POLICIES TOWARDS TECHNOLOGY-BASED COMPANIES IN A REGIONAL CONTEXT

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Abstract

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Centres of excellence (CoE's) can arise from a regional cluster of technology-oriented enterprises, but also from a cluster of research institutes and innovation-supportive service institutions such as technology parks and information and advisory agencies. Strengthening of the regional innovation and technology base can take place when the CoEs are embedded in a regional network, so that other firms and institutions are also able to participate in the regional research and technology potential.

In this paper the thesis is put forward that it is not sufficient to use CoEs as a regional technology policy instrument without additional measures. CoEs can only contribute to strengthening the regional innovation potential if the scientific and technological capacities of firms located in the region are increased, or if the founding of new technology-based firms is supported. One precondition for the formulation of appropriate promotion measures is knowledge of the regional entrepreneurial and technology potential.

The paper first presents the technology policy measures and instruments for the support of technology-based firms in Germany, paying particular attention to the Federal Ministry of Research and Technology's two pilot schemes "Promotion of new technology-based firms" and "Venture capital for new technology-based firms". The former programme (1983 - 1988) aimed to create favourable conditions for firm foundations and innovation. In addition to nationwide promotion aspects (microelectronics, biotechnology), this first pilot scheme included a regional variant. One intention was that supporting incubater and technology centres and advisory services can build up a network of regional contacts, thus supporting the development of regional centres of excellence. The second pilot scheme (started in 1989) aims to support new technology-based firms indirectly by removing barrier factors in venture capital and seed capital companies and other investment agencies. As well as discussing these nationally implemented support measures, the paper will consider the question of the extent of "freedom of action" in support policy of the various individual regions (federal "Länder" and smaller administrative units).

The paper will then go on to review the results of some empirical studies on the technology potential of one German region, the Rhine-Main area. The definition of a "technology-based firm" will first be clarified before describing the regional potential of this type of enterprises, the research infrastructure of the region and selected technology support measures. Empirical analysis aims to answer the question of what starting-points can be deduced from the entrepreneuerial and research potential for the creation of regional CoEs as an instrument to secure regional technological competitiveness.

The last part of the paper gives a brief assessment of technology policy instruments for the support of technology-based firms and CoEs, regarding their degree of success in broadening the entrepreneurial base and creating or strengthening regional networks.

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1. PROBLEM AND CENTRAL THESIS

In recent years an approach has been revived under the slogan "valorizing diversity" (Hingel 1992) which was already to be found in regional and structural policy in the 1970s under the rubric of "endogenous potentials". Not only does this approach make regional potentials in their existing variety the starting point for individual development patterns, but it also propagates a re-consideration of the regions as the setting for structural and technology policy support measures.

The spatial approaches collectively referred to as "innovative milieus" can also be regarded as a part of this strengthening of the regional level. They are based on the following considerations (Toedtling 1990):

- Innovation is regarded as a collective process involving a large number of companies and institutions, and as a functional/sectoral and territorial phenomenon (Aydalot/Keeble 1988, Perrin 1988, Bramanti/Senn 1991).
- Innovation is a result of the interaction and synergy of factors, not of the individual factors themselves (Stoehr 1987, Perrin 1986, 1988).
- The spatial proximity of the actors is considered as an important precondition for interaction and cooperation, and thus as a factor favouring innovative activity.

Stoehr (1987) emphasises the synergy effect, which arises from the interaction of innovation-relevant functions (training, procurement of information and consultancy, financing and decision-making) at a regional level. Perrin (1988) describes different types of innovative networks with various permutations of relationships between large companies, small and medium sized firms and public institutions:

- Networks built up around large, established companies of long standing (e. g. Philips in south Netherlands);
- Networks of small and medium sized firms (e. g. "third Italy")
- Networks formed by the spatial concentration of functionally integrated branches of large companies (e. g. Sophia Antipolis in southern France);

- Networks arising through incubation (e. g. Silicon Valley).

One important precondition for the formation of networks and innovative milieus is the spatial proximity of the actors. According to Camagni (1990) this proximity is necessary, since human capital is less mobile between regions than within them. Camagni suggests that relationships between actors often run on personal contacts, and a common cultural, psychological and political background gives rise to synergetic effects.

The ideas of innovative milieus and the strengthening of regional innovation potential are in conformity with the approach of "Centres of Excellence" (CoEs). These can arise from a cluster of technology-oriented enterprises, but also from a cluster of research institutes and innovation-supportive service institutions such as technology parks and information and advisory agencies. Due to decreasing scope of production in manufacturing firms ("lean production", "outsourcing") on the one hand and the increasing scientific bonding of technology development on the other (microelectronics, biotechnology, materials technology), close cooperation of the innovating firms with users, suppliers and external services has become a precondition for the mastering of new technologies and the development of new products and processes (Grupp (ed.) 1992).

In Europe, but also in other parts of the world, regional production clusters - regions with strong internal networking - are forming. Some of these are young, expanding regions with new technology-based enterprises; some are traditional industrial regions with a structure of small and medium sized enterprises. New production and logistics concepts, and information and communication technology, favour the formation of these clusters. They are often connected by large-scale development axes such as the "Rhine axis" in Europe, which extends north as far as greater London and south to the industrial regions around Milan/Turin and Grenoble/Lyon/Marseille.

In the light of this background explanation of innovative milieus, regional networks and spatial production clusters, the strengthening of regional innovation and technology bases by CoEs would seem possible, provided that the CoEs are embedded in a regional network, also enabling other enterprises and institutions to participate in the regional research and technology potential. Thus in this paper the thesis is put forward that it is not sufficient to use CoEs as a regional technology policy instrument without additional measures. They can only contribute to strengthening regional innovation potential and help to maintain and create jobs if the scientific and technical absorption capacity of firms already in the region is increased, or if the foundation or location of new technology-based firms is encouraged. As economic and technology policy measures have to be applied to the regional actors,

knowledge of the regional entrepreneurial, scientific and technological potential is an important prerequisite for the elaboration of this type of regional development strategy.

The thesis of this paper will be illustrated more explicitly by presenting a regional example from Germany. The technology policy measures and instruments used on a national level to support technology-based firms and create regional innovation networks will then be described. This will be followed by an outline of the instruments available to regional units in Germany for the development of their technology-base, with specific examples. This is intended to give an idea of the policy framework within which regional techology policy can take place in Germany.

2. TECHNOLOGY POLICY MEASURES AND INSTRUMENTS TO STRENGTHEN TECHNOLOGY-BASED FIRMES IN GERMANY

2.1 Basic technology policy framework in Germany

In view of the specific competitive advantages of the Federal Republic of Germany in the factors of human capital and research and development, public support of (high) technologies is an obvious possibility for strategic reasons. The instruments used in public research and technology policy include institutional support, various forms of financial incentives and the support of an innovation-oriented infrastructure, including technology transfer (Meyer-Krahmer, Kuntze 1992; Koschatzky et al. 1992). An overview of the instruments of public technology policy is given in Figure 2-1.

Long-term orientation is important for efficiency and effectiveness in the use of technology policy instruments. Actors in science and industry have a chance to adapt efficiently if frame conditions are stable. It is also important to achieve a mixture of supply and demand orientation in the use of instruments. Institutional support and the support of (joint) projects, which are mainly applied early in the technology life cycle, have to be complemented by innovation-oriented services, technology transfer measures, demand and regulation, in order to create an effective demand pull.

The measures and instruments presented in the following section can be placed within this technology policy framework. According to Figure 2-1 they belong to the group of financial incentives (No.2) and support of other infrastructure and technology transfer (No.3). Although the technology policy of the Federal Government has a national dimension, individual programmes also include regional components, and description is concentrated most on these.

