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# Regional concentration of innovative potential in Western Germany

By B. Gehrke and H. Legler, NIW

## Summary

*Due to continuing globalisation competition between nations is increasingly going to change into competition between locations which offer innovative enterprises, attractive markets and an attractive infrastructure for R&D as well as for production. The study analyses the spatial distribution of innovative potentials in West Germany and shows different technological and sectoral structures between agglomerations although their endowment with human capital and innovative potential seems to be rather similar. A polycentric variety of differently specialised competencies in technology-intensive industries and high-quality services can be identified. Thus most of the West German regions are in a favourable starting position in the growing "competition of regions" within Europe. Nevertheless, there is no reason to relax. On the contrary, structural change has to be focussed towards the generation of new growth poles requiring selected promotion policies. From an overall economic point of view and considering scarce public funds it seems to be more efficient to strengthen available innovative potentials and localisation economies instead of creating expensive (intra)structures in regions where no innovation — related networks exist.*

## 1. Introduction

The globalisation of industry in international technology competition has led to strong "locational competition". "Location" from the viewpoint of international companies is meant in its narrower sense: despite drastic advances in information and communication technology one can say as a rule that know-how is being developed and applied at the local level first, so that regional research networks and development and production clusters become even more important in global competition. Companies check the real conditions for implementing their production and innovation projects very carefully according to a number of criteria such as attractive public and private infrastructure, innovative potentials and high-quality demand etc. Macroeconomic and national levels lose some of their importance with the emphasis being shifted to the regional level where the conditions for marketing, production and innovation take shape in real terms: competition in technology and growth is increasingly going to change from competition between nations to competition between regions especially in Europe. This is speeded up by European Economic and Monetary Union. "Endogenous" innovative potential and innovativeness are decisive determinants for differences in regional innovation and growth patterns as well as for success or failure in global competition. They also play an important role in the settlement of

technology-oriented industries, know-how intensive services and national and multinational corporations' R&D centres.<sup>1</sup>

## 2. Conclusions from theoretical discussions

### 2.1 Basic theories:

#### industrial districts and innovative milieux

A great deal of regional economic research has been done to explain interregional variations in innovation and growth performance, some of them with reference to old theoretical concepts like the Marshallian industrial districts,<sup>2</sup> others based on more recent concepts like the innovative milieu approach.<sup>3</sup>

Industrial districts are characterised by networks of firms acting in the same economic and technological field and

<sup>1</sup> Fritsch/Lukas (1997, 29) emphasise the relevance of "regional systems of innovation" for differences in innovation performance and growth: Regions are characterized by specific innovation systems that should be analysed in order to understand the forces that make some regions competitive while others fall behind.

<sup>2</sup> See e.g. Storper/Walker (1989), Storper (1993) or for an overview Zeitlin (1992) or Sternberg (1995b).

<sup>3</sup> This approach was created by GREMI (Groupe de Recherche Européen sur les Milieux Innovateurs) in the mid-eighties (see e.g. Camagni 1991, Hall 1990).

co-operating by using the benefits of specialisation, integration and division of labour. Specialisation induces efficiency, both individually and at a regional level; in combination with integration it promotes collective capability: the result is economies of scale and scope. Flexibility and specialised production are characteristics of prospering industrial districts.<sup>4</sup> The underlying theory was founded in the 1980s as an answer to Fordism, which meant inflexible organisation of production and mass market production lines, using dedicated machines and employing specialised, often unskilled or semi-skilled workers,<sup>5</sup> while successful districts require skilled and flexible workforce. The industrial district approach is based on the assumption that each new (innovative) industry calls for special locational qualities, therefore choosing a location either on the edge of existing traditional industrial areas [suburbanisation] or in rural areas,<sup>6</sup> creating its own region there. Inter-firm and intraregional division of labour based on mutual trust and advantages as well as on formal and informal communication and co-operation should guarantee high flexibility and productivity. In regional economic theory the concept of industrial districts is often used to explain regional agglomerations of high tech industries.<sup>7</sup> Agglomerations are provided with several advantages intraregional, "localisation and urbanisation economies" especially (intraregional availability of high-skilled labour, special supplier-customer linkages, technology-oriented services, research institutions and other R&D-infrastructure, spillovers and others) are valuable for innovative firms in particular.<sup>8</sup>

The concept of innovative regional milieus (IRMs) and the related network approach<sup>9</sup> emphasise the importance of local and regional interdependencies between different actors for the development and growth of innovative firms and for the dynamics of the region as a whole.<sup>10</sup> The network approach particularly focuses on the economic actors within a region, the milieu approach emphasise the role of the local 'milieu' (environment) as being responsible for innovative behaviour. Essential characteristics of IRMs are co-operation, trust and reciprocity based on intra- and inter-regional, formal and informal networks between a large number of regional actors. Collective learning promotes local creativity, capabilities of product innovation and a better use of the local innovative potential as a whole (synergetic effects). The term 'milieu' is not only meant in its local/regional sense. It also implies a socio-historical context that encourages development-inducing innovation.<sup>11</sup> A reduction in transaction costs and support "of the elements of dynamic uncertainty that are intrinsic to technological development and innovative processes"<sup>12</sup> are made easier through geographical (interpersonal face-to-face contacts) and socio-cultural proximity.<sup>13</sup> The long-term alignment of networks prevents opportunistic behaviour from the co-operating actors.<sup>14</sup>

In recent years a huge number of publications on IRMs and networks has appeared,<sup>15</sup> most of them drawn on a

qualitative and theoretical basis. As far as empirical studies are concerned they are mainly restricted to high tech-regions. They simply assume the existence of an innovative milieu without any attempt at testing it. Followers of the IRMs concept just as for those of the theory of flexible production and specialisation often analyse Silicon Valley and Greater Boston in USA and Emilia Romagna ("Third Italy") and Baden-Württemberg<sup>16</sup> in Germany, each of them showing characteristic features of industrial districts.

<sup>4</sup> The most prominent example in literature is "Third Italy", especially the Emilia Romagna (see e.g. Cooke/Morgan (1992), Trigilia (1992)). Zeitlin (1992) gives an overview of a huge number of international examples certainly showing characteristics of industrial districts, but differences in sectoral specialisation, firm size, stage of economic development, history and other factors do not allow comparative studies.

