities and four technical colleges educating 75.000 students as well as a large number of R&D institutes in the state's core could advance the transformation of Saxony's so-called "Urban triangle" into a "Research triangle" with Dresden as its strongest vertex in high-technology facilities.

Technology Policy and Innovation Subsidies

In addition to subsidies paid by the German government and the European Union to help industry R&D especially in smaller enterprises, Saxony initiated its own program to foster innovation activities. The state government seeks to focus the regional funds from the EU together with its own money on R&D and enterprise co-operation programs. Basis for the state's technology policy are the "Technology policy guidelines in the state of Saxony", which show a close affiliation with the innovative-milieu-approach. Main aims are "improvement of R&D infrastructure", "modernization of technology-oriented economic structures", "strengthening of technology-oriented competitiveness and productivity" and "stimulation of dynamic growth" for higher employment (SMWA 1992). These aims are in accordance with the EU's regional policy of the EFRE, which explicitly names measures to strengthen the endogenous potential of regions by technology transfer and funding of R&D. Additional aims of the state's policy are "broadening of firm's R&D", "creation of (inter-)regional networks", "supply of information infrastructure and focal points for regional clusters" and "preservation of R&D capacities" referring to the funding of research companies.[12]

With the exemption of the funding of research companies and some other R&D facilities, the state's technology policy programs of the early 90s were integrated into the European Union's system of regional and technology-oriented aid for 1995 to 1999. Funding of patents, innovation assistance, and loan programs were added (HAGEN and TOEPEL 1997: 34). The funding of independent and co-operative innovation projects accounted for 70 to 80% of the budget. 290 million euros were assigned in the five-year-period to 1999, financed 75% out of EU-funds and the remaining 25% by the state of Saxony.

The funding of co-operation projects aims at the build-up of regional and interregional networks important for innovation activities and competitiveness of enterprises. In particular, small firms are meant to initiate contacts with R&D facilities of the region, utilizing the given potentials and accelerating technological change. The strengthening of the transfer of technologies, therefore, constitutes a main feature of Saxony's technology policy, corresponding to the central message of the innovative milieu approach.

Research Parks and Incubation Centers as Elements of Innovative Milieux

Research Parks and facilities for "incubating" start-ups are another element of technology-oriented regional policy aiming at "focal points for innovative regional clusters" (HAGEN and TOEPEL 1997: 37). Because of the importance of establishing new enterprises in the build-up of a market economy after unification research parks as well as facilities for technology transfer were seen as an adequate instrument to help young and innovative firms.

After the economic crisis in the early eighties, the research-park-concept was adopted in Germany with the aim of strengthening technological change through innovative start-ups. But instead of establishing big "technopoles", smaller "incubators" were created with the specific aim of supporting innovative start-ups in high-tech-industries. Often, the incubators were established in university cities ensuring close contacts of the young enterprises with R&D and giving spin-offs incentives to stay in the region. Successful co-operation with universities is a condition for transforming research parks into an element of regional innovation potential. In 1998 there were about 200 research parks and incubators in Germany.

The dramatic de-industrialization of East Germany after the collapse of the centrally planned economy and the accompanying loss of industrial R&D potential made research parks into an attractive instrument of technology-oriented regional policy. Because of the high relevance of

[12] In addition to this, Saxony's technology policy guidelines provide for the support of specific technologies relevant for the future, like biotechnology, information technology, material sciences, micro-systems technology, medical sciences, energy-saving and environmental protection. These fields are defined by a consultationary gremium to the state ministry of industry and trade (SMWA 1992: 8).

innovative SMEs for economic recovery in the East, research parks in the new Laender are co-funded by the federal government. In a program by the federal ministry of technology, the establishment of 26 “model facilities” was subsidized with 20 million euros. In Saxony, six incubators were partly funded out of this program (PLESCHAK 1995: 14).

After a rapid build-up-process, 51 facilities already existed in 1993, employing about 4,200 people in 722 SMEs (BURKHARDT 1994: 9). Many of these were established jointly with West-German research parks. In the middle of 1998 73 incubators and parks in Eastern Germany counted 1,743 firms with more than 10,000 employees, Saxony’s share was 3,320 employees or 33% (DNN: 22.08.1998). Today, the density of facilities in Eastern Germany is higher than in the West. But more than a few of these incubators are in small towns far away from universities or technical colleges. At these locations so-called research or technology parks are often pure business parks without high-tech firms (STERNBERG et al. 1996). There are about 50 “real” research parks or incubators (TAMÁSY 1997: 187).

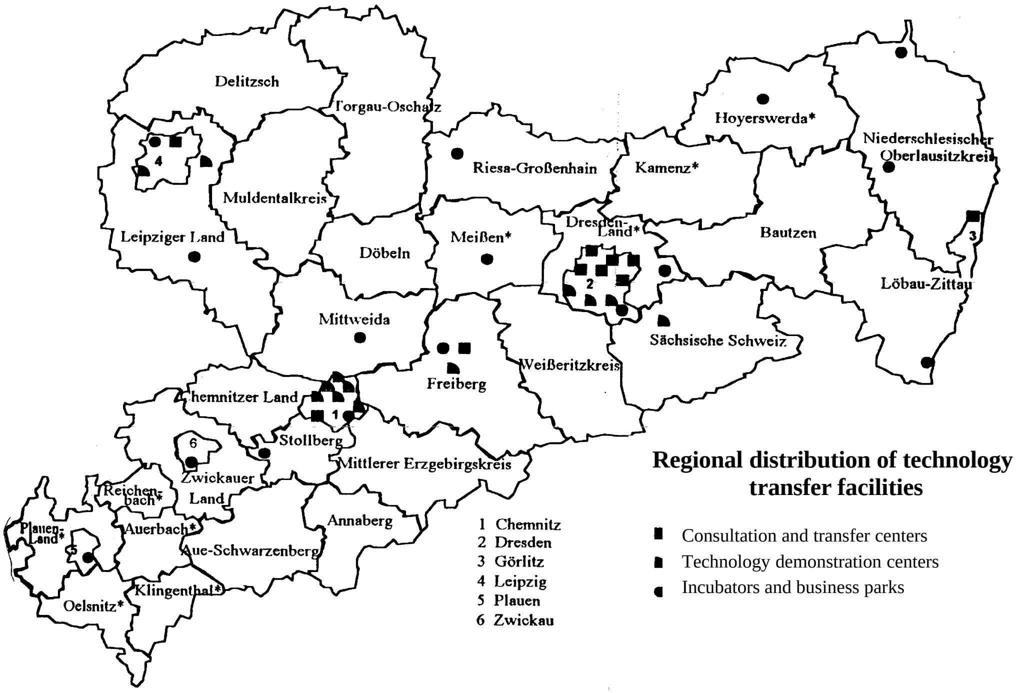
A comparison between East and West German facilities is given by STERNBERG et al. (1996). Most East German incubators are very small, causing high overhead costs and isolating high-tech enterprises. Generally, the technology-intensity of start-ups in Eastern incubators is lower than in West German facilities (TAMÁSY 1997, 195), giving an indication that too many research parks and incubators were established.

