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Introduction

The concentration of economic activity across space percolates through every spatial scale. An often cited example at the cross-country level is certainly Roger Brunet's concept of Europe's Blue Banana.[1] It describes the densely populated industrial region that stretches across several countries in Europe, notably from the North West of England down to the North of Italy including major cities like Amsterdam, Cologne and Frankfurt am Main. Core-periphery patterns of industrial activity are equally observed at the sub-national level like the U.S. manufacturing belt, Route 128 in Massachusetts or Île-de-France to name just a few examples. Moving further down the spatial scale, the existence of cities is probably the most conceivable example to illustrate the irregular nature of economic activity in space. Measuring the degree to which economic activity concentrates and unveiling the underlying (economic) factors is at the heart of regional and urban economics. However, much as the clustering of economic activity is a fascinating area of research of its own it is also closely linked to public policy questions as firm location choices inevitably affect households' welfare through demand and supply side effects. Moreover, recent years have witnessed a steadily growing literature which relates agglomeration economies[2] to questions in public finance. As will be laid out in detail below, recognizing the propensity of economic agents to co-locate in space has important implications for tax policy and qualifies results obtained in previous tax competition models.

The doctoral dissertation presents the author's contributions on the consequences of agglomeration economies for local business taxation and policy competition.[3] Chapter 1 begins with the identification of localized manufacturing and service industries in Germany. Using a rich data set on the population of German firms we apply two

[1]Brunet (1989).

[2]The terms 'agglomeration' and 'localization' will be used interchangeably. I also follow Hoover (1936), who defines localization economies as the benefits generated by the geographical proximity of firms producing similar goods. 'Urbanization' economies in contrast capture the benefits that arise from the overall economic activity in a particular location.

[3]Chapters 1 and 2 originate from collaborating work with Nadine Riedel. Chapter 3 is joint work with Rainald Borck and Michael Pflüger and Chapter 4 results from collaborating work with Ferdinand Mittermaier.

different identification approaches for localization, the distance based approach of Duranton and Overman (2005) and the discrete measure proposed by Ellison and Glaeser (1997) which are both well established in the literature and reflect the state of the art in that research field.[4] Traditional measures of agglomeration such as the spatial GINI coefficient used in Krugman (1991b) or Audretsch and Feldman (1996) compare the employment pattern of one industry to that in the aggregate but fail to distinguish between concentration stemming from industry characteristics[5] and concentration in response to agglomeration economies. We therefore employ more sophisticated measures which control for both the general tendency for firms to concentrate and the plant size distribution. We find the location pattern of most industries to depart substantially from randomness in the sense that firms are exposed to significant agglomeration forces. In line with previous studies on manufacturing firms in the UK and France, our analysis suggests that especially traditional manufacturing industries exhibit strong agglomeration 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.

Unquestionably related to the measurement of localization is the identification of the underlying causes of agglomeration, a research field which dates back to early contributions by von Thünen (1826) and Marshall (1890) and which still constitutes a lively research area both theoretically and empirically.[6]

In his Principles of Economics, Alfred Marshall envisages three main causes for industry agglomeration which result from 'thickly peopled' industrial districts that can be subsumed under the categories - knowledge creation and knowledge processing, sharing of intermediate goods suppliers and sharing a common labor market. The first channel refers to the spillover of ideas, (tacit) knowledge and skills which are immaterial and

[4]Combes and Overman (2004) provide an excellent overview on different agglomeration measures.

[5]In extreme a one-plant monopolist will be considered as being agglomerated simply because all employment is concentrated in one plant. Concentration however is not the result of agglomeration economies but simply due to the plant size distribution.

[6]Duranton and Puga (2004) provide a detailed survey on the micro-foundations of agglomeration economies. The interested reader is referred to Rosenthal and Strange (2004) who for a comprehensive overview of the empirical literature on the sources of agglomeration.

therefore hard to observe. The second describes a typical risk sharing effect: The spatial concentration of industry allows a division of the overall production process to many subsidiary industries which produce specialized intermediate inputs. The constant demand from different final goods producers in a densely populated area then facilitates the bearing of high fix costs for specialized machinery that is needed to produce intermediate inputs. Finally, similar to the preceding channel, Marshall (1890) mentions the benefits of producing in a densely populated area with a variety of employment as it offers a 'constant market for skill'. This involves improved matching between workers and employers as well as risk sharing among firms against idiosyncratic shocks. Firms are able to easily release workers in response to firm specific output contractions and to easily hire workers in times where output is expanded. Additionally, Marshall (1890) also stresses the importance of factors like the proximity to the sea, favorable climate conditions or fertile soil for a number of traditional industries.