Figure 2-1: Instruments of public technology policy

In the strict sense	In the broad sense
1. Institutional support - national research centres - Fraunhofer Society, Max-Planck Society - Universities and technical colleges - other institutions **2. Financial incentives** - indirect promotion - indirect-specific promotion - R&D projects/joint R&D - venture capital **3. Other infrastructure, and technology transfer** - information and advisory services - demonstration centres - cooperation, networking, "personal" transfer (change of jobs, etc.) - technology centres	**4. Public demand** (deliberate use of demand of public institutions to promote "desirable" technological developments, e. g. environmentally acceptable consumer goods (recycling paper, "ecological" cars)) **5. Corporatistic measures** - orientation knowledge, elaboration of "long term visions" - technology impact assessment - technology advisory council - awareness of significance of innovations **6. Training** (early organization of training facilities to meet potential demand) **7. Regulation policy** - competition policy - legislative framework - influencing private demand

2.2 Direct promotion of technology-based firms

With the pilot scheme "Promotion of new technology-based firms" (TOU) in the old Federal states (access: 4/83 to 12/88) the Federal Ministry for Research and Technology (BMFT) was aiming to create favourable conditions for new technology-based firms (NTBFs). These enterprises were expected to make an important contribution to the conversion of technological innovations into marketable products, processes or technical services. The pilot scheme was based on the premises that the financing issue is the main barrier to founding an enterprise, and that founders will have deficits in the non-technical aspects of building up a firm. Thus its "tool box" contained both financial support instruments and

advisory assistance for the problems which arise in building up the organization of a firm, the conception and implementation of market strategies and the acquisition of dept and equity capital.

There were three phases of support, relating to foundation concept consolidation, the development of innovative products, processes and services, and their marketing. In order to consolidate the founder's ideas for the new foundation, technology experts and market experts could be brought in (to evaluate technical feasibility, assess market chances, give suggestions for opening up the market, etc.). 253 NTBFs and potential founders made use of this promotion offer. For expenses relating to the development of a new product, new process or technical services, non-returnable grants totalling 240 million DM were distributed to 319 NTBFs. When designing the TOU pilot scheme, the BMFT assumed that the subsequent marketing of the supported projects would also require support. However, no grants were paid for this; bonds of indemnity were made available for bank credits. 97 NTBFs made use of this offer (Kulicke et al. 1991, 1992).

Three access variants for use of the pilot scheme were created. The technology variant emphasized the technological aspect, the regional variant and technology centre variant emphasized the regional context of NTBFs. In the nationwide technology variant, innovative projects in the areas of microelectronics and biotechnology were supported. The advisory offices in this scheme were able to draw on a broad technological and specialist competence in the fields concerned, to enable them to deal with the specific features of technologies and their markets when supporting NTBFs. They were advising NTBFs throughout Federal Germany, so that there was only spatial proximity between adviser and enterprise in a few cases.

The advisory approach of the regional variant[1] and the technology and incubator centre variant[2] was based on the idea that special benefits for NTBFs receiving support would arise from the nearness of the applicant and the advisory office, even if this office did not have specific specialist knowledge in the technology field of each NTBF (see also Chapter 2.4). The selection of six regions for this regional variant - which accounted for approximately half the successful applications for R&D grants under the TOU pilot scheme - was primarily oriented towards the presence of a suitable technology advisory office to advise NTBFs and administer the running of this promotion measure. Due to lack of

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1 NTBFs eligible for this scheme were those already located or planning to locate in the six following regions: East Bavaria, Saarland, the Ruhr, (West) Berlin, Greater Hamburg or the region covered by the Chamber of Industry and Commerce "Mittlerer Oberrhein" (the region around Karlsruhe and Pforzheim).

2 Support was given to NTBFs located in 15 selected technology and incubator centres. Of the 50 enterprises receiving grants for their R&D expenses under this variant, approximately half were situated in the Munich technology centre or the Aachen technology centre.

experience with the initiation of NTBFs in the Federal Republic, especially regarding the institutional "origin" of the founders, the choice of regions was not made on the grounds of the largest possible regional potential for technology-based firm foundations. The decision about which technology and incubator centres to include in the third variant was made by the individual Federal states.

The advantage of spatial proximity was seen in the possibility for advisory offices to support the acquisition of resources and problem-solving in the building-up of an NTBF, by using their regional contact networks. These contact networks, formed during the previous advising of small and medium sized enterprises, would include informal relationships with credit institutes, investment companies, chambers of industry and commerce, technology and incubator centres, universities and non-university research centres, business promotion institutions, enterprises and engineering bureaux. As well as the integration of technical and non-technical know-how, and support in the procurement of capital, contact was also provided to manufacturing subcontractors and in the acquisition of personnel. In this way, it was possible for the NTBF to become embedded in the existing regional research- and innovation-supportive service infrastructure at an early stage. Location of the enterprise in a technology and incubator centre had the advantage for NTBFs that when acute problems arose, they could have informal discussions not only with the centre managers but above all with other firms located in the centre.

Another possibility - though little used - for participating in the TOU scheme was the "venture capital" variant. One condition for participation in this variant was that an investment company should invest in the NTBF. Apart from American-style venture capital companies, "MBGs" (Mittelstaendische Beteiligungsgesellschaften) were among the investors in NTBFs. These MBGs are organizations for the promotion of small and medium-sized business which provide venture capital but generally have very limited possibilities of their own for providing enterprises with management support. However if the need arises, they bring in publicly-funded advisory agencies, i.e. they use their network of relationships to these advisory institutions to obtain support in building up the firm. The best known example of this kind is the MBG Baden-Württemberg, which cooperates with the Steinbeis Foundation (Steinbeis-Stiftung) on the evaluation of technical and market aspects; the Steinbeis Foundation is then also available as a discussion partner for the duration of the investment.

The first two advisory approaches have both benefits and disadvantages. It very soon emerged in the TOU pilot scheme that most of the founders had such good technical knowledge themselves that there was no especial need for external help in resolving technical problems, nor for advisers with special technical knowledge. The founders or their

employees often already had appropriate contacts to universities or research institutions, where they could clear up difficulties with experts if necessary. However, a lot of founders proved to have deficits in non-technical areas. They often lacked experience on the operative side in opening up and establishing markets (e. g. preparing for fairs, carrying out advertising campaigns, dealing with inquiries and orders, etc.). On the other hand, supported NTBFs often had the sort of problems which needed an adviser near at hand - and embedded in a (regional) network of suppliers of innovation-supportive services - to play an important role in problem-solving. Especially when NTBFs had difficulty in raising capital due to an uncertain business development or to lack of securities, an expertise from the advisory office, or its participation in negotiations, often proved very helpful.

The TOU pilot scheme showed that in the Federal Republic of Germany a number of interesting technology-based firm foundations took place. As expected, only a few NTBFs grew rapidly and achieved a turnover of the order of 50 to 100 million DM after the first five years. However, the supported NTBFs do show relatively high survival rates compared to firm foundations in general: up to the end of 1991, the failure rate for all supported firms which completed the product development phase was 14 % (bankruptcy, voluntary liquidation). Another 12 % were only able to carry on as engineering bureaux or service companies, or had only achieved a relatively small turnover up to that point. The rest of the supported NTBFs had an average workforce of about 20 employees (Kulicke et al. 1992).

Macroeconomically speaking, the employment impacts of NTBFs are small in the short and medium term. However, regional focuses are emerging in firm founding activities, so that the economic impacts are regionally concentrated and thus significant. The areas around Munich, Aachen and Karlsruhe, which also have a high concentration of enterprises engaged in R&D and university and non-university research institutions, derived more than average benefit from the scheme. In regions with a generally unfavourable economic structure the number of technology-based firm foundations was also small. Apart from the direct (employment) impacts for the region, however, the indirect effects should also be emphasized, as shown by the examples of Aachen and Dortmund. Additional measures (the creation of technology parks, regional supply of venture capital) meant that R&D laboratories of established companies settled there, and that endogenous potential was strengthened, thus enabling the location to develop as a technology region. The employment effects achieved in this way are many times higher than the employment effect of the NTBFs themselves.

The pilot scheme TOU/NBL, started in 1990 in the new Federal states of Eastern Germany (access: till 12/94) basically uses the same support instruments as the pilot scheme in the old Federal states, but without any different access variants, i. e. NTBFs may be supported

whatever their location or field of technology. As an accompanying measure, the BMFT is also supporting the creation of technology and incubator centres. Subsequently, individual Federal states have also participated financially in building up more of these centres. As an appropriate innovation-supportive infrastructure was totally lacking in the new Federal states, and its construction is very time-consuming, these technology and incubator centres fulfill a special function: they can act as focal points for the construction of an innovation-oriented infrastructure.

