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Economic Growth of Agglomerations and Geographic Concentration of Industries: Evidence for Germany

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1 The Question

This paper takes up a phenomenon in European geographical development: the simultaneity of regional economic convergence on the one hand and the continued spatial concentration of economic activities on the other. Overall, the disparities in productivity and income between regions in the European Union have diminished considerably in the last two decades. The poorest regions have caught up to a certain extent, while many of the relatively rich regions have grown at only below-average rates. However, a small group of particularly high-performing areas has developed contrary to this convergence trend and is moving further away from the rest (CHESIRE and MAGRINI, 2000).

The picture is similar in West Germany. The regional density functions shown in Figure 1 for gross domestic product (GDP) per person employed show the two opposing processes. The number of lagging regions fell considerably between 1980 and 2000, and above the average the density also decreased.[1] Altogether the distribution is much more concentrated around the middle than at the start of the period under review, in other words regional productivities have converged. But at the same time the extension of the upper tail of the density function indicates that there is also a contrary movement: agglomeration.

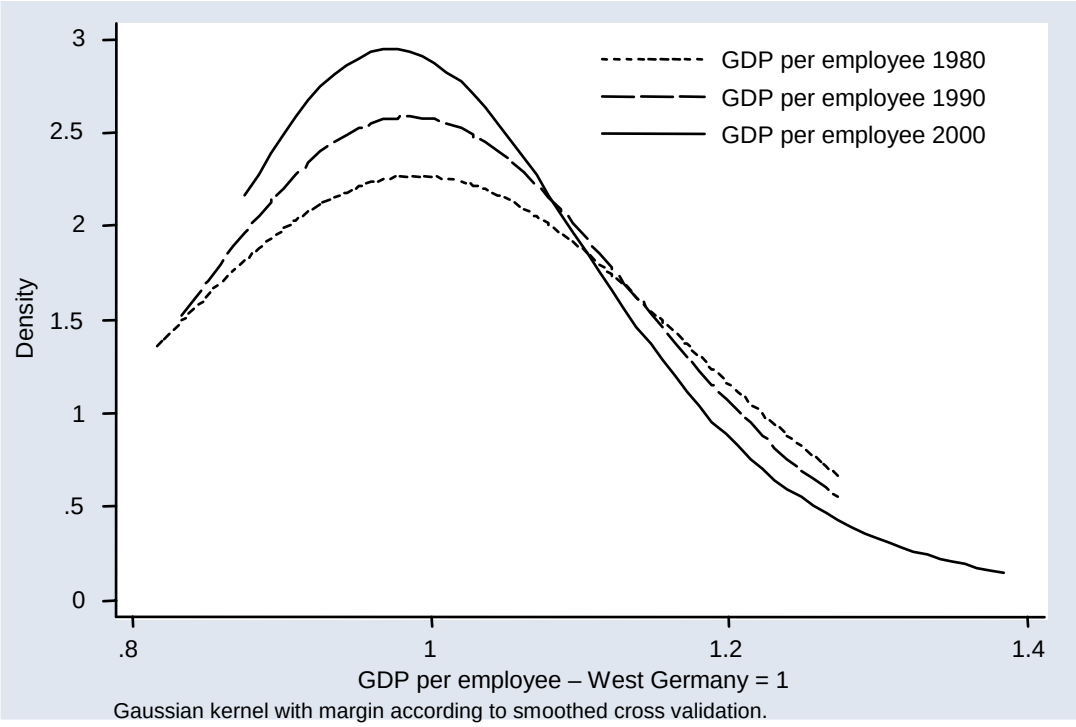
This latter tendency is examined in more detail in this paper. Unlike for Europe as a whole disaggregated information is available on the economic structure of Germany. On that basis we analyse the connection between the sectoral composition of regions, changes in the spatial concentration of sectors and the development in regional productivity. Or to put it differently: We examine whether the fact that a number of high-productivity regions have improved their positions even further can also be attributed to the greater spatial concentration of economic sectors. However, focussing on the *sectoral* perspective certainly does not mean that other factors are unimportant in explaining differences in productivity growth. Recent studies on the spatial structure of employment, for instance, have shown that the *functional* division of labour between regions has continued to develop in favour of urban centres (DURANTON and PUGA, 2004; BADE *et al*., 2004).