In accordance with Krugman (1991a) primary factors exogenously assigned by nature are defined as first-nature geographies whereas agglomeration that emerges from the interaction of individual economic agents are labeled second-nature geographies. Opposed to first nature geographies, second nature geographies are to a large extent endogenous and could therefore be influenced by policy actions.

Industry clusters that rely on second nature geographies have caught recent attention with Paul Krugman who has been awarded the Nobel prize in 2008 for his analysis of trade patterns and the location of economic activity. His path breaking 1991 *Journal of Political Economy* paper introduced a novel research area also referred to as the 'New Economic Geography' (NEG).[7] The prominent Krugman (1991e) core-periphery model combines increasing returns to scale, love for variety household preferences and Samuelson (1954) iceberg transport costs in a general equilibrium framework and is perceived as the prototype of agglomeration models. For certain parameter ranges, pecuniary externalities that arise from the interaction of producers and workers de-

[7] The label 'New' in NEG is however debatable - it is rather the combination of existing ideas borrowed from trade theory and modelling approaches like the Dixit and Stiglitz (1977) monopolistic competition framework than the invention of a completely new research field (see also Neary (2001) and Ottaviano and Thisse (2004)).

manding manufactured varieties trigger a circular causality process that concludes in a core-periphery constellation of industrial activity of ex ante identical regions.

By now, a sizeable number of contributions have enriched this field of research accounting for partial agglomeration (Pflüger (2004)) or highlighting alternative sources of circular causation such as input-output linkages between final goods producers and intermediate input suppliers (Krugman and Venables (1995) and Venables (1996)), institutional labor market effects (Picard and Toulemonde (2006)), the availability of local public goods (Roos (2004)) or endogenously qualified labor force (Picard and Toulemonde (2004)) and agglomeration resulting from local technological spillovers (Ulltveit-Moe (2007) and Borck et al. (2009)).[8]

One eminent feature that characterizes agglomeration models is the possibility that economic activity can get locked-in in either location. In particular, accounting for locational hysteresis challenges those predictions obtained from traditional tax competition models[9] where fiscal externalities between competing governments lead to a race to the bottom of tax rates and sub-optimal levels of public goods provision. In contrast, local governments in a world with agglomeration tendencies are able to tax agglomeration rents up to a certain threshold without triggering an immediate outflow of the mobile factor.[10] But whereas the predictions of economic geography for governments' tax setting behaviour are widely acknowledged in the theoretical literature by now, empirical validation of taxable agglomeration rents still lags behind.[11]

The paper presented in the second chapter fills this gap and provides empirical evidence for taxable location rents. It further identifies factors which favor the extractability of agglomeration rents. Precisely, we empirically investigate the impact of firm agglomeration on jurisdictional tax setting behavior. Our testing ground is the German local

[8] For a recent survey of the new economic geography literature see Redding (2009). Other surveys of the economic geography literature include Ottaviano and Puga (1998) and monographs by Fujita and Thisse (2002) and Fujita et al. (1999).

[9] See Wilson (1999) for a detailed survey of the literature.

[10] This key insight of economic geography models for public finance has been pushed forward notably by Ludema and Wooton (2000), Kind et al. (2000), Baldwin and Krugman (2004) and Borck and Pflüger (2006).

[11] Notable exceptions include Charlot and Paty (2007) and Buettner (2001).

business tax which is set at the municipality level. Exploiting a rich data source on the population of German firms, we find evidence for effects of urbanization and localization economies on the jurisdictional tax rate choice. In addition the paper shows that a jurisdiction's potential to tax agglomeration rents depends on the difference of its agglomeration characteristics to neighboring communities. German municipalities tend to set high local business taxes if they face large firm and industry agglomerations *relative* to neighboring communities. To account for potential reverse causality problems, the analysis exploits long-lagged population and infrastructure data to instrument for the agglomeration measures.

Likewise, multiple spatial equilibria and path dependency, both typical features of economic geography models are particularly appealing for public policy analysis. Broadly speaking, the Krugman type of model predicts that ex ante identical locations may end up as a core or periphery region with residents in the core enjoying higher real income than residents in the periphery. Which location evolves as the industrial core region is however purely random. Rich anecdotal and empirical evidence support the idea that an industry's initial location is only to a limited extent predictable and often simply caused by 'historic accidents'.[12] For instance, German expellees from Jablonec nad Nisou (Czech Republic) who have been employed in the jewelery industry prior to World War II settled to Neugablonz, a suburb of the city Kaufbeuren. Today Kaufbeuren still shows considerable specialization in the manufacture of jewelery and is considered as a major cluster of this industry.[13]

Additionally, the fact that economic activity is not evenly distributed across space but separates into economically prosperous and peripheral regions is, of course, interrelated

[12]See for instance Redding et al. (2007) for a recent contribution on the location of German Airports. Davis and Weinstein (2002) note that multiple equilibria are empirically irrelevant which is however contradicted by Brakman et al. (2004) who confirm the existence of multiple equilibria for German city growth.

