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Long-term processes of regional concentration and dispersion – fuzzy evidence for Western Germany

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Draft version, please do not quote!

Abstract

This paper sheds new light on the long-run development of the concentration of economic activity in Western Germany by considering a time period of 20 years. We measure concentration with the relative locational Gini coefficient and the Ellison-Glaeser index. Our data covers the time period from 1986 to 2006. The analysis is conducted for Western Germany both for NUTS3-regions and labour-market regions and up to 178 sectors. The Establishment History Panel, a comprehensive micro-level database provided by the Institute for Employment Research, provides information about employment at the level of individual firms.

JEL classification: R11, R12

Keywords: concentration, sectoral change

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1 Introduction

In previous years, the debate whether concentration and/or specialisation of economic and industry-specific activities prevail in space has gained a renewed interest both in empirical and theoretical work. This is reflected by a growing body of literature dealing with this issue. It is difficult to retrieve general outcomes from these studies. The following reasons may be responsible for this statement:

- First, studies apply different measures and indicators in order to assess the degree of geographical concentration. Each indicator is characterized by specific advantages and disadvantages (e.g. Beaudry/Schiffauerova, 2009).
- Second, there are only a few studies which take into account a more dynamic perspective. This is to say studies which consider de- and concentration processes over a longer period of time are missing. This lack impedes the research on factors which determine whether agglomerative or de-agglomerative forces prevail in an economy or in an industry over time. Apart from that, most of these studies refer to a specific year and can give merely a snapshot of industry-specific concentration in space. Thus, these studies are restricted to industrial rankings of geographical concentration.
- In addition, empirical evidence on concentration and specialisation apply to different industrial and spatial scales (e.g. regions, countries, cross-country studies). For instance, studies relying on the Ellison-Glaeser-Index reveal varying outcomes according to territorial aggregation levels.

To sum up, the current state of research on this topic is quite fuzzy. In the following, the arguments which sustain either a process of concentration and specialisation or a process deconcentration are to be introduced. Each argument will be complemented by a short review of the empirical evidence. With respect to Europe, economic space in Europe has experienced increasing economic and political integration since the mid of the 1980s. The integration of Southern European Countries, the introduction of a Common Market, the access of Eastern European Countries to this market and the introduction of the European Economic and Monetary Union have led to a significant weakening of trade barriers. It is argued that such a rapid integration affects spatial patterns of economic activity. As consequence Krugman (1993) presumed a growing specialisation and concentration of economic activities in Europe. This assessment is widely known as Krugman thesis. There is a set of studies which corroborate the growing specialization and concentration of economic activity for European countries during recent decades: e.g. Amiti (1999), Haaland et al. (1999), Midelfart-Knarvik/Overman/Venables (2000), Brülhart (2001), Aiginger/Pfaffermayr (2004). This accelerated tendency of economic and political integration

is to be observed also in other areas of the world (e.g. North America, East and South East Asia, Australia and New Zealand,). Hence, Krugmans thesis might be also essential for other areas and countries. For example, Australia's (Leahy/Palangkaraya/Yong, 2007), China's (Lu/Tao, 2008), and Chile's (Echeverria/Gopinath, 2007) manufacturing sectors are characterized by increasing spatial concentration. The other side of the coin is made up by arguments sustaining deconcentration of economic activities and in turn more evenly distributed patterns of economic activities in space. The latter should be true above all at more disaggregated spatial scales (cf. Südekum, 2006). Old manufacturing industries have undergone structural crisis and decline in previous decades. Therefore, a weakening of concentration is expected to occur in these industries. Firms of old industries prefer traditionally to locate in industrial agglomerations because of the access to advantageous agglomeration externalities. This path-dependency in location decisions might contribute, in contrary, to persistent spatial concentration. Besides, it is assumed that geographical distance is not anymore a barrier that impedes mutual interactions between economic actors. Technological progress, such as the introduction of information and communication technologies in business and private life, and the improvement of the traffic infrastructure (e.g. speed trains, airports) enable either more intense distant communication between actors or contribute by means of cheaper transport costs to increased commuting between places. All in all, these reasons sustain a deconcentration of economic activities. The occurrence of more decentralized patterns of economic activity have been affirmed by the studies of Barrios et al. (2005) for Ireland and by Alecke et al. (2009) for West Germany. The alternative to a predominance of either agglomerative or deagglomerative forces is a counterbalanced process which is shaped by both. Then, more stabilized patterns of economic activities are more likely to occur within a territory. A stable development of spatial patterns is evidenced, for instance, by the studies of Barrios et al. (2005) for Portugese and by Bertinelli/Decrop (2005) for Belgium. Südekum (2006) states that no obvious process of industrial concentration is to be observed at different spatial scales in Germany. All in all, this current state of research revealed a set of challenges for further research on this topic. The aforementioned arguments for motivating the research on concentration, specialisation and deconcentration omit the fact that agglomerative and deagglomerative forces might operate each differently at the level of industries. Therefore, a great heterogeneity among industry-specific spatial patterns are more likely to occur. There is a need for long-term investigations on overall and industry-specific processes of concentration at different spatial and industrial scales. This challenge encloses also the question on industry-specific determinants which shape such developments. This work should be based on a concentration indicator that compares the actual pattern of industry-specific activities with a random distribution. In addition, the study should be designed in such a manner that its results could be compared to a set of existing studies in order to reveal more general outcomes on this topic.

Against this background, the objective of this study consists of analysing the evolution of the overall and industry-specific spatial patterns in Germany. A unique firm and employment database provides a long observation period which ranges from 1985 to 2006. The Ellison/Glaeser (1997) index fits best for this analysis. First, it has a lot advantages compared to other indicators (section 4.2). Second, a set of country-specific studies applies this index which facilitates an international comparison of our empirical results. The detection of determinants explaining long-term variations of industry-specific patterns in space is also a major target of this study.

The remainder of the paper is organized as follows. Section 2 presents central theoretical arguments for and against spatial concentration of economic activity. In section 3 we summarize and discuss empirical evidence on concentration and specialisation in West Germany. The data and measures for analyzing concentration are introduced in the next section. Section 4 provides detailed evidence on the long-run concentration processes in West Germany at different spatial and industrial scales and also compares these results with the outcomes of other country-specific studies. The econometric analyses explaining these processes are contained in section 5. The key results and conclusions of this analysis and future challenges for further research make up the last section.

2 Theoretical considerations

The question why economic activity is not distributed randomly across space but rather concentrated in a limited number of locations is one of the oldest in regional science. Notable theoretical works on this topic include the famous German scholars von Thünen (1826), Christaller (1933) and Lösch (1940) as well as Hotelling (1929). A widely accepted explanation why establishments from the same industry benefit from their mutual proximity is called MAR-externalities after seminal works from Marshall (1890), Arrow (1962) and Romer (1986). There are three causes for these externalities: first, proximity of establishments within the same supply chain saves transport costs. Even nowadays, where freight is cheaper than ever, flexible production, cooperation with suppliers and stockkeeping of small quantities, i.e. ‘just-in-time’ delivery and production, still depend from closeness. Second, a local concentration of related firms creates a pool of specially skilled personnel. According to search and matching theories, this decreases hiring costs for employers and leads to better matches. Third, spatial proximity increases the likelihood of knowledge spillovers between establishments. Knowledge and ideas can be transmitted through formal and informal channels leading to innovation and technological change. All of these explanations suggest that spatial concentration leads to an increase in productivity. Thus, establishments have pecuniary incentives to seek their mutual proximity.

Knowledge spillovers in particular play a major role in the models of the New Growth

Theory (cf. Lucas, 1988; Romer, 1990). Here, input factors are considered to be constant and do not affect growth. Due to the fact that ideas cannot be kept completely secret, technological change spreads among all establishments within a region or even between contiguous regions and thus leads to endogenous growth. Finally, the New Economic Geography (cf. Krugman, 1991; Fujita/Krugman/Venables, 1999) presents a closed mathematical model to explain agglomeration. Within this framework, proximity again saves transport costs. These do not only apply to commodities but also to people (labor pooling) and ideas (knowledge spillovers) (cf. Glaeser, 2008). Under certain conditions, the reduction of transport costs leads to self-augmenting processes that further increases concentration and attracts even more establishments.

All of these approaches are in a way static as they regard the effects on a steady state (cf. Boschma/Frenken, 2005). When concentration is considered over a longer period of time it seems necessary to consider that agglomeration effects can change over time. There is no reason to believe that positive external effects eternally prevail in the same magnitude or even increase over time. This would mean that one region eventually attracts all employment of a whole industry, which is highly unlikely for most industries.¹ At this point, it is advisable to take an evolutionary point of view where path dependent processes and inertia play a major role. One has to take into account that the development of an industry's geographical concentration strongly depends on the phase of its product's life cycle.

Brenner (2004) derives a model of the emergence of local industrial clusters with regard to the development of the respective industry.² Within this model, a region's firm population is determined by exogenous conditions including the market situation. There are two stable equilibria where this firm population eventually converges to. During the initial phase there are rather unfavorable exogenous conditions. There is a high number of entry of new firms and product innovations are of great importance. There is a low steady state where only a small firm population exists that does not form a cluster. If the number of firms grows beyond its steady state level, competition gets stronger and shakeouts of firms might occur. During the growth phase demand increases and process innovations become more important. Only if the exogenous conditions exceed a certain critical value, self-augmenting processes come into existence and a higher steady state is possible. If a critical mass in form of a large firm population is reached, a local industrial cluster emerges. This process is also reversible. When the industry eventually reaches the maturity phase of its product's life cycle, the market situation might deteriorate. In this phase both product and process innovations become less important. Even if the exogenous conditions fall below the former critical mass, the higher equilibrium is still stable. As long as there is sufficient demand, the majority of firms will not close. Since there is no

¹NEG models heal this by imposing a so called "no-black-hole condition".

²For an overview about the industrial life cycle cf. Klepper (1997).

reason to relocate, the firms are still clustered even though agglomeration externalities are not important any more. When the industry reaches the end of its product's life cycle, the exogenous conditions can be expected to decrease sharply. Eventually the higher steady state is not possible any more. The dying industry converges to the lower steady state and the cluster disappears.

The implications of this model can easily be transferred from local industrial clusters to the concentration of an industry as a whole. During the growth phase, an industry can be expected to benefit from agglomeration externalities and firms seek their mutual proximity. As a consequence, one observes that the industry is geographically concentrated. When the maturity phase is reached and externalities eventually cease to exist, there is still concentration, simply because it would be costly to relocate. This might be the case especially in traditional manufacturing industries. Here, the past agglomeration might still be in place while specific externalities have become obsolete due to declining demand and modern production technologies. When finally demand decreases too strongly, establishments die and concentration dissolves.