<sup>5</sup> See Piore/Sabel (1985).

<sup>6</sup> Popular examples for the first group are Greater Boston (Route-128-Phenomenon) or Silicon Valley, prominent locations in former rural areas are Colorado Springs, Dallas or Phoenix (Sternberg (1995a)).

<sup>7</sup> See e.g. Storper (1993) comparing selected German, French, Italian and American "technology districts", or Storper (1992) analysing the impact of important "technology districts" on international trade with technology-oriented products.

<sup>8</sup> Agglomerations are also linked with negative factors such as high costs and strong competition, so the net effects of agglomerations have to be taken into account (Pfähler/Hoppe, (1997)) as a rule they turn out well in the case of firms with innovation activities as opposed to pure manufacturing enterprises ("regional and functional division of labour", see Bade (1979)). Based on the argumentation of Vernon (1966), the regional variant of product life cycle theory argues that firms at the beginning of the product life cycle will choose locations in agglomerations offering them innovation and the production factors they need, whereas in later phases of the product life cycle labour cost serving processes and more decentral locations become more important (see Schätzl (1996), Sternberg (1995a)).

<sup>9</sup> Regional economic theory has for a long time been dealing with networks in the form of supplier-user relationships. By means of the involvement into the milieu concept the network approach received a regional dimension and was extended with reference to different regional actors (see Camagni (1991), Bergmann/Maier/Tödtling (1991) or Grabher (1993)).

<sup>10</sup> Schöner (1996).

<sup>11</sup> Hansen (1992), p. 96.

<sup>12</sup> Camagni, (1991), p. 3.

<sup>13</sup> Fromhold-Eisebith (1995) argues that socio-cultural proximity also strengthens the 'outside-oriented' image of the region.

<sup>14</sup> See Fritsch (1992).

<sup>15</sup> See e.g. DeBresson/Amesse (1991), Brödner/Pekruhl/Rehfeld (1996), Amin/Thrft (1994), Cooke/Morgan (1993), Spielberg (1993), Johansson/Karlsson/Westin (1994). For an overview of regional empirical studies see Hansen (1992).

<sup>16</sup> See e.g. recent studies (Sternberg (1997), Fritsch/Lukas (1997)) within the research project "Technological change in regional development in Europe" funded by the German Research Association ("Deutsche Forschungsgemeinschaft"), dealing with innovation potentials and innovative networks in three German regions, Baden (responsible F. Meyer-Krahmer, K. Koschatzky, Fraunhofer-Institute of Systems Analysis in Karlsruhe), Saxony (responsible M. Fritsch, Technical University Bergakademie

## 2.2 Lessons from the concepts for empirical analysis

For a long time these regions were economically successful. But since the beginning of the 90s several of them have been confronted with severe structural adjustment processes, giving cause for growing criticism concerning the relevance of the IRM concept for regional development.<sup>17</sup> In addition the concept is not able to explain the successful performance of lots of other regions, e.g. Milan, Frankfurt, London and many more.<sup>18</sup>

However, the main criticism of both theories mentioned above is directed at the lack of operationality and empirical validity of the model. In addition it is impossible to deduce universally applicable statements and instructions for technology policy.<sup>19</sup> The indicators characterising technology districts, IRMs or networks are nearly identical, the argumentation only differs in describing the processes how innovative regions are developing. Localisation economies play a crucial role in both concepts. Innovative industries and services in particular take advantage of them and therefore prefer agglomerate locations. In theory a lot of indicators determining the innovative potential of regions can be deduced, e.g. the qualification of labour force, R&D-efforts of industries, firm size and sectoral specialisation, intra- and interregional R&D-linkages between different actors, fluctuation of R&D personnel between firms on the one hand and firms and R&D-institutions on the other hand, the number of firms rooted in the region, the role of firms within regional and functional division of labour, the attractiveness for technology-oriented firms from "outside" and many more. Most of these indicators require case studies and detailed regional investigations<sup>20</sup> which do not provide results representative for other regions.

Regional centres of innovation can be found at locations richly endowed with relevant innovative potentials and competencies. They are characterised

- by a concentration of R&D-intensive firms, not at least among small and medium-sized enterprises, and their customers,
- by a high degree of division of labour and an appropriate specialisation of firms,
- by an adequate supply of qualified labour force,
- by an innovation-oriented environment in the form of institutions of education, science, research, knowledge transfer and consultancy,
- in many cases by the existence of "leading customers" and
- by a high intensity of communicative and co-operative relationships between manufacturing firms, science and research institutions as well as supporting services.

As a whole these conditions lead to exceptional dynamics in innovation and growth. In recent years a great deal of regional economic research based on different schools of

thought has been done on the organisation of innovative networks<sup>21</sup> and their importance for regional growth processes as well as for shaping internationally relevant "technopoles" and attractive potentials (magnets) in recent years. A growing number of scientists additionally express the opinion that especially under the circumstances of rising globalisation regional clusters of production and innovation are going to be increasingly important for the technological performance and international competitiveness of nations.<sup>22</sup>

## 3. Measuring the spatial innovative potentials in West German regions

Therefore it seems to be indisputable that the concentration of competencies not only shows a national or international, a sectoral or functional, but always a regional dimension, too. The creation, adaptation and diffusion of know-how, the conversion of technical knowledge into innovative and marketable products and services and the starting of

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Freiburg) and what is known as research-triangle Hanover-Brunswick-Göttingen in Lower-Saxony (responsible L. Schätzl, Department of Economic Geography at the University of Hanover and R. Sternberg, Department of Economic and Social Geography at the University of Cologne). First results dealing with intra-regional versus interregional linkages show that spatial proximity is very important for co-operations between SMEs and R&D institutions. Fritsch/Lukas (1997) take this as a confirmation of the relevance of localisation economies.

<sup>17</sup> See e.g. Amin/Robbins (1990) or Sternberg (1995b), supported by empirical studies from Dutch regional economics (Davelaar (1991)), which were not able to prove a significant influence from the 'milieu' on firms' innovation activity level.