In Saxony, there are 21 technology-oriented incubators supported by the state government. These facilities are not restricted to agglomerated areas, but also provide space for potential start-ups in peripheral areas of the state, as is shown on the map below. Saxony’s biggest incubation facility for high-tech start-ups is located in the city of Dresden. In 1991, this technology center was founded jointly by the city, the university and the Dortmund technology center. After a process of steady growth, in 1999, the “TechnologieZentrum Dresden” provided space for more than 80 companies working on different fields of technology with close to 700 employees, more than 98% of its 14.000 m² office and laboratory space were rented.[13]

The activities of the Dresden technology center are closely related to the city’s university, which maintains a contact office called “TUDtransfer”. The aim of the co-operation is to facilitate technology transfer from university research and R&D institutes and to provide better possibilities for spin-offs. Consultation and the arrangement of contacts to university researchers and other companies and public institutions are offered besides office and laboratory space. Activities of the start-ups are concentrated on industries well represented in the Dresden area like microelectronics and computational sciences, communication technology, medical sciences and new materials, microsystems and sensor technology.

[13] An “outpost” of the Dresden technology center was established in 1997 on a site adjoining the Infineon-plant in Northern Dresden, giving SMEs of the semiconductor industry direct access to this important establishment with the aim of creating linkages between small local firms and external subsidiaries (DIW, IfW, IWH 1998).

Technology and Innovation Centers in Saxony



Source: SMWA 1997: 131.

Another five centers for start-ups exist in the vicinity of Dresden. The “InnovationsCentrum” in Meissen holds 33 SMEs with more than 200 employees. The main focus lies with ceramic material sciences, electrical engineering and environmental protection. Firms co-operate with Dresden and Freiberg universities and Dresden’s technical college. An incubator with 12 start-ups opened in 1995 at the Rossendorf research center. Two small facilities are located at Klingenberg and near Riesa to the north of Dresden. A bigger technology park is located at Freiberg, a university town 30 kilometers from Dresden. 60 SMEs with more than 450 employees are established on 15.000 m² of usable space. Technological fields are process technology, environmental sciences, material sciences, medical sciences, automation technology, electrical engineering, communication technology and computational sciences. A co-operation agreement is kept with Freiberg Technical University. As a seventh incubator exists in the East Saxonian periphery, the regional supply is likely to exceed the demand given by the number of potential high-tech start-ups.

Saxony also maintains an array of technology transfer, consultation, and demonstration facilities providing contacts to universities, colleges and research institutes. Their main focus is on helping SMEs in innovation projects. These facilities are often connected to universities and colleges using their resources and offering direct relations to researchers and university know-how (SMWK 1997: 131). Patent information centers exist at Dresden and Chemnitz universities of technology with the aim of helping start-ups as well as established enterprises in the patenting of their innovations.

Technology transfer offices are established with the aim of arranging contacts between enterprises and experts at institutes and universities or inter-firm contacts to speed up the diffusion of know-how. STAUDT et al. (1994) name information, initiation of contacts with

R&D institutions and start-up-consultation as their main objectives, though SMEs criticize badly specified information and a lack of external experts and co-operation with universities.

Technology demonstration centers show state-of-the-art technologies and solutions in specific industries like textiles or mechanical engineering, while consultation offices have a similar but somewhat broader field of activities. Especially SMEs, which account for more than 90% of enterprises in the new Laender, have considerable difficulties in their innovation adoption process, that are thought to be reduced by these facilities. As is shown by above descriptions, the boundaries between the three types of facilities are blurred, often one center exercises more than one task. Holding 13 consultation offices, seven technology demonstration centers and ten transfer offices, there is a concentration of facilities on the district of Dresden.

The effectiveness of the facilities described above in the support of innovation diffusion and adoption remains disputed. Critics see a strong orientation towards enterprises that seek the services of technology centers and transfer offices by their own initiative (FELLER 1997). Thus aid is concentrated on firms that are above-average in their innovation activities anyway, widening the gap between "winners" and "losers" instead of developing a strategy that could be labelled "make more winners". An additional problem is the diversity of programs confusing SME decision makers and deterring them from utilizing the services offered.

4. The Developing Cluster of High-Tech-Industries in Dresden

Although the former "people's owned factories" operating in the microelectronics sector were confronted with even greater challenges after unification than other firms and often had to be liquidated, the technological orientation of the Dresden region towards the semiconductor industry was the basis for its more successful development in the nineties compared to other East-German regions. The distribution of microelectronics establishments in Saxony with its obvious concentration on the Dresden agglomeration is shown by the map below.