3 Short Review of Empirical Evidence for West Germany

There are only a few studies which explore the industry-specific degree and change of geographic concentration and the factors determining concentration. Based upon the concentration index of Ellison/Glaeser (1997) (EG) the study of Alecke et al. (2006) and of Alecke/Untiedt (2008) investigate the rankings of geographical concentration in manufacturing industries and in all sectors of the economy at different industrial and regional levels for the year 1998. The work of Alecke et al. (2009) replicates this analysis for the years from 1999 to 2006 for all industries, too. These studies reveal that most of the industries in West Germany are stronger spatially concentrated when could have been expected in case of a random distribution. However, the overall degree of concentration is modest. Industries relying on site-specific characteristics such as the access to natural resources and local infrastructure as well as old-fashioned and traditional manufacturing industries are strongly concentrated in space. In contrast, technology- and R&D-intensive industries and also trade- and supply-oriented services are not or only weakly concentrated. A multivariate analysis confirms these results (Alecke et al., 2006). A main finding of Alecke/Untiedt (2008) is that there is not a general relationship between agglomeration and technology-related industries. This result is confirmed by a multivariate statistical analysis which explores the influence of industry-specific characteristics and of agglomeration determinants on the degree of geographical concentration in the high-tech-sector.

Apart from these static analyses, there is a set of studies dealing with dynamic changes

of industry-specific patterns in space in West Germany. In the following, we shed light on the major outcomes of this work: The analysis on the factors influencing regional employment growth in West Germany from 1970 to 1982 reveals a negative statistical relationship between the initial regional employment shares and the long-term industry-specific growth rates of employment (Bröcker, 1989). According to Südekum (2006) this evidence suggests a convergence of the industrial compositions of regional economies in the 1970s and beginning 1980s in West Germany. Bode's (1999) cross-sectional regression analysis for 75 West-German regions reveals spatial concentration for the manufacturing sector in the period from 1976 to 1994. Based upon a shift-share-regression Möller/Tassinopoulos (2000) analyse the factors determining employment growth rates for a range of industries over all districts in West Germany for the years from 1987 to 1996. This work corroborates also a process of structural convergence of region-specific industrial patterns. The first study investigating the trends of overall specialization and of geographic concentration in Germany is the work of (Südekum, 2006). He investigated long-term processes of specialisation and concentration for East and West Germany from 1993 to 2001 at the industrial level of 28 sectors and at three regional levels: nuts 1, 2 and 3 regions. This study applies the GINI as a measure for industry-specific concentration over all regions and the Krugman-Specialisation-Index as a measure for the degree of region-specific specialisation. One major result is that there are no overall developments of regional specialization and spatial concentration to be observed. Although, this analysis found out that on average region-specific economic structures have become more diversified during the 1990s. This hints to the occurrence of more decentralized spatial patterns of industries all over Germany. In accordance to the aforementioned industrial rankings of geographical concentration Südekum (2006) points to the fact that especially shrinking industries are strongly concentrated, and that they have even become more concentrated in the past. The reason for this high degree of concentration is a faster decrease of employment in regions situated outside the respective industrial agglomerations. Service industries have undergone a process of concentration. These results are valid at all three levels of territorial aggregation. These results can be observed for West German regions, too, although the trends are less intense. For West Germany, Alecke et al. (2009) explore the change of geographical concentration for all 2-digit-industries at the level of planning regions (aggregation of districts). This study relies on the EG index for the observation period 1999 to 2006. The authors find evidence for stable patterns of geographic concentration over all industries. The median of the EG over all industries is stable throughout this period of time whereas the respective values of the mean vary a little bit more. In addition, the rank correlation coefficients between the yearly rankings of all two-digit-industries are higher than 0.8 and statistically significant. Thus, geographic concentration at these more aggregated regional and industrial level remains quite stable over time. Note, that the aforementioned studies apply different methods in order to examine specialisation

and concentration in most instances. Although, these country-specific studies for (West) Germany reveal especially for the 1970s and 1980s a process of deconcentration whereas this trend is less clear for the 1990s and for the begin of the 21th century. All in all, these studies point to a more or less evident trend of deconcentration. In other words, one may conclude that the emergence of more balanced patterns of economic activity in West Germany has become evident in the past.

4 Empirical evidence

This section provides in-depth evidence on the long-run concentration processes in Germany. We start by describing the data set and how geographical concentration is measured. Then, the general patterns that emerge over the period under consideration are described before we focus on detailed patterns for selected sectors. A brief econometric analysis tries to shed some light on the determinants of the processes that could be observed over the observation period.

4.1 Data

For our analysis we use yearly data from the Establishment History Panel (*Betriebs-Historik-Panel*) constructed and provided by the Institute of Employment Research at the Federal Employment Agency (Bundesagentur fuer Arbeit) for the period from 1985 to 2006. This comprehensive database contains information about all plants throughout Germany that have at least one employee required to make social security contributions as of June 30 of a given year. The Social Insurance procedure was introduced in 1973 and compels employers to regularly report all changes that have occurred in the number of workers who are subject to health or unemployment insurance or who participate in a pension scheme. Since there are legal sanctions for misreporting, the data is very reliable. The Establishment History Panel draws on the Employee and Benefit Recipient History file of the Institute of Employment Research, in which the data on individuals are aggregated to the plant level using the plant numbers (Spengler, 2008). These numbers are assigned to the plants when they enter the database, i.e. when they record their first employee liable to social security contributions. Overall, we have at our disposal a database that provides information on the number of employees in 1.3 to 2.5 million plants per year.

In order to check the consistency of our results the analysis is conducted on two different levels of aggregation regarding both the regional and the sectoral dimension. The data is available at the level of the German counties, which correspond to the NUTS3-regions. They are aggregated to labour-market regions (LMR) in the delineation by Eckey/Kosfeld/Türck (2006). Eastern Germany is excluded from the analysis, because

the peculiarities of the transformation process require a separate analysis of the sectoral concentration processes. This results in a total of 326 districts and 112 LMR.

The sectoral dimension covers 43 two-digit and the 191 3-digit sectors that are classified according to the NACE classification (NACE 2 and NACE 3). The consideration of a time period of more than 20 years raises problems due to a break in the official classification of industries. There are several German versions of the NACE classification, introduced in 1973 (WZ73), 1999 (WZ93), and 2003 (WZ2003). While changes between the latter two were minor, there was a severe break between the WZ73 and the WZ93. Even though there had been a transitional period from 1999 to 2002, it is very difficult to convert observations from the older to the newer classification scheme. Yet converting the older data, which is available only under the WZ73 until 1999, to the newer classification is indispensable for our analysis, since the WZ73 is not adequate for analyzing agglomeration. First, the high tech or computer industry, which might be particularly prone to concentrate geographically, is not explicitly included in the WZ73.³ Moreover, this classification often fails to distinguish between manufacturing and sales. Hence, class 280 (manufacturing of automobiles and motors) covers car makers as well as local car dealers.⁴ This disperses the observed distribution of the involved industries, which makes the identification of localization hardly feasible. To include the years before 1999, the WZ93 industry classes of establishments that were observed during the transitional period are used for the whole span back to 1985. The industry of establishments that died before 1999 had to be estimated. In each region separately, for each industry class of the WZ73, that of WZ93 where most employees switched to when WZ73 was abolished is taken as replacement. This of course can cause some problems. First, establishments can change their sector. Second, the estimation of the industry is not completely accurate. Still, regarding the problems of the WZ73, this seems to be a reasonable “second-best” solution. Unfortunately, since the WZ73 has only three digits, it is not possible to use a 4-digit industry classification like in some other studies. We think the possibility of considering a really large period of 21 years justifies this drawback.

We concentrate on the private sector and hence exclude the primary and the public sectors from our analysis. Agriculture and fishing are characterized by a large share of self-employed who are not included in the social insurance statistics. The mining sector is highly dependent on geographical location factors. Finally, civil servants in the public sector that is only remotely subject to market-based forces, and furthermore the location decisions in the public sector are strongly influenced by political judgements.⁵

³Software development, for example, is hidden within class 770: publishing of books, newspapers and magazines.

⁴Another example is 351 (manufacturing of optical products) which contains both lens producers and opticians.

⁵We also exclude “space transport”. This is a very small industry where one establishment often changes between Kiel and Munich. This leads the industry to change between either highly concentrated or highly dispersed in a high frequency.

4.2 Measuring agglomeration

Generally geographic concentration of industries can be measured using the same methods that are used to measure industrial concentration. Beginning with Hoover (1936), there is a huge number that use variation of the Gini coefficient: in his “very preliminary statistical work” (Krugman, 1991, pp. 55 ff.) uses the Gini coefficient and finds that most industries are localized. Several other studies resort to the Gini coefficient as well (e.g. Litzenberger, 2006; Südekum, 2006). One point of criticism of this measure is that it treats regions as discrete entities and does not take into account the proximity of firms across regional borders. Since it is very plausible that borders of administrative regions are not taken under consideration when establishments agglomerate because of spillovers, this measure is prone to underestimate geographic concentration. This should be particularly severe for very disaggregate regional levels. To solve this problem, distance based measures were created (Marcon/Puech, 2003; Duranton/Overman, 2005). These directly use information on distances between establishments to analyze concentration at any geographical scale. Another disadvantage applies to both, the Gini coefficient and the afore mentioned distance based measures. They do not take into account the industrial size structure. Thus, a high share of an industry’s employees in a given region would be interpreted as geographic concentration, no matter if there are several smaller establishments or a single huge one. Since we intend to analyze concentration as a result of external effects between related establishments, this could cause problems.

To this end we resort to the agglomeration measure proposed by Ellison/Glaeser (1997) (EG) that is derived from an explicit model of location decisions made by individual firms. EG begin with constructing a measure of an industry’s “raw” geographic concentration defined as $G = \sum_{r=1}^N (s_r - x_r)^2$, where s_r is the share of the industry’s employment in region r and x_r is the share of total employment in that region. G is very similar to the Gini coefficient used in earlier studies and measures concentration relative to total employment; as long as an industry mimics the pattern of aggregate employment it is not considered as being concentrated.

However, this does not control for the structure of the respective industry. The raw concentration index cannot distinguish between internal and external economies of scale. If an industry was dominated by one large establishment, G would indicate geographical concentration even if there was no actual agglomeration of different establishments. EG take this into account by deriving their index from a model of location choice.