<sup>18</sup> Sternberg (1995a).

<sup>19</sup> Thus in theory you do not find any hint concerning the influence of technology policy towards the development of industrial districts (see Sternberg (1995a)). Furthermore there is no general definition for IRMs (Schätzl (1996)), so that is most of the case studies are not comparable. An exception is actual GREMI group studies of 10 selected European regions on the one hand and a project of Cooke and his scholars, dealing with innovative networks in four European regions (see e.g. Cooke (1995)) on the other hand.

<sup>20</sup> Thus the effects of network structures cannot be isolated in economic analysis. Nevertheless, assuming their existence and influence, differences in the nature of networks can be taken as one explanation for differences in regional innovation and growth patterns in similarly structured regions.

<sup>21</sup> Cooke, Morgan (1993) in this context use the term "network paradigm".

<sup>22</sup> The global regions concept is taking the view that there are regions and not firms or industries (as Porter (1990) argues) which have to stand up against global competition. The employment of new technologies as a key for innovation induces more and more inter-industry interactions with synergy effects with the prospect of more regionally effective innovations. The industries in successful global regions "which are able to integrate geographically-restricted economies into the global web of industry and commerce" (Huggins (1997), p. 3) are mostly highly involved showing a lot of intra- and interregional linkages.

production is part of a complex process which cannot be distributed in any space. On the contrary, this process is taking place in a network of different actors from science and industrial R&D, manufacturing and services, producers of final goods and suppliers of components, SMEs and big companies, suppliers and customers. Integration into networks is making the development of new technologies easier. In many cases the spatial concentration of competencies determines the formation of international locations for technical innovations and therefore in the end is important for the technological performance of nations. Hence, in order to assess for technological competitiveness it is essential to know

- which competencies German agglomerations are endowed with compared to agglomerations in other industrial countries and
- how they succeed in converting their innovative potentials into attractiveness, investment and growth potential.

Being part of the Report on German's Technological Performance<sup>23</sup> this analysis is initially restricted to the innovative potential of manufacturing industry expressed by its R&D staff and by the endowment with technology-oriented industries. This standard approach<sup>24</sup> is extended by an analysis of services and qualification potentials. Other indicators concerning

- the innovative infrastructure (e.g. public R&D institutions)
- forthcoming structural change as indicated by new start-ups in technology-oriented industries and technical services.<sup>25</sup>
- the output of R&D (e.g. patents<sup>26</sup>)

principally can be included as well as regarding competencies in special technology fields (e.g. multi media<sup>27</sup> or biotechnolgy).

### 3.1 Indicators

Most indicators are human capital based, i.e. they show the employment of the (highly) qualified work force and their use for R&D purposes.

#### Use of scientists and R&D staff

Research and development (R&D) capacities form a main determinant of the technological performance of firms, regions or nations. R&D-personnel intensity of manufacturing (measured as the share of R&D personnel in work force) serves as an indicator for the industrial innovative potential of regions. R&D personnel can be taken as a direct expression for firms' R&D-capacities indicating the extent to which firms are investing in own product development.

The share of scientists and engineers (scientist intensity)<sup>28</sup> is serving as an indicator for exceptional know-how

intensive production (new products, new production processes). It shows the regional endowment with key qualifications for technical innovation processes. Due to their qualification those groups can principally be used for R&D.<sup>29</sup> Production of high-quality goods always requires a high share of scientists and engineers even if the firm does not have any own R&D capacities and prefers to adapt product developments and new processes from 'outside', e.g. from allied firms.

Actual data concerning R&D-personnel intensity of "regional planning areas" ('Raumordnungsregionen') refer to 1995 (chart 1), those concerning scientist intensity already cover 1996.

#### Human capital and functional structure

A high level of technological performance requires highly qualified workers who receive regular training. Their "human capital" is indispensable for using technological know-how and is by far the most important factor for successful R&D activities. Since it is not possible to cover all aspects of human capital in one single measure, several indicators are taken to reflect the position of Western German regions with respect to skills and human capital.<sup>30</sup>

- The rate of skilled employees (share of employees who have completed some form of vocational training) is an indicator for the qualification generally demanded in each industry. This criterion is rather undifferentiated, yet it gives evidence of where and to what extent there are still employment prospects for low skilled workers.
- From a regional point of view it is also important to know to what extent the qualifications supplied are really used. This depends particularly on the firms' assignment to 'interregional functional division of labour' which reveals the competencies firms are mainly endowed with. The functional structure is defined by the

<sup>23</sup> NIW (responsible), DIW, FhG-ISI, WSV, ZEW (1997).

<sup>24</sup> See Legler (e.g. 1993 or 1994).

<sup>25</sup> See Beise/Gehrke et. al. (1998).

<sup>26</sup> See Koschatzky (1997).

<sup>27</sup> See Eckert, Egeln (1997).

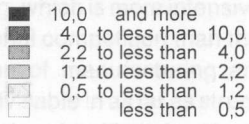
<sup>28</sup> See Bade (1979).

<sup>29</sup> Some particular differences between the two indicators have to be considered: on the one hand the R&D-intensity underlies a narrower definition than the scientist intensity because it only includes those employees who explicitly participate in R&D processes — often in special R&D departments. On the other hand the R&D personnel does not only consist of scientists and engineers but of a much broader range of qualifications, e.g. laboratory assistants, technicians, test drivers ('elk test'). These differences between the two indicators can result in different interpretations of the data.

<sup>30</sup> See Gehrke et al. (1995) and Jung (1984).