In the following Sections the theoretical background is sketched out (Section 2), and the method and data bases are explained (Section 3). Section 4 lays the basis for our estimations. Regions are classified according to the level and development of productivity, and sectors are

[1] See further information on the data base in Section 4.

grouped according to the level and development of geographical concentration. Section 5 presents estimation results from a logit model and a bivariate non-parametric regression approach, while Section 6 draws some conclusions.

Figure 1
Regional distribution of productivity in West Germany



Gaussian kernel with margin according to smoothed cross validation.

2 Theoretical Background

The contrasting spatial developments can be explained theoretically in very different ways. The neo-classical growth model, which is based on perfect competition and diminishing returns to capital predicts convergence of all regions towards a unique growth path determined by general technical progress (SOLOW, 1956 and 1957). In this model regional differences in the *level* of productivity can only persist if regions differ in important conditions or behaviours. The latter applies particularly to modified versions of the model that explicitly take into account the endowment with human capital and institutional factors (SALA-I-MARTIN, 1990 and 1996; MANKIW *et al.*, 1992). But lasting regional differences in productivity *growth* would only be possible if regions constantly diverged in these fundamental conditions, too.

In more recent theories of endogenous growth that explicitly consider the process of knowledge formation (ROMER, 1990; AGION and HOWITT, 1992), innovation and growth depend on the input of labour in the production of knowledge and on the stock of knowledge already available. Assuming that new knowledge does not spread freely across regions - unlike the assumption in the traditional neo-classical model - areas with a relatively large number of researchers will show relatively high growth in productivity and per capita income. They are not only rich, but also grow faster than regions with a smaller research potential. According to these approaches regional disparities can also evolve to the extent that backward regions differ in their ability to imitate technical know-how and so reduce the gap to the leading regions.

The explanation of the geographical distribution of economic activities made considerable progress with the New Economic Geography established by KRUGMAN (1991) - at least theoretically (FUJITA *et al.*, 1999). In this theory economies of scale and distance-related transaction costs are major factors. Access to markets and (sector-specific) inputs are the decisive criteria in companies' choice of location. Location decisions by individual firms add up to cumulative processes of geographical concentration and specialisation. These, however, do not only lead to increasing market potentials, the costs of immobile factors also rise (PUGA, 1999). If transaction costs fall below a certain level (e.g. as obstacles to trade are removed or the infrastructure is improved), the disadvantages of agglomeration in causing higher production costs will be greater than its advantages in distribution costs. Firms react to this by shifting plants to less dense areas.

While the New Economic Geography concentrates on externalities that are transmitted via markets (input, output and labour markets), it is non-market interactions that predominate in other agglomeration theories; such effects also play a central role in the theories of endogenous growth. These localised spillovers of human capital and technical-organisational knowledge can result from urban size and variety (urbanisation effects) or from sector-specific interactions (localisation effects) (MARSHALL, 1925; LUCAS, 1988; HENDERSON, 1988; FUJITA and THISSE, 2004). Here, the reasons for spatial concentration are rather different from those in the New Economic Geography, but the side-effects, i.e. congestion costs, are the same.

All the theoretical approaches outlined here can explain regional disparities in productivity and income, and, except for the traditional neo-classical growth model, they can account both for the rise and the fall of these disparities. The outcome depends on the specific assumptions made concerning the relative power of centripetal and centrifugal forces, and to the degree that these forces differ in strength between industries sectoral specialisation of regions are likely to emerge. According to the New Economic Geography scale intensive and/or transactions cost intensive industries will tend to concentrate spatially. And according to agglomeration and growth theories that are based on technological externalities knowledge-intensive activities that benefit greatly from local spillovers will tend to locate in densely populated – and possibly specialised - areas, while standardised production processes and routine operations will be shifted to less expensive areas.

In empirical research, agglomeration effects are generally shown to play a key role for regional income levels. Estimates of the elasticity of productivity and wages in relation to density of employment in a region show differences ranging from 20% to 50% between densely and sparsely populated regions (CICCONE, 2002; ROSENTHAL and STRANGE, 2005). However, it is a matter of dispute what weight should be attached to effects of sectoral specialisation (localisation) compared to urbanisation advantages (PORTER, 1990; GLAESER *et al.*, 1992; CAPELLO, 2001; BODE, 2002). Using West Germany as an example, the present paper examines whether sectoral growth and concentration processes are making a major contribution to regional income differentiation, and especially to spatial agglomeration.