EG assume that, in absence of agglomeration forces, firms choose their location as if dartboards were thrown at a map and that there exists an allocation process which yields the observed employment distribution in expectation. They show that under these assumptions $E(G) = (1 - \sum_{r=1}^R x_r^2)(\gamma + (1 - \gamma)H)$, where γ is a combined measure of the strength of natural advantages and spillovers between firms in a broad sense and H is

the industry's Herfindahl index $H = \sum_{j=1}^B z_j^2$, with z_j the firm j 's share of the industry's employment. Rearranging yields γ , which is the variable of interest:

$$\gamma = \frac{G - (1 - \sum_{r=1}^N x_r^2)H}{(1 - \sum_{r=1}^N x_r^2)(1 - H)} \quad (1)$$

γ is a sophisticated measure for the geographical concentration of an industry that takes its establishment size structure into account. Unlike other measures of geographical concentration it also allows to test if the observed spatial concentration is significantly stronger than what would be expected by a purely random location choice where technical or pecuniary externalities due to locational advantages do not play a role. In absence of agglomeration effects, γ would be equal to zero, and consequently $E(G) \equiv (1 - \sum_{r=1}^R x_i^2)H$. Assuming normality, EG propose that in the case of significant concentration, G is at least two standard deviations larger than its expected value $E(G)$.⁶ This offers the unique possibility to test the significance of geographical concentration, which distinguishes the EG index from comparable measures.

In contrast to a simple Gini coefficient, the EG index λ is sensitive to the industry size structure. It takes high values if an industry's employees are evenly distributed between establishments but are concentrated geographically. Since the theory assumes that concentration is motivated by establishments exploiting external economies of scale, this feature is desirable and is one of the reasons why this index has been widely used since its introduction. However, sometimes one could argue that spillovers could emerge particularly from large establishments. It is not clear how the EG index reacts if a few small establishments are located in the vicinity of a very large establishment, like it is often the case in automobile manufacturing. Another drawback is the aforementioned fact that regions are considered as discrete units. Neighborhood or proximity of regions are not taken into account. Agglomerations that stretch over more than one region might not be discovered. This is why different regional levels are taken into account. LMRs are created according to commuting patterns. One could argue that the distance that people are willing to travel each day, is also the distance that is relevant for spillovers. A further drawback, which applies to all agglomeration indices, is that it cannot detect co-location of establishments from completely different industries. Ellison/Glaeser (1997) also calculate a co-agglomeration index which measures co-location of establishments from different 4-digit industries that belong to the same 3-digit aggregate. However, this also falls short of Porter's (2000, p. 15) definition of a cluster, where firms from completely different but related industries are co-located. There is no way of solving this problem

⁶The variance of G can be obtained by:
 $\sigma_G^2 = 2H^2 \left[\sum_{r=1}^N x_r^2 - 2 \sum_{r=1}^N x_r^3 + (\sum_{r=1}^N x_r^2)^2 \right] - 2 \sum_{j=1}^B z_j^4 \left[\sum_{r=1}^N x_r^2 - 4 \sum_{r=1}^N x_r^3 + 3(\sum_{r=1}^N x_r^2)^2 \right]$

as long as official industrial classifications are used. Only case studies can shed light into these kind of co-agglomeration patterns. Two more caveats have to be kept in mind when using the EG index. First, it is always difficult to interpret the absolute values of an index. Even though Ellison/Glaeser (1997) argue that their index is comparable across countries and across different levels of aggregation, one should be careful to rely on comparisons between countries with huge disparities in their economic structure. Second, the EG index cannot distinguish between concentration due to natural advantages and due to true spillovers. This must be taken into account, when concentration patterns of different sectors are interpreted.

Each way of measuring agglomeration has its benefits and drawback. We use the EG index because it is simple to calculate, backed by a theoretical model and enables us to compare the results for Germany to results from other countries.

4.3 General patterns

In a first step, we discuss the long-run development of the EG index as a combination of our sectoral and regional classifications. Thus, we have four possible combinations at our disposal: 2-digit and 3-digit sectors and counties and labour-market regions (LMRs). At a later stage, we will focus our analysis on the 3-digit sectors and the LMRs. Mamelì/Faggian/McCann (2008) argue that an analysis of geographical concentration should use a preferably highly aggregated industry classification. At the same time, we feel that counties might be too small to be the relevant regions for spillovers. In order to avoid the discrete spatial unit problem described in section 4.2, we use the larger LMRs. As for now, the significance test is calculated for all combinations for the whole period as well as for each year separately.

The difference between G and its expected value if location choice was purely random is positive and significant for 67 % (counties) respectively 73 % (LMR) of the 2-digit sectors. For the 3-digit sectors, it is 61 % (counties) respectively 64 % (LMR). This means that the majority of the sectors in Western Germany has been stronger concentrated across space over the last 20 years than it would be the case if the plants had chosen their locations randomly. The test of significance calculated for each year reveals that especially for the LMR, the share of the 2-digit and 3-digit sectors featuring a significant concentration is similarly high. On the county level, the share of the 2-digit sectors rises over the years (from 64 % in 1985 to 70 % in 2006), whereas the share of the concentrated 3-digit sectors falls from 64 % to 53 % in the same period. This difference between the two regional demarcations regarding the temporal stability of the results is not surprising, since on the finer disaggregated level of the counties, the concentration processes show stronger dynamics, which is not revealed on the level of the LMR. Generally these first results lead to the conclusion that the majority of the West German sectors is highly concentrated in

the long run and therefore unevenly distributed in space.

Similar results are provided by Alecke/Untiedt (2008) and Alecke et al. (2006). The former find a significant concentration on the level of the 97 planning regions⁷ for 67 % and 75 % of all 2-digit sectors in the period 2000 to 2006. These figures correspond to our results. A lower value (41 %) is detected by Alecke et al. (2009) only for 1999. According to Alecke/Untiedt (2008), 80 % of the 3-digit sectors are concentrated more strongly on the county level in 1998 than in the case of a pure random distribution. In comparison to our results this value is considerably higher. Due to the sectoral reclassification problems our analysis comprises less 3-digit sectors, which might be one reason for the diverging results. Analyses for several countries based on the EG-index⁸ confirm this result.

Table 1 presents the absolute frequency distribution of the statistically significant EG values according to the number of sectors and years under observation. Almost every other 3-digit sector features a significant EG index in all 22 years. Out of the total of 191 3-digit sectors there are 85 which have a significant EG index both on the level of the LMR and the counties. In the case of the 2-digit sectors this applies to more than half of the sectors. No significant EG index can be attested to 20 to 25 % of the sectors between 1985 and 2006.

Other studies show that the values of the EG index differ with the sectoral and regional level of aggregation and that the level of the EG index increases with the regional level of aggregation. When looking at the descriptive data for the two- and three-digit sectors and differentiated according to counties and LMR, some analogies appear. Let us first concentrate on the level of the EG index. Table 2 shows that the median for the 2-digit sectors across all LMR and years is 0.004 and 0.003 across all counties. For the 3-digit sectors the median is 0.006 (LMR) and 0.003 (counties). The means for the LMR also exceed those of the counties. Figure 1 shows that the mean across the 3-digit sectors decreases significantly for both regional aggregations over the years. As to the 2-digit sectors, the mean on the EG index decreases much more for the LMR. Averaged over the sectors, this result hints toward a decline in the spatial concentration of sector-specific economic activities in Western Germany.

Calculating the differences between the median and the mean for every year of observation reveals that the EG values are continuously higher for the LMR than for the counties. This holds for both the 2-digit and the 3-digit level.

The coefficient of variation, a measure for the relative dispersion, is a useful means for comparing the variances of different distributions. For both sectoral aggregations, it is higher for the county than for the LMR level. Hence, the dispersion on the county level is higher. For both regional aggregations, the coefficient of variation is higher for the 3-digit

⁷Planning regions are a highly aggregated spatial delineation developed by the Federal Institute for Research on Building, Urban Affairs and Spatial Development.

⁸e.g. Lu/Tao (2008), Leahy/Palangkaraya/Yong (2007), and Bertinelli/Decrop (2005)

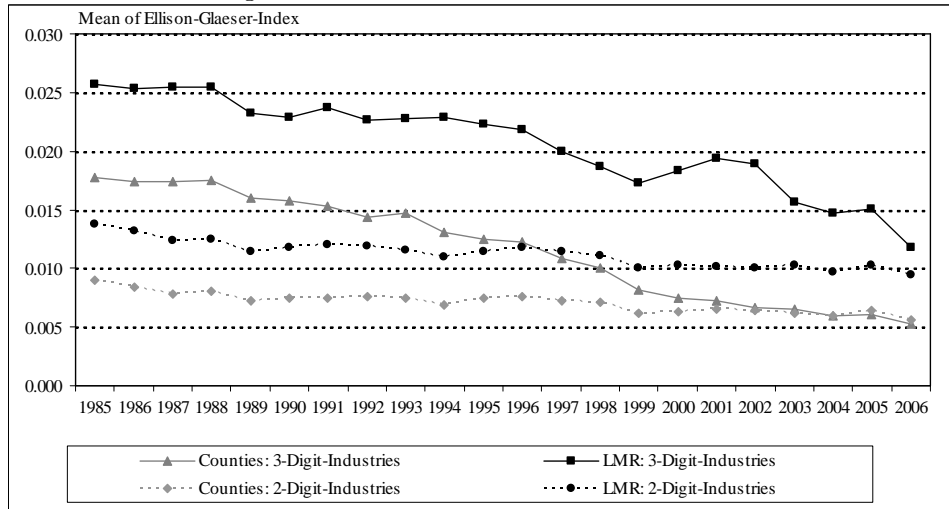
Table 1: Numbers of industries and years with a significant EG-Index value

Years of significant concentration	2-digit industries		3-digit industries	
	county	LMR	county	LMR
0	11	8	48	37
1	0	0	5	6
2	0	0	1	4
3	0	2	2	3
4	1	0	2	2
5	1	0	1	2
6	0	0	1	3
7	1	0	3	2
8	1	2	2	1
9	1	0	2	4
10	0	0	4	0
11	1	1	2	2
12	0	1	6	4
13	0	0	4	4
14	0	0	5	8
15	0	0	2	3
16	0	1	2	1
17	1	0	1	3
18	0	1	3	1
19	1	1	1	7
20	1	0	3	4
21	0	0	6	5
22	27	30	85	85
total	47	47	191	191

Table 2: Descriptive data for the EG-Index, averaged over the years 1985-1986

industry	region	median	min	max	mean	std.dev	coeff. var.
2-digit	county	0.003	-0.029	0.133	0.007	0.018	2.5
	LMR	0.004	-0.031	0.194	0.011	0.026	2.3
3-digit	county	0.003	-0.187	0.506	0.012	0.042	3.6
	LMR	0.006	-0.435	0.910	0.021	0.066	3.2

Figure 1: Development of concentration



than for the 2-digit sectors. Hence, the variance is lower at the 2-digit level. An increase in the dispersion of the EG is visible only for the 3-digit sectors and counties.

The rate of the EG index gives information on how pronounced the geographical concentration of a sector is. A disadvantage of this concentration measure is the problem that there exist no conventional ranges according to which the strength of a spatial concentration can be assessed. Ellison/Glaeser (1997) propose the following as a rule of thumb: sectors are strongly concentrated if their EG value is higher than 0.05. They are substantially concentrated if their EG is lower than 0.02. If the EG is equal or smaller than 0, there is no concentration.

