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Assessing the Localization Pattern of German Manufacturing & Service Industries - A Distance Based Approach*

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Abstract

This paper assesses the agglomeration pattern of four-digit industries in Germany using a rich data set on the population of German firms. To identify geographical agglomeration, we follow the distance based approach of Duranton and Overman (2005) and find that the location pattern of 78% of our industries departs from randomness in the sense that firms exhibit significant geographical localization. In line with previous studies on manufacturing firms in the UK and France, our analysis suggests that especially traditional manufacturing industries exhibit strong localization patterns. Moreover, we find that geographical localization is not restricted to the manufacturing sector but that it plays an equally, or even more important role in service industries.

Keywords: Geographic concentration, agglomeration

JEL Classification: R12

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1 Introduction

More than a hundred years ago Marshall (1890) pointed out the stylized fact that some industries tend to geographically cluster whereas others do not. However, for the century to come a rigorous empirical tests of industry agglomeration in space turned out to be impossible due to a lack of appropriate data. The few studies that addressed the problem were refined to a comparison of the industry structure of large geographic units like countries or regions and could thus provide a rough insight into agglomeration patterns at most.[1] It has just been in recent years that access to micro-geographic data sets has become available in several countries which allow researchers to assign firm activity to smaller geographical units like municipalities or postcode areas and thus to determine (more) precise agglomeration patterns in space.

The first influential approach to test for industrial localization in space using micro-geographic data was developed by Ellison and Glaeser (1997) (in the following abbreviated with EG). They construct an index for industrial agglomeration which is based on the idea to compare the concentration of industries in a jurisdictional unit to the jurisdiction's overall firm activity while at the same time controlling for the industry's plant size distribution. If an industry tends to cluster over and above general agglomeration tendencies in a geographical area, it is defined to be localized. Although the EG approach obtains several advantages,[2] it has nevertheless been criticized in the literature on the grounds that it relies on the unrealistic assumption that geographical agglomeration ends at the jurisdictional border which makes the results sensitive to the spatial aggregation of the geographical units used for the calculation. This problem has been addressed in a recent contribution by Duranton and Overman (2005) (in the following abbreviated with DO) who calculate industrial agglomeration patterns based on bilateral firm distances in an industry and determine whether the industry's location pattern significantly deviates from randomness. Consequently, they avoid the jurisdictional border issue faced by the EG methodology.

In this paper, we employ the DO approach to identify localized four-digit industries in the manufacturing and service sector in Germany based on a unique data set on the population of German plants. Our findings suggest that 78 % of the industries show

[1] For an overview for the European Union see Combes and Overman (2004).

[2] Advantages of the Ellison and Glaeser (1997) that have been noted in the literature are: a) it is comparable across sectors, b)it controls for the overall concentration of economic activity and c) it accounts for the industry's plant size distribution (see e.g. DO).

a geographical concentration in space that deviates from randomness. This fraction is somewhat larger than the one reported in previous studies for the UK and France (DO and Maurel and Sedillot (1999)). In line with these previous papers, we find especially traditional manufacturing industries like e.g. textile production to be strongly localized which is consistent with Marshall's predictions on the sources of agglomeration that should be invariant to country characteristics.[3] Note, however, that the study also suggests some important differences between industry agglomeration in Germany and other countries. For example the metal industry seems to exhibits especially strong localization patters within German borders. As many of the traditional localized industries in our study belonged to the drivers of the industrialization process during the 19th century and the production pattern of the German economy has changed enormously since then, our study equally suggests that agglomeration patterns are quite persistent over time. Moreover, the analysis indicates that localization occurs at shorter distances and that localized industries hold an overproportional share in employment.

A second contribution of our paper is that we do not follow DO in restricting the analysis to manufacturing industries. In the contrary, our aim is to present a comprehensive picture of the location pattern of four-digit industries in Germany and thus, we equally include service industries into the analysis. Interestingly, we find that the majority of service industries included in our analysis show spatial agglomeration whereas especially financial administration and the entertainment industry show strong localization patterns. Thus, our analysis indicates that agglomeration tendencies are not unique to manufacturing firms but are equally, or even more pronounced in the service sector.

Last, we complement our paper by rerunning the analysis based on the EG methodology and find a slightly larger percentage of industries to be localized, namely 86 %. This reflects that the EG methodology is in general less rigorous in declaring an industry to be agglomerated than the DO approach as it is not based on statistical departure from randomness. Moreover, we also show that the EG index is not invariant to the geographical unit of observation which is used for its calculation but that it strongly increases in the aggregation level of the observation units employed. For example, some of our industries exhibit a negative EG index indicating a dispersed location pattern if the index is calculated

[3]Marshall (1890) identifies three potential sources for geographical agglomeration: saving on transport costs through input sharing, labor market pooling effects and technological spillovers of which all three are expected to be largely independent from country-specific characteristics. Moreover, large local labor markets offer further productivity advantages additional to labor pooling effects e.g. improved matching between workers and firms (see e.g. Helsley and Strange (1990) and Duranton and Puga (2004)).

at a disaggregated level and at the same time show a strong positive EG index indicating agglomeration if the index is calculated at more aggregated levels. This sensitivity makes results obtained with the EG methodology difficult to interpret and thus, we consider the distance-based DO-approach to be the superior measure which derives more reliable results.

Our paper adds to a small set of existing studies which determine industry agglomeration on the basis of micro-data. In recent years a small number of studies has applied the EG approach to determine agglomeration patterns of manufacturing industries in the US, UK and France (Ellison and Glaeser (1997), Maurel and Sedillot (1999), Dumais et al. (2002), Devereux et al. (2004)). The paper most closely related to ours is Alecke et al. (2006) who employ the EG methodology on three-digit industry data for German counties to identify agglomeration patterns for the manufacturing industry in Germany. As pointed out above, the EG approach is, however, very sensitive to spatial aggregation which makes the results difficult to interpret.

The number of studies which resolve these problems and apply the more sophisticated DO approach to determine the agglomeration in manufacturing industries is tiny however and restricted to the countries of UK and France (see DO and Barlet et al. (2008)). Our paper complements the literature here as we find that many traditional manufacturing industries which show localization patterns in the UK and France are also localized in Germany. Moreover, in the contrary to DO, we do not restrict our analysis to manufacturing industries, but equally include the service sector into the analysis which we find to be strongly characterized by geographical localization.[4]

The paper is organized as follows. Section 2 describes the data set and presents basic summary statistics. In Sections 3 and 4, we summarize the DO methodology and present our results. Section 5 reruns the analysis applying the EG methodology and Section 6 concludes.

[4]Despite the continuously rising importance of industries in the tertiary sector, only a small number has looked into the agglomeration of service industries so far. Except for a few contributions by Barlet et al. (2008), Kolko (2009) and Alecke and Untiedt (2006), where the latter two analyses are based on the discrete EG index, the location pattern of service industries has remained rather unexplored.

2 Data

Our analysis draws on a data set for the population of German firms provided by the German Employment Agency ("Bundesagentur für Arbeit") for the year 1999. The data includes information on every plant in Germany that employs at least one worker who is subject to compulsory social security contributions[5] and provides information on the number of employees, the four-digit industry code and the host municipality. In total, the data set comprises 2,139,383 plants whereas we drop 6,902 observations due to a missing industry code.

In contrast to previous studies on geographical localization that are restricted to the manufacturing sector we include both, service and manufacturing industries in our analysis. However, as the DO methodology is demanding in terms of computation time and server capacity, we limit the calculation of the DO index to the year 1999 and drop industries which are highly unlikely to show agglomeration patterns like public libraries or activities of membership organizations. Furthermore, we disregard retail and most wholesale industries as these commonly comprise a large number of plants which convexly increases the computation time for the DO methodology. The sample for our baseline analysis then comprises 981,997 plants and 337 four-digit industries (of which 254 belong to manufacturing and 83 belong to service industries[6]) with a total of 15,280,213 employees located in 11,677 municipalities (see Table 1).