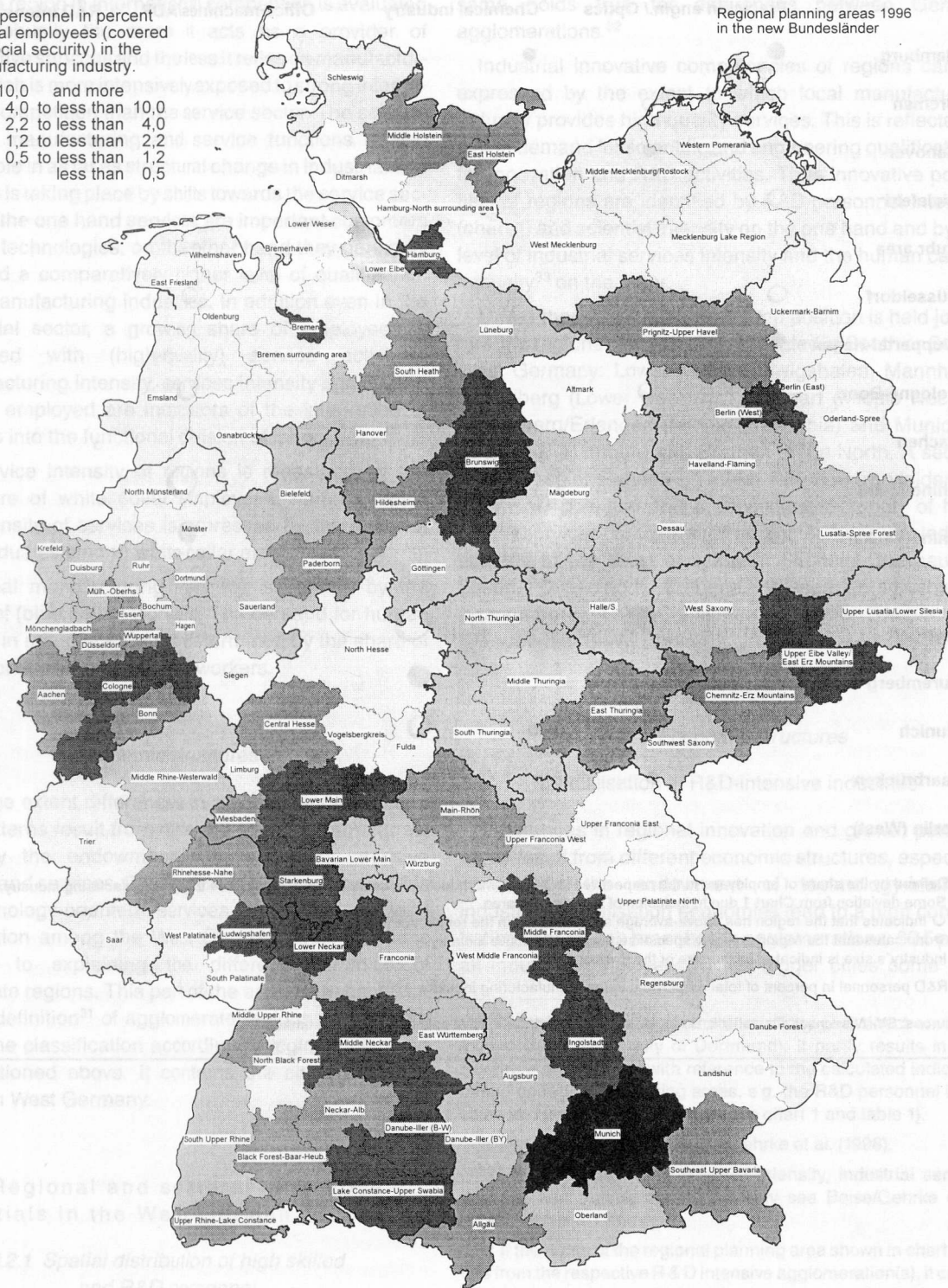
**Chart 1: R+D intensity in Germany 1995**

R+D personnel in percent of total employees (covered by social security) in the manufacturing industry.



Regional planning areas 1991 (Raumordnungsregionen) in former West Germany

Regional planning areas 1996 in the new Bundesländer



Sources: SV-Wissenschaftsstatistik; Bundesanstalt für Arbeit (Federal Employment Service); NIW calculations.

Table 1

## Specialisation in R&amp;D-intensive industries in Western Germany's agglomerations 1996\*

Specialisation in...	Mechanical engineering Precision engin./ Optics	Motor vehicles Chemical industry	Aero-space Office machines/ADP	Electrical machinery R&D intens. in %**	
Hamburg	●	●	○		3.4
Bremen		○			3.3
Hanover		●			2.4
Bielefeld	○				1.4
Ruhr area					1.7
Düsseldorf	○			○	2.1
Wuppertal-Hagen	●				1.7
Cologne-Bonn				○	4.8
Aachen				○	2.5
Rhine-Main				○	6.4
Rhine-Neckar	○			●	6.5
Karlsruhe			○	●	3.0
Stuttgart	●	●	○		7.6
Nuremberg			●		4.9
Munich		○	●	●	14.7
Saarbrücken		●			0.7
Berlin (West)			○		5.6

\* Defined by the share of employees in the respective R&D-intensive industry in percent of total employees in the manufacturing industry. Some deviation from Chart 1 due to inclusion of surrounding area.  
○ indicates that the region has above-average specialisation in the respective industry.  
● indicates that the region is highly specialised in the respective industry.  
Industry's size is indicated by the size of the symbol.

\*\* R&D personnel in percent of total employees in the manufacturing industry 1995.

Sources: SV-Wissenschaftsstatistik; Bade, University of Dortmund; NIW calculations and estimates.

share of manufacturing on the one hand and, on the other, by high-quality dispositive functions such as product and process development, programme and investment planning and distribution or purchasing. The position of a region in international competition is evaluated more robustly the more it acts as a provider of dispositive services and the less it relies on manufacturing, which is more intensively exposed to strong international competition than the service sector. The separation of manufacturing and service functions is also advisable in as far as structural change in industrialised nations is taking place by shifts towards the service sector. On the one hand services are important customers of new technologies, on the other hand they generally demand a comparatively higher level of qualification than manufacturing industries. In addition even in the industrial sector, a growing share of employees is entrusted with (high-quality) service activities. Manufacturing intensity, services intensity and human capital employed are indicators of the integration of regions into the functional division of labour.

- Service intensity of regions is measured by the share of white collar employees, human capital intensity of services is expressed by the share of graduates among white collar employees.
- Regional manufacturing intensity is defined by the share of (blue collar) workers. The demand for human capital in manufacturing is determined by the share of total workers who are skilled workers.