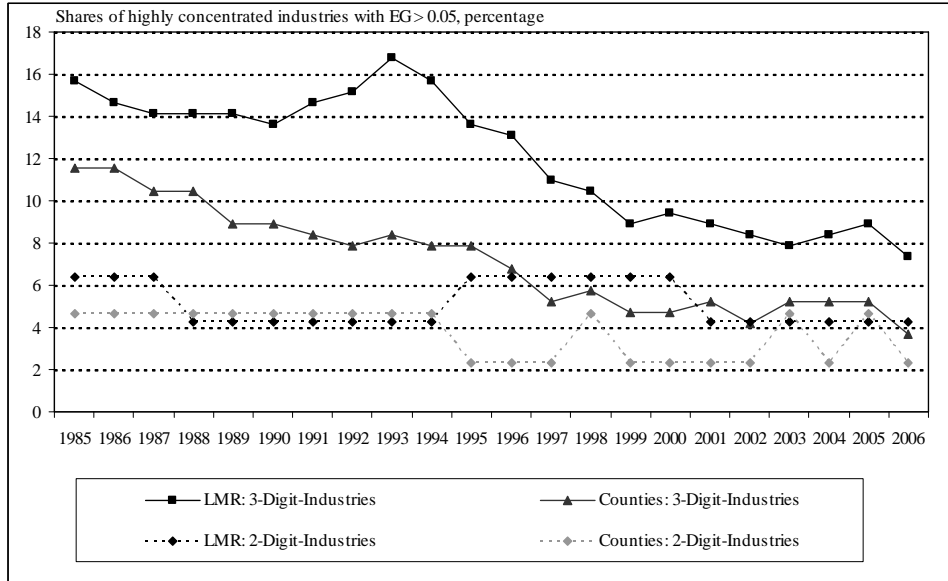
Table 3: Frequencies (percentage) of EG-Index-Classes 1985-2006

industry	region	EG index			
		≤ 0	> 0 to ≤ 0.02	> 0.02 to ≤ 0.05	> 0.05
2-digit	county	16.3	74.3	5.7	3.7
	LMR	9.9	79.6	5.4	5.1
3-digit	county	25.2	57.9	9.7	7.2
	LMR	17.0	60.1	10.8	12.0

As table 3 presents, in 25 % (counties) respectively 17 % (LMR) of the 3-digit sectors and 16 % (counties) respectively 10 % (LMR) the EG-index has a value of 0. Hence, these sectors are not concentrated in space. More than half of all sectors is weakly concentrated, as can be inferred from 58 % (counties) resp. 60 % (LMR) of all 3-digit sectors and 74 % (counties) resp. 80 % (LMR) of all 2-digit sectors reaching EG values between 0 and 0.02. The share of the strongly concentrated sectors with an EG index > 0.05 , however, is very low (2-digit sectors: 4 % (county), 5 % (LMR); 3-digit sectors: 7 % (county), 12 % (LMR)).

Figure 2 shows that, over the observation period, the share of the strongly concentrated

Figure 2: Shares of highly concentrated industries



3-digit sectors distinctly declines by more than half. This development can also be seen for the 2-digit sectors. In return, the share of the dispersed sectors ($EG\text{-Index} < 0$) slightly increases. For the majority of the weakly concentrated sectors the pattern is mixed: either the shares remain stable over time or increase slightly. Altogether, in the long run there is a slight shift of the EG index towards the two lower classes. The weakly concentrated sectors dominates, and the number of strongly concentrated sectors has declined over the observation period.

Regarding the EG values in figure 1, we find that the average EG index has been rather stable above the threshold of 0.02 until the year 1996. This pattern can be recognized in table 4, which displays the development of the EG index and its main components over the time. Note that the unweighted mean EG is between two and three time as large as the employment weighted mean value. This is first evidence that geographical concentration in Germany mostly takes place in smaller industries. Dumais/Ellison/Glaeser (2002, p. 195) propose that changes in the EG can be approximated by changes in the difference of the raw concentration index G and the industrial concentration H. This can be confirmed by the patterns in table 4 and by figure 3. Both measures seem to be stable until the early nineties and then start to dwindle. However, the decline of both is parallel at first which leads only to a moderate decline of the EG. Then both, a slight decrease in G and a slight increase in H occur at the same time. This leads to a steeper decline in the EG first in the late nineties and then in the year 2002 and later. This development is similar to the observations of Barrios et al. (2005) for Ireland, while the absolute values of the indices are somewhat smaller in Germany.⁹ Unfortunately, these patterns are not as clear

⁹These differences in the levels are not surprising. While both, Ireland and Portugal, are rather small countries with centralized economic systems, Germany is a comparatively large and decentralized country. Consequently, the levels are more similar to the findings of Dumais/Ellison/Glaeser (2002) for the US.

as what Barrios et al. (2005) found for Portugal. So far, we can only infer that both, a decline in the raw concentration and a change in the industrial size structure caused the concentration, measured by the EG index, to decline. To understand the actual processes that led to these observations, a disaggregate view is needed.

Table 4: Mean levels of geographic concentration

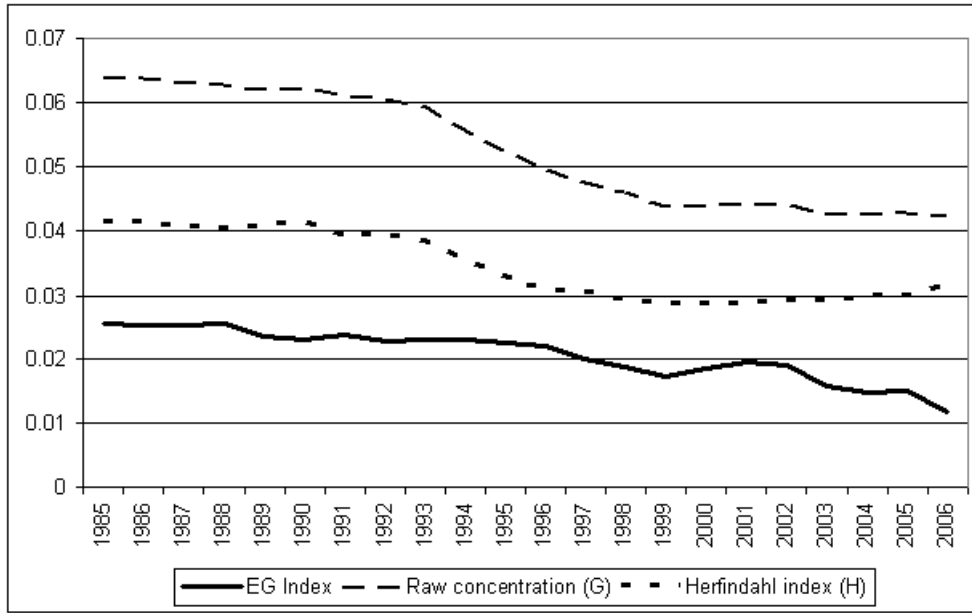
	1986	1991	1996	2001	2006
3-digit industry, LMR					
EG index	0.026	0.024	0.022	0.019	0.012
Raw concentration (G)	0.064	0.061	0.050	0.044	0.042
Plant Herfindahl (H)	0.041	0.039	0.031	0.029	0.032
Employment weighted mean EG	0.010	0.009	0.007	0.006	0.005
3-digit industry, county					
EG index	0.018	0.015	0.012	0.007	0.005
Raw concentration (G)	0.058	0.054	0.042	0.036	0.037
Plant Herfindahl (H)	0.041	0.039	0.031	0.029	0.032
Employment weighted mean EG	0.006	0.005	0.004	0.003	0.002
2-digit industry, LMR					
EG index	0.014	0.012	0.012	0.010	0.009
Raw concentration (G)	0.027	0.024	0.021	0.020	0.024
Plant Herfindahl (H)	0.014	0.013	0.010	0.010	0.015
Employment weighted mean EG	0.005	0.005	0.004	0.004	0.004
2-digit industry, county					
EG index	0.008	0.007	0.007	0.006	0.005
Raw concentration (G)	0.022	0.020	0.017	0.016	0.020
Plant Herfindahl (H)	0.014	0.013	0.010	0.010	0.015
Employment weighted mean EG	0.003	0.003	0.002	0.002	0.002

From this first analysis, we can learn that geographic concentration of industries is not an empirical regular phenomenon. In fact, it is very important to regard the extend of concentration and the dynamic processes on the level of single industries to take into account the idiosyncrasies of these industries that caused these processes. The empirical regional science shows that there is a huge variation in the geographical concentration of single industries.

4.4 Detailed patterns

The analysis of detailed patterns of industry-specific concentration relates to the combination of 191 three-digit-industries and labour market regions. This section provides answers to the following questions: What industries exhibit an explicitly low or high level of geographic concentration throughout the observation period? What industries are characterized by an outstanding process of spatial concentration or deconcentration? Are

Figure 3: Development of the mean EG and its components, 3-digit industries and LMRs



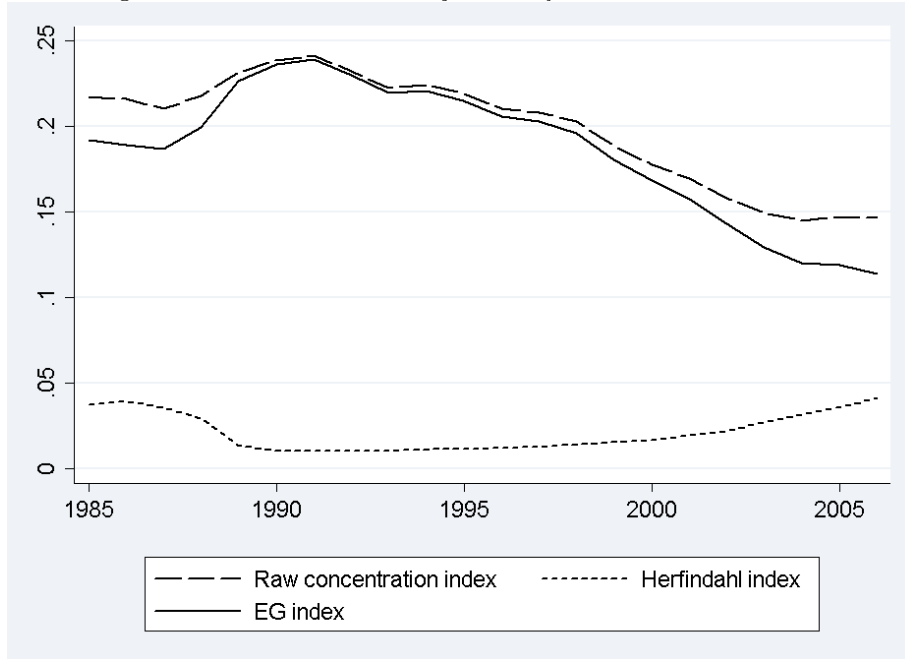
the main empirical findings in line with the results of other country-specific studies on the EG? In this section, we pool the 191 industries to different industry groups. Manufacturing industries were pooled according to the intensities of the four factors: relevance of marketing activities, labour costs, capital costs and the application and development of technologies. The personal and business service industries were each subdivided with respect to the relevance of qualified human capital in non- and human capital-intensive categories (cf. Peneder, 2002; Alecke/Untiedt, 2008). Table A.1 depicts for all industries that have undergone changes over the observation period the average annual value of the EG, the average number of years with a significant EG value and the absolute difference between the EG values of 1985 and 2006. The industries marked either with an ++ or – exhibit a distinctly low/high level of geographic concentration or a strong growth/decline of the EG. The marketing-intensive industries enclose a lot of weakly concentrated industries, namely the production of food and beverages and the manufacturing of different kinds of consumer products. These industries may rely on a more decentralized locational structure of production capacities due to the perishableness of a great range of their products and in order to avoid high transport costs. The highly concentrated industries among the marketing-intensive industries are building and repairing ships and boats and processing and preserving of fish and fish products. These industries rely on site-specific advantages: the access to the sea and to ports. Anyhow, there are also strong concentrated industries amongst the marketing-intensive industries. These are traditional and old-fashioned industries such as the manufacture of footwear, die manufacture of cutlery, tools and general hardware, manufacture of knitted and crocheted fabrics, the manufacture of watches and clocks, manufacture of games and toys and the reproduction of

recorded media. All of these industries experienced a slight or a strong decline of geographical concentration and have a statistically significant EG value almost in every year of the observation period. This result points to stable spatial patterns of industry-specific activities, although some of these industries are in the last stage of their life cycle.