[13]Other examples are documented in Marshall (1890). He points out that the expansion of a family group into a village in Russia caused the localization of industry resulting in a number of villages all specialized in one industry branch e.g. manufacturing the spokes for a wheel of a vehicle. Krugman (1991b) himself begins his chapter on localization with the story of a girl named Catherine Evans who presumably played a decisive role in the localization of the U.S. manufacturing carpet industry in Dalton, Georgia.

to disparities in regional welfare. (Immobile) workers in the rural area suffer from high consumer prices and less attractive job opportunities contrary to households in the industrial core. This unequal allocation of firms is clearly hard to accept especially for policy makers. As a matter of fact, numerous corrective industrial policy programs on every government level evidently indicate politicians' effort to influence the location choice of firms which eventually results in a competition for mobile capital between local governments. This policy competition however occurs within an environment where firms' responses to policy interventions proceed non-linearly. Subsidy payments to the mobile factor are harmless up to a certain level but fully reverse an existing location pattern once this threshold is exceeded.[14] Chapter 3 and 4 deal with the possibility that economic activity is inefficiently locked-in in a region with smaller region size (Chapter 3) or distorted labor markets (Chapter 4). In both cases 'history' has chosen a less suitable location, i.e. welfare of the whole economy could be enhanced if economic activity relocated to the other location. Both chapters assess under which conditions this inefficient allocation can be corrected by means of state subsidies.

In detail, the third chapter presents a subsidy game among two asymmetric regions where geographically localized intra-industry spillovers serve as a source of agglomeration. This allows for stable locational equilibria where all industrial activity is inefficiently locked-in into the smaller region. When regions weigh workers' and capitalists' welfare equally, the core region will set its subsidy low enough that the industry relocates to the larger region, restoring an efficient allocation. Jurisdictional competition in this case corrects inefficiencies that result from external scale economies. When workers' welfare is weighted more heavily, the core may pay subsidies that are high enough to prevent a relocation of industry. In this case industry remains inefficiently locked-in in the smaller region.

Chapter 4 analyzes competition for capital between welfare-maximizing governments in a framework with agglomeration tendencies and asymmetric unionization. We find that a unionized country's government finds it optimal to use tax policy to induce industry

[14]For a detailed illustration see Baldwin et al. (2003).

to relocate towards a location with a competitive labor market instead of realizing the benefits from higher wage income while exporting part of the wage burden to foreign consumers. Via the tax regime effect, which favors the factor capital, and the efficiency effect, consumers and producers alike benefit from off-shoring industry towards a low-cost country. Our result qualifies first intuition that defending high wage industries is beneficial to a country as part of the associated cost is shifted to foreign consumers.

Contrary to the preceding chapters 3 and 4, the last chapter of the dissertation presents a true vertical linkage model in the spirit of Venables (1996) that considers production linkages as a source of agglomeration. The paper recognizes the recent shift in several national industrial policy strategies as outlined in the latest OECD report on regional policies (OECD (2007)). It assesses a cluster strategy where public funds are distributed to firms of an industry of which local authorities believe that it fosters an ongoing co-agglomeration process. The attraction of one industry induces further establishments of related industries to co-locate as this lowers the cost of purchasing intermediate inputs. In contrast to the preceding theoretical models, overall welfare could not be enhanced by shifting the core to the other location. The equilibrium outcome of the subsidy race then reveals that a welfare maximizing periphery will abstain from snatching the industrial core as the financing costs exceed the benefits of attracting a core industry. The allocation of economic activity remains unchanged. Except for capital owners of the subsidized industry core residents suffer from financing sector specific subsidies that are necessary to prevent a relocation of industry.

All in all, the doctoral dissertation comprises theoretical and empirical contributions to topics in industry agglomeration and public finance. It provides a detailed picture of the industry structure in Germany and unveils that first and second nature geographies considerably shape the location pattern of economic activity in Germany. In addition it also documents the persistence of industry agglomeration over time. The subsequent chapter confronts theoretical predictions of the economic geography literature with German firm level data. The empirical findings confirm the existence of agglomeration rents and unveils factors that may hamper the extraction of location rents. The dissertation continues with three theoretical contributions which emphasize different sources of agglomeration. In the broader sense, the theoretical models elaborate on inefficiencies that arise from increasing returns to scale and/or labor market distortions. The results qualify traditional views that inter-jurisdictional competition is always inefficient. They also highlight distributional tensions that arise between different factor owners notably workers and capitalists.

Chapter 1

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

1.1 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 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 has 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

[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).