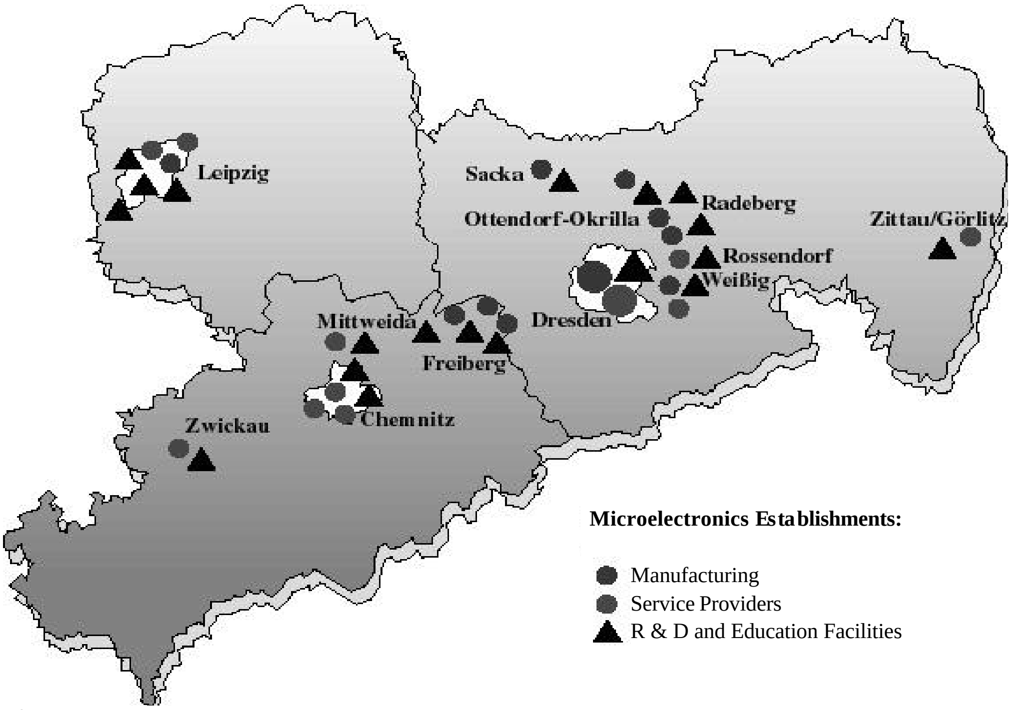
The transformation of Dresden into a center of the GDR's microelectronics sector left a legacy of qualified engineers and computer scientists and a potential of university research and education that constituted a basis for high-tech regional growth under market economic conditions even if the socialist firms could not survive. The combination of this surviving high-tech potential with the extensive programs of technology and regional policy laid up for Eastern Germany encouraged the decisions of Siemens and later AMD to establish large production plants in Dresden against substantial international locational competition.[14]

The planning process for the Siemens semiconductor-plant "SIMEC" at the Dresden location – now part of Infineon – started in 1993. The micro-location in northern Dresden near the city's airport was chosen in 1994. Due to the close co-operation with officials of the state, district and the city of Dresden, the detailed planning was finished in the exceptionally short time of five months. Construction began in June 1994, only one month after approval. Initial plans included a workforce of 1,450 employees, but in 1998 more than 2,200 people were

[14] These decisions cannot be explained with the massive public funding alone, as other locations like Scotland offered financial subsidies on a similar scale. A positive factor seems to be the high acceptance of large scale investments in the population.

already employed. This extension was made possible by the company's decision to locate its „Center of Development and Investigation"in Dresden, upgrading the plant through establishing a R&D center for process engineering in semiconductor technologies. Thus the Dresden site has become a research provider for the other semiconductor plants of Siemens. The 1999 re-organization of Siemens with the disincorporation of semiconductor production under the new name „Infineon" and its floatation in 2000 doesn't seem to have negative consequences for the Dresden establishment.

Locations of Microelectronics Research and Manufacturing Establishments in Saxony



Source: WfS 1997.

The investment volume was planned at 1.4 billion euros over a ten-year-period, but by 2000 more than 1.5 billion have already been spent due to the expansion of the plant.[15] Capital intensity per employee amounts to 700,000 euros, which is well above the 200,000 euros average for new industrial establishments in Germany (DIW 1997: 19), but still below capital intensity of the new Leuna plants of the chemical industry in central Eastern Germany which is as high as 1.6 million euros per employee. Investment subsidies are 0.25 million euros p.e. at Siemens-Dresden, but double that amount at the new chemical plants in Saxony-Anhalt.

To promote the creation of a "microelectronics cluster", the state government is willing to attract further companies to the Dresden area. In 1996 the US-based semiconductor company Advanced Micro Devices (AMD) decided to set up a production plant in Dresden. In addition to manufacturing the latest generation of microprocessors, a design center for IC-development is part of the investment, further strengthening the region's R&D potential. The investment volume of 1.5 billion euros is similar to the Siemens plant, though employment was planned

[15] Of 900 million euros investment volume in 1994 to 1996 buildings and infrastructure had a share of 360 million, spent mainly locally, but 540 million euros were invested in equipment, that was procured from abroad for the most part (DIW 1997: 38).

to be somewhat lower with a workforce of about 1,500. This number has risen to 1,900 employees by now, but capital intensity – and subsidies per employee – are nevertheless higher than at the Siemens subsidiary. AMD spends 180 million euros of its own money, while receiving public funding of more than 400 million (MÜLLER 1997).

The employment effects of the Siemens and AMD establishments are shown in the following table, including suppliers and indirect effects through the income multiplier. The total domestic employment effect was calculated at about 10,000 in 1997 (DIW 1997: 59), but due to the expansions, this number has risen to 16,600 in the meantime, with almost 14,000 in the Dresden region. The electronic industry plays a significant role in the Dresden labor market. Direct employment at the Infineon and AMD plants of 5,800 people after the current expansion will be 2.7% of the city's total employment of about 212,000, but more than 22% of manufacturing employment in Dresden and still about 12% of the region's manufacturing workforce including the three adjoining counties. The total employment effect is more than double that number according to the table presented below. Dresden's employment in electronics and electrical engineering grew by 23% to 7,000 from 1994 to 1997. In the greater region it grew by 17% after a 26% decline in the preceding three-year-period. The number of companies in the electronics and electrical industry rose from 44 in 1992 to 64 in 1997. Industry sales grew at the same time by 111% to 810 million euros (DIW, IfW, IWH 1998: 124f). But recently the industry's expansion in the region is becoming constricted by a scarcity of qualified engineers and computer scientists despite the educational capacities of the city's University of Technology and its technical college.