Table 1. Descriptive Statistics

Number of plants	981,997
Number of four-digit industries	337
Number of employees	15,280,213
Average number of employment per plant	16
Number of municipalities	11,677

Moreover, Table 2 indicates that the size distribution of plants in our data is skewed toward small establishments as 28 % of firms observe 1 employee only, 50 % employ between 2 and 10 workers, 17 % between 11 and 50 workers and only 5 % of the plants observe more than 50 employees. Moreover, the distribution of firms across industries shows that the number of firms which operate within one four-digit industry varies strongly between

[5]Not subject to social security contributions are civil servants, self-employed workers and workers with minor jobs below an earnings threshold of about 400 Euros.

[6]The term service industry refers to industries that create an intangible object.

10 and 56,535 firms whereas the median industry consist of 485 plants (see Table 3).

Table 2. Plant Size Distribution (DO index)

No. of employees per plant	*No. of plants*	*in % of total firm number*
1	278,223	28
2-10	492,732	50
11-50	164,498	17
>50	46,544	5
$\sum$	981,997	100

Table 3. Industry Size Distribution

No. of plants per industry	*No. of industries*	*in % of total industry number*
10-199	111	33
200-499	61	18
500-999	49	15
1000-4999	74	22
>5000	42	12
$\sum$	337	100

Last, to apply the DO methodology, we have to determine the bilateral distances between the plants in our sample. For this purpose we add Gauss-Krueger coordinates for each municipality in our sample and assign the respective coordinates to all firms located within the municipality's borders. Consequently, firms located within the same municipality observe a bilateral distance of zero. As German municipalities comprise a rather small geographic territory, we presume that this approach delivers sufficiently precise distance measures for the firms in our data set. The median of the bilateral distance between all plants in our data is determined with 312 kilometers whereas it varies between a minimum of 0 kilometers and a maximum of 888 kilometers.

3 Estimation Methodology

As indicated above, we follow the methodology proposed by DO to identify localized industries in Germany. In the following, we will shortly sketch the underlying rationale of the DO approach. The general idea of the approach is to determine the distribution of bilateral distances between the firms in an industry and to compare this distribution to a randomly drawn set of bilateral distances. An industry is defined to be significantly localized or dispersed respectively if its distribution of bilateral distances significantly deviates

from the simulated random draws.

3.1 Step 1: Calculation of Kernel Density Estimate

In a first step, we calculate the bilateral distance between all establishments in an industry $m = 1, .., M$. We define $d_{i,j}$ as the distance between plant i and j of industry m and estimate the density of the bilateral distances $\hat{K}_m(d)$ at any point (distance) d with[7]

$$\hat{K}_m(d) = \frac{1}{n(n-1)h} \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} f\left(\frac{d - d_{i,j}}{h}\right) \tag{1}$$

where n is the number of plants in the industry, f is the Gaussian kernel function with bandwidth (smoothing parameter) h.

3.2 Step 2: Constructing Counterfactuals

The goal of the analysis is to identify whether the location pattern of a considered industry departs significantly from randomness. To do so, we calculate counterfactual kernel density estimates for each industry m which are then compared to the actual kernel density determined in (1). The counterfactual industry $\tilde{m}$ is created as follows: (i) From the overall sample which comprises all plants located within Germany, we randomly draw as many plants as the industry under scrutiny has.[8] Two comments are in order. First, we sample from the overall population of existing plants to control for the overall tendency of economic activity to agglomerate. Put differently, we do not assume economic activity to be uniformly distributed but account for the overall pattern of firm activity in Germany. Second, each hypothetical industry needs to consist of the same number of plants as the industry under scrutiny in order to control for industrial concentration. (ii) We then calculate the bilateral distances of this hypothetical industry $\tilde{m}$ and estimate the kernel density

[7] See Silverman (1986) for details concerning the choice of the kernel function.

[8] Hence, the underlying assumption being that each location occupied by a plant of some industry is also a potential location for plants of other industries. Our approach slightly deviates from DO as the construction of our counterfactuals is based on locations of manufacturing and service industries in Germany (as both, the manufacturing and the service sector are included in our analysis) whereas DO account for the location of manufacturing firms only when constructing their counterfactuals (as their whole analysis accounts for the manufacturing sector only). Thus, we compare the location pattern of an industry to the the location pattern of all other industries, i.e. to the location pattern of economic activity in general, and not only to the location pattern of the manufacturing sector.

of the bilateral distances $\tilde{K}_{\tilde{m}}^{s}(d)$ according to (1).

We repeat (i) and (ii) a thousand times such that the simulation provides us with 1000 counterfactual samples for each industry m and consequently 1000 counterfactual estimates for kernel densities of the bilateral distances $\tilde{K}_{\tilde{m}}^{s}(d)$.

3.3 Step 3: Global Confidence Bands

In the next step, we compare the actual kernel density estimates to the simulated counterfactuals. In order to make a statement about the statistical departure of the localization pattern from randomness, we construct confidence bands using the simulated counterfactual distributions. Following Duranton and Overman (2005), we consider only the range of distances between zero kilometers and the median of all bilateral distances within the data, in our case distances between 0-312 km.[9] By interpolation we construct an upper and a lower global confidence band to which the actual distribution of bilateral distances will be compared to. Any deviation from randomness can then be concluded to indicate localization or dispersion. These global bands are created as follows: For each distance d we pick a $\tilde{K}_{\tilde{m}}^{s}(d)$ such that only 95 % of all randomly generated distance density functions lie above or below this band. Put differently, only 5 % of our simulated estimators hit the upper global confidence band when considered over all distances (0-312 km), the same holding for the lower band. Hence, for each d in the interval [0,312] there is a $\overline{\tilde{K}_m(d)}$ which creates an upper bound if viewed over all d. And there is a $\underline{\tilde{K}_m(d)}$ for each $d \in [0, 312]$ which creates a lower bound if viewed over all $d \in [0, 312]$.

3.4 Step 4: Identification of Localized Industries

The last step is to compare the actual estimated distribution of bilateral distance with the global confidence bands. An industry m is said to be localized if $\hat{K}_m(d) > \overline{\tilde{K}_m(d)}$ for at least one $d \in [0, 312]$, i.e. the estimated density departs from randomness for at least one distance. In contrast, an industry is said to be dispersed if $\hat{K}_m(d) < \underline{\tilde{K}_m(d)}$ *and* the industry is not localized. The localization and dispersion indices are then defined as

[9] As Duranton and Overman (2005) note a distance greater than the median distance could in principle be interpreted as dispersion. However, we capture any dispersed industry within the range 0-312km as we define an upper and a lower confidence band.

$$\Gamma_m(d) \equiv max(\hat{K}_m(d) - \overline{\tilde{K}_m(d)}, 0) \tag{2}$$

for localization and

$$\Psi_m(d) = \begin{cases} max(\underline{\tilde{K}_m(d)} - \hat{K}_m(d)) & \text{if} \quad \sum_{d=0}^{312} \Gamma_m(d) = 0, \\ 0 & \text{otherwise.} \end{cases}$$

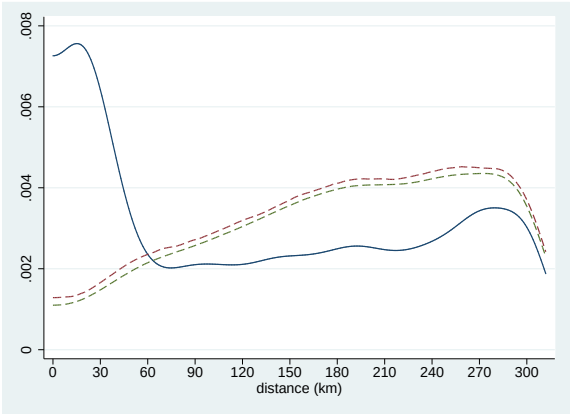
for global dispersion. Graphically this means that the estimated distribution of distances of a localized industry lies above the global confidence band for at least one distance d. An industry is identified as being dispersed if its estimated kernel density function lies below the lower confidence band for at least one distance d and never lies above the upper bound. Summing up the localization (dispersion) index over all distances yields a measure $\Gamma_m \equiv \sum_{d=0}^{312} \Gamma_m(d)$ ($\Psi_m \equiv \sum_{d=0}^{312} \Psi_m(d)$) for the degree of localization (dispersion). The larger the indexes, the larger is the localization and dispersion pattern respectively. Figure 1 shows three industries which are either globally localized or dispersed. Solid lines indicate the actual density as estimated according to (1) whereas the upper (lower) dashed line indicates the upper (lower) global confidence band.