### Economic structures

To a large extent differences in regional innovation and growth patterns result from different economic structures, particularly the endowment with technology-intensive industries and services. Distribution of high tech industries and technology-oriented services and their sectoral specialisation among the West German agglomerations contribute to explaining the different dynamics of agglomerate regions. This part of the analysis is based on a special definition<sup>31</sup> of agglomerate regions which is different to the classification according to regional planning areas mentioned above. It contains the cities and their environs in West Germany.

## 3.2 Regional and sectoral innovative potentials in the West German economy

### 3.2.1 Spatial distribution of high skilled and R&D personnel

The classification of West German regions ('Raumordnungsregionen') with reference to their human capital indicators has clearly changed in time. Certainly the transition to a know-how intensive economy has been accom-

panied by constantly increasing personnel qualification requirements and declining manufacturing intensity. But the differentials between agglomerations and rural areas continue to exist in spite of all regional policy efforts. The same holds true for differences between German agglomerations.<sup>32</sup>

Industrial innovative competencies of regions can be expressed by the extent to which local manufacturing industry provides high-quality services. This is reflected in a high demand for scientific and engineering qualifications for innovation and R&D activities. Thus innovative potentials of regions are identified by R&D-personnel intensity (chart 1) and scientist intensity on the one hand and by the level of industrial services intensity and the human capital intensity<sup>33</sup> on the other.

Under these assumptions the top position is held jointly by eight regions of which six are located in South or South-West Germany: Lower Main, Ludwigshafen, Mannheim/Heidelberg (Lower Neckar),<sup>34</sup> Stuttgart (Middle Neckar), Nuremberg/Erlangen (Middle Franconia) and Munich in addition to Hamburg and Bremen in the North. A second group of regions whose industries still show a considerably high R&D potential and a sophisticated supply of high-quality services contains eight agglomerations located particularly in the West and South: Mülheim-Oberhausen, Essen, Düsseldorf, Cologne, Wiesbaden, Darmstadt (Starkenburger), Lake Constance — Upper Swabia, Ulm (Danube-Iller/B-W), Berlin.<sup>35</sup>

### 3.2.2 Economic structures

#### Specialisation in R&D-intensive industries

Differences in regional innovation and growth patterns partly result from different economic structures, especially concerning the endowment of technology-intensive industries. Localisation economies lead to a high concentration of high tech branches in agglomerations: 53.5 p.c. of all industrial employees in the bigger cities come from

<sup>31</sup> This definition of agglomerations (city plus direct environs) follows Bade (University of Dortmund). It partly results in considerable divergences with reference to the calculated indicators based on regional planning areas, e.g. the R&D personnel intensities for Hamburg and Bremen (see chart 1 and table 1).

<sup>32</sup> For detailed data see Beise/Gehrke et al. (1998).

<sup>33</sup> For data concerning scientist intensity, industrial services intensity and human capital intensity see Beise/Gehrke et al. (1998), tables A.1 and A.2.

<sup>34</sup> If the name of the regional planning area shown in chart 1 differs from the respective R & D intensive agglomeration(s), it can be found in brackets.

<sup>35</sup> Taking R&D-personnel intensity, the only indicator which can be compared between West Germany and the new Bundesländer without problems (see Beise/Gehrke et al., (1998)), the second group of regions also contains Dresden, which in this sense turns out to be the main innovation centre in East Germany.



those industries compared to the West German average of nearly 50 p.c. Thus 2 million of a total of 3.5 million jobs in West Germany's technology-intensive industries are located in agglomerations. Differentiated results are again at the level of single industries and agglomerations:<sup>36</sup>

- R&D-intensive industries play an above-average role in the Northern regions compared to the average of the 17 agglomerations included and the most significant role in Southern regions of West Germany.
- The great importance of high tech industries in the cities is attributed in particular to cutting-edge technology branches<sup>37</sup> (aerospace industry, parts of the electrical machinery and chemical industries). Those industries especially depend on localisation economies whereas advanced technologies such as mechanical engineering, precision engineering/optics or motor vehicles are more broadly distributed.
- With the exception of the Ruhr area ("Ruhrgebiet")<sup>38</sup> all West German agglomerations focus on at least one high tech industry (see table 1):
  - The most striking agglomeration is Munich showing a specialisation in five R&D-intensive industries: motor vehicles, electrical machinery and in particular the aerospace industry, precision engineering/optics and office equipment/ADP are represented here more than on average.
  - Hamburg and Stuttgart have each specialised in three high tech branches. In the case of Hamburg this concerns mechanical engineering and the aerospace industry and beyond that precision engineering/optics, too. Stuttgart displays special strengths in mechanical engineering, motor vehicles and electrical engineering. Hamburg is considered to be the second aerospace centre in West Germany, Stuttgart the leading centre for motor vehicles.
  - Five out of the 17 agglomerations show a regional specialisation in two high tech industries: Bremen (motor vehicles, aerospace industry), Düsseldorf (mechanical engineering, chemical industry), Cologne-Bonn (motor vehicles, chemical industry), Rhine-Neckar (mechanical engineering, chemical industry) and Karlsruhe (electrical machinery, precision engineering/optics).
  - In the Ruhr area only one technology-intensive industry (mechanical engineering) is represented at an average level, all others are represented below average. The motor vehicle industry has regional centres in Hanover and Saarbrücken (compared to Stuttgart the number of employees is definitely low in both regions), Wuppertal-Hagen and Bielefeld form regional centres of mechanical engineering. Nuremberg and Berlin show relative strengths in electrical machinery, Rhine-Main in the chemical industry and Aachen in office equipment/ADP.
- The ratio of scientists employed in each technology-intensive industry can be used to "evaluate" the innovative potential of each industry in the different agglomerations.<sup>39</sup> This approach partly shows extreme differences between regions. On the one hand innovative potentials of high tech industries are exhausted to a very different extent. This may depend on the diverging roles the regions play within the functional division of labour. On the other hand there may be quite a high sectoral concentration of know-how in some agglomerations which, from a quantitative point of view, do not have special strengths in high tech industries (see table 2). For instance Aachen shows a particularly high concentration of know-how in office equipments/ADP where 440 scientists and engineers are employed. Aachen's Scientist intensity of 32 p.c. is much higher than in Munich (10 p.c.), the leading ADP-centre in West Germany. Furthermore a high level of know-how can be found in Berlin (12 p.c.) and particularly in Karlsruhe (26 p.c.), but both locations rank lower in absolute terms.
- The main knowledge centres of the aerospace industry are found in Bremen (32 p.c.) and Munich (26 p.c.). Though the second-highest number of scientists and engineers in aerospace industry (1,800 people) is employed in Hamburg, scientist intensity there is relatively low (13 p.c.). This gives an indication of the regional division of labour within the German aerospace industry group: manufacturing activities are highly concentrated in Hamburg.
- Just as in the aerospace industry, Munich (with 22 p.c., 11,100 scientists and engineers) and — with a lower absolute number — Bremen (p.c.) show the highest knowledge concentration with respect to electrical machinery. This can be explained by spillovers of regional networks (e.g. instruments, engineering or information and communication technologies for the aerospace industry). Munich is in the top position with respect to intrasectoral structural change towards high quality services: cutting-edge technology fields of electrical machinery are particularly concentrated here, and a good 80 p.c. of the personnel is employed within service activities.