Table 3: Effects of the Dresden plants of Infineon and AMD on the local labor market

	Germany			**Dresden Region**		
	Infineon	**AMD**	**in total**	**Infineon**	**AMD**	**in total**
Direct employment	4,000	1,800	5,800	4,000	1,800	5,800
Inputs and equipment	3,354	1,612	4,966	2,782	1,265	4,047
Income multiplier	3,700	2,126	5,826	2,546	1,464	4,010
Total employment	**11,054**	**5,538**	**16,592**	**9,328**	**4,529**	**13,857**

Employment numbers from 2001. Calculations by the author based on different sources.

The third biggest semiconductor-firm in the region is ZMD, which evolved from the GDR's former microelectronics research center Dresden, a facility of 3,900 employees in 1989. Today ZMD has a workforce of about 400; it is a state-owned enterprise soon to be privatized. Products include tailor-made logic circuits. R&D co-operation is conducted with several partners, including research facilities of the region. The firm's R&D department employs 60 researchers (DIW 1997: 21f; WfS 1997: 10). Demand grew only slowly in the early nineties, but recently sales picked up and in 1999 turnover was more than 50 million euros.

International equipment firms and other suppliers of the electronics industry have established subsidiaries in Dresden to serve the Siemens-Infineon and AMD plants, but these affiliates are often quite small. While most of the construction and engineering was done by German firms, the equipment industry for semiconductor manufacturing is dominated by American and Japanese companies and there are only few domestic suppliers of specialized equipment.

In the supply and equipment industry, a process of concentration has taken place over the last decade that was caused in part by growing costs for R&D and capital goods as machines became more and more sophisticated and expensive with every generation of semiconductors. Up to now, only a few big suppliers have decided to locate production in Dresden, as the high share of international inputs of the Infineon plant demonstrates (DIW 1997: 43). In order to secure long-term development of the region, the state's technology policy should therefore concentrate on equipment suppliers and service firms to create regional linkages between the two "big players", subsidiaries of international suppliers and local SMEs, as a step towards innovative-milieu-formation.[16] First signs of such a process taking place can now be identified: The Dresden firm DAS is one of the fastest growing regional suppliers. It invented an innovative process for the environmentally save disposal of poisonous wastes associated with semiconductor manufacturing. Besides DAS – a ZMD spin-off from 1991 – new enterprises like „FHR Anlagenbau", producing thin-film coating machines for semiconductors, and „Xenon Automatisierungstechnik" and ASEM in the equipment sector are hopeful candidates for an "electronics cluster" (WfS 1997: 12).

The industry's R&D sector received further impulses through the decision, made in 1998, by Siemens and Motorola to establish a joint-venture for the development of a new generation of chips based on silicon wafers with 300 instead of 200 mm diameter in Dresden. This revolutionary semiconductor technology opens up the possibility of a drastic reduction in production costs. The first use in large-scale production will be made at the Dresden Infineon plant, at which construction for an enlargement is under way in the second half of 2000. The investment volume for the R&D joint-venture was 230 million euros, and 450 jobs were created with a high share of highly qualified engineers.[17] Total employment at the Infineon establishment will rise to 3,400, making it by far the biggest industrial employer in the region.

The large amount of subsidies paid to co-fund only two microelectronics establishments was criticized heavily. Critics feared the creation of capital but not research-intensive subsidiaries, that help little in the formation of the region's technology potential as part of an innovative milieu. Another point of view is that the attraction of large-scale investment is a necessary condition in generating a high-tech-region, because capital-intensity in the microelectronics sector has reached a level preventing endogenous regional development through innovative SMEs alone (DIW 1997: XVII). The danger of a purely capital instead of human-capital-intensive production seems to be banned for Dresden with the location of the "Center of Development and Investigation" by Siemens, the laboratory for chip-design by AMD and the R&D-joint-venture between Siemens and Motorola. As the Saxonian economy is not characterized by a general lack of R&D, but by a scarcity of big enterprises (RÖHL 2000) that account for the greatest part of research activities in Western Germany and other industrial

[16] To cope with growing demand, the US company Applied Materials – the world's leading provider of equipment for semiconductor production – established its biggest German subsidiary with more than 100 employees in Dresden. Japanese companies like Canon and Tokyo Electron have opened subsidiaries, too. But most of these are relatively small as R&D is conducted in the home countries (DIW, IfW, IWH 1999: 187).

[17] The investment is subsidized with more than 60 million euros by the state; another 96 million are paid by the federal ministry of science to finance research activities.

countries, Saxony's minister of economics SCHOMMER (1997: 37) defends the concentration of public funding on large investments and stresses the importance of Infineon, AMD and Volkswagen for the development of regional SMEs as suppliers and service providers.

The intention of this technology policy through subsidies is based on the belief that the microelectronics sector will remain one of the fast-growing high-tech industries of the 21st century. But the market for semiconductors shows strong fluctuations: world-market sales slumped from US $ 144 billion in 1995 to 129 billion in the following year. In 1997 and 1998 there were high growth rates of 17% and 22%. This trend continued in 1999 and 2000, when worldwide sales might reach about US $ 225 billion. A continuation of this growth rate is very unlikely as a strong expansion of production capacity is driving prices down.

In spite of the big establishments of the computer industry, an unbalanced development was avoided, which may cause dangerous dependencies of the regional economy.[18] Besides microelectronics, other technology-intensive industries like medical devices, measuring and control instruments and the pharmaceutical industry, are showing signs of new growth. Asta Medica and SmithKline Beecham took over the city's two pharmaceutical plants. Also expanding are printing and publishing with a state-of-the-art plant by Gruner&Jahr (DIW, IfW, IWH 1999: 188). In printing machinery, Planeta with its Radebeul plant close to Dresden was able to preserve its strength in R&D, despite being taken over by a West German company, and is now one of East Germany's firms most active in patenting.

