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The role of higher education institutions for entrepreneurship stimulation in regional innovation systems – Evidence from the network-oriented "EXIST: Promotion of university-based start-ups" programme in Germany*

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Contents Page

Figures

Tables

1. Introduction

In recent years, not only has the "network paradigm" as defined by Cooke/Morgan (1993) become the starting-point for policy measures aiming at a better exploitation of innovation potentials, but also the region, i.e. sub-national spatial entities, has been made an important platform for innovation and technology policy implementation by national governments (cf. Koschatzky/Sternberg 2000: 494-499). Specifically, the cluster concept as developed by Michael Porter (cf. Porter 1998 for an overview) and other theoretical approaches of the "new economic geography" (Krugman 1998) contributed to the popularisation of innovation promotion at the regional level. However, not every region in a country (or, in other words, in a national innovation system) has the infrastructure and knowledge potential to develop into a highly networked high-tech island with leading-edge technology, industry and research. Nevertheless, those regions in a country which already possess some innovative and technological strengths in research and industry can be made the starting point for further exploiting and strengthening their innovative performance and by this contributing to employment and income generation (Koschatzky 2000: 8).

One aspect in the spectrum of different innovation and technology promotion measures is the exploitation of the scientific-technological capacity of research and higher education institutes by linking research more closely to the market. This can be done by improving the regional conditions for start-ups. Major aspects and influential factors in this respect are the supply of and the access to venture capital, the qualification of the potential firm founders, the culture of entrepreneurship in a region or a nation and the general framework conditions which either support or hamper the readiness for taking the risk of founding an own firm. Especially with regard to innovative or technology-oriented firm foundations, the hypothesis is put forward in this paper that higher education institutions (HEIs) such as universities and technical colleges (polytechnics) could play an important role in activities aiming at qualifying and supporting potential firm founders such as students, graduates and staff personnel. Since these institutions cannot develop all necessary resources on their own, they have to establish networks by which the different supportive activities can be linked and utilised.

Thus, this paper has two major objectives: Firstly, it intends to shed some light on the role which HEIs can play for promoting entrepreneurship in their region and for increasing the number of university-based start-ups, and, secondly, to discuss the possibilities for network formation in regions by public promotion measures implemented by the national government. Empirical basis for dealing with these objectives will be the "EXIST: promotion of university-based start-ups" programme of the German Federal Ministry of Education and Research. The paper intends to answer the following questions:

- By which theoretical arguments can a regionally- and network-oriented innovation policy be justified?
- Which role could HEIs play in their region?
- By which incentives and measures can regional network formation around HEIs be promoted?
- Which role does the specific regional environment (economic structure, existing institutions, openness for network formation) play in the emergence and development of networks aiming at the promotion of entrepreneurship in different regions?
- Which kinds of networks emerge and which obstacles do they face?
- Is network building the right instrument for activating the firm foundation potential of HEIs and for integrating them more closely into the regional economy?
- Which contribution to the regional economy can be expected by increasing start-up activities at HEIs?

The paper is therefore structured as follows: in sections 2, 3 and 4 the first three questions will be discussed, while in section 5 the innovative infrastructure and the technological potential of the regions under investigation will be described. Section 6 discusses certain aspects of network building and network obstacles based on a regional network analysis. Section 7 finally draws conclusions from the empirical analysis and answers some of the remaining open questions.

2. Theoretical arguments for regional innovation and network promotion

The "new economic geography" not only "...serves the important purpose of placing geographical analysis squarely in the economic mainstream", as Krugman (1998: 7) puts it, and thus is not only fuelled by models of the new growth and the new trade theory, but comprises many other theoretical concepts dealing with economic and social aspects of the regional distribution of technological development and innovative activity in space. Since these concepts were much less formalised than economic models, they were hardly noticed in economic science. Nevertheless, many of them apply the findings of evolutionary innovation economics, according to which innovation is a path dependent, complex and cumulative process consisting of learning processes and knowledge flows between different actors and activities, acting in an uncertain and risky environment (Dosi 1988: 222-223). Pointing to the interactive character of innovation and to the importance of spatially limited spillover effects in knowledge ex-

change, these concepts are an integral part and a substantial complement of a new economic geography.

As a matter of fact, two major aspects elaborated in the different models should be highlighted which underline the relevance of regions and networking in innovation processes. As emphasised in the concept of regional innovation systems (Cooke 1998), but also in the learning region (Boekema *et al.* 2000; Florida 1995; Morgan 1997) and innovative milieux approaches (Ratti *et al.* 1997 for a recent summary), *spatial proximity* between knowledge producers and knowledge users plays an important role especially in early phases of innovation processes, when relevant knowledge is of tacit character and therefore localised, when technology producers and technology users have to co-operate closely for meeting specific user needs, or when uncertainty about future development prospects is high. Proximity advantages are explained by positive external effects and thus productivity and cost advantages. According to the *concept of industrial districts* (e.g. Pyke/Sengenberger 1992; Messner 1995; Sternberg 1995; also Antonelli 2000 for technological districts), external effects predominantly develop from localisation advantages, i.e. from regional specialisation. A different position is taken by the *innovative milieux approaches* which argue with a diversified economic structure in a region and with the importance of a regional culture and identity. This creates the basis for trustful cooperation and for the development of informal, hierarchy-poor and horizontal networks within a region. According to the *concept of learning regions*, the generation of collective learning processes based on tacit and spatially immobile knowledge explain that interactions between the different actors in innovation processes emerge over short physical distances, especially in new technologies or at the early phases of innovation. Although the reasons for explaining the importance of spatial proximity differ, it is common understanding of all the mentioned concepts that limited spatial entities (i.e. regions) act as seed-beds for new technological, organisational or social developments. *Spatial and cultural proximity* between knowledge producers and knowledge users is especially *important* (cf. Koschatzky 2001)

- when new technological trajectories emerge,
- in the early phase of innovation processes,
- when technologies are science-based which is especially the case in young technologies,
- when relevant knowledge is disembodied, can only be exchanged by observation or personal communication and is thus localised, and
- when technology producers and technology users have to co-operate closely for meeting specific user needs.

Proximity is *unimportant*

- in cases of incremental innovation with a low level of uncertainty,

- when it comes to standardised technologies and the production of mass consumption goods, and
- in cases of process innovation.

A second important factor making the region the starting point for policy action is the special role attributed to *innovation networking* for utilising and exploiting innovative potential by network and transaction costs economics and summarised in the concept of regional innovation systems (RIS). According to the concept (cf. Braczyk *et al.* 1998; Cooke *et al.* 1997; Cooke 1999), RIS are characterised by

- the existence of firms, universities, research institutes, intermediaries, financial institutions and other agencies and a close networking between them,
- the existence of a local capital market,
- a certain degree of autonomous public spending competence,
- the responsibility for the extension of classical infrastructural facilities, and
- an innovative atmosphere and a learning orientation of firms and the whole population.

Horizontal, hierarchy-poor and trustful co-operative relationships are an important mechanism for linking innovation actors, resources and activities in and between innovation systems and a means of information and knowledge exchange and for facilitating learning processes. The importance of interacting in innovation processes makes it clear that networking is an essential means of knowledge exchange and learning (Coombs/Hull 1998; Cowan/Foray 1997; Cimoli/Dosi 1996; Håkansson 1989; Lawson/Lorenz 1999; Lundvall 1988; Nonaka/Takeuchi 1995; Spender 1996). The advantage of networks lies thus in the acquisition of complementary resources, which an individual actor does not have at his own disposal. The degree of external effects which can be realised by networking strongly depends on the ability to search for appropriate partners, and of utilising external, innovation-relevant knowledge. The higher this so-called absorptive capacity (cf. Cohen/Levinthal 1990: 128), the more firms and other actors are able to seek out co-operation partners and to co-operate within network relations, not only within their regional environment, but on an international scale. Networking ability, learning and knowledge accumulation represent a cumulative process, by which firms and other economic actors might enter into path dependency. Institutions which do not co-operate and which do not exchange knowledge reduce their knowledge base on a long-term basis and lose the ability to enter into exchange relations with other firms and organisations.[1] On the other hand, organisa-

[1] The terms "institution" and "organisation" are used synonymously here, although in new institutional economics a distinction is made between institutions, which comprise all formal or informal rules that constrain human interaction, and organisations, which are groups of individuals bound by

tions which are integrated into multilayered networks, continuously improve their abilities for learning as well as their knowledge base, and concomitantly, the possibility of using new knowledge (Capello 1999). According to the RIS concept, spatial proximity within a region favours network formation and public policy (e.g. by regional or local governments) can play an active role in network stimulation between so far not co-operating institutions. By this, it can make essential contributions for overcoming system fragmentation (Landabaso *et al.* 2001).