3 Empirical Approach

Does the probability that a region exhibits an above-average growth of GDP per employee depend on the importance of sectors in that region that are both continuing to concentrate geographically and increasing their employment? To answer this question, our empirical analysis proceeds in two steps:

1. We first classify regions and sectors according to the development of their productivity and geographical concentration, respectively.
2. We then estimate the relationship between the probability of a region exhibiting a non-converging development of productivity and its share of employment in sectors with increasing geographical concentration.

While the details of steps 1 and 2 are described in sections 4 and 5 below, the purpose of this section is to give an overview of our empirical strategy.

We classify regions as showing an atypical, i.e. non-converging development of productivity, if they have started from a high initial level of productivity and have further improved their relative position. That is, they must show both an above-average development in productivity during the period under study and an above-average initial level in the corresponding base year.

Atypical regional development is thus converted into the following discrete dependent variable:

$$Y = \begin{cases} 1 & \text{If a region shows above-average productivity in the base period and above-average development in productivity} \\ 0 & \text{otherwise} \end{cases}$$

Classifying sectors according to the development of their geographical concentration is not as clear cut. There is a broad discussion in the literature regarding appropriate ways to measure the geographical distribution of economic activities (e.g. OVERMAN, REDDING and VENABLES, 2001). Accounting for the differences in specialisation between regions as comprehensively as possible is often cited as the main challenge.

However, the focus of our examination is not the specialisation of regions but the geographical concentration of sectors. To measure the latter, we use the Herfindahl Index as a simple yet robust indicator. Sectors continuing to concentrate geographically are identified in

a straightforward way by examining their level of geographical concentration in the starting year and its subsequent development in the relevant observation period. A region's share of employment in atypical sectors, i.e. industries with increasing geographical concentration and above-average employment growth in the period considered, serves as the explanatory variable *X*.

To actually compute the values of *Y* and *X* for each region we need data on aggregate regional productivity (regional GDP per employee) and on the distribution of sectoral activity across regions. As is evident from both our research question and the definitions of *Y* and *X* we are aiming at a long-term comparison of regions using West Germany as a reference. However, an uninterrupted series of GDP per employee for the entire period (1980 to 2000) is not available. The data from the old European System of National Accounts (ESNA79) covers the period 1980 to 1996, while data according to the new system ESNA95 is available for the years from 1991. We interlink these two time periods by using conversion factors for the years 1991 and 1992. In our empirical work we focused on the years 1980, 1990 and 2000, with the interim years 1985 and 1995 used for robustness checks.

Differentiated information on the regional distribution of production by individual economic sectors is not routinely published in Germany. However, such information is available for the input factor labour, which we use here as an approximation for the regional distribution of sectoral production. Differentiated information on the sectoral structure can be obtained from the statistics on employees paying statutory social insurance contributions. To obtain a long series that matches the GDP data we use the pre-1993 sectoral classification of the Federal Employment Agency.[2] Our geographical units of observation are the planning regions defined by the Federal Building Office.[3]

To model the relationship between the probability of a region being atypical (Y=1) and its share of employment in atypical sectors (X) we initially employ the logit model defined as:

$$P(Y=1|X)=\frac{1}{1+\exp[-(\beta_0+\beta_1 X)]}$$

[2] That system of classifying sectors has been replaced by the 1993/2003 systems. This does not result in any real disadvantages for our study, but it should be noted that the information technology sector is not treated as a separate entity in the old classification but is subsumed in engineering. The classification used here comprises 83 economic sectors.

[3] The delimitation of these “Raumordnungsregionen” mainly follows commuting patterns and socio-economic linkages although the Federal State boundaries are observed. In the case of the city states this yields units that are hardly meaningful economically, and for that reason the planning regions that directly adjoin Hamburg and Bremen are grouped into one unit with the core city. Altogether this enables an analysis of 71 West German regions that remained unchanged from 1980 to 2000.

The logit model is easily estimated and interpreted and offers a first assessment of the influence of the share in regional employment of atypical sectors on the probability of a region showing an atypical trend in productivity. However, this advantage comes at the expense of its relatively restrictive functional form it imposes on the relation between the probability that a region will show an atypical growth of aggregate productivity and its share of employment in atypical sectors. Hence, in a second step we non-parametrically modelled the influence of a region's share of employment in atypical sectors on its probability of exhibiting an atypical development in productivity.