The decision by Volkswagen to locate a "crystal factory" for the assembly of the firm's new luxury car in Dresden shows that the city offers attractive conditions for industries of medium technology level, too. In contrast to West German cities, low-priced centrally located plots and an industry-friendly attitude of local politicians and the population act in favor of industrial investments. The co-operation in manufacturing with VW's plant near Zwickau in Southwestern Saxony and its local suppliers strengthens the Saxonian "auto industry cluster". A second plant of the transportation industry are the "Elbeflugzeugwerke", now belonging to EADS, with a workforce of 500. This establishment of the technology-intensive aircraft industry is a supplier to Airbus and rebuilds used aircraft into freighters. The university with its department of traffic and transportation sciences and the technical college are two important research and education facilities for the industry.

Dresden had above-average rates of business creation and growth in the first half of the nineties, and LEHMANN (1994: 347) already discovered signs of a developing innovative milieu. But most measurable criteria didn't show a leading role of the agglomerations in the East German economy up to 1995, and the possibility of a growth-pole-function of the bigger cities – other than Berlin – for the New Laender was seen with skepticism (GENOSKO 1996: 140). The manufacturing industries that are clustered around Dresden and Zwickau received large amounts of subsidies. This dependency on public aid initially did not indicate the

[18] GLAESER et al. (1992) find in an analysis of growth rates of different industries in 179 US-cities from 1956 to 1987 a negative correlation between regional concentration of industries and their growth rates. They conclude that inter-industrial spillovers through urbanization economies are more important than locational economies of specific industries. Urbanization economies even seem to be growing, but especially in metropolitan areas of more than two million inhabitants (SCOTT 1993; CASTELLS 1991).

possibility of a self-enforcing growth path transmitting spillovers into the regional economy. But since the middle of the 1990s, the East German manufacturing sector has regained a strong position in export markets with new products (DIW, IfW, IWH 1998: 60f), and the assessment regarding the industries clustered in Saxony, especially the technology-intensive electronics production in the Dresden area, can be much more positive now.

5. Conclusion and Outlook

Applying CAMAGNI's concept of „potentially innovative milieu" to Saxony's agglomerations Dresden, Leipzig and Chemnitz, the criteria seem to be met most comprehensively in the capital, Dresden, with its concentration of public research institutions and facilities of higher education. In the past five years, Dresden became one of Germany's leading centers of the IT and semiconductor industry with huge establishments by Siemens and AMD and a growing number of smaller firms, but the building of linkages between these elements is still in a very early phase (DIW, IfW, IWH 1998b: 129). The Chemnitz region has a long-lasting industrial tradition in textiles and machinery, but small scale production structures typical of industrial districts were destroyed in the centrally planned economic system of the GDR. Leipzig's economic structure is characterized by a lack of manufacturing industries. Milieu formation might be possible in services, but the important sector of business services suffers from the small base in manufacturing. The situation is more positive in trade and financial services.

Agglomeration economies play an important role in milieu formation, but in Saxony their effects are diminished by a spatial structure with three main cities of less than half a million inhabitants each. If any of these is too small to allow economies of urban scale, there may be a possibility for interurban synergies generating joint agglomeration economies. The build-up of co-operations between elements of the research and enterprise sector of the three cities – like R&D institutes, universities and colleges, technology-transfer facilities, high-tech firms and innovative SMEs – opens up the possibility for synergies and spillovers adequate to their combined scale. The creation of network structures between the three cities is made easier by their short distance; driving time between each city pair is only about one hour. The state's economic structure with its capital and high-tech-cluster Dresden, the trade and services city of Leipzig and the re-emerging manufacturing heartland at Chemnitz and Zwickau acts in favor of network structures to tap the specialized potential of the other cities. Thus Dresden can develop its high-tech potential towards an innovative milieu while using the trade services provided by Leipzig and co-operating with manufacturing firms from the Chemnitz area.

Up to now, only little co-operation with partners in Poland and the Czech Republic is conducted, though Dresden's close proximity to the East European neighbors represents a potential for cross-border networks. Co-operation fairs are offered by the city's chamber of trade and commerce (DIW, IfW, IWH 1999: 191). Linkages towards East European countries are important in order to be positioned on their markets after their integration into the European Union, but there is also the possibility of lowering production costs by transferring labor-intensive steps of manufacturing eastwards. In the long run, the spatial proximity and growing dividends of European integration could become a decisive economic factor for the South-Eastern part of the new Laender and the region's main city Dresden.

An impressive number of research institutions, the University of Technology and the technical college with close to 10.000 employees and about 30.000 students taken together, big industrial establishments like Infineon and AMD as well as a growing number of smaller local firms in the high-tech-sector form the basic ingredients of a potential innovative milieu in the Dresden metropolitan region. The state government seems to be aware that ongoing efforts on the regional and technology policy side are needed to make the region more attractive for new industries, as is demonstrated by its recent program to fund R&D facilities and start-ups in the biotechnology sector in Dresden and Leipzig with 200 million euros.

The development path initiated for the Dresden region, with a growing cluster of the microelectronics industry in conjunction with an according orientation of its R&D facilities and educational sector, opens up the chance of a successful milieu formation. The process of de-industrialization of the upper Elbe valley seems to be reversed, as other high-tech industries like biotechnology are starting to make investments in the area.

The low level of network-building between the local actors is still to be criticized, as these regional linkages play an important role in the formation of innovative milieux.[19] Innovative activities are a cumulative process with firms and individuals building on their former experiences. As former linkages of the East German R&D system were abruptly destroyed following the demise of the socialist economy, this process had to be started anew. Comparing the successes reached in some regions of the new Laender in the past 10 years, especially the Dresden metropolitan area, with the generation process of other innovative clusters like the “Research Triangle” in North Carolina or “Silicon Glen” in Scotland, the milieu formation is rather more advanced than to be expected. But whether the formation of interlinked creative milieu structures will succeed depends on different factors, including a new entrepreneurial spirit that is still missing in the former socialist East German Laender and generally seems to be rather scarce in Germany.

References

Acs, Zoltan J., Audretsch, David B. (1990): Innovation and small firms, Cambridge (Mass.).