<sup>36</sup> For data see Beise/Gehrke et al. (1998).

<sup>37</sup> For a definition of cutting-edge and advanced technology see Grupp/Legler (1991).

<sup>38</sup> In spite of a huge number of public R&D-institutions the high percentage of old industries within the region up to now has prevented the development of modern, forward-looking industrial topics.

<sup>39</sup> The science intensity and the absolute number of scientists and engineers are considered to avoid misinterpretations caused by very small industries.

Table 2

## Scientist intensity in R&amp;D-intensive industries in Western Germany's agglomerations 1996\*

Agglomeration:	Mechanical engineering		Motor vehicles		Aero-space		Electrical machinery		Precision engin./
industry	Office machin./ADP		Total R&D- intensive industries	Optics	Chemical		Total manu-facturing industry		
Hamburg	8.3	1.0	12.9	12.5	3.3	5.5	3.8	7.5	4.8
Bremen	6.3	3.0	32.2	19.4	1.0	4.5	13.9	9.8	5.7
Hanover	6.5	3.4	3.1	8.0	2.3	4.2	9.8	5.0	3.9
Bielefeld	4.6	0.9	0.0	6.8	1.6	3.1	1.9	4.3	2.1
Ruhr area	8.5	0.8	5.3	6.1	1.4	6.0	8.0	5.4	3.6
Düsseldorf	7.8	2.5	2.6	8.7	2.0	8.5	4.4	7.0	4.2
Wuppertal-Hagen	5.0	1.4	0.0	4.9	0.6	10.0	5.6	5.1	2.7
Cologne-Bonn	8.4	6.0	1.8	7.6	5.2	8.1	6.9	7.4	4.9
Aachen	5.5	1.0	0.0	6.3	1.5	3.1	32.3	5.6	3.3
Rhine-Main	9.2	6.2	6.0	11.6	5.2	7.0	5.0	8.0	6.0
Rhine-Neckar	6.0	3.0	3.8	14.7	2.6	8.4	4.5	8.0	6.0
Karlsruhe	5.4	5.0	1.7	11.7	3.6	4.3	26.3	7.6	5.1
Stuttgart	8.1	8.3	13.6	15.6	3.7	3.4	9.6	9.9	7.1
Nuremberg	6.0	2.2	0.0	14.7	0.9	2.5	4.7	10.8	7.1
Munich	9.9	6.8	26.8	21.8	6.1	6.4	10.3	14.1	10.1
Saarbrücken	4.7	1.8	0.0	4.9	1.3	4.4	6.8	3.1	2.3
Berlin (West)	7.7	1.8	2.9	12.3	2.5	5.9	11.8	8.4	5.4
<b>Total</b>									
<b>agglomerations</b>	<b>7.3</b>	<b>4.7</b>	<b>17.7</b>	<b>12.2</b>	<b>3.3</b>	<b>7.0</b>	<b>10.2</b>	<b>8.0</b>	<b>5.1</b>

\* Defined by the share of scientists in percent of total employees in the respective R&D-intensive industry.  
Some deviation from Chart 1 due to inclusion of the surrounding area.

Sources: SV-Wissenschaftsstatistik; Bade, University of Dortmund; NIW calculations and estimates.

The most important locations of electrical machinery, Stuttgart and Nuremberg, still definitely have a huge innovative potential (15 p.c.). Compared to these regions Berlin and Karlsruhe (12 p.c.) are falling behind.

- The four main chemical regions distinguish themselves by a between average and-high scientist intensity and a corresponding huge innovative

potential. In addition Wuppertal-Hagen, a principally less important location of the West German chemical industry shows a definitely high scientist intensity of 10 p.c.<sup>40</sup> Other more important locations for the chemical industry in absolute terms such as the Ruhr area or Hamburg clearly fall behind.

<sup>40</sup> "Bayer" has a biotechnology R&D centre located at its birthplace.

- R&D and other high-quality service activities are particularly concentrated in the motor vehicle industries in Stuttgart and Munich (with scientist intensities between 7-8 p.c.). Furthermore in the Rhine-Main and Cologne-Bonn areas, equally "large" locations of motor vehicles have an above-average scientist intensity. Compared to this Hanover (3.4 p.c.) and Saarbrücken (1.8 p.c.) are obviously trailing behind. In both regions a good two thirds of the employees work in manufacturing activities compared to clearly less than 60 p.c. in the other main motor vehicle locations and even less than 50 p.c. in Munich.<sup>41</sup>
- The innovative potentials of precision engineering/optics are mainly concentrated in "large" locations. Once again the top position is held by Munich with a scientist intensity of 6 p.c. Less important agglomerations in absolute terms like Karlsruhe or Cologne-Bonn are also provided with above-average scientific and engineering qualifications in their precision engineering and optics industry.
- The indisputable leading position of Munich<sup>42</sup> not only depends on its numerous technology-intensive industries, but in addition applies to industries like mechanical engineering (with a scientist intensity of 10 p.c. with 1,400 people) which from its point of view are much less important. The same number of scientists and engineers is employed in the Bielefeld region, but with twice as many total employees. Thus Bielefeld shows the lowest scientist intensity. The main mechanical engineering areas Wuppertal-Hagen and Rhine-Neckar also have very high concentrations in manufacturing activities. With respect to scientists in mechanical engineering the "Ruhr area" is in a very favourable position.