2.3 Indirect promotion of technology-based firms

The pilot scheme "Venture capital for new technology-based firms" (BJTU) was started in mid-1989 as the successor to the TOU pilot scheme in the old Federal states. It represents a fundamental change in the instrumental "tool box" for NTBFs. NTBFs no longer receive grants; the intention is to stimulate the private investment capital market into showing more interest in the financing of this type of firms than it has shown so far. The reason for this change of tactics was the recognition, gained from the TOU pilot scheme, that NTBFs need large amounts of equity capital both for product development and market introduction, and that in most cases they also need management support. When planning the BJTU pilot scheme, the BMFT acted on the assumption that both these tasks could be fulfilled most effectively by investment companies. Thus the measure supports investment companies, when the companies provide financial support for NTBFs in product development or market introduction (Braeunling et al. 1989).

Now that the promotion measure has been running for more that three years, two definite "types" of investment companies have emerged. On the one hand there are venture capital and seed capital companies, which, in addition to providing equity, also explicitly offer detailed management support. However the biggest group consists of investment companies which provide equity for SMEs for motives of business promotion, with virtually no management support. No explicit regional promotion aspects are included in this pilot scheme.

2.4 Promotion of technology transfer

"Technology transfer" is understood to mean the transfer of applicable technological knowledge, or of a technology that is already being applied, from one use to another. Technology transfer takes place on the one hand within normal business relationships or in specialist communication between scientists, without being designated as such ("natural"

technology transfer). If, however, technology transfer takes place via intermediaries such as e. g. transfer offices in order to overcome contact barriers, for instance, it is called "institutional technology transfer".

Especially since the 1970s, precipitated by the microelectronics shock in the German clock and watch industry, which had failed to recognize the substitution potential of microelectronics and was in danger of losing its national basis, there have been numerous technology transfer measures. The main instruments have been (Koschatzky et al. 1992):

- Improving the overview of R&D results, and improving access to results (e. g. by building up data banks);
- Application-oriented transformation of R&D results (e. g. development of user-specific adaptations by technology development companies);
- Creating and supporting the conditions for successful exploitation of R&D results in industry (e. g. by support for the employment of additional R&D personnel, promotion of R&D cooperations);
- Building up a market for R&D results, and an infrastructure for the exploitation of R&D results (e. g. by setting up innovation advisory offices and technology transfer offices).

Since the late 1970s, many transfer and innovation advisory offices have been started up. This designation, however, covers an extremely heterogeneous performance profile. Following different functions can be found in the increasingly complex and diversified landscape of technology and innovation advisory services (cf. also Figure 2-2):

- **Contact offices**, situated in "trustworthy institutions" (such as chambers of industry and commerce), offering initial orientation assistance;
- **Advisory offices** with sufficient diagnostic capabilities to mediate specialist advisers and monitor the innovation process;
- **Information brokers**, who carry out data bank searches for clients;
- **Patent information centres** which, based on the great volume of worldwide patent literature, pinpoint specific technological and business information for firms, thus supporting their R&D activities;
- **Advisory centres**, with teams of advisers that are able to make detailed problem diagnoses, perform specialized consulting in selected areas of technology, and act as qualified consulting mediators;
- **Transfer centres** as R&D establishments which perform further development and adaptation contracts in individual specialist areas, and can offer reliable expert advice;

Figure 2-2: Classification of technology and innovation advisory centres

	staffing requirements[1)]	problem identification by	problem solving by
Contact office	representative or employee of organizing institution, with SME acceptance	client enterprise	external consultant
Advisory office	at least 2 staff with technical training	jointly by enterprise and advisory office	external experts, advisory office as catalyst
Information broker	at least 2 staff with technical training	client enterprise	data bank searcher (together with enterprise)
Patent information centre	at least 5 staff, including at least 1 patent searcher	client enterprise in cooperation with patent searcher	patent searcher in cooperation with enterprise
Advisory centre	at least 2 staff with technical and scientific experience	usually by advisory centre	advisory centre, sometimes bringing in specialists in order to find the "most appropriate solution for the application"
Transfer centre	at least 3 staff with R&D experience	mostly by the transfer centre	transfer centre, which also provides advisory services and carries out adaptation development
Demonstration centre	experts with relevant application experience	the enterprise, with support from the centre	demonstration centre, which gives information about possible applications and provides training
Technology centre	specialists in the area of applied research	technology centre	technology centre, which works out the "best" technical solution

1) The figures used here are empirically based, but are given mainly as an indication of the necessary degree of qualification and the division of tasks.

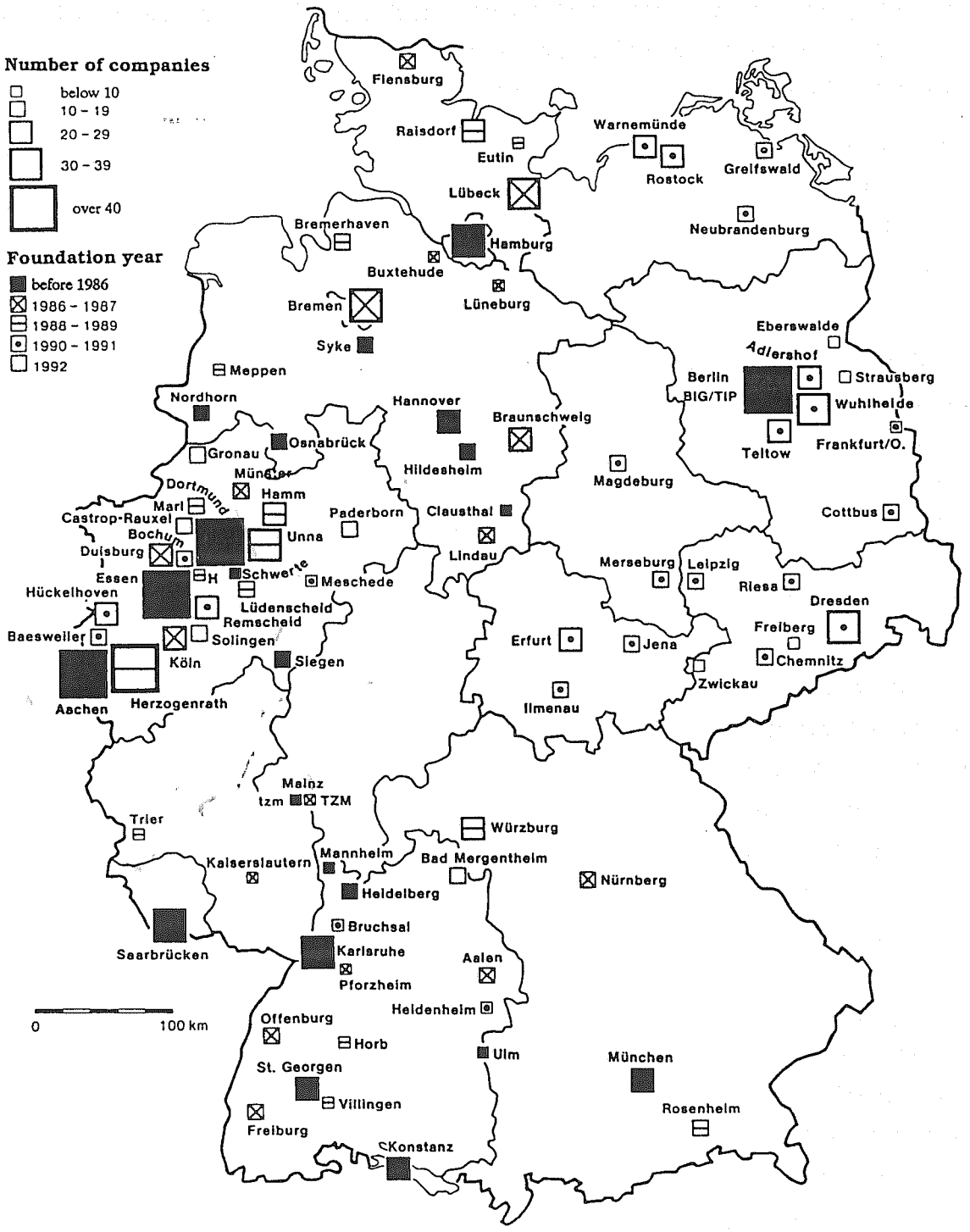
Source: Bräunling 1988, modified

- **Demonstration centres**, which provide neutral information (i. e. independent of manufacturers) on possibilities for application and use, advise employees of enterprises - especially small and medium sized firms - on purchasing decisions, and help them to acquire qualifications by running seminars on new technologies;
- **Technology centres** as R&D establishments which are primarily concerned with the development of new technologies, and whose specialists can cover the whole range of consultation from initial inquiries to in-depth consulting.
- **Technology and incubator centres** as a local community group usually consisting of new technology-based firms (cf. Chapter 2.2) with the purpose of developing, producing and marketing technologically innovative products, services and processes (Sternberg 1992).