It can be concluded from the different theoretical approaches briefly discussed above that regional innovation networks might act as catalysts in the exploitation of regional innovation potentials (e.g. Tödtling 1994, 1999) and that network stimulation within a region can be publicly triggered. As different examples show, this perspective was taken as a serious argument by policy makers for the formulation and implementation of regionally-oriented network-based promotion measures (Koschatzky/Sternberg 2000).

3. The role of HEIs in regional innovation systems

HEIs are important actors in regional innovation systems and in learning regions (Morgan 1997). They not only act as knowledge producers, knowledge exchange agents and teaching organisations (Etzkowitz *et al.* 2000), but often are important bridgeheads to national and international scientific, technological and economic networks, especially for those firms and institutions which cannot establish comparable network relations by their own. HEIs generally carry out two main functions (Koschatzky/Héraud 1996: 3-6):

- they manage the common knowledge base of a region by producing and diffusing knowledge through education, by distributing scientific and technological information and by demonstrating and transferring technological or scientific solutions; and
- they provide expertise knowledge by training, consulting, contract research and development, or by transfer services, taking into account the specific needs of single actors.

Although several spillover studies have found that spillover effects (or knowledge externalities) are spatially confined and that agglomeration economies favour the generation of spillover effects and thus also of innovative linkages between research and

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some common purpose to achieve certain objectives (cf. North 1990: 4-5; Kelm 1996). Nevertheless, the term institution is often used interchangeably with organisation.

industry (e.g. Jaffe *et al.* 1993; Anselin *et al.* 1997; Varga 2000), a distinction is necessary between the type of institution. The spatial range of spillover effects is larger for industrial firms than for research institutes (ISI *et. al.* 2000: 412-413), but also differs between different types of research institutes. In co-operating with German universities and technical colleges for realising publicly funded research projects, 18 % of the universities, but 50 % of the technical colleges were located within a distance of 25 kilometres around the co-operating firm. Within a distance of 100 kilometres, 80 % of the technical colleges, which were mentioned by the firms as a relevant partner for realising the innovation project, but only 53 % of the universities were located (Beise/Stahl 1999: 413). This is an indication that knowledge from universities has a wider catchment area than that of German technical colleges, which usually serve the local industry. As a matter of fact, universities have only weak innovation-oriented linkages to their respective region (Backhaus/Seidel 1998). From a regional point of view it can be argued that the knowledge potential of universities for stimulating innovative activity in a region is often under-utilised.

HEIs are not only knowledge producers, but can act as incubators for new firms. In countries like the USA, many scientific discoveries and technological developments are commercialised by researcher-owned spin-off firms (Abramson *et al.* 1997). Universities are part of privately organised dense networks between research institutions, industry and the financial sector (e.g. venture capital firms, business angels), but also with the government (cf. Etzkowitz/Leydesdorff 2000 for the triple helix model of university-industry-government relations). In the past, the situation looked different in Germany. For the years 1990-1996, the ATHENE project estimated an amount of 2,465 firm foundations originating from universities and technical colleges, which makes an average of approx. 350 university-based start-ups per year (ADT 1998). Keeping in mind that approx. 850,000 students, staff members and graduates could potentially found a new firm, the firm foundation activity at HEIs can be rated as quite low. This is also shown by the average start-up rate which reaches 6.9 persons involved in start-ups per 100 adults in the USA, while it is only 1.8 for Germany (Reynolds *et al.* 1999: 15).

University-based start-ups are not only a means for transferring scientific research into commercial application, but they are also an important element in a regional/national economy. Firm foundations in industry and service are a substantial mechanism for the renewal and development of a national and regional economy. The technological efficiency of a national and regional economy does not only depend on the innovation performances of the existing enterprises, but also on a permanent supply of new enterprises. Especially knowledge- and technology-based new firms implement business ideas which are not further pursued in existing enterprises. They generate application fields which only become possible through new technological developments, they create new and secure jobs, and they can become technology and market leaders on

growth-oriented future markets and thus influence regional, national or international competition.

The current technology-oriented firm foundation activity in Germany (as also in other industrial nations) is very manifold (Lessat *et al.* 1999): new technology based firms (NTBFs) cover a large range regarding growth potential, production or service spectrum, endowment with material and immaterial resources and also objectives of the founders. Only a small group are ambitious foundation projects, which aim at pushing forward into the class of middle or large enterprises within a decade. Besides, only some of such foundations achieve these targets. The large mass of NTBFs act as niche providers and belongs to the group of small enterprises with up to 50 employees. Nevertheless, their networking with suppliers and customers as well as their demand for production-oriented services allow their economic effect to go far beyond their firm-internal value added. If one would like to stimulate the resource and the job supply in a region by increasing the firm foundation activity, then not only the number of annual firm foundations should be increased, but also the quality of each foundation project with respect to the innovation level, its growth potential and its realisation. Here, HEIs could play a crucial role as incubators.

However, various restraining factors exist at universities. They are related to problems in transfer and commercialisation, to entrepreneurship education and to incentive-less public payment schemes (cf. Schmoch *et al.* 2000):

- Until quite recently, there were only very few universities in Germany which took an interest in the inventions of their professors and academic personnel and which supported them in patent application and licensing activities (Schmoch/Koschatzky 1996; Becher *et al.* 1996). Only in 2000, the Federal Government through its Ministry of Education and Research announced an initiative to systematically develop a professional patent commercialisation system at German HEIs for exploiting the so far unused innovation potential of universities and technical colleges (BMBF 2000a).
- For many years, entrepreneurship education and specific teaching courses for potential entrepreneurs were more a niche activity than a standard element in the curricula of many HEIs. Entrepreneurship as a subject for training appeared in the United States only in the middle of the 1960s and then diffused quite slowly to Europe (Fayolle 1998). Although the question is still being raised whether entrepreneurship can be taught (cf. Schefczyk/Garrecht 2000 for a short overview; see also Brockhaus 1993; Klandt 1991, 1994; Szyperski 1990), a sharp increase in training programmes can be observed since the first half of the 1990s in Germany (e.g. Håkansson 1998 for the first empirical results of Kaiserslautern's ExTra! training programme; see also Müller-Böling 2000). Nevertheless, the establishment of entrepreneurship education at German universities is an ongoing process.

- Regarding public payment schemes, it was the case at least until recent years that unlimited work contracts at universities, even without good payment, were more highly valued than the uncertain perspective of founding and managing an own firm. Klofsten/Jones-Evans (2000: 299) found out for academic institutions in Sweden and Ireland, that "...there is considerable entrepreneurial experience among academics in both countries, and that this translates into a high degree of involvement in 'soft' activities such as consultancy and contract research, but not into organisational creation via technology spin-offs." External factors do not seem to play a major role in explaining this behaviour, since the supply of seed and venture capital has been drastically improved during the last few years (cf. Kulicke 2001: 191 for Germany).

As has been shown so far, HEIs should have quite large potentials for a stronger integration in regional innovation systems and also for a better exploitation of the commercial use of their creativity and research activities. Based on empirical evidence from the EXIST programme, the networking ability of HEIs will be looked at in more detail in the following sections.

4. Regional network formation as a policy approach for activating the incubator function of HEIs in regional innovation systems: the EXIST programme

In December 1997, the "EXIST-Promotion of university-based start-ups" programme was launched by the Federal Ministry of Education and Research (BMBF) as a contest. Its general objective was that concepts for regional co-operation between universities, technical colleges, the business sector and further partners should be initiated. EXIST can thus be regarded as a multi-actor/multi-measure approach. Four guidance objectives are pursued (BMBF 2000b):

- The permanent creation of a "Culture of Entrepreneurship" in teaching, research and administration at higher-education institutions targeting at students, university personnel and graduates;
- increasing knowledge spillover into economic value added;
- the goal-directed promotion of the large potential for business ideas and entrepreneurs at higher-education institutions and research establishments;
- a significant increase in the number of innovative start-ups and the resulting creation of new and secure jobs.

These objectives can however only be achieved if the universities succeed in establishing foundation-oriented teaching programmes which aim at improving the personality features of potential firm founders, and if they are able to reform the study orders in a way that professional independence and entrepreneurship is put across as an interesting future option (see also Sternberg 2000: 150-151).