Acs, Zoltan; Audretsch, David B.; Feldman, Maryann P. (1992): Real Effects of Academic Research: Comment, *American Economic Review*, 82: 363-67.

Albach, Horst (1993): Zerrissene Netze - Eine Netzwerkanalyse des ostdeutschen Transformationsprozesses, Berlin.

Andersson, Ake E. (1985): Creativity and Regional Development, *Eighth Pacific Congress of the Regional Science Association*, Vol. 56: 5-20.

Antonelli, Cristiano (1998): Localized technological change, new information technology and the knowledge-based economy: the European evidence, *Journal of Evolutionary Economics*, 8: 177-198.

Audretsch, David B.; Feldman, Maryann P. (1996): R&D Spillovers and the Geography of Innovation and Production, *American Economic Review*, 86: 630-640.

Aydalot, Philippe (Ed.) (1986): Milieux Innovateurs en Europe, Paris.

Aydalot, Philippe, Keeble, David (Ed.) (1988): High-Technology Industry and Innovative Environments: The European Experience, London, New York: 1-21.

[19] This deficit is caused by the ongoing effects of the structural crisis after 1989 with its sudden destruction of old network structures (ALBACH 1993). The establishment of regional clusters of innovative industries requires networks of complementary service firms that are normally focused on large companies. As bigger enterprises in eastern Germany are almost exclusively subsidiaries of western companies, they form “outposts” of existing interregional networks slow in developing local relations.

Baptista, Rui; Swann, Peter (1998): Do firms in clusters innovate more?, *Research Policy*, 27: 525-540.

Becattini, Giacomo (1992): Le district Marshallien: une notion socio-économique, in: Georges Benko, Alain Lipietz (Ed.): Les Régions qui gagnent, Paris: 35-56.

Bergman, Edward; Maier, Gunther; Tödtling, Franz (1991): Reconsidering Regions, in: Edward Bergman, Gunther Maier, Franz Tödtling (Ed.): Regions Reconsidered, London: 283-300.

Bramanti, Alberto; Senn, Lanfranco (1991): Innovation, firms and milieu: a dynamic and cyclic approach, in: Roberto Camagni (Ed.): Innovation Networks: Spatial Perspectives, London: 89-104.

Bröcker, Johannes (1995): Comment to: „Agglomerationen und regionale Spillovereffekte" by Dietmar Harhoff, in: Bernhard Gahlen, Helmut Hesse, Hans J. Ramser (Ed.): Standort und Region – Neue Ansätze zur Regionalökonomik, Tübingen: 119-23.

Burkhardt, Manfred (1994): Technologie- und Gründerzentren in der Bundesrepublik Deutschland – Eine Zwischenbilanz, Tagung am 2.11.93 in Magdeburg, Friedrich-Ebert-Stiftung (Ed.), Bonn.

Camagni, Roberto (1991): Local milieu, uncertainty and innovation networks: towards a new dynamic theory of economic space, in: Roberto Camagni (Ed.): Innovation Networks: Spatial Perspectives, London: 121-44.

Camagni, Roberto (1995): The concept of innovative milieu and its relevance for public policies in European laging regions, *Papers in Regional Science*, 74, 4: 317-340.

Castells, Manuel (1991): The Informational City – Information Technology, Economic Restructuring, and the Urban-Regional Process, Oxford.

Castells, Manuel; Hall, Peter (1994): Technopoles of the world: The making of twenty-first-century industrial complexes, London, New York.

Courault, Bruno; Romani, Claudine (1992): A Reexamination of the Italian Model of Flexible Production from a Comparative Point of View, in: Michael Storper, Allen J. Scott (Ed.): Pathways to Industrialization and Regional Development, London, New York: 205-215.

Crevoisier, Olivier; Maillat, Denis (1991): Milieu, industrial organisation and territorial production system: towards a new theory of spatial development, in: Roberto Camagni (Ed.): Innovation Networks: Spatial Perspectives, London: 13-34.

Davelaar, Evert-Jan (1996): Regional Economic Analysis of Innovation and Incubation, Aldershot u.a.

DIW - Deutsches Institut für Wirtschaftsforschung (1997): Gesamtwirtschaftliche und regionale Effekte von Bau und Betrieb eines Halbleiterwerks in Dresden – Untersuchung im Auftrag der Deutschen Forschungsanstalt für Luft- und Raumfahrt e.V. (also: *DIW - Sonderheft*, 164, 1998), Berlin.

DIW - Deutsches Institut für Wirtschaftsforschung, Institut für Weltwirtschaft (IfW), Institut für Wirtschaftsforschung Halle (IWH) (Ed.) (1998): Gesamtwirtschaftliche und unternehmerische Anpassungsfortschritte in Ostdeutschland – Achtzehnter Bericht, *IWH-Forschungsreihe*, 6/98.

DIW - Deutsches Institut für Wirtschaftsforschung, Institut für Weltwirtschaft (IfW), Institut für Wirtschaftsforschung Halle (IWH) (Ed.) (1999): Gesamtwirtschaftliche und unternehmerische Anpassungsfortschritte in Ostdeutschland – Neunzehnter Bericht, *IWH-Forschungsreihe* 5/99.

DNN (Dresdner Neueste Nachrichten), 22.08.1998: 50 neue Technologiezentren – Motoren für die Wirtschaftsentwicklung in Ostdeutschland.

Dosi, Giovanni (1988): Sources, Procedures, and Microeconomic Effects of Innovation, *Journal of Economic Literature*, 26: 1120-1171.

Feldman, Maryann P. (1994): The Geography of Innovation, Dordrecht, Boston, London.

Feller, Irwin (1997): Manufacturing Technology Centers as Components of Regional Technology Infrastructures, *Regional Science and Urban Economics*, 27, S. 181-197.

Fritsch, Michael (1995): Arbeitsteilige Innovation – Ein Überblick über neue Forschungsergebnisse, *Freiberger Arbeitspapiere*, 95/20.