Sectoral specialisation patterns in West Germany have generally turned out to be very robust in time, only "disturbed" by the decline and adjustment processes within the German office equipment/ADP industry during the 1980s.<sup>43</sup> This structural change can be observed particularly in Stuttgart and Nuremberg, whereas the actual centres Munich and Aachen were not specialised in those industries at the beginning of this shrinking process.

#### Innovation-oriented services

The comparison of employment data in 1980 and 1996 impressively indicates

- that services are the winners of intersectoral structural change (manufacturing industries have declined within the economy as a whole) and
- that within manufacturing industry high tech branches have developed most favourably.

Structural change is characterised by an accelerated transition to a know-how intensive economy. In spite of the still high importance of R&D-intensive industries for innovation and as a supplier and customer of high-quality services as well as for dynamic growth and employment manufacturing industry as a whole will continue to decline. The sectoral structure of most advanced economies is rapidly shifting toward the service sector, which is also an important user of new technologies. As a consequence the industrialised world is looking to the service sector for hope in alleviating unemployment problems. Particularly jobs in technology-intensive service fields, including technical services, other company-oriented services, education, media, publishing and the like are showing a remarkably rapid growth in Germany.

In West German agglomerations more than 1.5 mill. people were employed in those service fields in 1996 compared to 940 thousand in 1980.<sup>44</sup> For comparison R&D-intensive industries which determine the innovative potential of manufacturing offer 2 mill. jobs.

In Munich technology-oriented services play the relatively most important role with 19 p.c. of total employees in trade and industry (see table 3). West Berlin and Hamburg come a distant second and third respectively, followed by Karlsruhe, Hanover, Cologne-Bonn, Aachen and Rhine-Main which also supply an above-average number of jobs in innovation-oriented services. Other agglomerations are less attractive for those branches. This especially holds true for Bielefeld and Wuppertal-Hagen each showing a rate clearly less than 10 p.c. of total employees. The distribution of innovation oriented services much more than the spatial distribution of technology-intensive industries reflects the effects of universities and other R&D-institutions. By providing potential for new start-ups they significantly influence the development of innovative services: spin-offs may play an important part here.<sup>45</sup>

<sup>41</sup> In this case the definition of agglomerations used here shows weaknesses. The Lower-Saxonian region Brunswick/Wolfsburg, one of the main motor vehicle areas in West Germany is not considered because it does not meet the criteria of an agglomeration.

<sup>42</sup> The R&D-personnel intensity in Munich is twice as high as that for second placed Stuttgart.

<sup>43</sup> The number of employees declined from 80,000 in 1980 to 45,000 in 1996 (see Beise/Gehrke et al. (1998).

<sup>44</sup> For data see Beise/Gehrke et al. (1998).

<sup>45</sup> Calculations of the ZEW in Mannheim show that the start-up activity of technical services has more dynamic strength in those regions which have a lot of newly founded firms in the cutting-edge technology sector too. Furthermore one can consider a relatively high start-up dynamic in the environment of universities and other R&D-institutions, although the industrial innovation potential in the respective regions is rather low. Besides for Aachen this holds true for the university locations Göttingen, Münster, Bielefeld and Paderborn and would suggest spin-offs. Aachen is the leading education and research centre for mechanical and process engineering and also for electrical engineering/transport engineering in Germany. The latest fields are equally well staffed in Berlin and Dresden. Berlin's research institutions are in the top

Table 3

## Specialisation in innovation oriented-services in Western Germany's agglomerations 1996\*

Specialised on... services	Legal and economic consultancy			Technical consultancy		Advertising		Other
	Education	Media	Publishing	Total in %				
Hamburg	○		●	○		○	●	15.2
Bremen								11.5
Hanover					●			14.5
Bielefeld								8.8
Ruhr area								11.4
Düsseldorf	○		○					11.2
Wuppertal-Hagen								8.0
Cologne-Bonn	○			○		●		14.3
Aachen		●				●		14.0
Rhine-Main	●		○	○				13.7
Rhine-Neckar								12.1
Karlsruhe					●	○		14.6
Stuttgart							○	12.0
Nuremberg		●		●				13.1
Munich	○	●	○		●	●	●	19.0
Saarbrücken				○				10.5
Berlin (West)	○	○		●	●	○		16.8

\* Defined by the share of employees in the respective innovation oriented branch in percent of total employees (covered by social security) in industry and trade (excl. agriculture and government).  
Some deviation from Chart 1 due to inclusion of surrounding area.  
○ indicates that the region has above-average specialisation in the respective branch.  
● indicates that the region is highly specialised in the respective branch.  
Branch's size is indicated by the size of the symbol.

Sources: Statistisches Bundesamt (Federal Statistical Office); unpublished calculations by Bade, University of Dortmund; NIW calculations.

- Karlsruhe, Aachen or Hanover are highly ranked because they are important locations for public R&D (in universities and/or other R&D institutions) with many personnel in the education sector. In Aachen technical planning is also significant. A less direct connection is assumed for Karlsruhe, Rhine-Neckar and Hanover. Munich once again is in the leading position with respect to technical services. Rather unexpectedly Nuremberg comes second here, despite its rather weak education sector.
- Legal and economic consultancy is concentrated particularly in the Rhine-Main region and furthermore is represented at an above-average level in Hamburg, Munich, West Berlin, Düsseldorf and Cologne-Bonn. Hamburg, Düsseldorf, Rhine-Main and to a smaller extent Munich are specialised in economic advertising. In particular Nuremberg and West Berlin and in addition Hamburg, Saarbrücken, Cologne-Bonn and Rhine-Main show a regional specialisation in "other services" which to a large scale employ less qualified manpower.
- Publishing is concentrated in Munich, Hamburg and less distinctly in Stuttgart. All other agglomerations clearly fall behind in this sector. The most important media locations are Munich, Cologne-Bonn (which has a long tradition in this field), Hamburg, Berlin and Karlsruhe. The development of the media sector obviously indicates the growing ties between services, manufacturing and technology supply.<sup>46</sup>
- In Munich the weight of all service branches except other company-oriented services is above-average. This emphasises the region's position as the most important innovation centre in West Germany. Both innovation-oriented services and technology-intensive industries play a dominant role there. The analysis has shown that the leading innovation centres distinguish themselves by a high demand for scientific and engineering qualifications in manufacturing industries and in the service sector. An innovative industrial structure favours the development of an innovative-oriented service sector. Service providers and technology supply grow more and more close.