Following the call for proposals, 109 concepts were submitted. To qualify for participation, at least three different partners from a region had to work together, and one of the partners had to be a higher-education institute (university or polytechnic). In March 1998, a jury selected 12 of the 109 concepts which seemed to be the most promising (i.e. university-based networks in the regions Stuttgart, Karlsruhe/Pforzheim, Munich, Berlin/Brandenburg, Hamburg, Rostock/ Mecklenburg-Westpommerania, Gelsenkirchen/Bocholt/Bochum, Wuppertal/ Hagen, Kaiserslautern/Trier, Saarbrücken/Saarland, Dresden, Ilmenau/Jena/ Schmalkalden). These regions were given the opportunity to make their ideas more concrete until July 1998. In August 1998, five of them were awarded prizes for the best regions (cf. Figure 1): the networks "bizeps" (Wuppertal/Hagen), "dresden exists" (Dresden), "GET UP" (Ilmenau/Jena/ Schmalkalden), "KEIM" (Karlsruhe/ Pforzheim), and "PUSH!" (Stuttgart). Since the end of 1998, these five regional initiatives have been working towards the realisation of their concepts.[2] Funding, which amounts to 15.34 million € p.a. for the whole programme, has been granted until the end of 2001. To this end, good practice models for the motivation, training and support of founders for new firms and of entrepreneurship have to be set up. Universities and technical colleges have to work together with different external partners from industry, education and training, consultancy, the financial sector and administration. Accompanying measures are public relation activities, the "EXIST-Seed" programme which provides grants to students, graduates and faculty members for promoting promising ideas, and the "EXIST-HighTEPP" (High Technology Entrepreneurship Post-graduate) programme which aims at the training of young academics, the support of start-up projects and the training of managers for dynamic high-tech firms in the biotechnology, pharmaceutical and information technology industries.

With regard to the statements of the different theoretical concepts discussed in section 2, but also with regard to empirical analyses, a regional approach for stimulating the spin-off activity at HEIs seems justified, because

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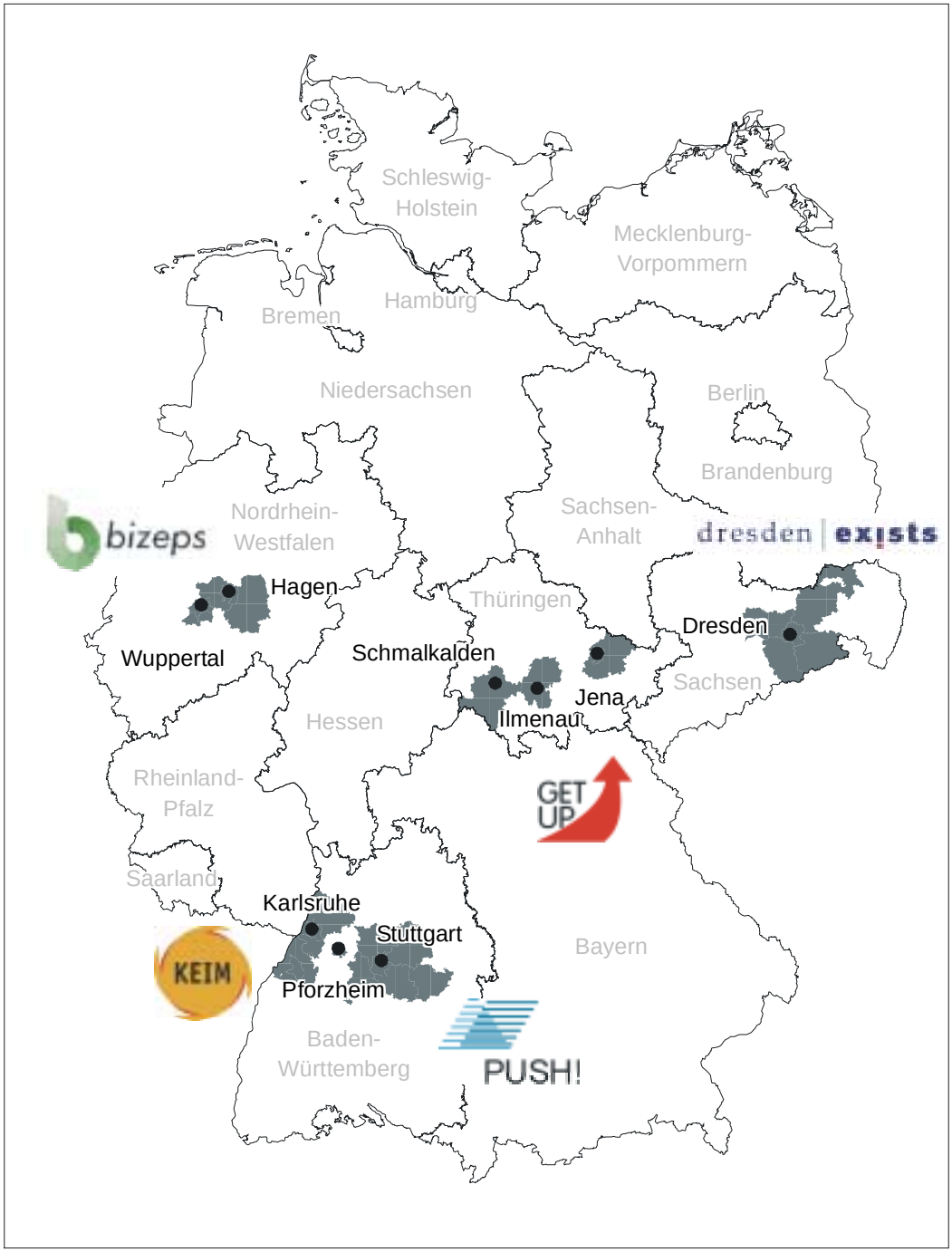
[2] The Department "Innovation Services and Regional Development" of Fraunhofer ISI is in charge of the scientific monitoring and evaluation of the five regional EXIST networks. The assessment of the five EXIST regions given in this paper reflects, however, only the personal estimation of the author and does not necessarily correspond with that of the scientific monitoring team.

Figure 1: The five EXIST regions in Germany



- approximately 70 % of all firm founders position their new business within a maximum of 25 kilometres from their place of residence (Schmude 1994: 80),[3]
- spatial proximity plays a crucial role in the exchange of tacit knowledge which dominates in research-based development projects and their commercialisation,
- the embeddedness in a well-known regional environment reduces uncertainties and risks for firm founders,
- more support can be given when breeding institution and firm founder are located close together,
- transaction and control costs within networks can be minimised.

On the other hand, the immobility of newly founded firms also contributes to regional labour market effects. As Werner (2000: 84-89) showed for East German new technology-based firms which received support under the promotion scheme TOU-NBL, the average employment figures reached 12.9 in the fifth business year and even 17.6 in the sixth year.[4] The survival rate of these firms is 88.1 % in the fifth year, so that only 11.9 % dropped out during the stage succeeding the foundation. These figures indicate that the support of founders and newly established firms seems worthwhile and that the spatial entity in which the support should take place should not be too large, because the intensity of supporting services would decrease with an increasing distance between the firm and the supporting agencies (cf. Sternberg 2000: 201). As a matter of fact, the EXIST regions should be of a size which allows close interactions between the different partners involved in entrepreneurship stimulation so that proximity really matters, but should on the other hand have a sufficient socio-economic potential for being able to act as a seeding-bed for new firms.

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3 Using empirical data from the "Grüncol! – Gründungen aus Kölner Hochschulen" survey, Otten (2000: 16) found out that 61.6 % of the interviewed nascent entrepreneurs intend to stay in the greater Cologne area.

4 According to Ziegler *et al.* (1990), the average size of NTBFs in their fifth year of operation is 5.4 employees. Young firms, which received equity capital support by the Deutsche Ausgleichsbank, had on average 9.2 employees in their fifth year (Heil 1997).

5. Major characteristics of the EXIST regions

5.1 General overview

The initiative "*bizeps*" covers the Bergisch-Märkische region in the Federal state of North Rhine-Westphalia including the cities of Wuppertal, Hagen, Solingen and Remscheid (which do not belong to any district), as well as the Ennepe-Ruhr region and the Märkische region. This region with currently about 1.7 million inhabitants has experienced substantial structural adaptation from its previously traditional industrialisation several times. Small and medium-sized firms predominate in this densely industrialised region and its rather agricultural environment with an under-represented service sector. Both of the important HEIs of the region – the Bergische Universität-Gesamthochschule Wuppertal (BUGH) with currently about 15,000 students and the FernUniversität Hagen where approximately 44,000 students from all over Germany are registered - are involved in the "bizeps" programme (BMBF 2000b: 14). Except for the FernUniversität Hagen the rate of students per 1,000 inhabitants is 11.7 so that *bizeps* holds the last position of the EXIST regions. No applied research institute is located in this region. The network is sustained by 21 permanent partners (cf. Table 1).

The catchment area of "*Dresden exists*" is the city of Dresden itself with almost 470,000 inhabitants, as well as the surrounding rural districts of Sächsische Schweiz, Kamenz, Weißeritzkreis and Meißen-Radebeul with about 530,000 inhabitants, which show only limited industrial structure. Located in the south-east of Saxony, the region is currently placed in an EU border position. Following a fundamental reorganisation of the former economic structure, as well as the location not only of many industrial research institutions but also of production and R&D units by internationally active companies, the city of Dresden in particular is on its way to becoming a high-tech industrial region for micro-electronics and its application fields. *Dresden exists* is a university-focused network which was developed around the technical university of Dresden with its approximately 24,000 students. In view of the density of students, Dresden holds the second position among the five EXIST regions with a proportion of 24.1 students per 1,000 inhabitants. The network is maintained by 32 permanent partners (cf. Table 1).