Manufacture of knitted and crocheted fabrics (WZ1760) is globally localized as the estimated kernel density function lies above the upper global confidence band for short distances. This industry has a large cluster in the Ruhr area and in the state of Baden-Württemberg as can be seen in Figure 2. Firms within these clusters are located close to each other which explains the high density at short distances. *Manufacture of soap and detergents* (WZ2451) is globally dispersed as the estimated distribution lies below the lower global confidence band (lower dashed line) for some distances and does simultaneously not exhibit localization patterns, i.e. the estimated distribution does not lie above the upper global confidence interval for any distance. As Figure 2 illustrates, the location pattern of this industry is consequently much more evenly distributed.

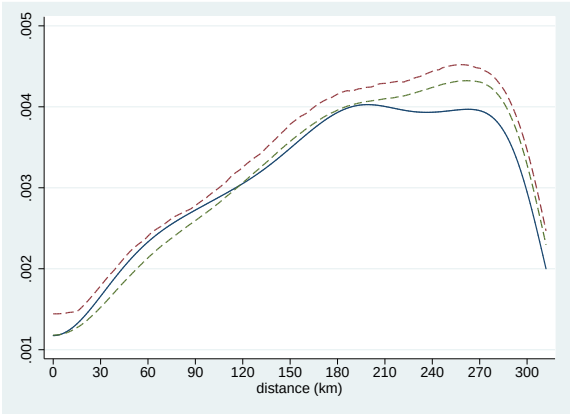
One major merit of the distance based DO approach is that it detects the localization of economic activity across different spatial scales. As in DO we encounter industries with kernel density functions that exhibit multiple peaks. *Manufacture of jewelery* (WZ3622) exhibits a high density for distances below 30 km and a high density for distances at intermediate distances 120-150 km (Figure 1 c). Figure 2 illustrates the location pattern of this industry. The clustering of firms within this industry begins in the Ruhrgebiet area and moves downwards to a cluster in the state of Rheinland-Pfalz and down to the state

Figure 1. Kernel Density Functions and Global Confidence Bands

(a) Manufacture of Knitted and Crocheted Fabrics (WZ1760)



(b) Manufacture of Soap and Detergents, Cleaning and Polishing Preparations (WZ2451)



(c) Manufacture of Jewelery (WZ3622)

of Baden-Württemberg.

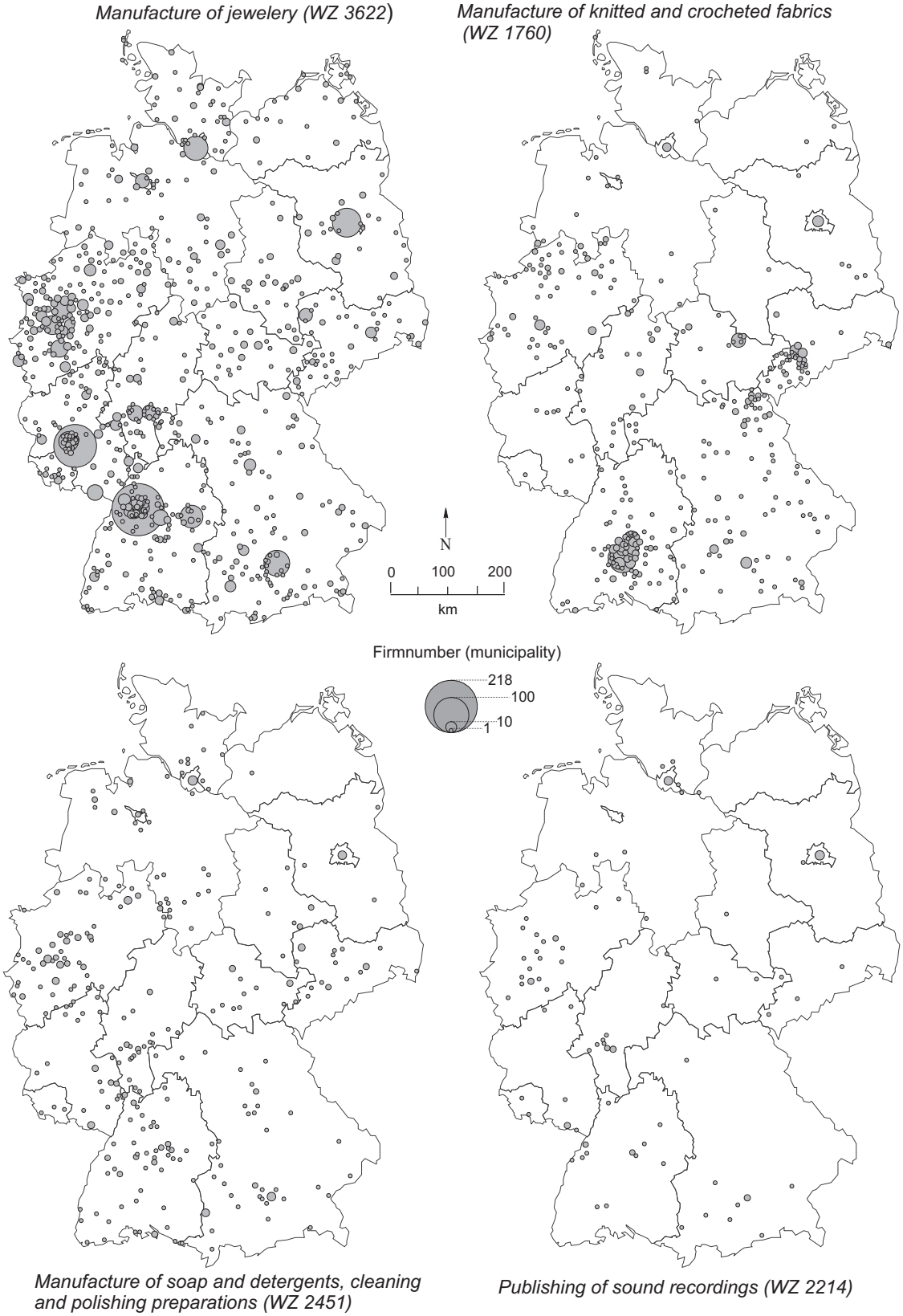
The last map in Figure 2 illustrates the location pattern of *publishing and sound recordings* (WZ2214). DO reported this industry together with *publishing of books* (WZ2211) to be strongly localized according to the DO index and only weakly agglomerated according to the EG index. For our data we find that this industry is only weakly localized according to the DO index (and, as will be shown later, among the most dispersed industries according to the EG index).

4 Results: Industrial Localization in Germany

We find that 262 out of 337 (78 %) industries deviate from randomness (at a 5 % confidence level) in the sense that they are globally localized. Decomposing our results to manufacturing and service industries suggests that 181 of 254 (71 %) manufacturing industries and 81 of 83 (98 %) of the considered service industries are globally localized in Germany.