#### 4. Conclusions

Regional growth patterns in West Germany show distinct differences not only between different types of regions (e.g. agglomerations on the one hand and rural areas on the other), but also between the agglomerations themselves. Both refer particularly to the spatial division of innovative potentials:

Furthermore one has to consider that the West German agglomerations have different ways of technological and sectoral development although their endowment with human capital and innovative potential seems to be rather similar. This in particular is important for the evaluation of

the German agglomerations in comparison with competing regions abroad: Germany offers international investors a differentiated supply of sectoral and regional innovation centres. Industrial knowledge is concentrated in several regions with varying main topics. Other industrial countries are characterised by different innovation systems. The innovative potentials in France, the United Kingdom and most of the smaller European countries are highly concentrated in their capital area, other regions clearly fall behind. Compared with this the United States shows a polycentric distribution. Different to the German model, particularly the younger and most dynamic regions in the USA are highly specialised in single high tech branches. Whether the German variety of technological and sectoral competencies is a long-term advantage or not can however, not be said with a high degree of certainty. Despite this, R&D personnel intensities of West German regions nearly always lie above those of other European regions outside the respective metropolis.<sup>47</sup> Therefore most of the West German regions at least are in a favourable starting position in view of competition between European regions.

Actual capacities of manufacturing, high-quality services and research and development determine the base of the endogenous regional innovative potential. They are quite robust, since the classification of the regions concerning their innovative potential has clearly changed in time. Leading agglomerations kept their appeal for technology-intensive industries as well as for high-quality services and research functions in spite of regional policy efforts to favour rural and "old industrialised" regions. One gets the impression that cutting-edge technology competition rather takes place on the level of metropolis whereas advanced technology competition rather happens on the level of less agglomerated and rural regions.

It would be wrong to infer from sectoral variety that Germany could do without the new generation of regional and sectoral concentration of expertise. On the contrary, structural change has to be focussed towards the generation of new growth poles ("future technologies"). This process requires selection because complete promotion of each "shoot" according to watering-can principles would be averse to structural change. Seen from an overall economic point of view and considering scarce public funds it is efficient to support innovations in those regions which already

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position with respect to chemistry/pharmaceutics/biology. In Munich all three selected education and research departments are well staffed. Considering the lower population density there, this is also true for Brunswick. Compared to West and South-West Germany there are only a few scientific and engineering or medical education and research departments in the relatively sparsely populated North and South-East German regions. Hamburg and as previously mentioned Munich are important university locations (see Beise, Gehrke et al. (1998)).

<sup>46</sup> See Eckert/Egel (1997).

<sup>47</sup> See Eurostat (1996).

have an adequate infrastructure and an innovative milieu. The long-run success of new, expensive (infra-)structures will be doubtful without functioning networks. Therefore diverse attempts to generate local innovative networks with the help of political incentives have up to now failed.<sup>48</sup> Instead available innovative potentials and localisation economies have to be strengthened instead. Regional policy should aim at the respective "innovative cores" instead of conserving traditional "industrial cores".

As a rule regional development is not limited by fixed assets, but by human and R&D capital. Incentive measures would be better employed in promoting the use of scientific and engineering qualifications and R&D capital instead of simply promoting investment in fixed assets. This only works if at the same time education policy cares for the respective supply of highly qualified persons. That requires an efficient education system concerning schools, technical colleges and universities as well as further train-

ing. In particular, universities and other institutions of higher education play a key part within the innovation system: as a "supplier" of highly qualified personnel on the one hand and due to their own scientific and engineering research and findings on the other hand which in particular new technologies increasingly depend on.

To what extent regional innovative potentials are really exhausted hinges upon the acknowledgement of firms' creativity and innovation activities: research, high-quality markets and production have to be brought together. R&D location decisions by global enterprises increasingly comply with the attractiveness of markets, available qualifications and actual conditions of production. In this context an efficient and particularly adaptable public sector is necessary for a successful innovation policy in Germany.

<sup>48</sup> See e.g. Malecki, Tödtling (1995).

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## Zusammenfassung

*Im Zuge fortschreitender Globalisierung kommt der regionalen Ebene im Innovationswettbewerb wachsende Bedeutung zu. Gerade multinationale Unternehmen suchen sich für ihre Produktions- und Forschungsvorhaben Standorte, die ein Bündel von attraktiven Leistungsangeboten, Infrastruktur und Innovationspotentialen (Forschungskapazitäten, hochwertige Qualifikationen) zu bieten haben. Die empirische Analyse macht deutlich, daß die westdeutschen Verdichtungsräume trotz ähnlicher Ausstattung mit Innovationspotential und Humankapital unterschiedliche technologische und sektorale Entwicklungspfade eingeschlagen haben. Im Ergebnis zeigt sich eine polyzentrische Vielfalt von Spezialisierungsvorteilen im Hinblick auf technologieintensive Industrien und höherwertige Dienstleistungen. Deshalb ist die Ausgangsposition für die meisten westdeutschen Regionen prinzipiell als durchaus günstig zu bezeichnen. Dennoch sollte auf die gezielte und selektive Pflege regional-sektoraler "Techno-Pole" nicht verzichtet werden, wenn der Anschluß im immer wissensintensiver werdenden Strukturwandel gehalten werden soll. Dabei ist es aus gesamtwirtschaftlicher Sicht angesichts knapper Mittel effizienter, vorhandene Innovationspotentiale und Agglomerationsvorteile zu stärken, als neue teure Strukturen zu schaffen, deren längerfristiger Erfolg ohne entsprechende Einbindung in funktionierende Netzwerke fraglich ist.*