The first **technology and incubator centre** in Germany was started in Berlin in 1983. The extension of the use of this instrument in space and time is shown in Figure 2-3. Today there are well over 80 of these centres functioning in Germany, designed to smooth the path of technology-based firm foundations with the special site facilities and infrastructure that they offer (e. g. office services, management and financing advisory services). In Germany, technology and incubator centres are set up by communities and urban authorities as an instrument for mobilizing the local and regional innovation potential, and thus represent an opportunity for regional decision-makers to engage in technology policy at a local or regional level. As the centres are situated near universities and research institutions, it is expected that regional innovation networks will form, and that technology transfer will be stimulated. After a temporary, successfully concluded stay in the technology and incubator centre, firms are expected to leave and set up business in the region, thus strengthening the innovation network and the regional technology base still further. Thus the concept of the technology and incubator centre is an instrument for the creation of regional CoEs.

However, judgements on the significance of technology and incubator centres in regional policy, and their impact on employment, tend to be reserved, in view of the limited macroecnonomic potential of technology-based firm foundations (Hilpert 1988, Dose 1990). The successful technology and incubator centres are mainly those which have been set up in an environment that was already innovative to start with, and the centres have intensified this (e. g. "technology region Karlsruhe"). Technology and incubator centres in peripheral locations have less chance of success, are often not completely occupied, and the firms using the site do not always fulfill the criterion of being technology-based. Nevertheless, technology and incubator centres are experiencing a new impulse in Germany just now, as they are being used as an innovation policy instrument to step up the pace of economic structural change in the new Federal states (cf. Figure 2-3).

Figure 2-3: Technology and Incubator Centres in Germany (as of September 1992)
(Source: Sternberg 1992)



3. TECHNOLOGY-BASED FIRMS IN THE RHINE-MAIN REGION

3.1 Definition

There is no definitive definition of the term "technology-based firm". In order to determine the potential of technology-based firms in the Rhine-Main region, the Fraunhofer Institute for Systems and Innovation Research (FhG-ISI), Karlsruhe, therefore worked out an appropriate definition for the "Umlandverband Frankfurt" (regional planning association) (Koschatzky et al. 1992). This definition is based on a product-oriented index divided into twelve fields of technology (cf. Figure 3-1). For each field, product groups and examples of products are given. The product groups are characterized by an R&D intensity (share of monetary expenditure on R&D as a proportion of turnover or value of production) of over 3.5 %, and can thus be categorized as high tech. The preliminary work for these high tech lists was carried out by Legler, Grupp et al. (1992).

Figure 3-1: Technologies according to FhG-ISI high-tech definition

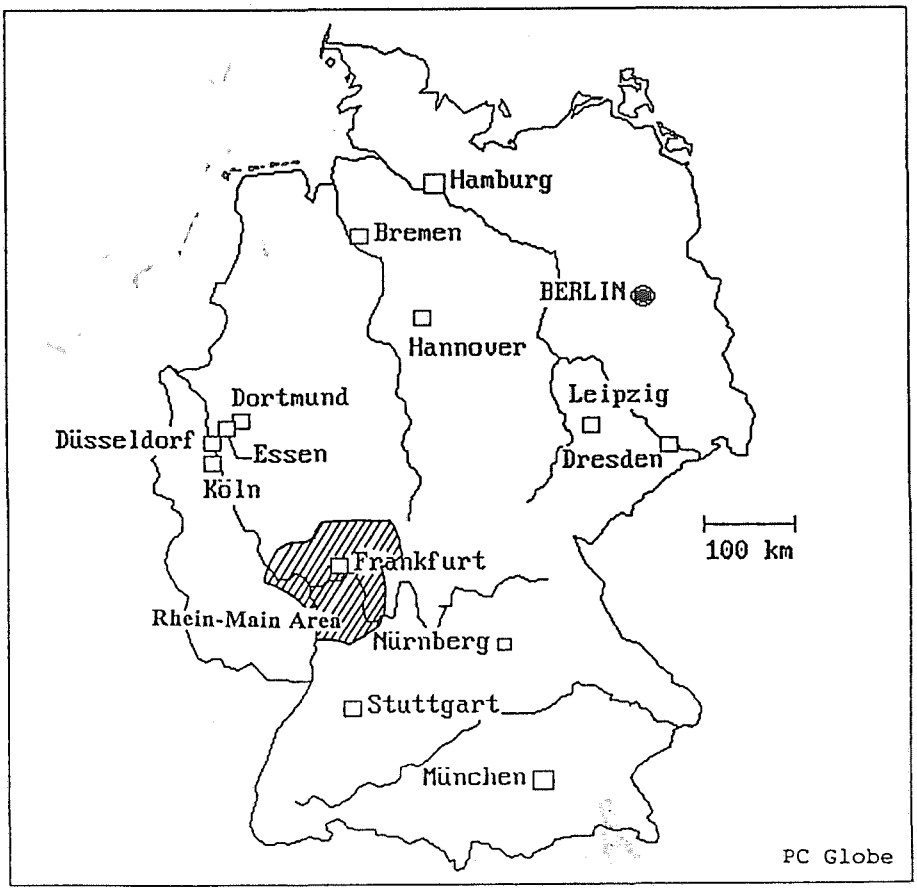
No.	Technical Area
1	**Biotechnology, Pharmacy**
2	**Advanced Chemistry**
3	**Energy Engineering**
4	**Information and Telecommunication Technology**
5	**Aviation and Space Technology**
6	**Medical Engineering**
7	**Micro- and Optoelectronics**
8	**Advanced Materials**
9	**Production and Process Engineering, Robotics, Computer-integrated technologies**
10	**Metrology, Sensor Technology**
11	**Environmental Technology**
12	**Transport and Traffic Engineering**

Technology-based firms are firms that develop, manufacture and sell products, or offer innovation-oriented services, which can be classified as belonging to the technology fields and product categories of the high tech index. These include not only manufacturing firms but engineering bureaux, commercial laboratories and sales centres insofar as they undertake customer-specific adaptation and training. Not included are enterprises which do not manufacture high tech products, but only use them.

The definition covers mainly small and medium sized enterprises with a clear product segment. No threshold values were fixed for a minimum share of high tech products in turnover; all enterprises were included which develop or manufacture products on the high tech index ("contamination" principle). Technology-based firms are identified by analysing their product spectrum.

The Rhine-Main region, situated centrally in Germany (cf. Figure 3-2) is not an administrative unit, but corresponds more or less to the network region of the Frankfurt area. Rhine-Main includes the southern part of the Federal state of Hessen, the neighbouring part of the Rhineland-Palatinate (the Mainz area) and the western part of Bavaria (Aschaffenburg). It has 4.5 million inhabitants, of whom 645,000 live in Frankfurt city. The area around Frankfurt is characterized by its function as a "cross-roads" of central Europe (airport), by numerous banking headquarters and by the Frankfurter Messe (trade fair centre). The region has a reputation as a service centre, but not as a technology region. These attributes apply to Munich and to the Stuttgart area.