Garofoli, Gioacchino (1991): Local Networks, Innovation and Policy in Italian Industrial Districts, in: Edward Bergman, Gunther Maier, Franz Tödtling (Ed.): Regions Reconsidered – Economic Networks, Innovation, and Local Development in Industrialized Countries, London: 119-140.

Genosko, Joachim (1996): Regionale Differenzierung der Wirtschaftsstrukturen, in: Wendelin Strubelt, Joachim Genosko, Hans Bertram u.a. (Ed.): Städte und Regionen – räumliche Folgen des Transformationsprozesses, Opladen: 111-142.

Glaeser, Edward L.; Kallal, Hedi; Scheinkman, José; Shleifer, Andrei (1992): Growth in Cities, *Journal of Political Economy*, 100: 1126-1152.

Goldstein, Harvey (1991): Growth Centers vs. Endogenous Development Strategies: The Case of Research Parks, in: Edward Bergman, Gunther Maier, Franz Tödtling (Ed.): Regions Reconsidered – Economic Networks, Innovation, and Local Development in Industrialized Countries, London: 241-263.

Gordon, Richard (1991): Innovation, industrial networks and high-technology regions, in: Roberto Camagni (Ed.): Innovation Networks: Spatial Perspectives, London: 174-195.

Grabher, Gernot (1991): Rebuilding Cathedrals in the Desert: New Patterns of Cooperation between Large and Small Firms in the Coal, Iron, and Steel Complex of the German Ruhr Area, in: Edward Bergman, Gunther Maier, Franz Tödtling (Ed.): Regions Reconsidered - Economic Networks, Innovation, and Local Development in Industrialized Countries, London: 59-78.

Hagen, Kornelia; Toepel, Kathleen (1997): Europäische Strukturfonds in Sachsen: Zwischenevaluierung für die Jahre 1994 bis 1996, *DIW - Beiträge zur Strukturforschung*, Nr. 171.

Hansen, Niles M. (1990): Innovative regional milieux, small firms, and regional development: Evidence from Mediteranian France, *The Annals of Regional Science*, 24: 107-123.

Harhoff, Dietmar (1994): R&D, Spillovers and Productivity in German Manufacturing Firms, Jahrestagung 1994 des Vereins für Socialpolitik, *Discussion Paper*.

HTW (Hochschule für Technik und Wirtschaft) Dresden (1998): Forschungsbericht 1997.

Jaffe, Adam (1989): Real Effects of Academic Research, *American Economic Review*, 79: 957-970.

Lehmann, Udo (1994): Regionale Aspekte des Betriebsgründungsgeschehens in den neuen Bundesländern, in: Institut für Arbeitsmarkt- und Berufsforschung (IAB) (Ed.): *Mitteilungen aus der Arbeitsmarkt- und Berufsforschung*, 4/94: 338-350.

Maier, Gunther; Tödtling, Franz (1995): Regional- und Stadtökonomik 1 – Standorttheorie und Raumstruktur, Vienna.

Maillat, Denis (1991): The Innovation Process and the Role of the Milieu, in: Edward Bergman, Gunther Maier, Franz Tödtling (Ed.): Regions Reconsidered – Economic Networks, Innovation, and Local Development in Industrialized Countries, London: 103-118.

Maillat, Denis; Vasserot, Jean-Yves (1988): Economic and Territorial Conditions for Indigenous Revival in Europe's Industrial Regions, in: Philippe Aydalot, David Keeble (Ed.): High-Technology Industry and Innovative Environments: The European Experience, London, New York: 163-183.

Malecki, Edward J. (1990): Technological innovation and the paths to regional economic growth, in: Jurgen Schmandt, Robert Wilson (Ed.): Growth Policy in the Age of High Technology, London: 97-126.

Marshall, J. Neill (1990): The Dynamics of Producer Services, in: Riccardo Cappellin, Peter Nijkamp (Ed.): The Spatial Context of Regional Development, Aldershot: 167-194.

Meske, Werner (1996): Zur Problemlage des ostdeutschen Innovationssystems unter besonderer Berücksichtigung der Forschungslandschaft, in: Klaus Schweickart, Ralf Witt (Ed.): Systemtransformation in Osteuropa, Stuttgart: 165-178.

Müller, Uwe (1997): Chip-City Dresden, in: Die Welt, 06.02.97.

Ostwald, Werner (1990): Raumordnungsreport '90 – Daten und Fakten zur Lage in den ostdeutschen Ländern, Berlin.

Perrin, Jean-Claude (1988): New Technologies, Local Synergies and Regional Policies in Europe, in: Philippe Aydalot, David Keeble (Ed.): High-Technology Industry and Innovative Environments: The European Experience, London, New York: 139-62.

Pfähler, Wilhelm; Clermont, Christian; Gabriel, Christian; Hofmann, Ulrich (1997): Bildung und Wissenschaft als Wirtschafts- und Standortfaktor: Die regionalwirtschaftliche Bedeutung der Hamburger Hochschulbildungs- und Wissenschaftseinrichtungen, Baden-Baden.

Pfirrmann, Oliver (1994): The Geography of Innovation in Small and Medium-Sized Firms in West Germany, *Small Business Economics*, 6: 41-54.

Pleschak, Franz (1995): Technologiezentren in den neuen Bundesländern, Heidelberg.

Preer, Robert W. (1992): The Emergence of Technopolis: knowledge-intensive technopolgies and regional development, New York, London.

Röhl, Klaus-Heiner (2000): Die Eignung der sächsischen Agglomerationsräume als Innovations- und Wachstumspole für die wirtschaftliche Entwicklung des Landes, *Diskussionsbeiträge aus dem Institut für Wirtschaft und Verkehr*, 1/2000, Dresden

Saxenian, Annalee (1994): Regional Advantage – Culture and Competition in Silicon Valley and Route 128, Cambridge (Mass.).

Schommer, Kajo (1997): Industriepolitische Überlegungen und Wirtschaftsförderung für sächsische KMU, in: Eli, Max (Ed.), Ifo-Institut, Niederlassung Dresden: Der Weg der KMU in die Zukunft – Globalisierung der Märkte, Management, Innovation, Dresden: 34-42.

Scott, Allen J. (1988): New Industrial Spaces, London.