In comparison to the remaining regions, the "*GET UP*" initiative is a special case. It includes the three separate academic locations of Jena (the city of Jena), Ilmenau (regions of Ilm and Saale-Holzland), and Schmalkalden (district of Schmalkalden-Meiningen) with a total of 461,000 inhabitants. The economy is characterised by a fundamental re-organisation of former structures, whereby new industrial cores will be created by activating endogenous potential. The centre of the *GET UP* catchment area is Jena and its university with a total of 17,800 registered students. In the past years,

Jena has distinguished itself as a high-tech region in the areas of microelectronics/optics, laser and bio-technology. In total, *GET UP* has 24,300 students, and with a density of 52.8 students per 1,000 inhabitants it ranks far ahead of the remaining EXIST regions. Due to the participation of several locations, more than 60 partners are permanently involved in the *GET UP* network (cf. Table 1).

The "*KEIM*" region integrates the technology region of Karlsruhe (Karlsruhe, Bruchsal, Baden-Baden and Rastatt) and the city of Pforzheim. Its large catchment area (about 1.3 million inhabitants) shows a wide range of firms of different sizes and from different branches without the predominance of large-scale enterprises, as well as several industrial research institutions (i.e. the Karlsruhe Research Centre, three Fraunhofer institutes). Due to its high share of technology branches (e.g. information and communication technology) among total employment, the region is assigned second place among the 15 leading European high tech regions by the EUROSTAT comparison. Main subjects of the Karlsruhe university and the technical college are technical and natural sciences; the technical college of Pforzheim is focused on economics. The total number of students registered at these three institutions is of 22,000. With a density of 17.8 students per 1,000 inhabitants the region is placed among the average of all EXIST regions. 15 partners are permanently involved in the network interconnecting the universities and the Karlsruhe Research Centre (cf. Table 1).

The catchment area of "*PUSH!* has the highest number of inhabitants (2.5 million) of all EXIST regions. For many years now, the area of Stuttgart has been one of the economically strongest regions of Germany including production and research units of many renowned large-scale enterprises and medium-sized firms. Only minor economic differences separate the individual districts from the city of Stuttgart. The region even beats Karlsruhe and holds first place in the EUROSTAT comparison of the 15 leading European high tech regions. A total of 40,000 students account for the region, 34,000 of which are registered at the universities participating in the *PUSH!* initiative (the universities of Stuttgart and Hohenheim as well as six technical colleges in Stuttgart, Esslingen and Nürtingen). Student density reaches 16 students per 1,000 inhabitants, thus holding fourth place following *KEIM*, and preceding *bizeps*. In contrast to the remaining EXIST regions, a dominant role is not played by the individual universities involved in the initiative. There is a great diversity of network partners with differing levels of participation (universities, research institutions, venture capital companies, financial institutions, consulting agencies and firms). Instead of a rigid organisational structure, demand-oriented services are offered. A total of about 60 partners are integrated into the *PUSH!* network (cf. Table 1).

5.2 Innovative and technological potential of the regions

Different indicators can be used to show a region's innovation and technology potential, however, most of them only outline the input for innovation processes (cf. the extensive illustration given in ISI *et al.* 2000). In the following analysis, the R&D rate (number of R&D staff in proportion to the total number of employees) and the number of patent applications for scientific inventions will be used as an example. Since the EXIST programme focuses primarily on academic institutions, the invention activities of the scientific staff give a better image of their technological specialisation and their innovation and founding potential than the number of inventions of all patent applicants. It must nevertheless be taken into account that, up to the present, the German scientific system has only offered university professors very limited incentives to process a patent application for an invention which may have developed within a research project. On the one hand, inventions by professors, lecturers or scientific assistants automatically belong to them according to the privilege for university professors regulated by § 42 Arbeitnehmererfindungsgesetz (legal invention regulation for employees), on the other hand, they have to process the patent application as well as possible license negotiations by themselves and at their own expense (Schmoch/ Koschatzky 1996: 111). Their interest in patent applications is therefore relatively low (about 4 % of the total of patent applications) due to the conflict between an interest in publication and patent application on the one hand, and the high costs for the patent procedure on the other hand. In contrast to the U.S., research institutions and in particular universities seldom apply for patents, which distinctly complicates database search for scientific inventions. Only quite recently, the Federal Ministry for Education and Research has launched an initiative to reform the German universities' patent right (BMBF 2000a). Another restriction regarding the use of patent data in general and especially in the scientific area is due to the fact that not all inventions are patentable (cf. Koschatzky 1997: 48-49), and that the creativity potential of university locations strongly focusing on social science is not sufficiently reflected in technology related patents. Nevertheless, patents have become an important indicator of input or throughput regarding innovation processes in the area of empirical research on innovation.

Regarding activities in the field of research and development, the greatest potential is found in the city of Stuttgart: 16.2 % of all employees subject to social insurance contributions are entrusted with R&D tasks. The planning region of Stuttgart, integrating the city itself and its surrounding areas, also shows a R&D rate of 7.6 %, distinctly exceeding the West German average of 3.4 % (figures for 1995; cf. ISI *et al.* 2000). Jena (8.6 %) and Dresden (7.6 %) also show above-average rates of R&D intensity, both considerably exceeding not only the West German average but also the East German average of 2.1 %. Related to *GET UP*, the Ilm district (Ilmenau) reaches a percentage of 2.7 %, whereas the district of Schmalkalden-Meiningen shows 1.8 %.

The R&D intensity in Karlsruhe is more or less average (municipal area: 4.5 %, district: 2.1 %), whereas the figures shown by the region of Wuppertal remain below average with a percentage of 2.6 % for the city itself and 2.2 % for the planning region (cf. Table 1).

With regard to patent applications by professors and scientific staff members, a slightly different sequence is found for the innovation potential of the five EXIST regions[5]. During the period 1994 to 1998, a total of 1,987 patents were applied for by scientific inventors from all five regions. Of these, 737 patent applications (37.1 %; cf. Table 1) come from the *PUSH!* region (Stuttgart and environments). Related to the total number of German scientific inventions during the above-mentioned period (8,555 patent applications), a share of 8.6 % was reached by *PUSH!*, which is equivalent to the figure found for the total of German patent applications accounting for the planning region of Stuttgart during 1998 (ISI *et al.* 2000). The following positions are held by *KEIM* (412 patent applications, which represents 20.7 % of all the scientific patents from EXIST regions), *Dresden exists* (376; 18.9 %), *GET UP* (264; 13.3 %), and *bizeps* (198; 10.0 %). If one takes the number of inhabitants per region as a reference, the above mentioned positioning shows different proportions. According to this indicator, the highest number of patent applications by scientists is reached by *GET UP* (with Jena as an internal leader) with 57 applications per 100,000 inhabitants, followed by Dresden with 38 applications per 100,000 inhabitants. These numbers reflect not only a higher potential of inventions developed by scientists in the two East German EXIST regions, but also an increased openness towards patent applications by East German universities. This is due to the higher ranking of scientific patents in the former German Democratic Republic, which was furthermore taken up by several universities at an early stage after re-unification (Koschatzky *et al.* 1995). With 32 patent applications per 100,000 inhabitants the *KEIM* region Karlsruhe/Pforzheim holds third place, closely followed by Stuttgart (*PUSH!*) with 30 applications. In an absolute comparison as well as in view of the R&D intensity and the number of patent applications, the figures for *bizeps* (Wuppertal/Hagen) point to an innovation and R&D potential which, in comparison with the remaining EXIST regions, remains below-average.

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5 The investigation includes applications submitted by German inventors (professors and research institutions) to the German Patent and Trademark Office and to the European Patent Office regarding Germany as country of destination during the period 1994 to 1998. I thank Rebecca Rangnow for carrying out the analysis in the database PATDPA.