The fraction of localized manufacturing industries is slightly larger than the one reported for the UK (52 %) and France (60 %) in earlier studies by DO and Barlet et al. (2008). While this result may reflect a larger importance of industrial agglomeration patterns in Germany compared to other countries, we think that the difference might also be driven by sample variations which affect the identification strategy. First, both DO and Barlet et al. (2008) choose a different counterfactual and constrain their sample of potential locations to those currently occupied only by manufacturing plants whereas we treat each plant location as a potential location irrespective of the industry sector. Moreover, the general distribution of economic activity in the UK and France differs substantially from the general firm location pattern in Germany as economic activity in both countries is far more concentrated in a small number of regions than for Germany. It may therefore not be surprising that less industries in the UK or France exhibit economic concentration over and above the general tendency to agglomerate than in Germany, which comparatively exhibits a more regular location pattern. In other words, a stronger urbanization pattern in the UK and France may make it more difficult to identify industrial agglomeration patterns which go beyond urbanization.

Figure 2. Industry Location Pattern for Four Illustrative Industries in Germany[a]



[a]Data source: German Employment Agency, 1999.

Table 4. Most Localized Manufacturing Industries (DO Index)

Four-digit industries		*No. of firms*	Γ_m
2861	Manufacture of cutlery	291	.648
3661	Manufacture of imitation jewelery and related articles	110	.640
1722	Weaving of carded yarn	17	.370
3350	Manufacture of watches and clocks	218	.328
1724	Weaving of silk yarn	29	.302
1760	Manufacture of knitted and crocheted fabrics	672	.242
1593	Manufacture of wine from grape	344	.237
1594	Manufacture of cider and other fruit wines	46	.203
2874	Manufacture of chain and springs, fasteners and screw machine products	479	.193
2710	Manufacture of basic iron and steel and of ferro-alloys	546	.180
2734	Cold drawing of wire	82	.180
2731	Cold drawing of bars	84	.177
2840	Forging, pressing, stamping and roll-forming of metal; powder metallurgy	492	.171
3511	Building of ships and floating structures	200	.153
1520	Processing and preserving of fish, crustaceans and mollusca	269	.123
2745	Other non-ferrous metal production	285	.122
3622	Jewelery and related articles	2183	.121
1721	Weaving of cotton	292	.107
2752	Casting of steel	104	.102
2753	Casting of light metals	354	.097

Table 4 presents the twenty manufacturing industries which are identified to be most localized according to the DO-index ($\Gamma_m \equiv \sum_{d=0}^{312} \Gamma_m(d)$). Interestingly, we find that especially traditional manufacturing industries tend to show strong spatial agglomeration patterns. Among the twenty most localized industries three belong to textile and nine industries are related to metal products. Some of these industries, in particular the manufacturing of textile, jewelery and watches, were also identified as agglomerated industries in the UK and/or France. As many of these agglomeration patterns evolved with the industrial revolution in the 19th century, our analysis provides strong evidence for the persistence of agglomeration patterns. One German peculiarity seems to be a strong spatial clustering of metal and metal related industries. Whereas DO report *cutlery* (WZ2861) as the only metal related industry among the ten most localized industries in the UK, nine metal related industries among the twenty most localized industries in Germany. Moreover, industries like the *building of ships and floating structures* (WZ3511) and the *processing and preserving of fish* (WZ1520) which depend on the proximity to the sea were found to be

among the most dispersed in the UK but list among the twenty most localized industries in Germany which may (partly) reflect first-order geographic differences between the two countries.

However, we do not restrict our study to the manufacturing sector but equally investigate location patterns in the service industry. Service related industries are in general less dependent on natural resources, exhibit lower transport costs and rely more on face-to-face interactions with their customers. One might thus expect them to be less agglomerated at the sectoral level. Nevertheless, we find that 81 of the 83 (pre-selected) service related industries exhibit global localization. Barlet et al. (2008) detect a similar pattern for French service and manufacturing industries, whereas the picture is less clear in the US (see Kolko (2009), which is however based on the EG methodology). Careful inspection of the type of localized service industry is informative. We therefore rank the twenty most localized service industries in Table 5.

Table 5. Most Localized Service Oriented Industries (DO Index)

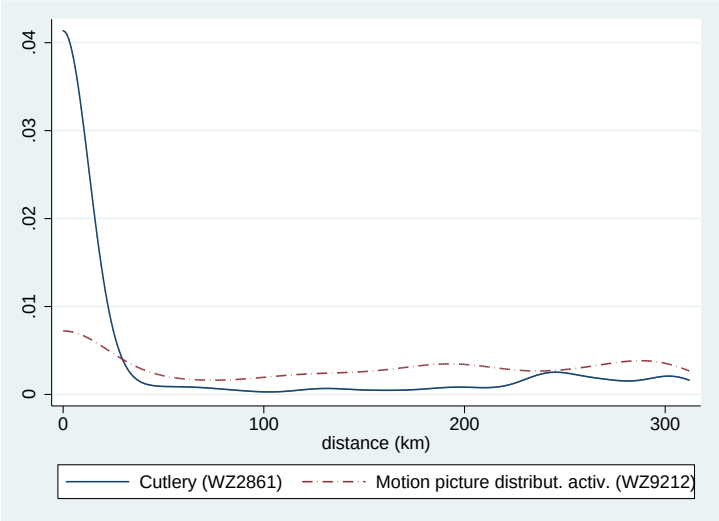
Four-digit industries		*No. of firms*	Γ_m
6110	Sea and coastal water transport	1,152	.276
9211	Motion picture, video and television programme production activities	1,864	.257
6311	Cargo handling	179	.234
6210	Service activities incidental to air transportation	438	.222
6711	Administration of financial markets	76	.214
6712	Security and commodity contracts brokerage	189	.208
9212	Motion picture, video and television programme distribution activities	299	.153
6322	Service activities incidental to water transportation	193	.142
9240	News agency activities	1,168	.096
7020	Renting and operating of own or leased real estate	17,613	.092
6602	Pension funding	119	.090
7413	Market research and public opinion polling	585	.090
6523	Other financial intermediation	891	.086
9232	Operation of arts facilities	1,285	.077
7032	Management of real estate on a fee or contract basis	20,748	.071
7414	Management consultancy activities	19,137	.061
7320	Research and experimental development on social sciences and humanities	537	.057
7440	Advertising	16,379	.051
6323	Service activities incidental to air transportation	552	.043
6120	Inland water transport	1323	.043

Apart from transportation industries which do rely on first nature geographies such as the proximity to the sea, the most strongly localized service industries are related to the administration of financial markets and the entertainment sector. As these industries heavily rely on skilled and specialized labor, this suggests that labor market pooling effects may be a major driver of the agglomeration pattern. Note, moreover, that the financial and entertainment industries have also been found to be strongly agglomerated in the US (see Kolko (2009)) or France (Barlet et al. (2008)). Additionally, several research industries in which knowledge spillovers may be expected to be the major driver of the agglomeration process occur to be globally localized in Germany.

Furthermore, in line with results reported for the US, service industries seem to be more urbanized than manufacturing industries. Whereas the median population of municipalities which host agglomerated manufacturing industries is 20,576, the median population of communities hosting service industries is two times larger with 41,957. As service industries such as financial intermediation and consultancy typically serve customers across different industries, interaction costs are minimized when locating in rather dense and urbanized areas. Note however that although a larger fraction of service than manufacturing industries is found to be localized, the DO indexes of the twenty most localized service industries falls short from the indexes calculated for the manufacturing sector. This indicates that the intensity of the localization pattern is stronger in the manufacturing industries than in the service sector. Figure 3 illustrates this point and depicts the estimated distribution of bilateral distances for the localized manufacturing industry *cutlery* (WZ2861) and the localized service industry *motion picture, video and television distribution* (WZ9212) which are both of similar industry size and listed among the most localized industries in Table 4 and Table 5, respectively. Whereas the distribution of bilateral distances between firms of the cutlery industry is highly skewed indicating that almost all firms are located at very short distances (as this minimizes high transport costs), the service industry exhibits a more uniform location pattern across distances.