Figure 3-2: Rhine-Main area in Germany

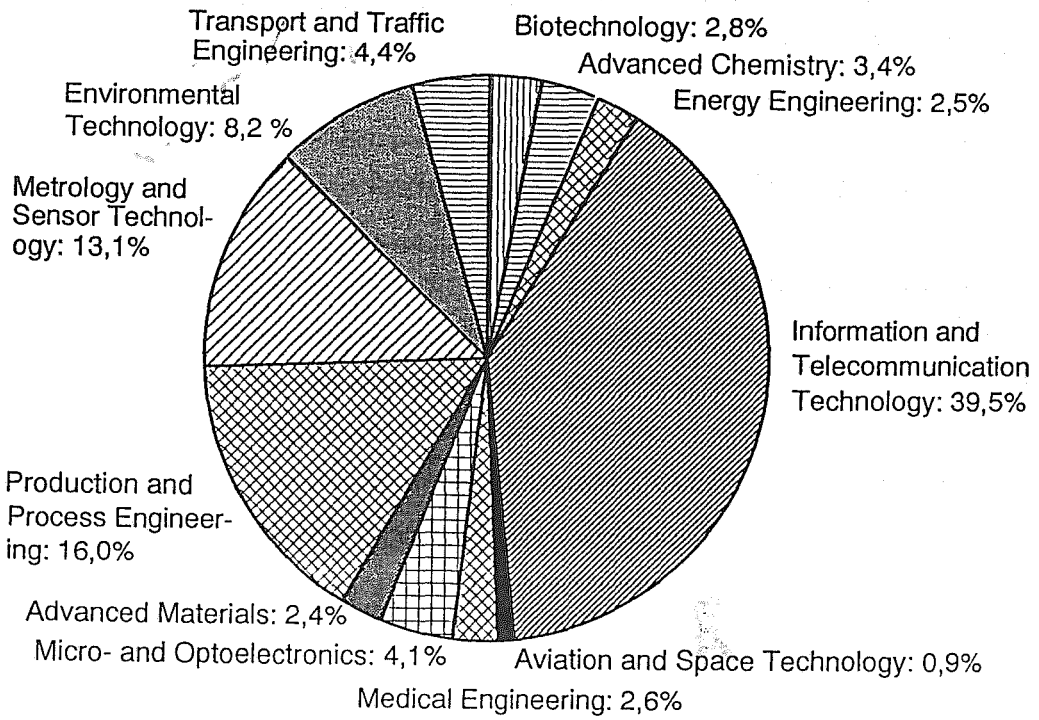


This area was selected as an example because the region does not yet have a reputation as a technology region, but the towns and communities are pursuing the aim of formulating a common technology-oriented policy, and because within the region technology policy from three different Federal states (Hessen, Rheinland-Palatinate and Bavaria) is in action.

3.2 Potential of technology-based enterprises in the Rhine-Main area

Following evaluation of the product spectrum of approximately 20,000 preselected enterprises, a total of 2303 technology-based firms were identified which fulfilled the criteria of the high tech index (Koschatzky et al. 1993). Despite incomplete employment figures, it can thus be assumed that the share of technology-based firms in total employment in the Rhine-Main area is of the order of 10-15%. Of the 100 largest German industrial companies, as many as 18 have their headquarters in this region (e. g. Hoechst, Boehringer). The majority of technology-based enterprises, however (ca. 95 %), are small and medium sized firms with a high degree of regional attachment. The technology spectrum of enterprises is shown in Figure 3-3. Thus the technological emphasis in the Rhine-Main area is definitely on information and communication technology. 1054 businesses

Figure 3-3: Technology spectrum of technology-based enterprises in the Rhine-Main area (Source: Koschatzky et al. 1993)



(corresponding to 39.5 % of all technology-based activities in the region[3]) are active in thisfield. These include eight main offices from the list of the worlds 40 largest software firms. If microelectronics and optoelectronics are included, a total of 1164 enterprises is reached. Thus a substantial proportion of technology-based firms in the Rhine-Main region are engaged in information and communication technology and microelectronics, regarded - not least because of their interconnections with manufacturing technology, traffic engineering and medical engineering - as future-oriented growth technologies.

The technology field "production and process engineering, robotics, computer-integrated technologies" ranks second, with 426 enterprises (16 % out of 2667 activities), followed by "metrology and sensor technology" (348 enterprises; 13 % share) in third place, and then by environmental technology, with 219 enterprises (8.2 %). Of the other fields of technology, only transport and traffic engineering (4.4 %) and microelectronics/optoelectronics (4.1 %) have more than 100 firms actively engaged in them. The forward-looking fields of biotechnology and advanced materials are represented by 76 and 65 firms respectively. However, it should not be concluded from these relatively low figures for biotechnology and advanced materials enterprises that these fields play only a subordinate role in the Rhine-Main region. The area of biotechnology/chemistry/pharmacy is strongly represented, for instance, by enterprises such as Hoechst (Frankfurt, Offenbach, Wiesbaden), Boehringer Ingelheim, Novo Nordisk (Mainz) and Biotest Pharma (Dreiech). There are also well-known enterprises active in materials research, such as Dow Corning (Wiesbaden), Vakuumschmelze (Hanau) and Heraeus (Hanau). In addition, a number of smaller firms are engaged in developing new materials for medical purposes (e. g. implants) or in manufacturing chemical plant, laboratory equipment amd biochemical analysis apparatus (e. g. for chromatography). Thus materials technology - and even more biotechnology/pharmacy - offer good starting-points for strengthening and expanding the technology base of the region. The relevant research capacities are described in chapter 3.3.

Regional distribution and the type of business activity can be seen in Figure 3-4. 40 % of technology-based firms are mainly concerned with production (926 enterprises). Just under 31 % mainly offer technology-oriented sales and training services, and 29 % mainly innovation-oriented services (engineering bureaux, laboratories, R&D). This is another expression of the strong service function of the Rhine-Main area.