Most of the labour-intensive industries are nowadays industries with small numbers of employees and firms because they have experienced a long-term decline during the past decades. Therefore, it should be noted that the entry or exit of firms in such industries which consists only of a small set of firms might shape significantly the values of the EG. Another cause for varying EG values may be the loss of geographical raw concentration within an industry. The declining process in labour-intensive industries brought about a new global organization of production. Highly specialised production units and also the distribution, logistics, R&D activities and the administration remained in Germany whereas labour-intensive parts of these industries are located abroad. For instance, this holds for textile and textile related industries and for the aforementioned shoe industry. Compared to the other groups of manufacturing industries most of the labour-intensive industries exhibit in almost all years of observation a significant EG value. This result hints to persistent and outlasting spatial patterns. The manufacture of jewellery and related articles, textile weaving, manufacture of ceramics goods and products, forging, pressing, stamping and roll forming of metal, manufacture of veneer sheets, dressing and dyeing of fur are distinctly concentrated highly in space. Although a set of labour-intensive industries has undergone a decline of the EG, these industries exhibit still a high degree of geographical concentration at the end of the observation period. In other words, their spatial patterns are strongly concentrated albeit a dynamic process of deconcentration. For instance, this fact holds for the manufacture of jewellery (figure 4): The value of the EG decreased since the beginning of the 1990s mainly due to a strong decline of the raw concentration index. The degree of firm concentration (Herfindahl Index) increased not evidently until the end of the observation period. This divergent developments are observed also in other labour-intensive industries (e.g. manufacture of ceramics goods and products). One may conclude that the employment in industrial agglomerations of the jewellery industry shrank slower than in the outer regions. There is apparently a tight relationship between the decline and dying process of old-fashioned industries and the persistence of historically established and agglomerated spatial patterns of their economic activities.

Capital-intensive industries: The machinery industry, the recycling industry, the publishing industry, and the manufacture of surgical and medical instruments exhibit dispersed spatial patterns of economic activity. The last named industry experienced a notable increase in geographical concentration. The same holds for the manufacture of electric motors, generators and transformers and for processing of iron and steel. The manufacture of basic iron and steel and of ferro-alloys, manufacture of ceramic tiles and flags,

Figure 4: Manufacture of jewellery and related articles



manufacture of prepared animal feeds and the manufacture of weapons and ammunition have, on average, also high EG values. The manufacture of coke oven products is an old capital-intensive and resource-bound industry which depicts, on average, the highest EG value among all 191 industries. The EG value of this industry dropped down dramatically to a value less than zero during the last years of the observation period (figure 5). This fall is caused by a strong decline of raw geographic concentration and an evident increase of firm concentration. This particular decline of this highly subsidized industry is related to political decisions in Germany. The government plans to close down finally the coal & mining sector in 2018. A similar pattern is to be observed in the manufacture of weapons and ammunition (figure 6). The EG value declined especially in the 1990s because of a loss of raw geographic concentration.

The studies of Alecke et al. (2006) and of Alecke/Untiedt (2008) examined industry-specific concentration based upon the EG in Germany for the year 1998 (see section 3). This work revealed that technology-intensive industries are not clustered at all. It is an outstanding result of our analysis that this evidence holds also true at long sight. Most of the technology-intensive industries exhibit only a weakly concentrated spatial pattern of their economic activities from 1985 to 2006. Note, only two out of 13 technology-intensive industries - manufacture of aircraft and spacecraft, manufacture of refined petroleum products - have an annual average EG which is explicitly above the averaged EG over all industries. The EG values of these two industries are statistically significant throughout the whole observation period. These stable spatial patterns are on the one hand due to the requirement of the manufacture of refined petroleum products to be located near to ports. On the other hand, the air- and spacecraft industry in Germany is made up mainly

Figure 5: Manufacture of coke oven products

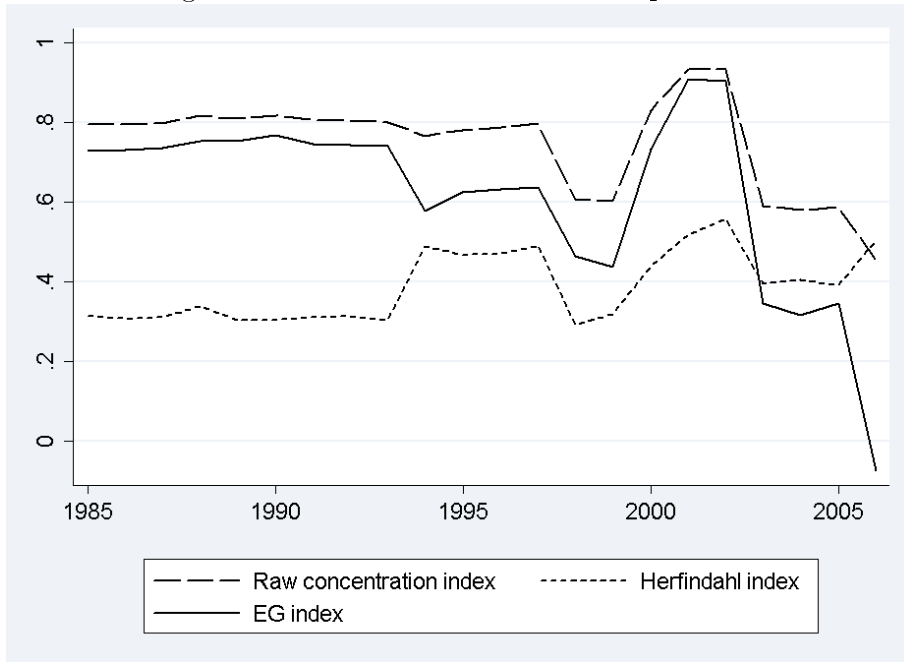


Figure 6: Manufacture of weapons and ammunition

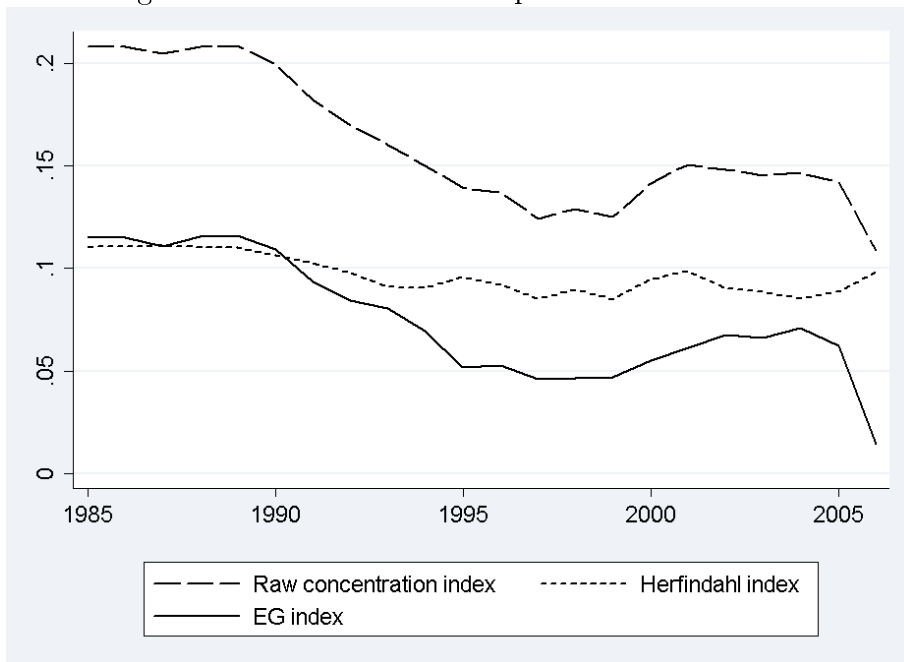
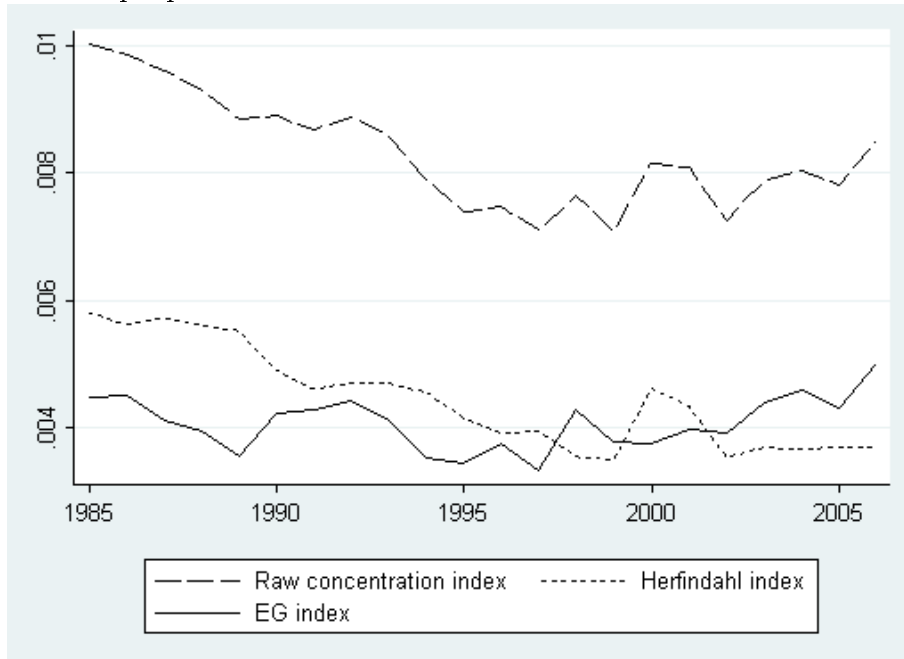