To complete our analysis, we list the most dispersed industries in Table 6. The results indicate that especially industries related to food production exhibit a dispersed location pattern. Note moreover that contrary to previous studies based on the EG methodology which report the counter-intuitive result that high and medium tech industries related e.g. to communication and electrical equipment show dispersed location patterns (see Devereux et al. (2004), Alecke et al. (2006)), our findings based on the DO index in the contrary propose that high-tech industries tend to be geographically localized (although with a

Figure 3. Kernel Density Functions for Cutlery (WZ2861) and Motion picture, video distribution activities (WZ9212)



relatively weak intensity).

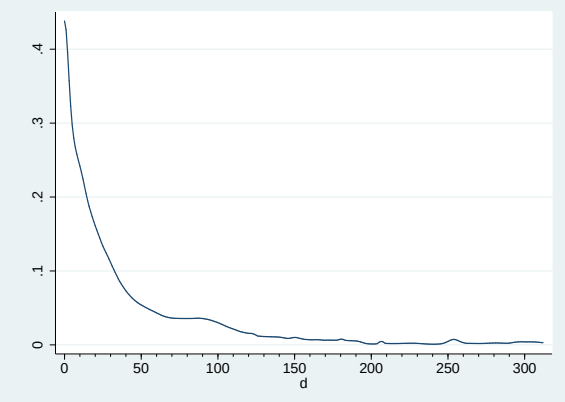
In a last step, we investigate whether the industries which are found to be agglomerated according to the DO index employ an over- or underproportional share of the overall workforce. Our findings indicate that the former is true and localized industries in Germany occupy an overproportional fraction of employees, precisely 95 % of the workers in Germany are employed in localized industries. This is in line with DO, who equally report manufacturing employment in localized industries to exceeds the percentage of localized industries. Moreover, our analysis confirms the findings in earlier studies (DO and Barlet et al. (2008) for the UK or France) which showed that localization occurs at shorter distances of 0 to 30 kilometers whereas dispersion shows no clear pattern. This is illustrated in Figure 4 which depicts the distribution for global localization and global dispersion of the industries in our sample across distances.

Table 6. Most Dispersed Manufacturing Industries (DO Index)

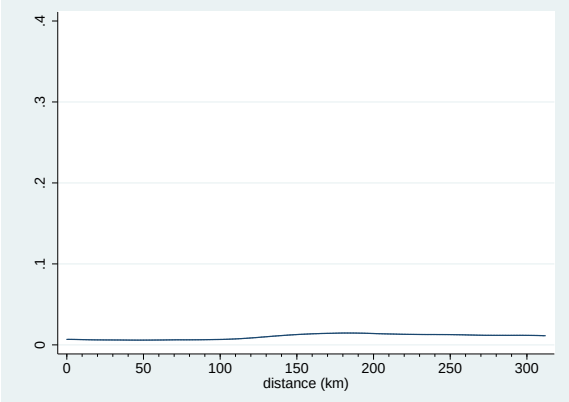
Four-digit industries		Ψ_m
3621	Striking of coins	.098
3543	Manufacture of bicycles and invalid carriages	.083
1588	Manufacture of homogenized food preparations and dietetic food	.075
2744	Copper production	.069
2411	Manufacture of industrial gases	.068
1717	Preparation and spinning of textile fibres	.068
2122	Manufacture of household and sanitary goods and of toilet requisites	.065
1543	Manufacture of margarine and similar edible fats	.064
1572	Manufacture of prepared pet foods	.061
1583	Manufacture of sugar	.060
2733	Cold forming or folding	.060
2743	Lead, zinc and tin production	.059
1542	Manufacture of oils and fats	.058
2111	Manufacture of pulp	.055
1552	Manufacture of ice cream	.054
2624	Manufacture of other technical ceramic products	.054
2417	Manufacture of synthetic rubber in primary forms	.054
1541	Manufacture of raw oils and fats	.053
1600	Manufacture of tobacco products	.052

Figure 4. Γ_m and Ψ_m by distance

(a) Global localization



(b) Global dispersion



4.1 Geographical and Sectoral Scope of Localization

Beyond identifying the location pattern of four-digit industries, it is interesting to learn about the geographical and sectoral scope of localization, i.e. to investigate in which German regions certain industries are agglomerated (geographical scope of localization) and whether four-digit industries in the same industry branch exhibit comparable location patterns (sectoral scope of localization).

In a first step, we illustrate the geographical scope of localization for some manufacturing and service industries which are strongly localized and listed in Tables 4 and 5. One of the most agglomerated manufacturing industries identified in our study is the *weaving* industry (WZ1722). A closer look exhibits that a major fraction of this industry is located in the county of Düsseldorf which holds 47 % of all firms and more impressively 80 % of total industry employment (see Table 7).[10] Within this county, the industry cluster spreads across several municipalities (whereas the cities of Mönchengladbach and Korschenbroich occupy the largest number of employees) illustrating the shortcoming of the EG index that does not take into account economic clustering across jurisdictional borders (see Section 5 below).

Why does the weaving industry cluster in the county of Düsseldorf? Several reasons may be decisive. Apart from history, the availability of unskilled labor in densely populated areas like Düsseldorf may contribute to the agglomeration tendency. Moreover, transport costs may foster the agglomeration of (manufacturing) industries as extensively discussed in models of the new economic geography. This agglomeration force indeed seems to be important as we find several manufacturing industries which are characterized by high transport costs to be localized, for examples industries related to *basic metals* (WZ27) and *fabricated metal products* (WZ28) that exhibit large geographic clusters in the two contiguous counties Arnsberg and Düsseldorf.

Several other examples can be named. For instance, the city of Solingen holds by far the largest share in the cutlery industry, with 68 % of the total industry firms and 65 % of total industry employment. Likewise to the British cutlery industry in Sheffield which Marshall (1890) mentions in his discussion of localization, Solingen is known for its long tradition in the manufacture of blades and forging. Analogously, historic traditions may

[10] To avoid pitfalls that may result from transforming 'dots on a map into unit of boxes', Table 7 reports the location of establishments at different administrative levels: at the finest level of aggregation (municipality) and a higher administrative unit ('Regierungsbezirk') which is comparable to French department levels.

(partly) explain the agglomeration of the manufacturing of *watches and clocks* (WZ3350) in Pforzheim, a city with a long tradition in the manufacture of gold (and therefore is also known as the 'city of gold'). Similarly, history likely shaped the agglomeration pattern of *imitation jewelery* (WZ3661) where the majority of the industry's workforce is tied to the city of Kaufbeuren.[11] Apart from that, industrial location patterns in Germany also suggest the importance of first-order geographical characteristics in shaping industry patterns. As an illustrative example, the Hanseatic city of Hamburg holds 52 % of total industry employment in *cargo handling* (WZ6311).

The tendency to agglomerate in the same geographical area equally applies to service industries which may on the one hand side be less exposed to transport costs but are on the other hand side likely to be more reliant on the availability of specialized labor. The city of Frankfurt am Main for instance is heavily localized in the financial service industry and holds 85 % of employment in the *administration of financial markets* (WZ6311). Moreover, fairly young service industries such as entertainment related industries (WZ9211 and WZ9212) do exhibit multiple clusters in large German cities like Berlin, Hamburg, Munich and Cologne.