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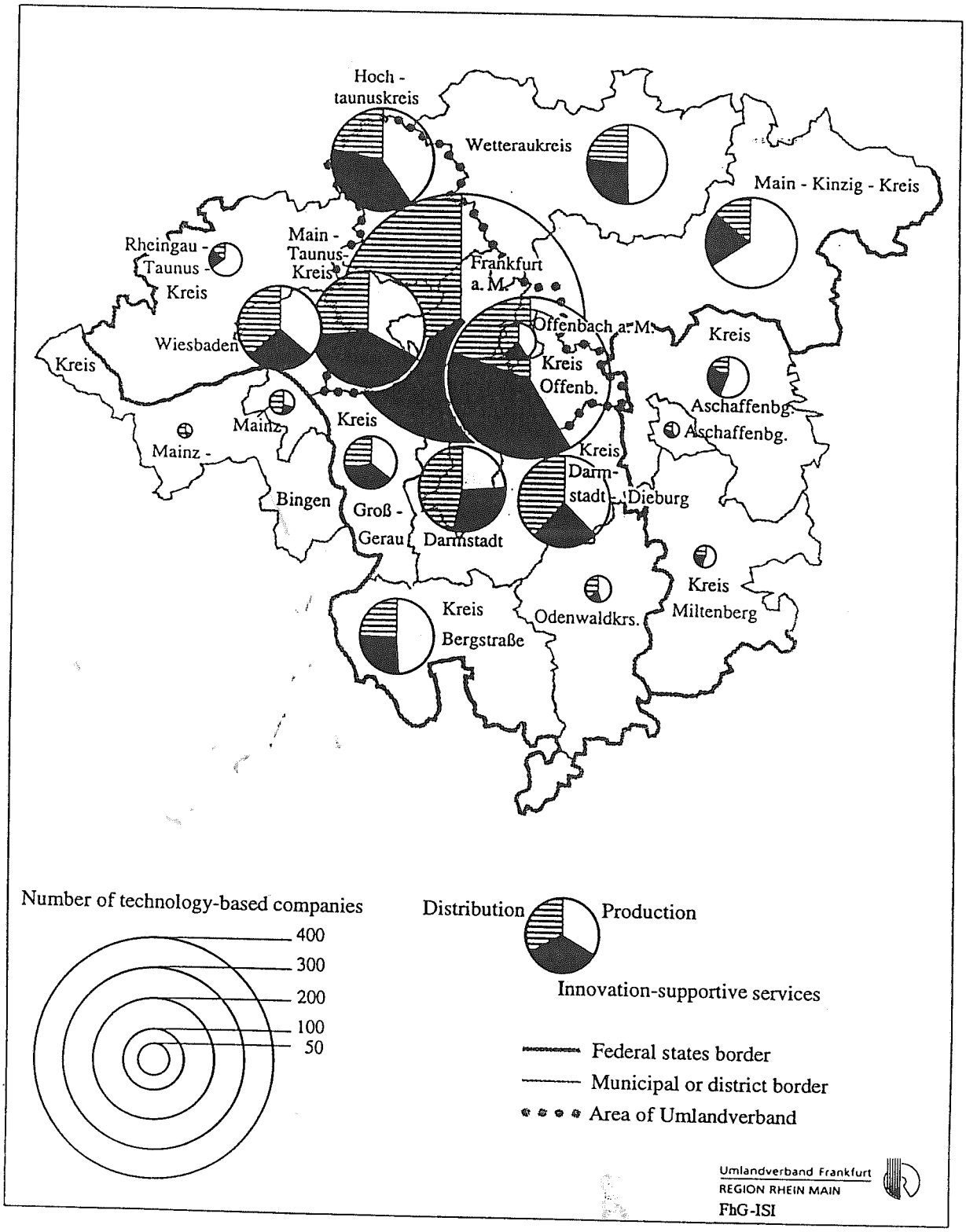
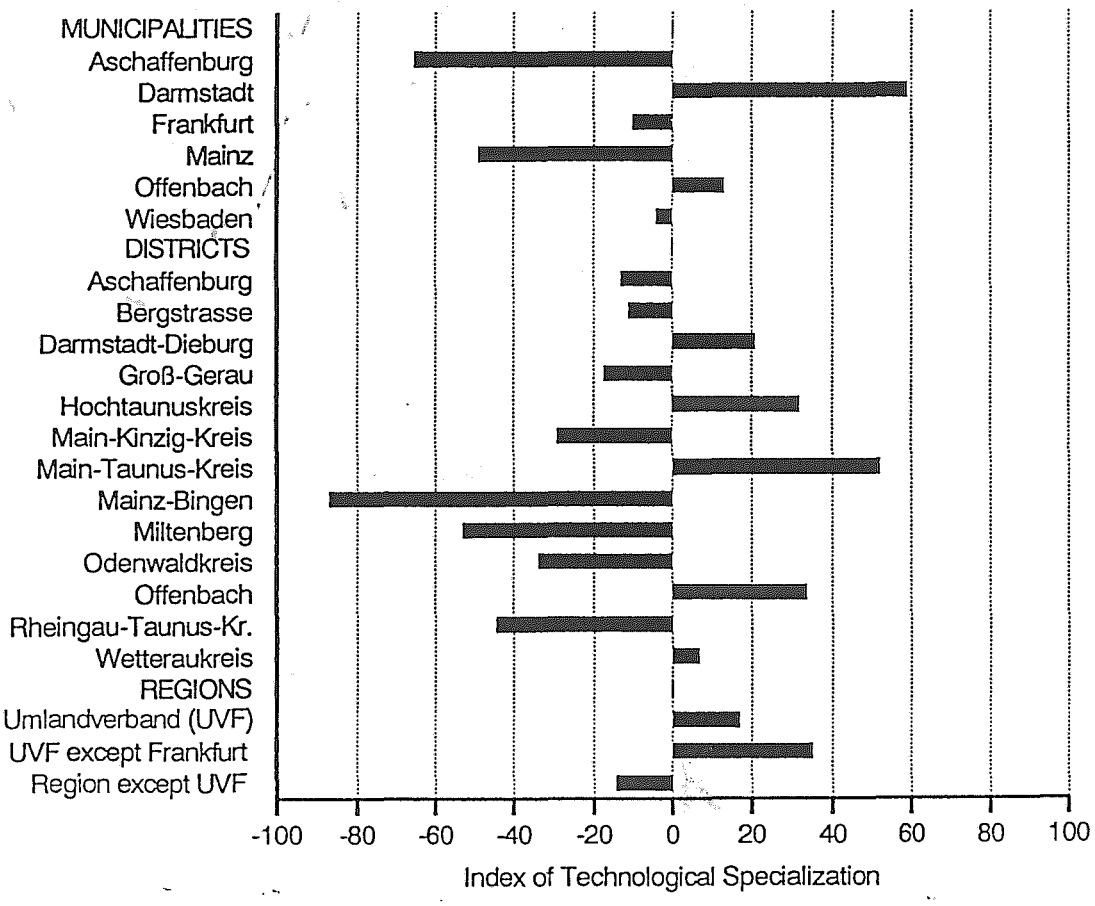
[3] Since some companies are active in more than one technological field, the reference for percentage figures will be 2667 technical activities of the 2303 technology-based firms.

Figure 3-4: Regional distribution of technology-based enterprises in the Rhine-Main area according to type of business



The most important location for technology-based firms is Frankfurt city, where 415 (18 %) are situated. The area immediately around Frankfurt is also attractive to these enterprises. As the distance from Frankfurt increases, there is a marked decrease in the number of firms, especially towards the south-east and the west. However the absolute figures for numbers of technology-based firms do not give an indication of their regional inportance. Figure 3-5 shows the technology specialization of the individual areas of the Rhine-Main region. Positive values indicate that the regional share of technology-based firms is greater than that area's share for all industrial enterprises. According to this criterion, Frankfurt itself is not the technology centre of the region, but the city of Darmstadt, where numerous information technology firms and software producers are situated. The area surrounding Frankfurt also has an above-average technology intensity, whereas the city itself shows a slightly negative value. This distribution between Frankfurt and its surroundings clearly illustrates the problems of a densely populated area. Industrial sites in Frankfurt are scarce and expensive, so that new technology-based firms in particular tend to seek a location which is outside Frankfurt, but still near the international airport and the motorways.

Figure 3-5: Technology specialization in the Rhine-Main area
(Source: Koschatzky et al. 1993)



All in all, the multicentric structure is advantageous for the region as a whole. In competition within Germany and in international competition between the industrial agglomerations and technology regions, the decisive factor is to keep firms in the Rhine-Main region, while getting new firms to settle there by offering attractive localities. The fact that interested investors can be offered a choice of alternative locations within the region improves its national and international competitive standing.