Table 1: Characteristics of the five EXIST regions

	bizeps	dresden exists	GET UP	KEIM	PUSH!
Population	1.7 million	470,000, within commuting area approx. 1.0 million	461,000	1.3 million	2.5 million
Students	20,000 plus 44,000 in Germany at "Fernuniversität Hagen"	24,100	24,300, Jena alone 17,800	23,400	over 40,000
Students per 100,000 inhabitants	1,170 (without Hagen)	2,410	5,280	1,800	1,600
No. of closely integrated network partners	21	32	over 60	15	60
Share of R&D employment in total employment	2.6 % for Wuppertal	7.6 % for Dresden	8.6 % for Jena, 2.7 % for Ilm-Kreis and 1.8 % for Schmalkalden	4.5 % for Karlsruhe town and 2.1 % for Karlsruhe district	16.2 % for Stuttgart
No. of firms in high-tech fields	889 of which 861 SMEs 28 large firms (share of all regional firms: 3.1%)	457 of which 442 SMEs 15 large firms (3.3%)	209 of which 200 SMEs 9 large firms (4.3%)	625 of which 605 SMEs 20 large firms (3.2%)	1,609 of which 1,491 SMEs 118 large firms (7.3%)
No. of high-tech firms per 100,00 inhabitants	52.3	45.7	45.4	48.1	64.4
Patent applications by scientists 1994-1998	total: 198 share EXIST regions: 10.0 % share in German total: 2.3 % per 100,000 inhabitants: 12	total: 376 share EXIST regions: 18.9 % share in German total: 4.4 % per 100,000 inhabitants: 38	total: 264 share EXIST regions: 13.3 % share in German total: 3.1 % per 100,000 inhabitants: 57	total: 412 share EXIST regions: 20.7 % share in German total: 4.8 % per 100,000 inhabitants: 32	total: 737 share EXIST regions: 37.1 % share in German total: 8.6 % per 100,000 inhabitants: 30

Source: internal material of EXIST evaluation; ISI *et al.* (2000); own patent searches in PATDPA

Patent data is an appropriate means not only for illustrating the innovation potential (in consideration of the above-mentioned restrictions) but also for analysing the technological specialisation of a given region. Therefore, the patent applications of scientific inventors were assigned to 30 technologies based on the International Patent Classification and divided into five technological fields. The regional patent specialisation was calculated by the relative patent advantage (RPA):

$$RPA_{ij} = 100 \tanh \ln [(P_{ij}/\sum_i P_{ij}) / (\sum_j P_{ij} / \sum_{ij} P_{ij})]$$

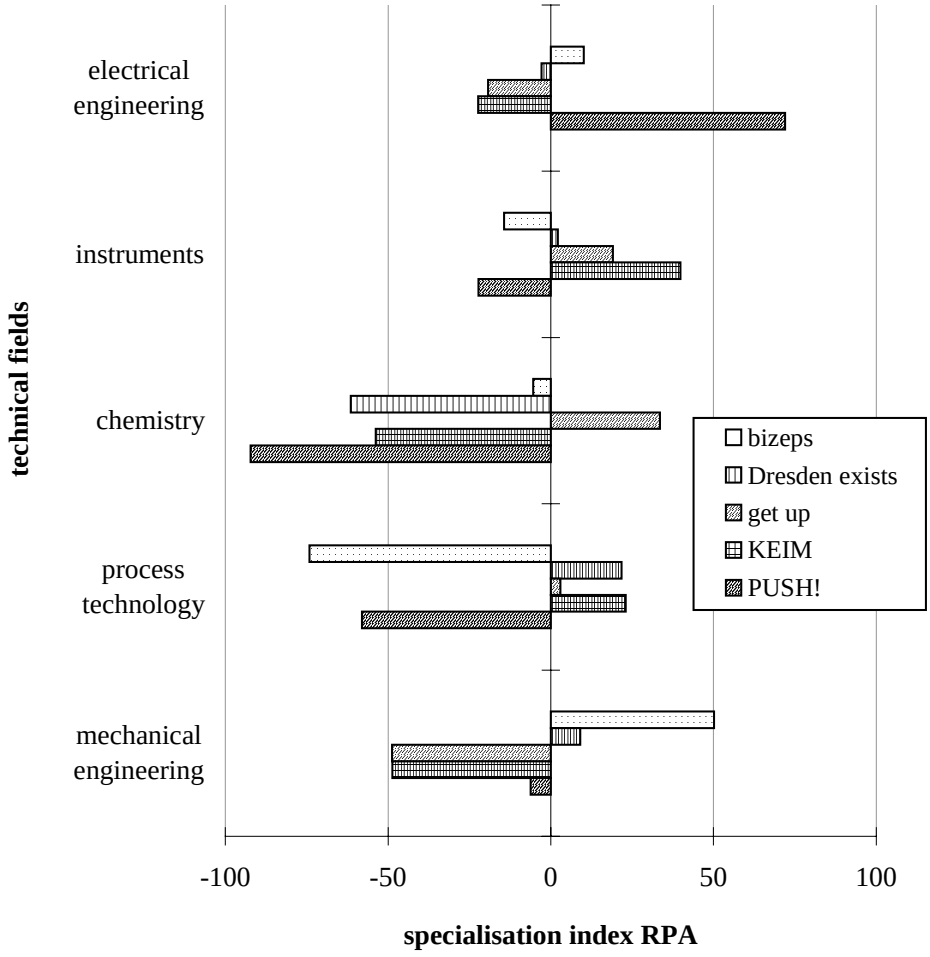
"P_{ij}" represents the number of patents in a country or a region "i" in the technological field "j".

The reference values are established either by the number of national scientific patent applications in the respective technological fields, or by the total number of scientific patent applications processed in Germany from 1994 to 1998. Herewith, the logarithm assures a symmetric range of value around the neutral point 0, the tangens hyperbolicus leading to a limitation of the range of value to ±100. Taking into account fault tolerances, index values of more than ±15 could be interpreted as an above or below specialisation.

Figure 2 shows the RPAs of the five technological fields electrical engineering, instruments, chemistry, process technology and mechanical engineering. Distinct difference is shown in view of the technological specialisation of the different regions, and consequently of the potential technological fields which could serve as a basis for firm foundations. Electrical engineering (RPA +72) is clearly shown as a strength of the *PUSH!* region of Stuttgart, especially telecommunication and data processing. In contrast to this, inventing scientists only play a minor role in the area of mechanical engineering (Greif 1998), another important sector of this region (RPA –6.2). Here, invention mainly takes place in companies. The remaining technology fields of the region too only show below-average specialisation in patents, which, however, concentrates on chemistry including biotechnology (RPA – 92). Some advantage is shown in the specialisation in electrical engineering by the *bizeps* region (Wuppertal/Hagen) as well as a distinct advantage in mechanical engineering with a RPA of +50.1. The scientific and technological strengths of the region are especially represented by machine tools, by consumption goods and in the transport area. Except for a negative specialisation regarding chemistry (RPA –61.5), an area in which almost all EXIST regions show weakness, Dresden's specialisation is in general average, but above-average in the field of process technology (materials, environmental technology) in view of scientific inventions (RPA +21.8). *GET UP* (Jena, Ilmenau, Schmalkalden) shows strengths in both areas of instruments (especially optics) and of chemistry (organical chemistry, polymers). In these fields, the region attains RPAs of +19 respectively +33.5. The *KEIM* region of Karlsruhe-Pforzheim excels with its scientific inventors' strengths in

the technological fields of instruments (RPA +39.9), especially regarding nuclear technology and measurement, as well as process technology (+30; environmental technologies, process engineering). In comparison with Stuttgart, weakness is mainly shown in the areas of electrical engineering and chemistry, as well as mechanical engineering.

Figure 2: Relative patent specialisation of scientific inventors in the five EXIST regions



Source: own calculations

Both the various fields of technological specialisation on the side of scientific inventors and the data presented above show the extent to which the individual EXIST regions differ from each other in view not only of their scientific potential but also their economic structure and the role played by the respective HEIs in this context. An in-

ter-regional comparison shows that the region Wuppertal-Hagen (*bizeps*) has the most unfavourable starting conditions, academic research potential emerging from only two higher education institutions (HEIs) and showing a distinctly lower degree of R&D intensity than the remaining EXIST regions. Although the activities of *Dresden exists* concentrate on only one university, the region is distinguished from Wuppertal-Hagen by a differentiated research infrastructure; moreover, several large-scale micro-electronic companies are located in this region, the R&D intensity of which far exceeds the East and West German average. *GET UP* (Jena, Ilmenau, Schmalkalden) is also part of a developing high- tech cluster in East Germany, made up of industries which drive R&D, and a diversified range of research institutions. According to the criteria mentioned in section 2, the Wuppertal/Hagen region cannot be considered as a regional innovation system due to the lack of a broad basis of various research institutions. Whereas a diversified research offer exists both in Dresden and in Jena/Ilmenau/Schmalkalden, only Dresden has autonomous governance competence due to its function as capital of the federal state of Saxony. Due to the location of substantial political institutions in the regional capital Erfurt, the autonomy of the *GET UP* region is limited. *Karlsruhe* and *Stuttgart* form a separate regions within the regional innovation system of Baden-Württemberg (Braczyk *et al.* 1995; Cooke/Morgan 1994; Heidenreich/Krauss 1997); their research and innovation potential also shows high diversity, and they also have autonomous political competence. Consequently, a differing potential for firm foundations from HEIs can be expected depending on the respective regional starting-conditions; moreover, in order to achieve the objective of promoting an entrepreneurial climate at HEIs, varying models and network configurations can be expected from one region to another.