Figure 7: Manufacture instruments and appliances for measuring, checking, testing, navigating and other purposes

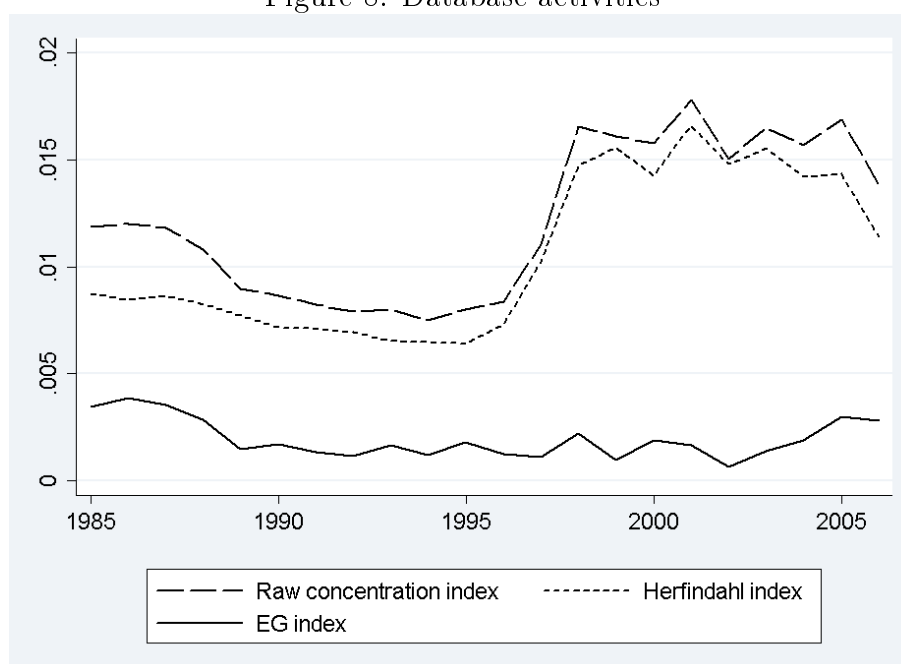


by a small set of large firms which are concentrated only in a few locations.

Aside from the low level of spatial concentration, the EG values of a major part of the technology-intensive industries increased strongly over time. This result may suggest, that a more spatially concentrated regional pattern still emerges and evolves in these industries. Barrios et al. (2005) presume that the low level of spatial concentration in technology-intensive industries is to be seen as a result of technological progress which is made up by successive generations of technologies which develop in different regions and then these generations overlap to a certain extent. In addition, these outcomes might suggest that the role of knowledge-spillovers as central driving force for the emergence and evolution of technology-intensive industrial agglomerations is overestimated by theoretical approaches (section 2). Another reason might be a lacking coverage of new technologies by the industrial classification system. For instance, this holds especially true for new cross-sectional technologies such as bio-, nano- and medical technologies and optoelectronics.

There are only two out of 26 personal service industries, namely news agency activities and motion picture and video activities, which are highly concentrated in space. In contrast, a vast range of personal service industries is not spatially concentrated at all. The values of the EG amount to zero or are less than zero in most personal services. Thus, this service sector is characterized by dispersed and decentralized spatial patterns. In addition, these spatial patterns were quite stable during the observation period. It is because the value of the EG changed only slightly in most of these industries. There are merely four personal service industries experiencing an increase of the EG which is above average. In turn, none personal service industry showed an outstanding decline of the EG.

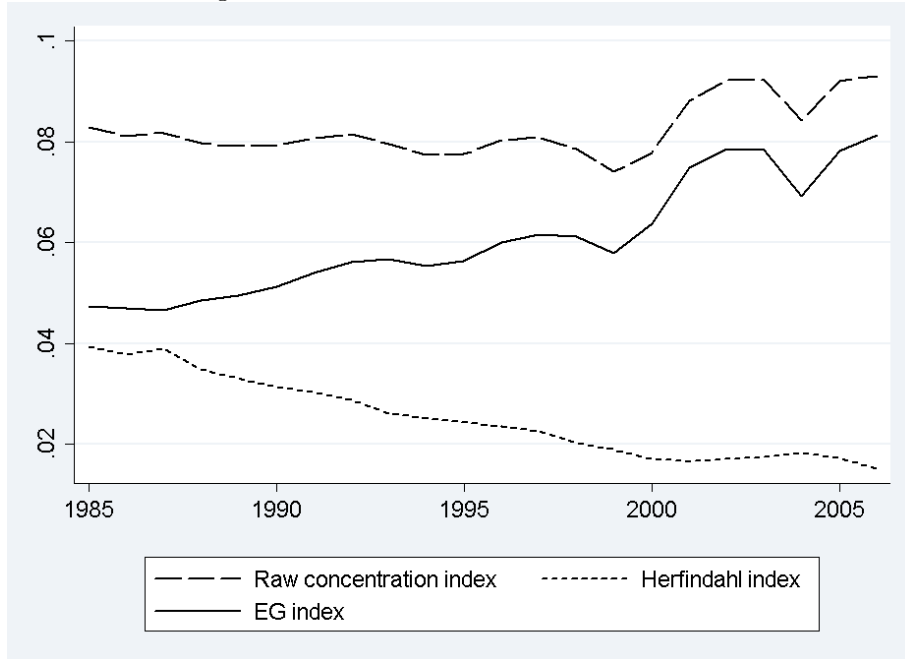
Figure 8: Database activities



These results might hint to the prevailing need of locating personal service firms close to their consumers. For instance, this applies to retail and sales activities, education, hotels and restaurants, repair activities and human health activities. These industries make up in most instances the personal service sector. In contrast, there is a larger set of business service industries showing more agglomerated geographical patterns. The following industries have a markedly larger EG value than the mean value over all industries: financial service industries, other computer related activities, research and experimental development in social sciences and humanities, industrial cleaning, other supporting transport activities, sea and scheduled air transport. The last named industry depends on site-specific factors, in the present case on the access to airports and ports. The literature on knowledge-spillovers suggests that explicitly human capital-intensive business services depend on the access to knowledge that is easier accessible in industrial agglomerations. The results show, however, that only a few human capital-intensive industries tend to agglomerate strongly in space. Note, these are four out of 18 human capital-intensive service industries. As mentioned beforehand, weakly concentrated patterns prevail in technology-intensive manufacturing industries, too. The role of knowledge-spillovers as agglomerative impact factor on locational patterns of human capital- and technology-intensive industries is, probably, not as important as theoretical approaches propose (section 3). Thus, it is presumably more realistic that agglomerative forces shape spatial industrial patterns not in one or two decades, but over several decades.

There are eight business service industries with a dynamic growth of the EG value over time, amongst them database activities and financial industries. For instance, the growth of the EG value in database processing activities since the mid of the 1990s was shaped

Figure 9: Other financial intermediation



by both the strengthening of geographical raw concentration and of firm concentration (figure 8). In contrast, the enhancement of agglomerative patterns in financial intermediation industry is mainly due to a weakening of firm concentration. Figure 9 depicts that raw geographical concentration increased not until the end of the observation period.

4.5 International comparison

Bertinelli/Decrop (2005) compared their results on industry-specific EG rankings for Belgium with those of four other countries: USA (Ellison/Glaeser, 1997), France (Maurel/Sédillot, 1999), UK (Devereux/Griffith/Simpson, 2004). We extend this comparison by the results of (Barrios et al., 2005) for Portugal and Ireland and for West Germany. The studies on the EG for Germany are not considered in this comparison because they apply the same database as our study does (see section 3). Note, this study refers to the three-digit industry level whereas the aforementioned studies analyzed the EG at the level of four-digit industries. This study, as mentioned in section 4.1, is restricted to the more aggregated level of three-digit industries due to changes of the industrial classification system. This comparison is, therefore, limited. It can be stated that in all of these studies textile and/or textile-related industries are highly concentrated in space. Taking into account Germany, this outcome can be corroborated partly because some of these industries are concentrated strongly or not. Some of the textile related industries are quite small and their EG values react sensitive when even a few firms exit or entry these industries. One outstanding result for older and more traditional manufacturing industries in Germany is that these industries tend to concentrate highly in space. This evidence is confirmed

by the studies for all six countries, too. Bertinelli/Decrop (2005) resume that a second general accordance is that industries which depend on site-specific requirements such as the access to natural resources or specific traffic infrastructure exhibit a high degree of spatial concentration. For instance, the petroleum refining industry, the ship building and transport and building, the fishing industry and aviation are mostly located near to the sea, ports or airports. In addition, industries which extract and treat raw materials rely also on natural advantages. One remarkable result is that the jewellery industry is characterized by an extraordinarily high degree of spatial concentration. These results hold also for West Germany, Portugese and Ireland. In contrast, industries with more decentralized and dispersed patterns of their economic activities are those which produce either perishable products (such as food) that require short distances for transport or those which need the spatial closeness to their consumers such as some personal service industries (hotels and restaurants, education, retail and sale activities). The last remarkable outcome of this country-specific comparison is that technology-intensive industries either cluster strongly or these industries are ranked at the lower scale of all industries. Thus, against general belief, high-tech industries do not fit to the more generalized assumption that this sector is highly concentrated due the predominance of agglomerative forces (e.g. knowledge spillovers).

5 Explaining the patterns

While the findings in the previous sections where only descriptive, it is also interesting to find out if there are systematic reasons for these developments to be found in a multivariate setting. Alecke et al. (2006) use a simple regression analysis to explain agglomeration in 116 German manufacturing industries in 1998. The present work takes up a similar approach but makes use of the large panel structure of the data at hand. Being able to observe the development of 191 industries in manufacturing and services over 22 years, we try to explore which influences led to the decline of concentration we observed previously.

Unfortunately, the structure of the data set imposes some difficulties on the selection of potential explanatory variables. Since the industrial classification WZ93 had to be estimated for observations before 1999 on establishment level, data sources that use the old classification WZ73 on industry level could not be used. Basically, this restricts the range of data sources to employment data.