The non-parametric regression model $P(Y=1|X)=m(X)$ does not fix the form of the regression function *m(X)* a priori. It merely assumes that $P(Y=1|X)$ does not abruptly change as a result of small changes in *X*, that is, that the function *m(X)* is assumed not to have any jumps. The kernel method uses this property to form an estimate of *m(X)* at a particular value $X=x$ by averaging over the values of *Y* of those observations whose values of *X* are within a narrow interval around $X=x$ (HÄRDLE *et al.*, 2004). The width of this interval has to be chosen to determine how "local" the average is to be. In this paper an optimal data-driven window width is chosen by employing a cross-validation criterion.

It is well known that estimates of a non-parametric regression are inflicted by the "curse of dimensionality", that is, they can be very imprecise if the number of explanatory variables is large because the observations tend to spread "all over the place" in multidimensional space with few observations left for forming local averages. Moreover, estimates of multivariate nonparametric regressions can be hard to interpret and communicate as they may neither yield a parametric formula (by definition) nor a graph (if there are more than two explanatory variables). Neither is the case, however, in this paper as only one explanatory variable is being considered.

4 Classification of Regions and Sectors

We identify atypical regions as those that, starting from a high level of performance in 1980 and 1990, respectively, even increased their relative productivities. The development between 1990 and 2000 is of particular interest, because it was in this sub-period that a number of regions outgrew the productivity distribution, as described in Section 1. But to underpin the results we also looked at the entire period from 1980 to 2000.

Table 1 shows the regions that exhibited both above-average productivity growth and an above-average initial level in the respective base year. From 1980 to 2000, 11 of the 71 adjusted planning regions fulfilled both of these criteria, and 9 out of the 71 did so for the years 1990 to 2000. In both periods, it was particularly the big agglomerations like Munich, Rhine-Main and Hamburg that were able to move away from the general regional convergence process in productivity. But the industrial region of Nuremberg, and the planning regions of Starkenburg and South West Schleswig-Holstein, both in the vicinity of agglomerations, also met the criteria in both periods. Then there are regions that had above-average development in productivity and an above-average initial level in only one of the two periods. Starting from a high level of productivity in 1980 the regions of Ingolstadt, Stuttgart and Braunschweig – all well known for their strength in automotive production - increased their performance even more in the 1980s, but not in the 1990s. In the 1990 to 2000 period Düsseldorf and two less densely populated areas in Baden-Württemberg also fulfilled both criteria.

Regarding sectoral classification, we seek to identify those industries that are increasing their geographical concentration. Since disaggregated data on the regional distribution of output is not available, the shares of employees paying statutory social insurance contributions are used as proxies for the output shares. Atypical sectors are identified as industries that have both increased their geographical concentration and shown an above-average employment growth. The latter restriction is introduced because only if sectors also have grown can they contribute to the explanation of the particular success of certain regions. When the additional criterion of employment growth was applied chemical fibres, clothing, tobacco processing and railways ceased to classify as atypical industries. The remaining sectors are listed in Table 2.

Table 1
Regions with above-average initial level and above-average growth of productivity

	GDP per employee	
	West Germany = 100	Change in index value
	1980	1980 - 2000
Munich	119,0	19,4
Rhine-Main	113,3	17,5
Hamburg region	105,7	14,7
Starkenburg	106,3	10,6
Middle Upper Rhine	105,6	5,6
Central Franconia industrial region	106,1	4,9
Ingolstadt	103,8	3,8
South West Schleswig-Holstein	109,3	2,3
Stuttgart	114,8	2,1
Franconia	104,4	1,8
Braunschweig	106,4	1,3
	1990	1990 - 2000
Munich	118,0	20,4
Starkenburg	101,6	15,3
Hamburg region	110,9	9,5
Central Franconia industrial region	104,7	6,3
Danube-Iler (Baden-Württemberg)	100,1	4,9
South West Schleswig-Holstein	108,1	3,5
Rhine Main	127,9	2,9
Lake Constance - Upper Swabia	101,4	0,2
Düsseldorf	117,8	0,2

Total number of regions: 71.

Sources: Employment statistics of the Federal Employment Agency and own calculations.

Of the 83 sectors observed, 7 met the two criteria in the period from 1980 to 2000, and 10 did so in the period from 1990 to 2000.[4] Traded services are particularly prominent among the industries that continued to concentrate geographically, and their employment has increased significantly. In both sub-periods the film industry, business consultancy, engineering, legal consultancy, arts/theatre and banking showed the necessary values to meet the two criteria.