Table 7. Location of Plants in the Weaving Industry (WZ1722)

Regierungsbezirk	*Municipality*	*Firm number*	*Employment*
Düsseldorf	Mönchengladbach	4	456
	Jüchen	1	9
	Korschenbroich	1	112
	Grefrath	1	7
	Willich	1	1
Cologne	Wegberg	1	17
	Burscheid	1	28
Braunschweig	Osterode am Harz	2	2
Oberbayern	Dietramszell	1	2
Leipzig	Hartha	1	8
	Lübeck	1	1
	Halle (Saale)	1	25
	Berlin	1	62
$\sum$		17	730

[11]Note that many ethnic German immigrants were engaged in the jewelery sector. After being expelled to Germany after World War II, they restarted their businesses in Kaufbeuren.

Table 8. Intra-Industry Localization

Two-digit branch		*No. of four-digit industry*	*% of globally localized*
15	Food products	32	50
16	Tobacco products	1	0
17	Textiles	20	85
18	Wearing apparel	6	67
19	Leather and related products	3	100
20	Wood and products of wood and cork, except furniture	6	100
21	Paper and paper products	7	57
22	Printing and reproduction of recorded media	13	100
23	Coke and refined petroleum products	1	100
24	Chemicals and chemical products	19	53
25	Rubber and plastic products	7	86
26	Other non-metallic mineral products	25	52
27	Basic metals	17	82
28	Fabricated metal products,except machinery and equipment	16	88
29	Machinery and equipment	20	90
30	Computer and electronic products	2	100
31	Electrical equipment	7	71
32	Electronic components, communication equipment	3	100
33	Instruments and appliances for measuring	5	100
34	Motor vehicles, trailers and semi-trailers	3	100
35	Building of ships and boats	8	88
36	Furniture, jewelery, bijouterie, musical instruments	13	69
40	Electricity, gas, steam and air conditioning supply	3	33
41	Water collection, treatment and supply	1	100
45	Construction of buildings	16	81
50	Wholesale and retail trade and repair of motor vehicles and motorcycles	4	100
51	Wholesale on a fee or contract basis	1	100
55	Accommodation and food service activities	1	100
60	Land transport and transport via pipelines	6	100
61	Water transport	2	100
62	Air transport	2	100
63	Support activities for transportation	6	100
64	Postal and courier activities	3	100
65	Financial service activities, except insurance and pension funding	5	100
66	Insurance, reinsurance and pension funding	3	100
67	Activities auxiliary to financial services and insurance activities	4	100
70	Real estate activities	5	100
71	Rental and leasing activities	9	78
72	Computer programming, consultancy and related activities	6	100
73	Scientific research and development	3	67
74	Service activities for businesses	12	100
90	Sewerage, waste management and remediation activities	1	100
92	Motion picture, video and television programme production	10	100
93	Other service activities	1	100
$\sum$		262	

Besides the geographical scope of localization, we investigate to what extent four-digit industries which belong to the same two-digit industry branch follow the same localization pattern (sectoral scope of localization). The results of this exercise are listed in Table 8. In general, we find that four-digit industries within the same industry branch tend to follow the same localization pattern whereas the picture is somewhat more pronounced for service industries compared to the manufacturing sector. For example, in the food products industry (WZ 15) a comparably large fraction of 50% of the firms exhibit a dispersed location pattern while the fraction of dispersed industries in the branch *printing and reproduction of recorded media* (WZ 22) is 0%. Our results somewhat deviate from the findings for UK reported by Duranton and Overman (2005) whereas the differences seem to be mainly driven by a higher overall fraction of localized industries identified in our study. For example, while 16 out of 32 four-digit industries (i.e. 50%) of the food products branch are localized in our study, only 1 out of 30 four-digit industries of this branch is globally localized in the UK. Similarly, all industries belonging to the branch *wood and products of wood* (WZ20) exhibit global localization in Germany whereas the same branch is dispersed in the UK.[12] In general, however, there is also a large overlap between localized industry branches in Germany, France and UK, see for example the *textile* (WZ17), *leather* (WZ19) or *publishing* (WZ22) industry.

5 Extension: The Ellison and Glaeser (1997) Approach

Despite the merits of the DO approach, it has the obvious shortcoming that its computation is demanding with respect to time and server capacity. Consequently, the majority of previous papers which try to assess industry localization based on micro-geographic data, relies on an approach proposed by Ellison and Glaeser (1997) which is easier to compute but also faces some methodological shortcomings (as was discussed in the Introduction). To complement our analysis, we rerun the investigation based on the EG methodology. In the following, we will shortly sketch the EG approach, present our results and in depth illustrate the methodological shortcomings.

[12]Germany seems to be more comparable to France as Barlet et al. (2008) report 52 % of industry branch (WZ15) and 83 % of industry branch (WZ20) to be globally localized.

5.1 Methodology

Based on a location choice model where individual plants make a location decision that maximizes their profits, the index proposed by EG accounts for both, the overall tendency to concentrate as well as the plant size distribution. It is assumed that profits of a plant are driven by three components. A random variable which captures the effect of observed and unobserved location characteristics (natural advantages) on the profitability of the plant. The second component reflects the existence of spillovers (localization economies) which raises a plant's profitability resulting from the interaction with other plants located in geographical proximity.[13] The last component is a purely random variable which captures factors that are idiosyncratic to the plant. In the absence of any agglomerative forces (spillovers and/or natural advantages) the resulting location pattern can be explained by firm-specific characteristics such as the plant size distribution and the overall tendency for economic activity to concentrate.

The presence of non-idiosyncratic factors such as localization economies or natural advantages, however, lead to a concentration of economic activity which goes beyond what would be expected given the overall concentration of plants and industry specific characteristics. The EG index is defined as

$$\gamma_{EG} = \frac{G - \left(1 - \sum_i x_i^2\right) H}{\left(1 - \sum_i x_i^2\right)(1 - H)}. \tag{3}$$

whereas G measures the raw geographic concentration of an industry and is defined as

$$G \equiv \sum_i (s_i - x_i)^2, \tag{4}$$

with x_i being location i's share in the overall employment and s_i being location i's employment share within a particular industry. Note that the EG index is appealing as it does not take a uniform distribution of employment as the benchmark but the overall employment of the geographical unit. Hence, as long as the respective industry reflects the employment pattern observed in the geographical unit, this industry will not be considered as being agglomerated. The Herfindahl index $H = \sum_j z_j^2$ of a particular industry captures the plant size distribution, with z_j representing employment share of the j-th plant. A small

[13] EG note that the expected location pattern resulting from natural advantages or spillovers are observationally equivalent. The proposed index therefore does not give evidence on the sources of agglomeration.

H indicates a competitive industry with many small plants whereas higher weight is given to plants with a high employment share. Ignoring the size distribution of plants would lead to false conclusions about the concentration of an industry. Including the Herfindahl index therefore washes out any concentration which can be attributed to the industrial structure. In general, it holds that the larger the EG index calculated in equation (3), the larger is the agglomeration tendency of the considered industry. EG report industries with a γ_{EG} less than 0.02 to be weakly concentrated, whereas $0.02 \leq \gamma_{EG} \leq 0.05$ reflects intermediate and $\gamma_{EG} > 0.05$ strong localization of an industry.