The following variables are used in the multivariate analysis:

size The size of an industry is included in the regression by the number of total employment. Per construction, the EG index only takes into account total employment indirectly via the Herfindahl index. However, a small industry is more likely to concentrate than a large one due to congestion effects. Thus, we expect this variable to have a negative effect.

share_lq As noted above, old manufacturing industries have faced a particularly strong decline in geographical concentration. These industries depend heavily on low skilled labor which can easily be offshored to low-income countries. To see if this really influences concentration, we include the share of workers that have neither a higher secondary degree (Abitur), nor a vocational education.

share_hq One reason to concentrate geographically is to make use of a pool of specifically trained employees. This might be the case especially for highly qualified employees. Consequently, the share of employees with university and technical college degrees in the industries' workforces is included as well.

share_small Agglomerative forces cause internal economies of scale to become external (Scitovsky, 1954). Thus, we could expect that small establishments are more likely to concentrate geographically in order to substitute internal with external economies, since they are too small to benefit from the former. The size structure of an industry is measured as the average establishment size.¹⁰ We expect this variable to have a positive effect on the magnitude of concentration.

By construction, the EG index controls for the industrial structure. It uses the Herfindahl index to decrease the EG value if employment is concentrated in a few big establishments. However, since this incorporates the establishment size in a very nonlinear way, we still feel confident to include the share of small firms in our calculations.

share_old This variable captures the maturity of an industry. Taking a similar approach as Neffke et al. (2008), we measure maturity as the share of employees in establishments that are at least ten years old.¹¹ Older industries might be geographically concentrated due to historical reasons. As explained in section 2, agglomeration externalities might have lost their importance in these industries. Thus, we expect this variable to have a negative effect on the EG, since concentration should decline with advancing maturity. This should particularly apply to industries of the manufacturing sector.

5.1 Econometric results

We estimate a simple panel model on industry level, regressing the EG of industry i at time t on the afore mentioned control variables:

$$EG_{it} = \mathbf{x}'_{it}\boldsymbol{\beta} + \alpha_t d_t + c_i + u_{it}, \quad (2)$$

¹⁰An alternative measure would be the share of employees in establishments with less than 20 employees. Substituting this variable does not change any of the results.

¹¹We cannot identify older establishments, since the date of formation is censored at 1975.

where $\mathbf{x}_{it} = (1, size, share_lq, share_hq, share_small, share_old)'$ is the 6×1 vector of a constant and the explaining variables, d_t is a time dummy, c_i is a term that controls for time invariant unobserved heterogeneity. u_{it} is an idiosyncratic disturbance. For the ease of interpretation, the industry size is measured divided by 1000 and the average establishment size is divided by 10.

Table 5: Random-effects regression for all industries
Dependent variable: EG-Index

<i>constant</i>	-0.0045 (0.018)
<i>industry_size</i>	-0.0000 *** (0.000)
<i>share_gq</i>	0.0809 ** (0.032)
<i>share_hq</i>	0.2068 *** (0.044)
<i>est_size</i>	0.0011 ** (0.001)
<i>share_old</i>	-0.0074 (0.017)
Year-Dummies	YES***
R ²	0.09
Hausman	28.52
Breusch-Pagan	29559.87***
Groups	191
Years	22

Robust standard errors in parentheses

Levels of significance: *** 1 %, ** 5 %, * 10 %.

Table 5 shows the results of a simple panel regression for all industries. The Hausman-test does not reject the null that the results of a random effects regression differ from a regression with fixed effects. We thus assume that the industry specific effect is not correlated with the other covariates and use the efficient random effects estimator. Regarding the small R², we must admit that there is a huge part of the variation in the EG-indices that we cannot explain. However, there are still some interesting conclusions to be drawn from these results. The size of the industry has a very small but significantly negative effect. This supports the presumption that bigger industries concentrate less. The average establishment size has a positive effect. It seems like external economies are no substitutes to internal economies of scale. It is rather very plausible that larger establishment also provide larger agglomeration externalities and make other establishments seek their proximity. The share of low qualified workers has a positive effect on the EG. This should be due to declining old manufacturing industries which reduced or offshored their domestic low skilled employment. The share of highly qualified employees shows the expected

Table 6: Separate random-effects regressions for industry groups
 Dependent variable: EG-Index

Variable	Technology intensive	Manufacturing	Services
<i>constant</i>	-0.0330 (0.039)	-0.1083 *** (0.042)	0.0591 *** (0.014)
<i>industry_size</i>	0.0001 (0.000)	-0.0002 *** (0.000)	0.0000 (0.000)
<i>share_gq</i>	-0.0882 (0.075)	0.2467 *** (0.058)	-0.1684 *** (0.049)
<i>share_hq</i>	0.2316 *** (0.066)	0.5394 *** (0.095)	0.0731 * (0.044)
<i>est_size</i>	-0.0007 * (0.000)	0.0010 * (0.001)	0.0022 *** (0.001)
<i>share_old</i>	0.0352 (0.027)	0.0425 (0.030)	-0.0380 *** (0.013)
year-dummies	YES***	YES***	YES***
R ²	0.14	0.15	0.14
Hausman	32.95	25.56	12.03
Breusch-Pagan	2886.27***	14252.43***	13817.7
Groups	37	103	79
Years	22	22	22

Robust standard errors in parentheses

Levels of significance: *** 1%, ** 5%, * 10%.

positive sign as well. Finally, there is no evidence that industries that consist of many old establishments concentrate differently.

Since the 191 observed industries form a very heterogenous population where many different mechanisms were at work, it is quite likely that some effects stayed hidden. To gain further insight on the different dynamics that took place over this period of 22 years, the same regression is carried out separately for three different groups. The first consists of both manufacturing and service industries that are technology intensive according to the classifications of Peneder (2002). The second and third group are the manufacturing and service sectors, respectively.¹² Table 6 shows the respective results. Again, the Hausman-tests do not reject the null and thus the efficient random effects estimator is used on each model. Here, the heterogeneity of effects allows for some interesting insights. The previously found negative effect of industry size can only be found for manufacturing industries. In services and technology driven industries, congestion effects do not seem to reduce concentration. The share of low qualified employees is particularly interesting since it displays the highest variation between groups. It has no influence on concentration in technology driven industries. This is not surprising since these rely the least on low skilled work. In manufacturing, this effect is quite strong. This should be due to old, physical labor intensive industries that are either still concentrated or display a decline in concentration. In services, the effect is negative. Supposedly, service industries that employ low skilled work are those who produce non tradeable services like sales, restaurants or hotels, which are dispersed by necessity. For all three groups, the effect of the share of highly qualified employees is positive. This presents strong evidence for the importance of labor pooling and/or knowledge spillovers. Establishments that depend on the access to human capital and knowledge created by others tend to co-locate with similar plants. The average establishment size has a negative influence on concentration of technology intensive industries. Considering McCann's (2001) argument that innovation mostly takes place in smaller establishments, this also emphasizes the importance of knowledge spillovers as a motivation for geographical concentration. Finally, the share of employees in establishments that are at least 10 years of age has a negative impact only in service industries. This is rather surprising since we expected that particularly older manufacturing industries tend to be concentrated due to historical reasons. Obviously, older service industries are personal services rather than business related services. The former tend to be geographically distributed according to the distribution of the population since these services are often not mobile (like retail sales). However, the age of an industry's establishments does not seem to have any effect on geographical concentration in the manufacturing sector.

¹²Note that the groups are not disjunct. Group two and three contain the industries of group one, while construction and supply of water, gas and energy are left out since they do not fit in any of the categories.

6 Conclusions

The short literature review on West Germany laid open that a set of studies, albeit relying on different methods, industrial and spatial scales, provide concurrent and not fuzzy evidence on deconcentration of economic activity in Germany, except for the study of Südekum (2006). Our analysis of the development of the EG at different spatial and industrial scales for West Germany confirms this outcome. We found evidence for a long-term trend of slight spatial deconcentration over all industries in West Germany from 1985 to 2006. Although, this result is more pronounced at more disaggregated spatial and industrial levels. In turn, one may conclude that deagglomerative forces prevail slightly as driving motor for spatial dynamics in West Germany. In addition, most of the industries are stronger geographically concentrated than purely random distributions of firms during this observation period. Thus, the spatial concentration of economic activity really matters! Compared to less-developed countries the level of the EG is lower, on average. This difference may be due to a more decentralized pattern of settlement and infrastructure in West Germany than in less-developed countries. The analysis of the detailed patterns showed great heterogeneity of the dynamics of geographic concentration among industries over time. This outcome confirms the diverging impacts of agglomerative and deagglomerative forces operating at the industrial level. We observed a persistence of established spatial patterns particularly in old-fashioned industries, although those have undergone structural crisis and decline. More concentrated patterns developed, in particular, in technology-intensive manufacturing industries and in human-capital-intensive business services. However, these industries are not as strong concentrated as one would have expected according to theoretical work. The group of personal service industries exhibits in most cases stable and more dispersed patterns of economic activity. Besides, a great range of single industries situated in the manufacturing or service sector experienced a weakening or strengthening of spatial concentration. We have put forward some industry-specific examples in order to shed light even on the varying developments of geographical raw concentration and firm concentration which make up the EG-Index. Accounting for this vast diversity of possible geographic dynamics at the industry level between the two poles concentration and deconcentration, one may pose the question whether it is empirically correct to consider overall trends of spatial dynamics at all. The international comparison of several industry-specific rankings of the EG-Index revealed a range of concurrent results. In particular, old-fashioned manufacturing industries as well as industries bound to site-specific requirements are highly concentrated in space. The contrary holds for personal service industries and those which produce perishable products. A unique example for a high degree of industrial agglomeration seems to be the manufacture of jewellery. This phenomenon may be due to dense and close social networks which are crucial for the ‘functioning’ of this industry within and between the

jewellery agglomerations worldwide. Technology-intensive industries are either strongly or weakly concentrated in space. One may state that this cross-country evidence of industrial rankings of the EG is not as fuzzy as the diverging country-specific outcomes of dynamics of spatial concentration. In a brief econometric analysis, we tried to examine some of the explanations for these developments. We could only include a limited set of industry-specific variables because of a change of the industrial classification system. A range of interesting variables which might contribute to explain the dynamics of geographic concentration could, therefore, not be enclosed in this analysis. Industry size, average firm size as well as the shares of low and high qualified employees affected distinctly the changes of industrial agglomeration in West Germany whereas the share of old firms did not show an evident impact. Again, we could confirm that the effects of these determinants were heterogeneous between different sectors. Apart from these industry-specific factors, there are overall factors which might have affected the change of spatial patterns of economic activity in West Germany, too. A set of potential factors, primarily institutional changes in the European Union and determinants of technological change, were listed in the first section of this paper. In addition, structural changes of Germany's economy and the specific features underlying the process of the reunification of its Eastern and Western part might have shaped the dynamics of geographic agglomeration in the past. In accordance with other studies (e.g. Barrios et al. 2005; Dumais, Ellison, Glaeser 2002), there remains in our analysis also a large unexplained part of the variance, and, thus, apparently a lack of knowledge about the processes which fuel spatial agglomeration and dispersion. Apart from our econometric analysis, there are further promising approaches in order to gain more insights into the forces underlying spatial dynamics of economic activity. Changes in the geographic concentration may be caused by job creation and job destruction in new firms and continuing plants, respectively. Barrios et al. (2005) give evidence that the weakening of geographic concentration in Portuguese and Ireland is fostered by new plants which tend to be located outside of the industrial agglomerations, and this, conversely, strengthens spatial deconcentration. Thus, a further challenge is, therefore, the exploration of the relationship between the plant life cycle and spatial concentration by deconstructing the Ellison-Glaeser-Index into the components of job construction and destruction. In addition, long-term analysis on the dynamics of geographic concentration for distinct industries may contribute to lessen the knowledge gap on this issue. This seems to be of peculiar interest for technology-intensive manufacturing industries and business services. The spatial distribution of these industries is expected to be strongly affected by knowledge-spillovers, although these industries exhibit mostly a low degree of spatial agglomeration.