But some services sectors that are more local in orientation also show atypical development tendencies in their location patterns. Especially in the 1990s there was further geographical concentration in security/courier services, cleaning of buildings, and real estate. At the same time employment increased strongly. These local services likely continue to concentrate because they are closely linked to traded services. If the latter are concentrating in a few regions, as is evident here for many of them, the suppliers of local services follow this geographical pattern.

[4] For the entire period from 1980 to 2000 road haulage and education also showed a (slight) increase in spatial concentration and above-average employment growth. Nonetheless, they are not included in the category of atypical sectors because location decisions in these fields are strongly subject to state regulations.

Table 2
Sectors with increasing geographical concentration and above-average employment growth

	Herfindahl index of geographical concentration	Employment
	Change in %	
	1980 - 2000	
Security, courier services	32,0	301,6
Business consultancy	18,9	270,0
Film industry	7,3	146,9
Engineering	0,9	110,8
Legal consultancy	7,6	80,0
Arts/theatre	4,7	35,3
Banking	18,1	27,2
All sectors	**-2,4**	**9,3**
	1990 - 2000	
Business consultancy	16,6	123,2
Security, courier services	20,2	119,5
Building cleaning	2,7	93,5
Film industry	5,4	89,2
Real estate	2,4	85,6
Engineering	0,0	48,7
Legal consultancy	8,4	36,0
Arts/theatre	6,6	10,2
Banking	14,0	7,6
Insurance	1,7	6,6
All sectors	**-1,3**	**2,4**

Total number of sectors: 83.

Sources: Employment statistics of the Federal Employment Agency and own calculations.

5 Estimates

We will now test empirically whether the probability for a region to show an atypical development in productivity depends on the importance of sectors in that region that are also atypical in their geographical development patterns.

First, logit models are estimated using as the explanatory variable the share in regional employment in those sectors that – contrary to the general trend - are concentrating geographically (see Table 2). The dependent variable is the type of region coded with 0, "normal development in productivity", or 1 "atypical development in productivity" (see Table 1). According to our hypothesis, the higher the initial employment share is of sectors in a region that are continuing to concentrate the greater is the probability that they are Type 1 and can depart from the general trend towards regional convergence. The periods through which the processes of concentration or growth take place are 1980-2000 or 1990-2000. The results of the logit estimates for both periods are given in Table 3. The results confirm our hypothesis. Both estimates show a statistically significant positive influence[5] of a region's employment share of atypical sectors in the initial year on a region's probability of experiencing atypical productivity trends.

Table 3
Results of the logit estimate

	Period observed					
	1980 - 2000			1990 - 2000		
	Coefficient	t-value	p-value	Coefficient	t-value	p-value
Share in employment	0.91	2.80	0.005	0.57	3.04	0.002
Constant	-6.00	-3.65	< 0.001	-6.59	-3.94	< 0.001
Pseudo-R^2	0.16			0.25		
n (number of regions)	71			71		

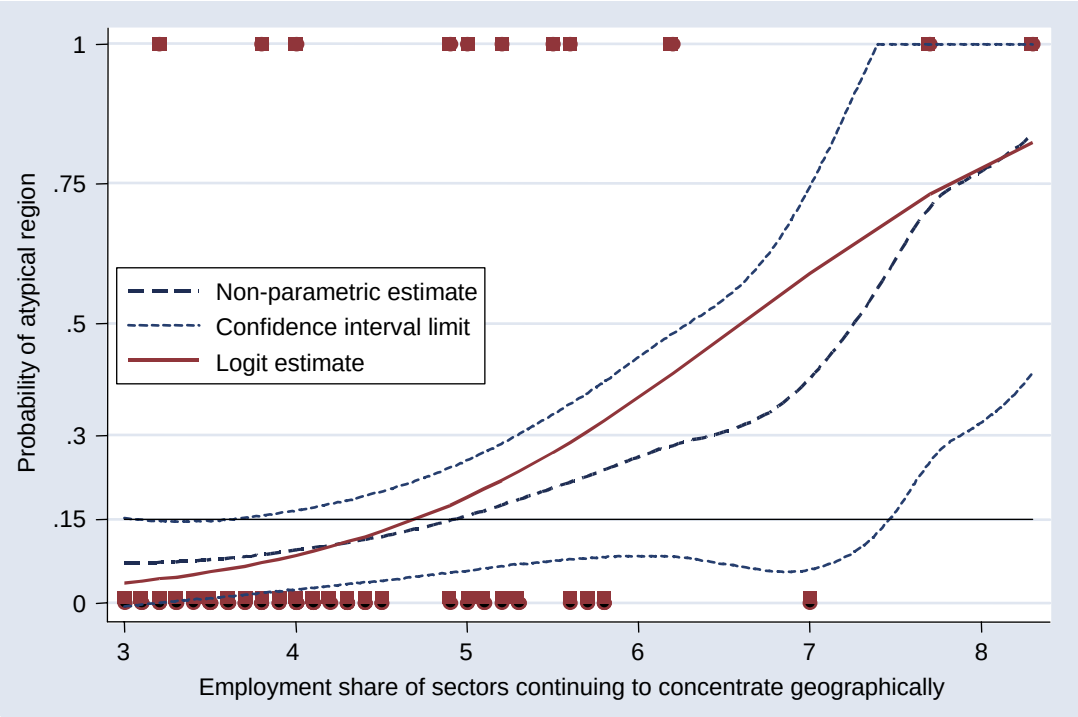
The extent to which the share in regional employment of geographically concentrating sectors is able to explain atypical regional development is noticeably greater in the period from 1990