5.2 Results with the EG Index

Figure 5. Distribution of γ_{EG}

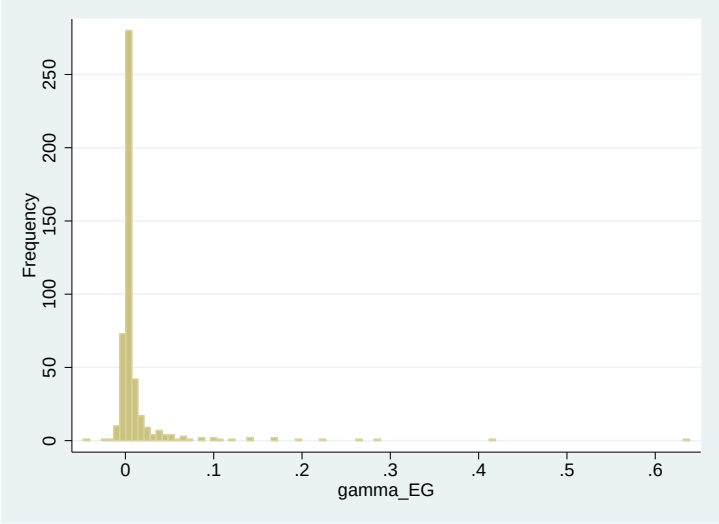


Figure 5 depicts the distribution of the EG index for the 337 German four-digit manufacturing and service industries in our data. As observed in studies applying the EG methodology to the US and UK before, the distribution of the index is very skewed indicating that only few industries are highly agglomerated. For our 337 four-digit industries in Germany the mean of γ_{EG} is 0.015, the median is 0.003.[14] Hence, the values obtained for our German industries are somewhat lower compared to the UK with a mean value of 0.033 and a median of 0.007 (Devereux et al. (2004)) or the US with a mean value of 0.051 and a median of 0.026 (Ellison and Glaeser (1997)). As indicated above, Ellison

[14]The median remains if restricting the sample to 254 manufacturing industries (the mean with 0.011 being somewhat lower).

and Glaeser (1997) report industries with a γ_{EG} less than 0.02 to be weakly concentrated, whereas $0.02 \leq \gamma_{EG} \leq 0.05$ reflects intermediate and $\gamma_{EG} > 0.05$ strong localization of an industry.

Out of the 254 German manufacturing industries, 213 industries (84 %) exhibit a positive value for γ_{EG}. According to the threshold levels reported above, 41 of our manufacturing industries (16 %) are dispersed and 188 industries (74 %) are weakly agglomerated. Only 14 industries (6 %) exhibit intermediate localization and only 11 industries (4 %) are considered as strongly agglomerated. Compared to studies based on the EG methodology for other countries, the fractions of industries with intermediate or strong localization patterns in our analysis are small. Ellison and Glaeser (1997), for example, report a fraction of 25 % of the industries to be subject to strong agglomeration economies, Maurel and Sedillot (1999) report 27 % of French manufacturing industries to be strongly localized and Devereux et al. (2004) find a still considerable fraction of 16 % of manufacturing industries with a strong localization pattern in the UK. All of these percentage values are substantially larger than the tiny fraction of 4 % of the industries which are reported to be strongly localized in our paper. Naive interpretation may lead to the conclusion that Germany seems to exhibit far less industrial agglomeration than other countries like the US, France or the UK.

However, a comparison between the different studies may not be reasonable since the EG index might be sensitive to the size and shape of the underlying zoning system as pointed out in a recent working paper by Briant et al. (2008). Precisely, the authors illustrate that the EG index tends to increase in the aggregation level of the unit of observation which implies that differences between our EG results and the ones reported by previous studies may be driven by differences in the underlying spatial observations units. While we calculate the EG index on the level of almost 12,000 German municipalities, previous studies tend to use fairly aggregated spatial units like 50 US states (Ellison and Glaeser (1997)), 95 French departments (Maurel and Sedillot (1999)) and 113 British postcode areas (Devereux et al. (2004)).

To confirm that indices obtained with the EG methodology are sensitive to spatial aggregation in our analysis, we recalculate the EG index for more aggregated spatial units, precisely on the level of 441 counties ('Kreise') and 97 commuting areas ('Raumordnungsregionen').[15] Table 9 lists the Herfindahl index (H), the mean raw concentration

[15]While German counties represent administrative jurisdictions, commuting areas are functional economic regions.

index (G) and the mean EG index for our 337 industries. Whereas the Herfindahl index is stable across different spatial units both, the raw index of geographic concentration as well as the EG index increase with a rising level of spatial aggregation and are therefore not invariant to the underlying geographical unit. Consequently, as reported in Table 10, our calculated EG indexes converge toward those reported for other countries when moving up the scale of spatial aggregation. Calculated on the level of 97 German commuting areas, weak agglomeration is now detected for 53 % of German industries (as opposed to 74 % if calculated on the municipality level), 22 % of German manufacturing industries exhibit intermediate agglomeration (as opposed to 6 % if calculated on the municipality level) and 14 % of German industries are strongly agglomerated (as opposed to 4 % if calculated on the municipality level).[16]

Table 9. Geographical and Industrial Concentration for Different Administration Units

Administrative unit	H	G	γ_{EG}
Municipality	0.047	0.060	0.015
County	0.047	0.065	0.020
Commuting Area	0.047	0.073	0.030

Table 10. EG index for different administration units

Administrative unit	$\gamma_{EG} > 0$	$0 < \gamma_{EG} < 0.02$	$0.02 \leq \gamma_{EG} \leq 0.05$	$\gamma_{EG} > 0.05$
Municipality	213 (84 %)	188 (74 %)	14 (6 %)	11 (4 %)
County	217 (85 %)	165 (65 %)	30 (11 %)	21 (8 %)
Commuting Area	227 (89 %)	134 (53 %)	57 (22 %)	36 (14 %)

Thus, the EG methodology is found to be sensitive to the underlying zoning system which is used to calculate the EG index, in particular on the aggregation level of the units of observations. As the size of jurisdictional units (on which data is available) differs between countries, it is to some extent problematic to make cross-countries comparisons of agglomeration patterns based on the EG methodology. As the DO approach does not face similar problems, it is superior in this respect.

Moreover, note that the fraction of industries which are identified to be localized is substantially larger for the EG methodology than for the DO approach. This reflects that

[16]The same increasing nature of the EG index has been observed in Devereux et al. (2004) who report the index for 447 local authorities, 113 postcode areas and 65 counties.

the latter approach is much stricter in declaring an industry to be agglomerated as it statistically tests for departures of the location pattern from randomness.

Table 11. Most Localized Industries with EG Index

Four-digit industries		G	H	γ_{EG}
6711	Administration of financial markets	.70	.18	.64
2861	Manufacture of cutlery	.44	.04	.41
1722	Weaving of carded yarn	.42	.19	.29
3661	Imitation jewelery and related articles	.28	.03	.26
6311	Cargo handling	.27	.06	.23
6323	Service activities incidental to air transportation	.27	.12	.17
1586	Processing of tea and coffee	.18	.05	.14
1717	Preparation and spinning of textile fibres	.24	.12	.14
6523	Other financial intermediation	.14	.02	.12
1723	Weaving of worsted yarn	.25	.16	.11
6110	Sea and coastal water transport	.11	.01	.10
2741	Precious metals production	.28	.20	.10
1520	Processing and preserving of fish, crustaceans and mollusca	.11	.03	.09
6712	Security and commodity contracts brokerage	.13	.05	.08
6713	Other activities auxiliary to financial services	.09	.02	.07
3622	Jewelery and related articles	.08	.01	.07
2955	Machinery for paper and paperboard production	.11	.05	.07
1542	Manufacture of oils and fats	.26	.22	.06
9212	Motion picture, video and television programme distribution activities	.10	.04	.05
9211	Motion picture, video and television programme production activities	.06	.005	.05

Tables 11 and 12 list the most localized and the most dispersed industries according to the EG methodology. The tables suggest that both indices are correlated but also point to important differences in the results. The EG methodology for example derives similar results like the DO approach, in the sense that it also identifies many of the traditional manufacturing industries to be strongly localized, most notably industries related to textile and metal production. Moreover, the EG index equally points to an important role of localization in service related industries like financial markets and the entertainment industry. However, on the other side, in Table 12 the EG analysis suggests that some medium and high tech industries such as *publishing of sound recordings* (WZ2214), *office machinery* (WZ3001) or *computer programming* (WZ72) show strong dispersion patterns whereas the DO approach proposes them to be localized. The differences between the re-

sults for the two approaches is also reflected in a rather low rank correlation of the indexes which is calculated with 0.40 (the correlation of the indexes themselves is 0.60).[17]