3.3 Scientific and technical infrastructure of the region

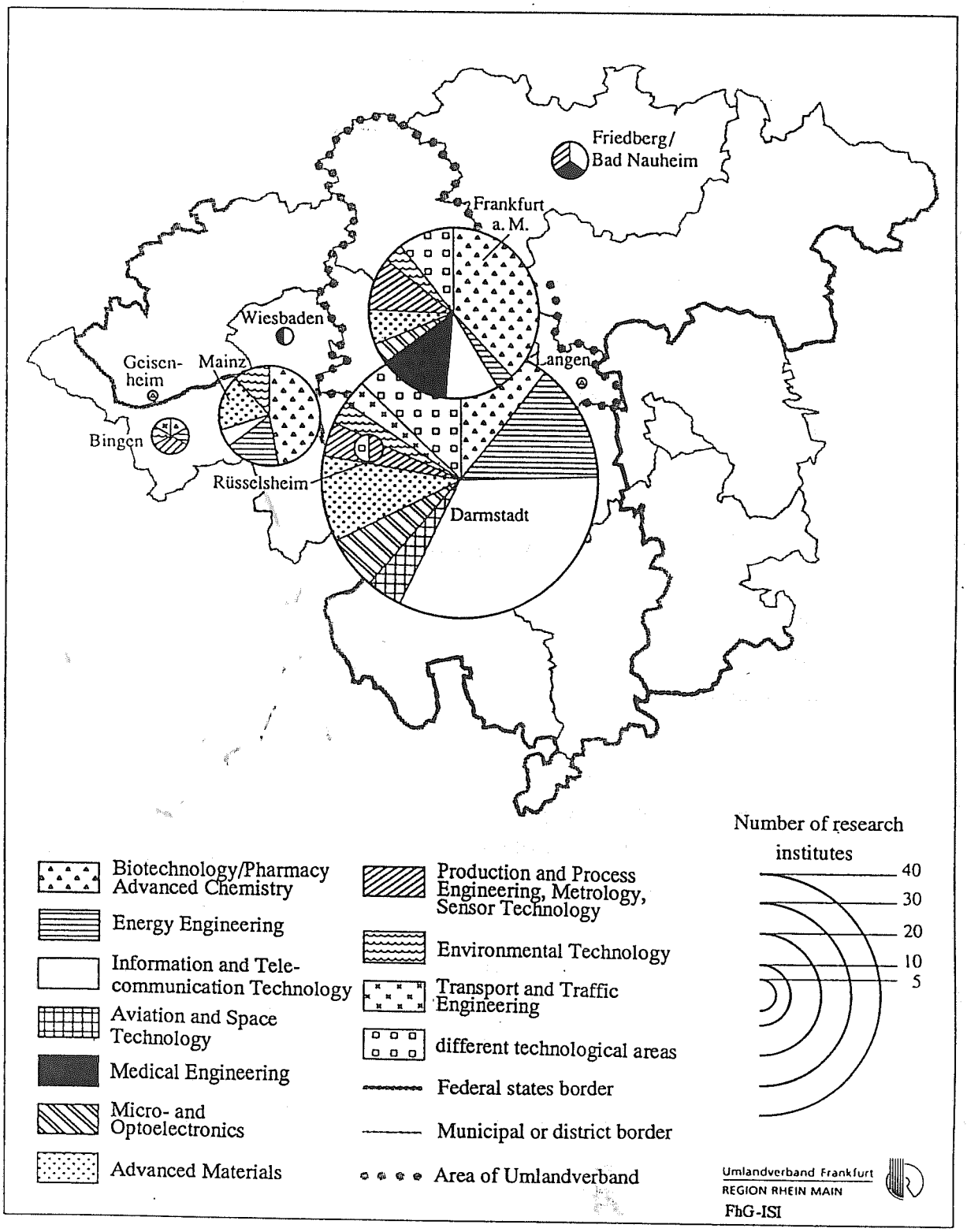
There are three universities in the Rhine-Main region (Darmstadt, Frankfurt and Mainz), as well as seven sites of "Fachhochschulen" (colleges of technology). In addition four institutes of the Max-Planck Society, two Fraunhofer Institutes and a number of other research establishments, some of them international, are situated in the region. Altogether 112 institutes (including university institutes) were identified which are engaged in research in high tech fields (Koschatzky et al. 1993). These institutes employ a workforce of 7880, of which 3700 are scientists. The majority of these research institutions are engaged in applied research and also carry out contract research for industry. Their regional distribution and their distribution according to fields of technology is shown in Figure 3-6.

The science centre with emphasis of information and communication technology is Darmstadt. The technological orientation of research in Frankfurt is lower by comparison. Here, as in Mainz, it is biotechnology/pharmacy that dominates.

As well as the research institutions, enterprises can draw on information mediation and innovation advisory offices, and technology transfer offices (cf. Chapter 2.4). However, the only place in the whole region with a technology centre is Mainz; there are no technology and incubator centres either in Hessen or in the Bavarian part of the Rhine-Main region.

From interviews with technology-based enterprises, it emerged that large companies engaged in worldwide activity hardly use the scientific and technological infrastructure of the region. They buy up knowledge and information worldwide through their global network. Small and medium sized firms, on the other hand, are much more strongly dependent on regional research institutions and transfer centres. On the one hand, they draw part of their technological knowledge from cooperation with research institutions; on the other, there is also "technology transfer through people", in the sense that students and academics are recruited to work for SMEs. The cooperation between research and SMEs is particularly close in "spin-off" foundations from universities and other research institutes, since for new teechnology-based firms the maintaining of former contacts is often an important element in ensuring the continuation of the firm.

Figure 3-6: Regional distribution of research institutions in the Rhine-Main area according to technology fields



Another conclusion from the survey was that the absence of technology and incubator centres in Hessen was not felt to be a disadvantage, as technology-based firm foundations took place even without the incubator function of these centres. If there had been a centre of this kind, it was felt that it would have been used anyway (free rider effect). This is not intended as an evaluation of the technology and incubator centre as a technology policy instrument. There are centres which function very successfully and have enhanced the "image" of a region (e. g. Aachen). On the other hand, it might be deduced from the example of the Rhine-Main region that in an industrially innovative environment, technology-based firm foundations are possible even without technology and incubator centres.

3.4 Technology policy support measures in the Rhine-Main region

All three Federal states represented in the Rhine-Main region (Hessen, Bavaria and the Rhineland-Palatinate) approve the public support of research and technology. One feature that their technology policy concepts have in common is an orientation towards the target group of small and medium sized firms (SMEs), which they regard as the Federal states' most important point of application in the support of development and the introduction of new technologies:

- Small and medium sized firms have fewer possibilities than large companies to spread their economic risks. This means that an unsuccessful development project may endanger the existence of the firm.
- SMEs often have problems with the financing of research projects, and have to work under conditions which are relatively unfavourable.
- A further problem is posed by the search for qualified personnel to develop new products and use modern techniques. Often SMEs are not in a position to keep development personnel in the long term.

Apart from this basic point of agreement in the policy of the three Federal states, there is a different emphasis in their individual policies. As an example, the technology policies of Hessen and Bavaria will now be described in more detail.

Hessen explicitly rejects the idea of a broad, non-specific promotion of high tech, placing more emphasis on the environmental area of technology support. On this principle, Hessen's Environmental Technology Programme offers financial support to firms that accelerate the development or introduction of ecologically acceptable products and production plants. The

Hessen state government has also launched an Environmental Conservation Programme which supports investments in environmental conservation measures with subsidies or credits. The category of environmental technology consulting is treated as being equal in importance to all other innovation consulting. Hessen also plans a centre for integrated environmental protection, the costs to be borne jointly by the state of Hessen and private enterprise.

Another main feature of Hessen's technology policy is support of information and communication technology. Measures are principally directed, in cooperation with science and industry and their institutions, towards strengthening the supply of information mediation and consulting, thus creating a "demand pull" for information and communication services. Hessen's support measures in the area of TIC also have an explicit regional policy background, i. e. measures are concentrated on the economically weaker regions of Hessen. As a consequence of these regional policy aims, various technology policy initiatives are being deliberately applied in areas which lie outside the Rhine-Main region.

As the procurement of venture capital for market introduction of innovative products and processes is an especial problem for small and medium sized firms, the state of Hessen founded the "Mittelstaendische Beteiligungsgesellschaft Hessen mbH" (MGB) in 1984. Since its foundation, the MGB has taken on 90 investments with a total volume of 45 million DM under the programme "Market introduction of innovative products and processes".

The Bavarian state government, with its "comprehensive innovation policy concept" of August 1991, has produced the most complete technology policy concept of the three Federal states represented in the Rhine-Main region. In this comprehensive concept, various measures and promotion programmes are grouped together under the following overriding aims:

Reducing the risks of small and medium sized enterprises in innovative projects

- Technology Advisory Programme for small and medium sized firms, to promote the use of external experts in technological problem-solving.

- Bavarian Innovation Support Programme and Technology Introduction Programme Both these programmes support the development and conversion of new technologies into marketable products and the use of modern technologies in products and in production.

- "Application variant" of the Technology Introduction Programme
  Since the stipulation limiting the content of projects to firm-internal development of products and processes excluded a lot of small enterprises from taking part, it has been possible since 1991 for firms applying innovative processes to be included in support measures.

Creating start-up opportunities

As well as the general incentives to firm foundation in the innovation policy programmes, technology and incubator centres in particular are planned to support innovative firm foundations. Technology centres in Bavaria at present are situated in Munich, Erlangen and Würzburg (cf. Figure 2-3).