[5] The estimated coefficient of the share in regional employment is statistically significant in both cases at the 1% level.

to 2000 than in the longer time span from 1980 to 2000.[6] The Pseudo-R^2 rises from 0.16 to 0.25. The better fit in the shorter period may be due to the fact that the variation in regions' shares of sectoral employment were clearly higher in 1990 than in 1980.

We then proceed to compare the logit estimates of the conditional probability of a region moving away from the convergence trend with non-parametric estimates for the two periods 1980-2000 (Figure 2) and 1990-2000 (Figure 3). The non-parametric kernel estimates[7] and the corresponding 95% confidence intervals are shown as dotted lines. The logit estimates, on the other hand, are shown as solid lines.

Figure 2
Logit and non-parametric estimates of the conditional probability of a region being atypical 1980-2000



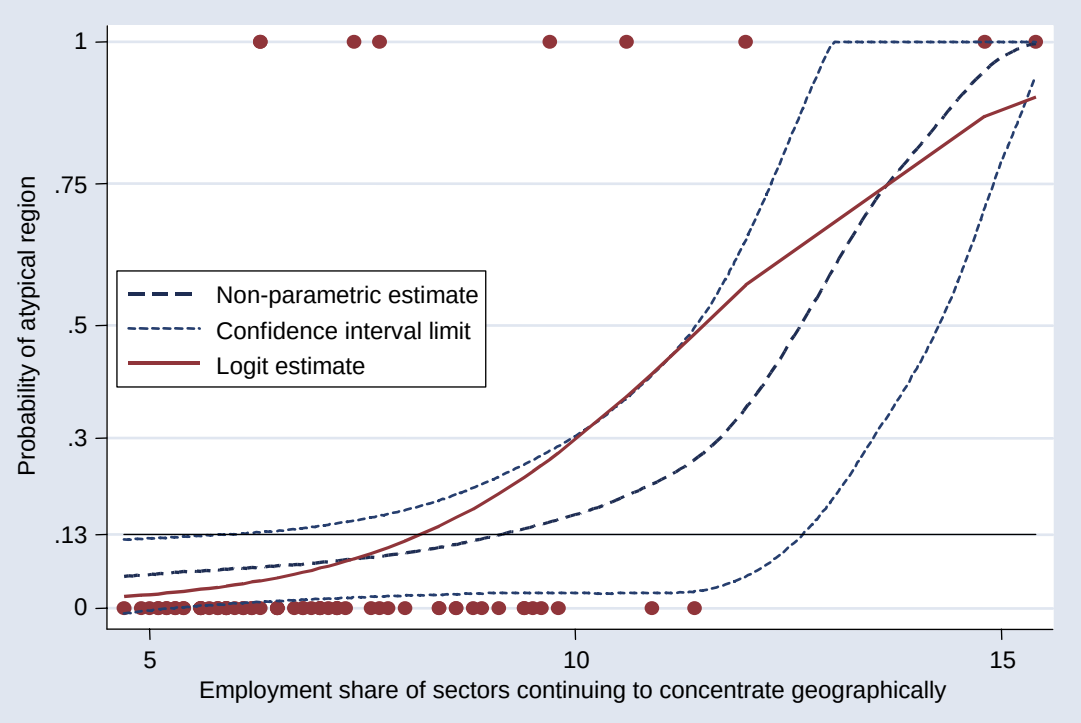
For both periods, the diagrams show consistency between the logit model and the non-parametric regression in two respects. Firstly, both show a positive relation between the probability of a region being atypical and the regional employment share of atypical sectors. Secondly, the logit curves lie almost entirely within the finely dotted confidence intervals around the non-parametric estimate.