Scott, Allen J. (1993): Technopolis – High-Technology Industry and Regional Development in Southern California, Berkeley, Los Angeles, Oxford.

Shefer, Daniel; Frenkel, Amnon (1997): Local Milieu and Innovations: Some Empirical Results, European Regional Science Association, 37. European Congress.

Silverberg, Gerald (1990): Adoption and diffusion of technology as a collective evolutionary process, in: Christopher Freeman, Luc Soete (Ed.): New Explorations in the Economics of Technical Change, London: 177-92.

SMWA (Sächsisches Staatsministerium für Wirtschaft und Arbeit) (1992): Leitlinien zur Technologiepolitik im Freistaat Sachsen, Dresden.

SMWA (Sächsisches Staatsministerium für Wirtschaft und Arbeit) (1997): Wirtschaft und Arbeit in Sachsen 1997 – Bericht zur wirtschaftlichen Lage im Freistaat Sachsen, Dresden.

SMWK (Sächsisches Staatsministerium für Wissenschaft und Kunst) (1997): Forschung in Sachsen, Dresden.

Statistisches Jahrbuch Sachsen 1996-1998, Statistisches Landesamt des Freistaates Sachsen (1996-1998), Kamenz.

Statistisches Landesamt des Freistaates Sachsen (Ed.): (1999): Studenten an den Hochschulen im Freistaat Sachsen, Statistische Berichte B III 1-1 - j/98, Kamenz.

Statistisches Landesamt des Freistaates Sachsen (Ed.): (1999): Personal an den Hochschulen im Freistaat Sachsen, Statistische Berichte B III 4 - j/98, Kamenz.

Staudt, Erich; Bock, Jürgen; Mühlemeyer, Peter (1994): Technology centres and science parks: agents or competence centres for small businesses?, *International Journal of Technology Management*, 9, No. 2: 196-212.

Sternberg, Rolf (1995): Innovative Milieus in Frankreich, *Zeitschrift für Wirtschaftsgeographie*, 3/4: 199-218.

Sternberg, Rolf (1996a): Regional Growth Theories and High-Tech Regions, *International Journal of Urban and Regional Research*, 20, 3, S. 518-538.

Sternberg, Rolf (1996b): Technology Policies and the Growth of Regions – Evidence from four Countries, *Small Business Economics*, 8, S. 75-86.

Sternberg, Rolf; Behrendt, Heiko, Seeger, Heike, Tamásy, Christine (1996): Bilanz eines Booms – Wirkungsanalyse von Technologie- und Gründerzentren in Deutschland, Dortmund.

Stöhr, Walter (1986): Regional Innovation Complexes, *Papers of the Regional Science Association*, 59: 29-44.

Tamásy, Christine (1997): Technologie- und Gründerzentren als Instrument der Technologiepolitik in Ostdeutschland, in: Innovationen in Ostdeutschland – Potentiale und Probleme, Tagungsband: 187-198.

Thwaites, Alfred; Alderman, Neil (1990): The Location of Industrial R&D: Retrospect and Prospect, in: Riccardo Cappellin, Peter Nijkamp (Ed.): The Spatial Context of Regional Development, Aldershot: 17-42.

Tödtling, Franz (1994): The uneven landscape of innovation poles: local embeddedness and global networks, in: Ash Amin, Nigel Thrift (Ed.): Globalization, institutions, and regional development in Europe, Oxford: 68-90.

Technische Universität Dresden (Ed.) (1999): Jahresforschungsbericht 1998, Dresden.

Von Hippel, Eric (1998): "Sticky Information" and the Locus of Problem Solving: Implications for Innovation, in: Alfred D. Chandler, Peter Hagström, Örjan Sölvell (Ed.): The Dynamic Firm – The Role of Technology, Strategy, Organization, and Regions, Oxford.

WfS - Wirtschaftsförderung Sachsen (1997): Mikroelektronik – Hochtechnologien aus Sachsen, Dresden.

Bisher sind als Diskussionsbeiträge erschienen:

1/97 **Bröcker, Johannes:** How would an EU-memberchip of the Visegrád-countries affect Europe's economic geography?

2/97 **Teubel, Ulf:** Wirkung von Straßenbenutzungsabgaben auf die Wohlfahrt von Berufspendlern - eine empirische Analyse -

1/98 **Röhl, Klaus-Heiner**: Gewerbeflächenmanagement in Agglomerationsräumen - Institutionelle Lösungsansätze und die Einflußmöglichkeiten der Regionalplanung

2/98 **Bröcker, Johannes** und **Frank Richter**: Entwicklungmuster ostdeutscher Stadtregionen nach 1945

3/98 **Bröcker, Johannes**: Welfare Effects of a Transport Subsidy in a Spatial Price Equilibrium

4/98 **Bröcker, Johannes**: Spatial Effects of Transeuropean Networks: preliminary results from a spatial computable general equilibrium analysis

5/98 **Bröcker, Johannes**: Spatial Effects of Transport Infrastructure: The Role of Market Structure

1/99 **Bröcker, Johannes** und **Martin Schneider**: How does Economic development in Eastern Europe affect Austria's regions? A multiregional general equilibrium framework

2/99 **Richter, Frank**: Ökonomische Hintergründe der Verwaltungsreform von 1952 in der DDR

1/2000 **Röhl, Klaus-Heiner**: Die Eignung der sächsischen Agglomerationsräume als Innovations- und Wachstumspole für die wirtschaftliche Entwicklung des Landes

2/2000 **Röhl, Klaus-Heiner**: Der Aufbau der ostdeutschen Infrastruktur und sein Beitrag zur wirtschaftlichen Entwicklung in Sachsen

3/2000 **Kummer, Sebastian; Mating, Anette; Käsbauer, Markus; Einbock, Marcus:** Franchising bei Verkehrsbetrieben

4/2000 **Westphal, Jan R.:** Komplexitätsmanagement in der Produktionslogistik

5/2000 **Röhl, Klaus-Heiner:** Saxony's Capital Dresden – on the Way to become Eastern Germany's first "Innovative Milieu"?