In Bavaria, unlike Hessen, technology policy is not linked with any regional policy aims. Since the measures are principally oriented towards innovative enterprises, however, innovation potential is mainly supported in those regions where innovative firms are already concentrated (e. g. in the region around Munich). Neverthess, in the Rhine-Main region Bavarian participation in support measures matches the size of Bavaria's population share.

From this brief survey, it is clear that the Federal states have opportunities to support innovation and technology, and build up regional CoEs. These opportunities are used in different ways. Generally speaking, the programmes of the Federal states have the common feature that their financial freedom of action is limited, and that they often have only an additive character. Regional technology policy is overlaid by national and international programmes. In spite of this Bavaria, for instance, has managed by means of specific promotion measures to create favourable locality conditions for technology-based firms and for an innovative milieu.

4. CENTRES OF EXCELLENCE IN THE RHINE-MAIN REGION

An analysis of the potential of technology-based firms and the scientific and technical infrastructure in the Rhine-Main region was carried out on behalf of the Umlandverband Frankfurt and the Wirtschaftsfoerderung Frankfurt. It is intended to use the resulting state of knowledge to formulate a target-group-oriented regional technology strategy. Three main elements arise from the discussion in this paper:

1. Integration into the promotion measures for technology-based firms already existing at national and state ("Laender") level (cf. Chapters 2.2 and 3.4), and intensification of advice on public support to encourage more use of the programmes by regional firms and potential firm founders. In this way it is hoped to extend the industrial base of the region, which is still small compared with the service sector, by the founding of new technology-based firms (direct promotion).

2. Building up the technology base of the region in fields of technology which provide suitable points of application for support in industry and research (cf. Chapters 3.2 and 3.3). Apart from the already broad information technology base, these include biotechnology, materials technology and environmental technology. The intention here is to accomodate technology development's increasing closeness to science, by ensuring compatibility between the regional research offer and the requirements of technology (cross-field technological-sectoral promotion).

3. Improvements in regional location conditions for existing technology-based firms, and intensification of the scientific and technical networking between enterprises on the one hand, and between enterprises and research institutes on the other (indirect promotion).

The principal target group should be the group of small and medium sized enterprises in the production and service sectors, which have a strong regional bonding and are dependent on cooperation with regional research institutions (technology transfer, acquisition of personnel). Large enterprises with no intensive regional context are also considered because of their networks of regional suppliers.

Based on the present state of knowledge in innovation theory, the following measures may be considered for an indirect regional support strategy:

- Simplification and shortening of the approval process for production plants for technology-based enterprises;
- Balanced "siting" of production and service enterprises, in order to achieve an economic structure which is as well-balanced as possible;
- Strengthening of regional production clusters, especially of regionally/nationally oriented industrial SMEs;
- Reinforcing technology demand in the region by giving preference to the location and founding of enterprises which are network-intensive;
- Building up the supply of innovation and technology-oriented services;

- Intensification of "natural" and institutional technology transfer from research establishments, and closer relations between enterprises and the regional research potential. Points of application here are seen especially in the large enterprises, which are still primarily externally oriented;
- Building up the subject range of the regional universities and technical colleges in areas of technology suitable for promotion, and possibly establishing additional institutes in the region with an orientation which is "close to industry";
- Possibly setting up a technology and incubator centre or a science park for enterprises which are developing or manufacturing products in technologies suitable for support.

The aim of this development strategy will be, by strengthening research, production and service networks in the areas of technology mentioned, and by intensifying technology-specific technology transfer, to create a system of scientific-technological-industrial clusters. In accordance with the thesis put forward in Chapter 1, these technology-specific "centres of excellence" should contribute to improving the innovative milieu of the region. It is expected that the intensive interlinking of research, technology development and industrial production in science-based, future-oriented technologies will strengthen the regional innovation and technology base, and improve the competitiveness of the Rhine-Main region in the national and international technology competition between regions.

5. REFERENCES

Aydalot, Ph., Keeble, D. (Eds.) (1988):
*High Technology Industry and Innovative Environments: The European Experience.*London

Braeunling, G. (1988):
"Oeffentliche Foerderung des Technologietransfers: Aktionismus - symbolische Politik - oder wirksame Unterstuetzung?" In: Technologietransfer Forschung Industrie. Dokumentation des Expertengespraechs am 24. Maerz 1987 bei IBM, Duesseldorf. *DABEI Deutsche Aktionsgemeinschaft Bildung - Erfindung - Innovation.* Juelich. Pp. 78-91

Braeunling, G., Gerybadze, A., Mayer, M. (1989):
"Ziele, Instrumente und Entwicklungsmoeglichkeiten des Modellversuchs 'Beteiligungskapital fuer junge Technologieunternehmen' (BJTU)". *FhG-ISI papers*, Karlsruhe

Bramanti, A., Senn, C. (1991):
"Innovation, firms and milieu: a dynamic and cyclic approach". In: Camagni, R. (Ed.): *Innovation networks: spatial perspectives.* London, New York. Pp. 89-104

Camagni, R. (ed.) (1991):
Innovation networks: spatial perspectives. London/New York

Dose, N. (1990):
"Technologieparks - eine Literaturauswertung." In: *Verwaltungs-Archiv*, 2

Grupp, H. (ed.) (1992):
Dynamics of Science-Based Innovation. Berlin/Heidelberg/New York/Tokyo

Hilpert, U. (1988):
"Oekonomische Krise und regionale Politik - mit Technologieparks zur regionalen Entwicklung?" In: Dose, N., Drexler, A. (Eds.): *Technologieparks.* Opladen

Hingel, A. (1992):
"Science, Technology and Community Cohesion - Research Results and RTD Policy Recommendation", *Commission of European Communities.* Brussels

Koschatzky, K., Grupp, H., Gundrum, U., Hinze, S., Kuntze, U. (1992):
"High-Tech-Unternehmen in der Region Rhein-Main. Grundlagenstudie." *FhG-ISI papers*, Karlsruhe

Koschatzky, K., Breiner, S., Boerdlein, R., Sternberg, R. (1993):
"Technologieprofil der Region Rhein Main." *FhG-ISI papers*, Karlsruhe

Kulicke, M., Bayer, K., Walter G. H. (1991):
"Modellversuch 'Foerderung technologieorientierter Unternehmensgruendungen' (TOU) - Zwischenbilanz zum 31.12.1990." *FhG-ISI papers*, Karlsruhe

Kulicke, M., Walter, G. H., Wupperfeld, M. (1992):
"Modellversuch 'Foerderung technologieorientierter Unternehmensgruendungen' (TOU). Zwischenbilanz zum 31.12.1991." *FhG-ISI papers*, Karlsruhe

Legler, H., Grupp, H., Gehrke, B., Schasse, U. (1992):
Innovationspotential und Hochtechnologie - Technologische Position Deutschlands im internationalen Wettbewerb. Heidelberg

Meyer-Krahmer, F., Kuntze, U. (1992):
"Bestandsaufnahme der Forschungs- und Technologiepolitik". In: Grimmer, K.,

Haeusler, J., Kuhlmann, S., Simonis, G. (Eds.):
Politische Techniksteuerung - Stand der Forschung. Opladen

Perrin, J. C. (1986):
"Les Synergies Locales - Elements de Théorie et d'Analyse." In: Adydalot, Ph. (Ed.): *Milieux Innovateurs en Europe.* Paris

Perrin, J. C. (1988):
"New technologies, local synergies and regional policies in Europe." In: Aydalot/Keeble (Eds.): *High-Technology Industry and Innovative Environments: The European Experience.* London

Sternberg, R. (1992):
"Methoden und Ergebnisse der Erfolgskontrolle von Technologie- und Gruenderzentren." In: Niedersaechsisches Institut für Wirtschaftsforschung (Ed.): *NIW-Workshop 1992: Erfolgskontrolle der Technologiepolitik.* Hannover. Pp. 89-115.

Stoehr, W. (1987):
"Territorial Innovation Complexes." In: *Papers of the Regional Science Association,* Vol. 59, pp. 29-44

Toedling, F. (1990):
Raeumliche Differenzierung betrieblicher Innovationen. Erklaerungsansaetze und empirische Befunde für oesterreichische Regionen. Berlin