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Appendix

Table A.1: Descriptive statistics of the EG Index (1985-2006) for three-digit-industries and labour market regions

Industry groups	Mean EG index (1985-2006)	Low/High level of concentration	Number of years with significant EG index	Absolute difference $EG_{2006} - EG_{1985}$	Strong decline/growth of EG index
Labour-intensive manufacturing industries					
275 Casting of metals	0.034	++	22	-0.002	0
183 Dressing and dyeing of fur; manufacture of articles of fur	0.006	0	9	-0.060	-
284 Forging, pressing, stamping and roll forming of metal; powder metallurgy	0.049	++	22	-0.042	-
342 Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers	0.001	-	3	0.009	++
264 Manufacture of bricks, tiles and construction products, in baked clay	0.008	0	22	0.005	++
362 Manufacture of jewellery and related articles	0.186	++	22	-0.077	-
181 Manufacture of leather clothes	-0.002	-	9	-0.058	-
262 Manufacture of non-refractory ceramic goods other than for construction purposes	0.072	++	22	-0.043	-
202 Manufacture of veneer sheets; manufacture of plywood, and other panels and boards	0.056	++	22	-0.012	0
204 Manufacture of wooden containers	0.001	-	0	0.002	0
172 Textile weaving	0.051	++	22	0.004	0
Marketing-intensive manufacturing industries					
351 Building and repairing of ships and boats	0.056	++	22	-0.007	0
212 Manufacture of articles of paper and paperboard	0.004	-	22	0.000	0
159 Manufacture of beverages	0.001	-	3	-0.001	0
286 Manufacture of cutlery, tools and general hardware	0.050	++	22	-0.026	0
155 Manufacture of dairy products	0.013	0	22	0.006	++
316 Manufacture of electrical equipment n.e.c.	-0.002	-	0	0.010	++
193 Manufacture of footwear	0.078	++	19	-0.128	-
365 Manufacture of games and toys	0.047	++	22	-0.019	0
313 Manufacture of insulated wire and cable	0.004	-	7	0.019	++
177 Manufacture of knitted and crocheted articles	-0.019	-	1	-0.109	-
176 Manufacture of knitted and crocheted fabrics	0.097	++	22	-0.062	-
192 Manufacture of luggage, handbags and the like, saddlery and harness	0.050	++	22	-0.066	-
158 Manufacture of other food products	0.001	-	21	0.000	0
268 Manufacture of other non-metallic mineral products	-0.003	-	0	-0.004	0
175 Manufacture of other textiles	0.019	0	22	-0.007	0
355 Manufacture of other transport equipment n.e.c.	-0.008	-	0	0.015	++
252 Manufacture of plastic products	0.005	0	22	0.005	++
364 Manufacture of sports goods	0.003	-	0	-0.017	0
283 Manufacture of steam generators, except central heating hot water boilers	0.017	0	2	-0.068	-

Table A.1: (continued)

160	Manufacture of tobacco product	-0.016	-	0	-0.043	-
272	Manufacture of tubes	0.026	0	19	-0.017	0
335	Manufacture of watches and clocks	0.187	++	22	-0.170	-
222	Printing and service activities related to printing	0.001	-	14	-0.002	0
152	Processing and preserving of fish and fish products	0.230	++	22	-0.006	0
153	Processing and preserving of fruit and vegetables	0.003	-	0	-0.003	0
372	Recycling of non-metal waste and scrap	0.003	-	13	-0.004	0
223	Reproduction of recorded media	0.112	++	12	-0.394	-
191	Tanning and dressing of leather	0.026	0	11	-0.058	-
Capital-intensive manufacturing industries						
271	Manufacture of basic iron and steel and of ferro-alloys (ECSC1)	0.041	++	22	-0.023	0
263	Manufacture of ceramic tiles and flags	0.067	++	13	-0.028	0
231	Manufacture of coke oven products	0.617	++	21	-0.802	-
311	Manufacture of electric motors, generators and transformers	0.008	0	0	0.017	++
331	Manufacture of medical and surgical equipment and orthopaedic appliances	-0.008	-	9	0.030	++
292	Manufacture of other general purpose machinery	0.003	-	22	0.001	0
295	Manufacture of other special purpose machinery	0.004	-	22	-0.001	0
157	Manufacture of prepared animal feeds	0.053	++	22	-0.025	0
296	Manufacture of weapons and ammunition	0.075	++	21	-0.100	-
273	Other first processing of iron and steel and production of non-ECSC1 ferro-alloys	0.022	0	22	0.010	++
221	Publishing	0.004	-	19	0.000	0
371	Recycling of metal waste and scrap	-0.002	-	0	-0.005	0
Technology-intensive manufacturing industries						
353	Manufacture of aircraft and spacecraft	0.054	++	22	-0.029	0
241	Manufacture of basic chemicals	-0.006	-	0	-0.002	0
333	Manufacture of industrial process control equipment	-0.002	-	0	0.038	++
332	Manufacture of instruments and appliances for measuring, checking, testing, etc.	0.004	-	22	0.001	0
247	Manufacture of man-made fibres	-0.009	-	0	-0.013	0
341	Manufacture of motor vehicles	-0.005	-	0	0.010	++
300	Manufacture of office machinery and computers	0.014	0	8	0.026	++
334	Manufacture of optical instruments and photographic equipment	0.026	0	22	0.007	++
242	Manufacture of pesticides and other agro-chemical products	-0.103	-	0	0.012	++
244	Manufacture of pharmaceuticals, medicinal chemicals and botanical products	-0.003	-	0	-0.005	0
232	Manufacture of refined petroleum products	0.066	++	22	0.008	++
322	Manufacture of television and radio transmitters and apparatus for line telephony	-0.005	-	0	0.011	++

Table A.1: (continued)

233	Processing of nuclear fuel	-0.140	-	0	0.036	++
Human capital-intensive business services						
671	Activities auxiliary to financial intermediation, except insurance and pension funding	0.187	++	22	-0.012	0
672	Activities auxiliary to insurance and pension funding	0.002	-	19	-0.003	0
744	Advertising	0.011	0	14	-0.066	-
742	Architectural and engineering activities and related technical consultancy	0.003	-	22	-0.002	0
723	Data processing	0.002	-	1	-0.001	0
724	Database activities	-0.078	-	1	0.297	++
721	Hardware consultancy	0.030	0	20	-0.044	-
741	Legal, accounting, book-keeping and auditing activities; tax consultancy; etc.	0.004	-	22	0.002	0
725	Maintenance and repair of office, accounting and computing machinery	0.036	0	14	-0.035	-
651	Monetary intermediation	0.003	-	22	0.003	0
726	Other computer related activities	0.067	++	12	-0.032	0
652	Other financial intermediation	0.061	++	22	0.034	++
701	Real estate activities with own property	0.002	-	5	-0.003	0
731	Research and experimental development an natural sciences and engineering	0.004	-	1	0.009	++
732	Research and experimental development an social sciences and humanities	0.058	++	22	-0.023	0
743	Technical testing and analysis	0.002	-	12	0.006	++
603	Transport via pipelines	-0.010	-	0	-0.006	0
516	Wholesale of machinery, equipment and supplies	0.004	-	20	0.003	0
Non human capital-intensive business services						
634	Activities of other transport agencies	0.002	-	22	-0.003	0
555	Canteens and catering	-0.003	-	0	0.013	++
747	Industrial cleaning	-0.001	-	14	-0.007	0
612	Inland water transport	0.063	++	22	-0.059	-
746	Investigation and security activities	0.004	-	15	0.011	++
745	Labour recruitment and provision of personnel	0.004	-	20	-0.012	0
602	Other land transport	0.000	-	0	0.000	0
632	Other supporting transport activities	0.131	++	22	-0.049	-
517	Other wholesale	0.046	++	22	-0.052	-
641	Post and courier activities	-0.006	-	0	-0.004	0
711	Renting of automobiles	0.019	0	21	-0.039	-
713	Renting of other machinery and equipment	0.004	-	13	-0.003	0
621	Scheduled air transport	0.027	0	11	0.010	++
611	Sea and coastal water transport	0.268	++	22	-0.059	-

Table A.1: (continued)

642	Telecommunications	-0.001	-	5	0.017	++
601	Transport via railways	0.001	-	0	-0.001	0
515	Wholesale of non-agricultural intermediate products, waste and scrap	0.003	-	22	-0.002	0
Human capital-intensive personal services						
804	Adult and other education	0.001	-	7	0.000	0
803	Higher education	-0.024	-	0	-0.019	0
851	Human health activities	0.000	-	0	0.000	0
925	Library, archives, museums and other cultural activities	-0.003	-	0	0.003	0
924	News agency activities	0.040	++	22	-0.026	0
923	Other entertainment activities	-0.004	-	0	0.002	0
801	Primary education	0.000	-	14	-0.002	0
922	Radio and television activities	0.015	0	6	0.020	++
523	Retail sale of pharmaceutical and medical goods, cosmetic and toilet articles	0.000	-	2	0.000	0
802	Secondary education	0.000	-	0	-0.002	0
852	Veterinary activities	0.000	-	0	-0.001	0
Non human capital-intensive personal services						
551	Hotels	0.004	-	22	-0.004	0
502	Maintenance and repair of motor vehicles	0.002	-	22	-0.001	0
921	Motion picture and video activities	0.086	++	22	0.005	++
927	Other recreational activities	0.002	-	14	0.002	0
524	Other retail sale of new goods in specialized stores	0.000	-	22	0.000	0
930	Other service activities	0.001	-	18	-0.001	0
527	Repair of personal and household goods	0.003	-	22	-0.003	0
553	Restaurants	0.002	-	22	-0.001	0
521	Retail sale in non-specialized stores	0.000	-	0	0.000	0
526	Retail sale not in stores	-0.001	-	0	-0.011	0
505	Retail sale of automotive fuel	0.001	-	14	-0.004	0
525	Retail sale of second-hand goods in stores	0.010	0	16	0.011	++
501	Sale of motor vehicles	0.004	-	22	-0.004	0
504	Sale, maintenance and repair of motorcycles and related parts and accessories	-0.006	-	0	0.007	++
926	Sporting activities	0.001	-	14	-0.003	0