6. Network building in the five EXIST regions – a general overview

6.1 Methodological issues

In order to achieve an insight into the formation process of networks in the five EXIST regions, the Fraunhofer Institute for Systems and Innovation Research carried out a network analysis within its scientific assistance granted to the EXIST regions. By means of communication analytical instruments taken from empirical social science, the following aspects were raised in a written survey (for more details, cf. Bührer/Görisch 2001):

- identification of the most important partners as well as their functions within the regional network;

- registration and assessment of communication channels and network structures, as well as
- pointing out existing obstacles in the networks.

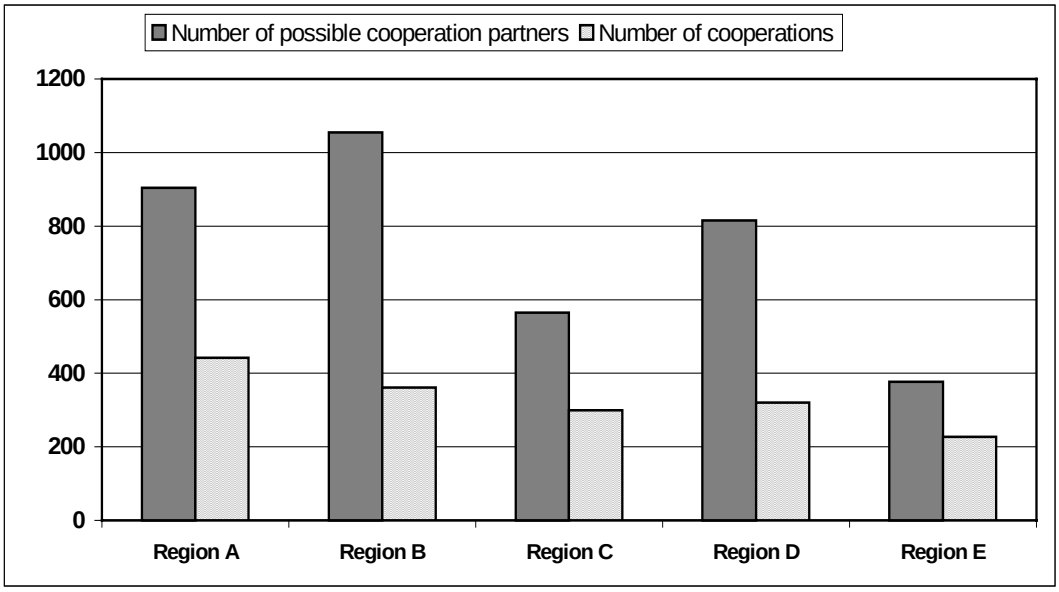
The survey results give an impression of the participants' individual (internal) assessment of the network structures and their impediments. The questionnaires were distributed from October 1999 to January 2000 to the most important network partners, which had previously been selected in cooperation with the network co-ordination centres. In total, 170 questionnaires were dispatched, and 126 could be analysed. The total response rate was 74 %, ranging from 67 % to 86 % according to the regions. Due to the fact that the efficiency of some of the network partners had to be evaluated, the five initiatives were assured that the analyses of their questionnaires would only be returned to them, and that any data would only be published anonymously. For this reason the results cannot be assigned to the five initiatives in this analysis, and the regions will be labelled from A to E disregarding the alphabetic order used up to now.

6.2 Network structures and network obstacles

As has already been shown, the five EXIST initiatives developed different network structures; this affects not only the number of permanently involved partners, but also the number of HEIs and their functions within these networks. Although the EXIST programme was focused on HEIs, these are only player (even though an important one) in a variety of organisations whose common objective is the encouragement and improvement of their respective regional climate for firm foundations.

For obtaining a first insight into the variety of potential cooperation relationships, the survey recorded the number of those institutions listed in the questionnaire which had been recognised as network participants. The results indicate the number of potential cooperation partners, which is compared with the number of actually existing cooperation relationships. The bigger the gap between possible cooperation partners and the number of existing cooperation relationships, the less the regional network potential is made use of or the less the network participants complement each other. In Figure 3 this relationship is illustrated for the five EXIST regions.

Figure 3: Size of network and number of cooperations



Source: EXIST network analysis

Regions B and D in particular do not make use of the possible cooperation potential offered by the existing network relationships. Here, the share of cooperation is 34 % and 39 %, while it lies between 49 % and 60 % (region E) in the remaining three regions. Possible reasons for the different regional cooperation frequencies are identified by answers to the questions whether the network relationships represent new contacts which have come into existence only in the framework of the EXIST initiative, or whether these contacts existed previously. The two regions in which the network potential is the less utilised are also characterised by the smallest share of new relationships (cf. Table 2). Only 19 % (region B) and 23 % (region D) of the contacts have recently come into existence, whereas 55 % or 51 % have been in existence for a longer period. The opposite is true in the three remaining regions with a majority of new relationships. At first sight, these figures lead to the conclusion that the EXIST networks of regions B and D were essentially built up on the basis of established contacts, while EXIST has led to the establishment of new founding-oriented networks in the remaining regions. However, due to the fact that at least one of the three regions is characterised by a long founding tradition, the presumption that these regions were not concerned with the promotion of founding activities cannot be confirmed as such. It is more probable that, in the regions B and D, EXIST activities were more strongly integrated into existing institutional structures regarding innovation and founding, whereas new partners were actively searched for in the regions A, C and E. This could be interpreted as a new orientation of existing networks in order to better adapt these through new knowledge, new resources and intensified competition within the network to the

EXIST challenge. In contrast to this, in regions B and D, where great cooperation potential exists, only established cooperation relationships are routinely used for EXIST.

Table 2: Duration and intensity of networking relationships

	Cooperations altogether (n)	of which are ... (in %)				
		newly established	noticeable intensified	long existing	reduced	no information
Region A	442	46	17	26	-	11
Region B	361	19	24	55	-	3
Region C	299	60	11	24	0.3	5
Region D	320	23	16	51	-	10
Region E	227	52	26	14	-	8

Source: EXIST network analysis

Intensified utilisation of the network potential in the regions A, C and E is because the new partners have to establish contacts in order to become acquainted with each other and to reduce uncertainty. Therefore, in an inter-regional comparison, regions A and C show the highest share of extremely frequent network exchanges. 29 % of the respondents from region A and 33 % from region C indicated daily or weekly exchange rates. These figures correspond with 22 % from region B, 27 % in D and 21 % in region E. However, intensified exchange does not necessarily mean more efficient network management and more successfully organised common support measures. Due to the fact that the establishment of new contacts demands cost and personnel resources, unsuccessful cooperation can lead to discontent. This is, however, not confirmed at the moment of the survey. In regions A, C and E the climate of cooperation is predominantly evaluated as excellent, in part distinctly better than in regions B and D (cf. Table 3). 48 % of the respondents from region A and 36 % from region C considered the co-operation climate to be very good (against only 24 % in region D). However, if the excellent and good assessments are condensed, then this evaluation is relativized in favour of regions B and D. With 67 % positive assessments, region D attains a similar share to region E with 68 %. Regions B and C reach 74 % respectively. The better rating "good" from the established networks of the two latter regions points to relationships which have grown and become stable over time, which – as experience shows – are assessed as "good" rather than as "very good" or "excellent".

Table 3: Cooperation climate

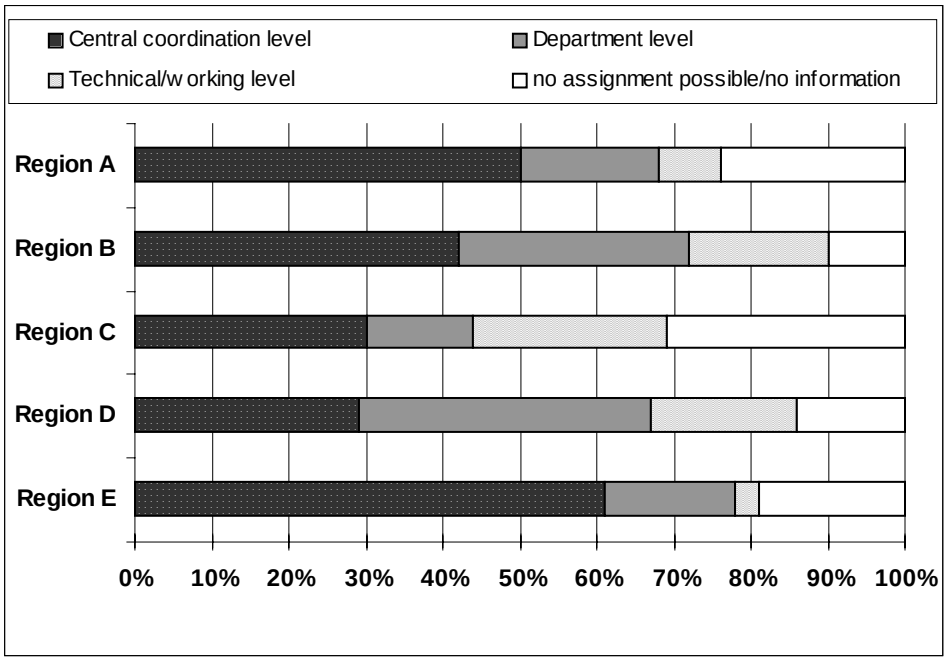
	Cooperations altogether (n)	of which are ... (in %)					
		very good	good	satisfac-tory	sufficient	insuffi-cient	no infor-mation
Region A	442	48	32	8	1	1	10
Region B	361	30	44	16	3	0.3	6
Region C	299	36	38	18	3	1	4
Region D	320	24	43	15	3	3	11
Region E	227	26	42	22	4	4	3