Table 12. Most Dispersed Industries: EG-Index

Four-digit industries		G	H	γ_{EG}
2744	Copper production	.317	.349	-.0476
2420	Manufacture of pesticides and other agrochemical products	.171	.188	-.0207
4524	Construction of water projects	.250	.265	-.0195
2214	Publishing of sound recordings	.312	.322	-.0120
4030	Steam supply	.065	.076	-.0115
2463	Manufacture of essential oils	.163	.173	-.0107
2665	Manufacture of fibre cement	.065	.074	-.0097
6030	Transport via pipeline	.071	.079	-.0089
6230	Space transport	.429	.436	-.0084
2441	Manufacture of basic pharmaceutical products	.209	.216	-.0082
1713	Preparation and spinning of worsted-type fibres	.125	.132	-.0077
6021	Urban and suburban passenger land transport	.009	.016	-.0065
7123	Renting of air transport equipment	.043	.049	-.0065
1595	Manufacture of other non-distilled fermented beverages	.456	.461	-.0057
3001	Office machinery	.047	.053	-.0054
9253	Botanical and zoological gardens and nature reserves activities	.020	.025	-.0047
4020	Manufacture of gas; distribution of gaseous fuels through mains	.035	.039	-.0046
3541	Manufacture of motorcycles	.329	.334	-.0045
7240	Data base activities	.069	.073	-.0040
7260	Other computer related activities	.053	.056	-.0038

6 Conclusion

This paper assesses the location pattern of four-digit industries in Germany using the distance based approach developed by Duranton and Overman (2005). We find that 71% of the manufacturing industries in Germany exhibit significant geographical localization, a fraction which is somewhat larger than previous results based on the DO approach for the UK and France. Moreover, we find that localization occurs at shorter distances and that

[17]Note that the EG- and DO-methodology differ in the respect that the calculation of the former is based on the number of employees in an industry while the latter is based on the number of plants in an industry.

localized industries hold a larger share in employment. In general, our results suggest that especially traditional manufacturing industries, e.g. the manufacturing of textile, show strong agglomeration patters. As many of these industries were identified to be localized in studies for the UK and France before, this suggests that agglomeration (in these industries) does not seem to be responsive to country specific political or geographical conditions. However, there are also some German specific features in the agglomeration pattern. For example, several industries related to metal production seem to exhibit stronger agglomeration patterns in Germany.

Moreover, in contrast to Duranton and Overman (2005) who restrict their analysis to the manufacturing sector, we equally investigate localization patterns in the service industry. Our analysis suggests that agglomeration forces play an equally or even more important role in the service sector as the vast majority of service industries included into our analysis turn out to be significantly localized. The strongest agglomeration patterns are thereby found in the financial markets sector and the entertainment industry.

In a last step, we rerun our analysis based on the discrete approach proposed by Ellison and Glaeser (1997). In line with the presumption, that the EG approach is less rigorous in identifying agglomeration patterns (as it is not based on a statistical test for deviations from randomness), we find a larger fraction of industries to be agglomerated according to the EG index. Moreover, we show that the calculation of the EG-index is sensitive to the aggregation level of its observation units which makes it difficult to interpret and hardly comparable across countries. As the DO approach is not prone to these problems, we consider it to be superior in this respect.

Thus, we might conclude that our analysis indicates that agglomeration forces play an important role in both, German manufacturing and service industries. This may have important economic implications for the productivity and wages of workers in these industries (as suggested by Henderson (1986),Glaeser and Maré (2001) and Gould (2007)). Moreover, rents which accrue through industrial localization patterns may be taxable for German municipalities which set the local business tax rate as pointed out in a recent paper by Koh and Riedel (2009).

Due to constraints in data availability we are unfortunately not able to assess the different sources of agglomeration in a rigorous framework. Nevertheless, the results of our analysis may allow for some speculations. As many traditional manufacturing industries (like e.g. metal production) face high transport costs and are simultaneously found to be localized in space, our findings might suggest that transport costs play a significant role in

shaping agglomeration patterns. Moreover, the fact that financial services and entertainment industries (with plausibly low transport costs for their products) are geographically agglomerated in large urban areas might support the idea that labor market pooling effects and knowledge spillovers exert positive externalities on firms belonging to these sectors and give rise to localization patterns. This are interesting avenues for future research to explore.

References

Alecke, B., C. Alsleben, F. Scharr, and G. Untiedt (2006): "Are there really high-tech clusters? The geographic concentration of German manufacturing industries and its determinants," *The Annals of Regional Science*, 40, 19–42.

Alecke, B. and G. Untiedt (2006): "Die geografische Konzentration von Industrie und Dienstleistungen in Deutschland. Neue empirische Evidenz mittels des Ellison-Glaeser-Index," *GEFRA Working Paper*.

Barlet, M., A. Briant, and L. Crusson (2008): "Concentration géographique dans l'industrie manufacturière et dans les services en France : une approche par un indicateur en continu," .

Briant, A., P.-P. Combes, and M. Lafourcade (2008): "Dots to Boxes: Do the Size and Shape of Spatial Units Jeopardize Economic Geography Estimations?" *CEPR Discussion Paper Series*.

Combes, P.-P. and H. G. Overman (2004): "The spatial distribution of economic activities in the European Union," in *Handbook of Regional and Urban Economics*, ed. by J. V. Henderson and J. F. Thisse.

Devereux, M. P., R. Griffith, and H. Simpson (2004): "The geographic distribution of production activity in the UK," *Regional Science and Urban Economics*, 34, 533–564.

Dumais, G., G. Ellison, and E. L. Glaeser (2002): "Geographic Concentration As A Dynamic Process," *The Review of Economics and Statistics*, 84, 193–204.

Duranton, G. and H. Overman (2005): "Testing for Localization Using Micro-Geographic Data," *Review of Economic Studies*, 72, 1077–1106.

Duranton, G. and D. Puga (2004): "Micro-foundations of urban agglomeration economies," in *Handbook of Regional and Urban Economics*, ed. by J. V. Henderson and J. F. Thisse.

Ellison, G. and E. L. Glaeser (1997): "Geographic Concentration in U.S. Manufacturing Industries: A Dartboard Approach," *Journal of Political Economy*, 105, 889–927.

Glaeser, E. L. and D. C. Maré (2001): "Cities and Skills," *Journal of Labor Economics*, 19, 316–42.

Gould, E. D. (2007): "Cities, Workers, and Wages: A Structural Analysis of the Urban Wage Premium," *Review of Economic Studies*, 74, 477–506.

Helsley, R. W. and W. C. Strange (1990): "Matching and agglomeration economies in a system of cities," *Regional Science and Urban Economics*, 20, 189–212.

Henderson, J. V. (1986): "Efficiency of resource usage and city size," *Journal of Urban Economics*, 19, 47–70.

Koh, H.-J. and N. Riedel (2009): "Taxing Agglomeration Rents: The importance of being different," *Munich, mimeo.*

Kolko, J. (2009): "Urbanization, Agglomeration and Co-Agglomeration of Services Industries," *mimeo.*

Marshall, A. (1890): *Principles of Economics*, Macmillan, London.

Maurel, F. and B. Sedillot (1999): "A measure of the geographic concentration in french manufacturing industries," *Regional Science and Urban Economics*, 29, 575–604.

Silverman, B. W. (1986): *Density Estimation for Staitstics and Data Analysis*, New York: Chapman and Hall.