[6] This result is also confirmed for the periods from 1985 and 1995, but this is not shown here.

[7] The bandwidths of 2.05 (for the period 1980-2000) and 4.15 (for the period 1990-2000) were chosen using the generalised cross-validation criterion, cf. HÄRDLE et al., 2004.

But the comparison also shows that the logit estimate implies a much more steady rise in the probability of being an atypical region. The non-parametric estimates, being local averages, show a more differentiated picture. The probability of a region to depart from the general trend towards regional convergence is small if it has only a low initial employment share of those sectors that are continuing to concentrate geographically. Very many of the 71 regions with low sectoral shares show a development in productivity towards convergence. With increasing employment shares of sectors that are continuing to concentrate geographically the number of regions that are moving away from the general convergence trend rises slowly. Then with very high sector shares the non-parametric estimates show a steep increase in the probability of being an atypical region. In the period from 1990 to 2000 the estimated probability is actually 1 for regions with the highest sector shares. All the regions with a share in employment of more than 13% in sectors that are concentrating geographically were moving further away from the average productivity level in West Germany.

Figure 3
Logit and non-parametric estimates of the conditional probability of a region being atypical 1990-2000



This progression, from an initially only very weakly but later rapidly increasing probability, is based on relatively few data points in the area of the steepest increase. This is evident in the diagrams as the confidence intervals widen considerably around the non-parametric estimate in this area. In order to assess in which areas of X the results of the non-parametric regression

are statistically significant, the horizontal line of the unconditional expected value for the share of atypical regions in all regions is entered as a reference.[8] The horizontal line at the reference value represents the null hypothesis that there is no relation between the probability of Y=1 and the initial employment share of concentrating sectors.

It is evident for both periods that the horizontal line of the absolute shares clearly moves out of the curves delimiting the confidence interval on the extreme right edge only. This implies that only if geographically concentrating sectors are of very great importance in a region will their positive influence on the region's ability to move away from the general regional convergence trend be regarded as statistically significant.

[8] The unconditional expected values for the shares of the atypical regions in all regions are 0.15 for 1980-2000 and 0.13 for 1990-2000.

6 Conclusions

In the 1980s and particularly the 1990s a number of rich regions in West Germany managed to rise ever higher above the average productivity level. As our results show, one reason for this is the heterogeneity of sector-specific developments. Most of the 83 sectors we looked at do show geographical de-concentration, analogous to the regional convergence trend. Yet some industries concentrated their activities even more in the 1980s and 1990s. Clearly, regions that can move away from the general convergence trend are particularly favourable locations for these sectors that both continue to concentrate spatially and grow faster than the rest of the economy.

However, it remains to be seen what these specific location conditions are that create the high affinity of certain sectors with individual regions. The identification and classification of regions and sectors undertaken here can only support assumptions. Knowledge-intensive services that are traded across regional boundaries predominate among the sectors that are continuing to concentrate geographically, such as the film industry, business consultancy, engineering, legal consultancy, arts/theatre and banking. At the same time major agglomerations like Munich, Rhine-Main and Hamburg predominate among the regions that can move away from the general trend of regional convergence.

This comparison suggests that a metropolitan environment attracts the knowledge-intensive services sectors, because of its rich supply of skilled labour, high quality transport infrastructure and many opportunities for cooperation between companies in the immediate neighbourhood, and between companies and the local research scene. The particular advantages of agglomeration for these sectors, and the particular dynamics of knowledge-intensive services, evidently boost economic growth of large metropolitan regions. The enormous progress in information and communications technology has apparently not changed this at all. On the contrary, the process we observed was more marked in the 1990s than a decade before.

But the empirical results also leave open questions. Why do some traded services , like advertising, not show further geographical concentration? Why can other big city regions, like Cologne, not benefit from the geographical concentration and dynamics of knowledge-intensive services? Is the success of the Stuttgart and Nuremberg regions due less to traded services and much more to clusters of high-performing manufacturing branches?

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