Source: EXIST network analysis

In general, horizontal networks are characterised by hierarchy-poor exchange relationships (cf. Powell 1990; Semlinger 1998). In the case of the EXIST networks, which are based partly on existing relationships and partly on newly established contacts, university-based or external coordination units are responsible for the formal operation of the project as well as for network coordination and information. The different organisational models of networks as chosen by the individual initiatives are reflected by the respective hierarchical levels of exchange between the network partners (cf. Figure 4). According to this, the networks of regions A and E are characterised by hierarchical exchange, while regions C and D show more decentralised organisational structures. Due to the fact that both the hierarchy-oriented network of region E and the more decentralised network of region D are coordinated by university-internal institutions, no correlation can be found between university-internal and university-external coordination and the level of hierarchy. In contrast to this, network management of regions A and C is carried out by university-external organisations. The difference in network hierarchy also cannot be explained by the share of newly established contacts (cf. Table 2). It can be assumed that a high share of new network relationships also entails more efforts for control, and consequently more intense hierarchical coordination. However, this is not the case for the EXIST networks: Region C, in which 60 % of all network contacts have recently come into existence, shows a level of hierarchy as low as that of the networks in region D, where the share of new contacts is only 23 %. Consequently, regional peculiarities seem to determine project organisation and channels of communication for the different levels of hierarchy.

Figure 4: Hierarchical pattern of network relations in the five EXIST regions

(shares of communication according to hierarchical levels)



Source: EXIST network analysis

Networks serve as an instrument of coordination, as well as for the exchange of information and resources. Due to the involvement of different partners with different interests and absorptive capacities, an increase in the network size leads not only to an increase in coordination efforts, but also to a lack of transparency and to obstacles in mutual exchange. The main purpose of EXIST networks is the support of a climate which stimulates entrepreneurship in HEIs and their regions. To achieve this objective, new entrepreneurship qualification opportunities must be created; furthermore, people (e.g. university graduates or university personnel) should be motivated to found their own companies. From the perspective of the network participants, the biggest obstacle in almost all regions was reaching the target group, at least during the starting phase of the EXIST project, during which the network analysis was carried out. Particularly in region E, which, together with region B, shows the highest potential of obstacles, the most important obstacle was seen in the lack of potential founders (68 % of the answers). Another situation is found in region C, where only 14 % of the respondents saw a bottleneck there. Since there is no higher foundation interest than in the remaining regions (cf. Table 5), expectations of the number of founding projects seem to be lower. Further important network-related obstacles are a lack of contact with other network participants (31 % of all answers from the five regions) as well as the lack of transparency in the network (also 31 % of all answers). A correlation between the size

of the network and its transparency could be presumed due to the fact that those regions which show a high level of the last-mentioned obstacle also show the highest number of answers to the obstacle "too many network partners" (regions B and E).

Obvious differences are shown concerning the assessment of the individual networks when the separate obstacles are condensed into categories (cf. Table 4). Obstacles regarding the cooperation process (i.e. a lack of coordination with the coordination unit, frequent turnover of responsible persons, lack of contact with other network participants, personal animosity, too few coordination meetings) are mainly shown in regions C and D. Here, the average figures reach 38 % and 36 %. There is a correlation between the obstacles mentioned above and the low level of hierarchically coordinated network relationships in these two regions; this points to the necessity for a central organisation to play an active role within the network management. Structural obstacles (i.e. priority setting of the own institution, gaps in the network offer, lack of network partners, too high a number of network partners, lack of sustainability of the initiative, lack of transparency, redundancies in the network) exist mainly in regions B and E (46 % and 44 % of the statements). Region A is especially characterised by external obstacles (42 %).

Table 4: Categories of network obstacles according to regions

	Number of statements altogether	of which are... (in %)			Statements per respondent
		obstacles in networking	obstacles due to structure of network	external obstacles	
Region A	66	21	37	42	2.1
Region B	86	28	46	26	3.2
Region C	43	38	35	28	2.0
Region D	64	36	39	25	2.4
Region E	58	25	44	31	3.1

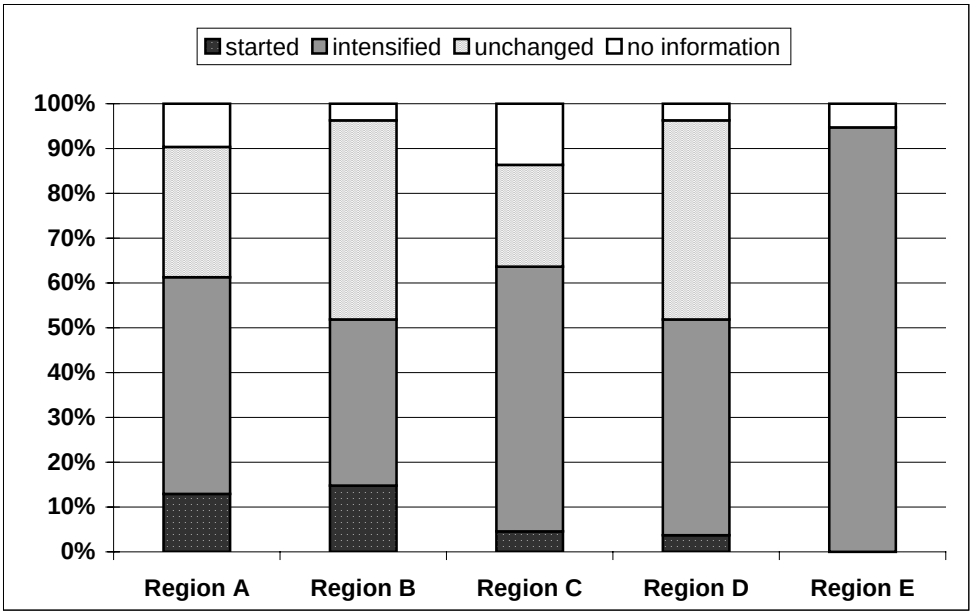
Source: EXIST network analysis

It is also interesting to note that the average number of statements given per respondent differs slightly between the regions. The lowest number of statements per respondent concerning network obstacles came from the regions C and A, while for region B - where the share of newly created contacts was lowest (cf. Table 2) – on average one more additional obstacle was indicated than for region C. This could point to a principally more critical approach towards the EXIST network but also to a real greater obstacle potential.

In spite of their different structural features the networks pursue common objectives, i.e. the encouragement of firm foundations and the creation of an entrepreneurial cli-

mate at HEIs. Despite different organisational models for the attainment of this objective, it should be asked whether or not the network activities had a positive influence on the players in view of their involvement in promoting entrepreneurship (cf. Figure 5). The direct effect on the involvement of the network partners must be considered as distinctly positive. At least 50 % of the respondents of all EXIST initiatives have either started or intensified their activities promoting entrepreneurship. In region E the activities of almost all players were reinforced. The most important mobilisation effect was shown in regions A and B, where almost one sixth of the players started their involvement in promoting entrepreneurship due to the initiative. However, regions B and D have the highest number of institutions (almost half) which have not modified the extent of their activities so far. Among the five EXIST regions, these two regions show the lowest share of new network partners, so that the high proportion of unchanged activities is another indicator for the integration of EXIST measures into existing activities in order to stimulate entrepreneurship in these regions.

Figure 5: Influence of EXIST on activities for entrepreneurship promotion in the five regions



Source: EXIST network analysis

6.3 Spin-off activity in the EXIST networks

Besides the general statement of intensified regional firm founding activities due to EXIST and the networks formed by the involved institutions, a great number of indi-

vidual measures and projects have come into existence in the separate regions which deal with different aspects of entrepreneurship stimulation at universities.[6] This analysis cannot discuss all of the aspects; however, the range of measures includes the creation of a culture of entrepreneurship in teaching and research, the transformation of scientific research results into economic value added, the encouragement of the potential of both business ideas and founder personalities, and the increase in the number of innovative firm foundations and, consequently, the creation of new and stable jobs.

Although the number of recently founded innovative companies[7] represents only one aspect in the assessment of the effects of networks and individual measures started by EXIST, it is an indicator of the successful implementation of the EXIST objectives, as well as of cooperation within the founding networks. As of 31 July 2000, a great number of innovative firm foundations could be registered which can directly or indirectly be attributed to EXIST activities and promotion (cf. Table 5).[8]

Table 5: Firm foundation activity in the EXIST regions*

	Region A	Region B	Region C	Region D	Region E	Total
Foundation projects	183	147	109	71	320	830
Firm foundations	67	57	49	27	40	240
Share of foundations (%)	27.9	23.7	20.4	11.3	16.7	100.0
Share in regional NTBFs (%)**	30.0	12.1	59.0	23.5	30.5	23.4

* as of 31 July 2000

** New technology-based firms founded in 1999 and 2000 in the five regions according to register of companies

With respect to the regional technological specialisation pattern identified on the basis of the patent analysis, a fairly large overlap can be found between the technologocal orientation of the new firms and the technologies in which the regions show an above degree of specialisation. Although in absolute terms the number of firm foundations is

6 Cf. for example the support process of the Karlsruhe and Pforzheim *KEIM* initiative, which includes the mobilisation and growth of potential entrepreneurs by raising awareness and talent testing, as well as the encouragement of concrete firm foundations through systematic preparation (coaching and feasability studies), the support of the foundation itself, as well as expansion support. Cf. also the various illustrations at www.exist.de, in particular the EXIST data bank with its description of individual measures.

7 According to the EXIST definition, innovative companies are firms offering products or services based either on scientific-technological ideas or on own research results.

8 According to estimates, about 50 to 100 new technology-based firms (NTBFs) showing high growth potential were founded every year in Germany during the second half of the 1990s, plus several hundred NTBFs with moderate growth potential, as well as many times this number of new technology-oriented small companies (cf. Lessat *et al.* 1999).

highest in regions A and B, regions C, E and A reach highest figures related to the regional potential of NTBFs. With regard to the indicators given in Table 1, i.e. regional high-tech companies or the patent application activities by scientific inventors (in shares respectively), the number of innovative firms founded in the regions A and C was distinctly higher than the respective comparative figures. In regions B and D none of the comparative figures was reached; region B showed particularly obvious negative deviation figures. Region E showed a level of EXIST foundations exceeding the regional proportion in patents, but remaining below the region's share of high-tech companies. It can thus be summarised that the regions C, A and E were particularly successful in initiating university-based firm foundations in the period under observation.

7. Conclusions and policy implications

At this point, it is difficult to create a link between network characteristics and the target achievement on the side of the networks, which is measured by the number of firm foundations. This is due to several reasons :

- The available data only enables qualitative conclusions due to the fact that the number of cases and the features of variables prohibit the use of multivariate statistical methods.
- The number of firm foundations is only one success indicator among others, which cannot reflect the range of activities of EXIST networks and their success very well.
- The assignment of firm foundations to EXIST could be unclear especially during the project's starting phase; moreover, assignment criteria were not homogeneous for all five networks.
- Causality between network organisation and the measure's results is not clear; moreover, complex non-linear correlations and inter-dependencies exist between individual measures and the total result of co-operation in networks.
- Network analysis and the number of firm foundations only reflect an intermediate status which covers the first half of the project; this does not represent the promotional measure throughout its lifespan.

Despite these limitations and in the background of the results presented above, it will be attempted to relate network structures and results of the network activities.

Regions A and C with their intense founding activities are distinguished by university-external network coordination showing frequent and broadspread participation by

HEIs. Both networks (including that of region E) are characterised by the highest shares of newly established contacts (cf. Table 2). Furthermore (again including region E), they show a higher degree of started or intensified EXIST related activities than the networks of regions B and D (cf. Figure 5), which are mainly based on established contacts, making only below-average use of the possible regional cooperation potential. The highest level of assessment of an excellent cooperation climate also goes to region A and C (cf. Table 3). As was the case for the comparison of the number of firm foundations with the regional high-tech potential and the patent activities, region E holds an intermediate position. Similar to that of region D, its network is strongly centred on HEIs and coordinated by a university-internal coordination unit. Whereas, regarding the evaluation of the co-operation climate as "excellent" it holds place 3 following regions A, C and B, it holds second place regarding its share of newly established network contacts. The network of region B, which shows a lower level of firm foundations in relative comparison (related to firm foundations induced by EXIST), is coordinated externally and shows a lower degree of HEI-orientation than those of the remaining regions. It is based on a low level of newly established contacts and ranks on average according to the assessment of a "very good" co-operation climate. Less intense orientation towards HEIs, as well as an innovative environment, could be some of the reasons for a higher number of EXIST-induced firm foundations during the observation period, which, however, could not be registered as such. As shown by the analysis of the regions' innovation and technology potential, however, more than one region offers innovation-friendly framework conditions; consequently, the argument according to which foundations cannot be exactly assigned to EXIST due to a great variety of regional promotional measures could apply to several regions. Regarding the remaining network characteristics and obstacles presented above, no clear correlation could be made between these and firm founding activities. In region A, 50 % of the contacts are centrally coordinated, and in region C, only 30 %. Similar differences are found between the regions B and D (cf. Figure 4). Regarding the main network obstacles, regions A and C as well as B and D also show differences, so that a uniform pattern cannot be found here either.

If all those factors from this analysis – which is unfortunately only possible in such a limited way – which had a positive influence on firm founding activities induced by EXIST during the observation period are summarised, it is found that the regional networks which could contribute to a mobilisation of founding potential have the following characteristics: they

- are linked with an university-external coordination unit,
- benefit from a high level of participation of regional HEIs both in the networks and with the development and testing of new concepts and seminar styles for the education and advanced training of entrepreneurs,
- are not based on routines,

- show a cooperation climate considered as positive,
- show, to a great extent, a regional environment stimulating entrepreneurship.

However, the role played by regional conditions is relative, as is shown by the fact that EXIST-related firm founding activities in regions with a strong potential remained below average, while an obvious increase in the number of foundations was possible in regions with less favourable starting conditions. As shown by regions B and D, obstacles are primarily seen in traditional network structures and a non-existent or too limited degree of competition for the best concepts within the network; these obstacles have a negative influence not only on the degree of contentment with the cooperation, but also – at least according to the analyses presented above – on the number of innovative firm foundations as one result of the cooperation in networks.

Another substantial aspect, which could not be grasped in the presented data, is the social competence of the key people working in the networks. According to findings from the scientific monitoring of the EXIST project, particularly effective functioning is shown by those networks where interaction between primary players is trustful, and where barriers to information flow are largely non existent. As a matter of fact, the empirical evidence gained from EXIST networks not only emphasises the importance of the absorptive capacity for the realisation of positive external effects from cooperation relationships, but also the fact that networking is a social process, the success of which depends to a high degree on the social behaviour and the networking ability of the involved partners.

With regard to policy implications, the research questions formulated in this paper can be answered as follows:

- The EXIST programme launched by the Federal Ministry of Education and Research has contributed to the stimulation of the establishment of networks and has brought players together who otherwise would not have cooperated by their own (multi-actor/multi-measures approach).
- Due to their complex synergy regarding training, consultation and support in founding and financing questions, the activities and resources required for the mobilisation of founders, as well as for the creation of an entrepreneurial climate in HEIs and in the region, can only be exploited through networks where different players and institutions work together, and are coordinated either by HEIs or by external organisations. From the perspective of network economics, these horizontal networks represent a form of loose but coordinated coupling.
- The networks set up in EXIST regions contribute to the mobilisation of endogenous innovation resources by initiating collective learning processes.

- Due to their training and transfer function, universities and technical colleges can play an important role within their regions to sensibilise, mobilise and qualify (potential) entrepreneurs. Regional effects can both be recorded for universities and technical colleges. Therefore, the network approach of EXIST has led to a better integration of universities in their regional innovation systems.
- Continuous personal contacts between the network actors encourage cooperation based on trust and a positive climate in the networks. Spatial proximity between the actors encourages mutual exchange. Due to the fact that specific regional competence is introduced into the development and implementation of concepts for the training and qualification of entrepreneurs - a competence which is spatially limited to these regions, - the successful establishment of networks is positively influenced when these are focused on the closer spatial environment of HEIs.
- The economic-technological environment influences the efficiency of regional networks for the stimulation of entrepreneurship. However, the type of network relationships, as well as the network organisation, have an even more decisive influence on network performance.
- Related to the total number of regional companies, the number of innovative firm foundations which were induced by the EXIST project during the observation period is small. Also, effects on employment due to the new companies are only marginal during at first; moreover, no experience is available yet regarding the survival rate of the new companies. Nevertheless, the climate regarding entrepreneurship was obviously improved within the participating HEIs, as is shown by the number of firm foundations realised up to the present. Some of the universities have included entrepreneurship training programmes in their obligatory curriculum; moreover, a start has been made on training the trainer (e.g. by teachers who introduce management business games into their lessons).

Despite the obvious success of this network-based support measure, the question remains open as to whether the change in the entrepreneurial climate at HEIs and the networks supporting these changes will be sustainable even in times when public money is no longer available. Answering this question will only be possible in the future.

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