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 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 exhibit 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. At 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 in 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

[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).

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 the fact 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 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 across different scales of aggregation.

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, 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.

1.2 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

[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.

[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.

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 1.1).

Table 1.1: 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 1.2 indicates that the size distribution of plants in our data is skewed toward small establishments as 28 % of firms employ 1 employee only, 50 % employ between 2 and 10 workers, 17 % between 11 and 50 workers and only 5 % of the plants employ 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 10 and 56,535 firms whereas the median industry consist of 485 plants (see Table 1.3).

Table 1.2: 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

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

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

Table 1.3: 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

municipality observe a bilateral distance of zero. As the majority of 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.

1.3 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.

1.3.1 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]

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

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

1.3.2 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 of the bilateral distances according to (1).

We repeat (i) and (ii) a thousand times such that the simulation provides us with 1000

[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.

counterfactual estimates for kernel densities $\tilde{K}^s_{\tilde{m}}(d)$, $s = \{1, ..., 1000\}$ for each industry m.

1.3.3 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 $\tilde{K}^s_{\tilde{m}}(d)$ 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 $d \in [0, 312]$.

1.3.4 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

[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.

least one distance. In contrast, an industry is said to be dispersed if $\hat{K}_m(d) < \underline{\tilde{K}_m(d)}$ for at least one $d \in [0, 312]$ *and* the industry is not localized. The localization and dispersion indices are then defined as

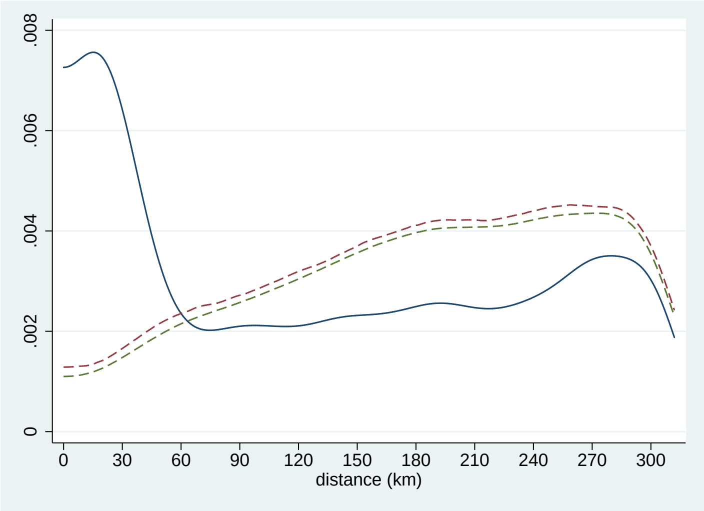
$$\Gamma_m(d) \equiv max(\hat{K}_m(d) - \overline{\tilde{K}_m(d)}, 0) \tag{2}$$

for localization and

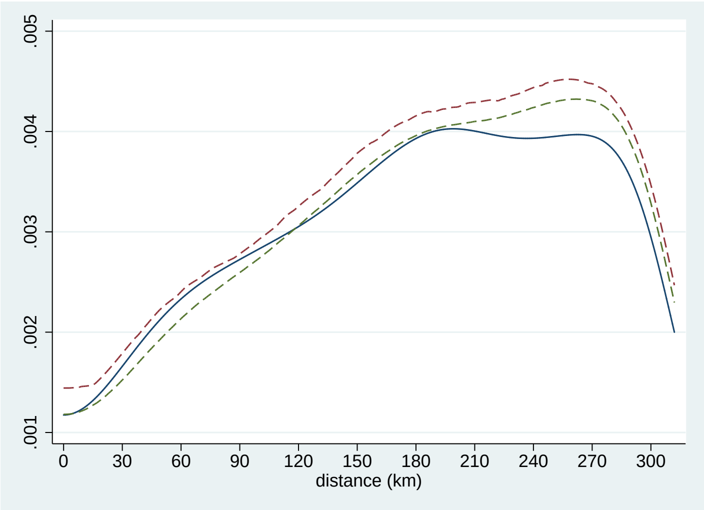
$$\Psi_m(d) = \begin{cases} max(\underline{\tilde{K}_m(d)} - \hat{K}_m(d)) & \text{if} \quad \sum_{d=0}^{312} \Gamma_m(d) = 0, \\ 0 & \text{otherwise.} \end{cases}$$

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 1.1 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, in the state of Baden-Württemberg and in Saxony as can be seen in Figure 1.2. 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



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



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

(c) Manufacture of Jewelery (WZ3622)

Figure 1.1: Kernel Density Functions and Global Confidence Bands

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 1.1c). Figure 1.2 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 of Baden-Württemberg.

The last map in Figure 1.2 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).

1.4 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.

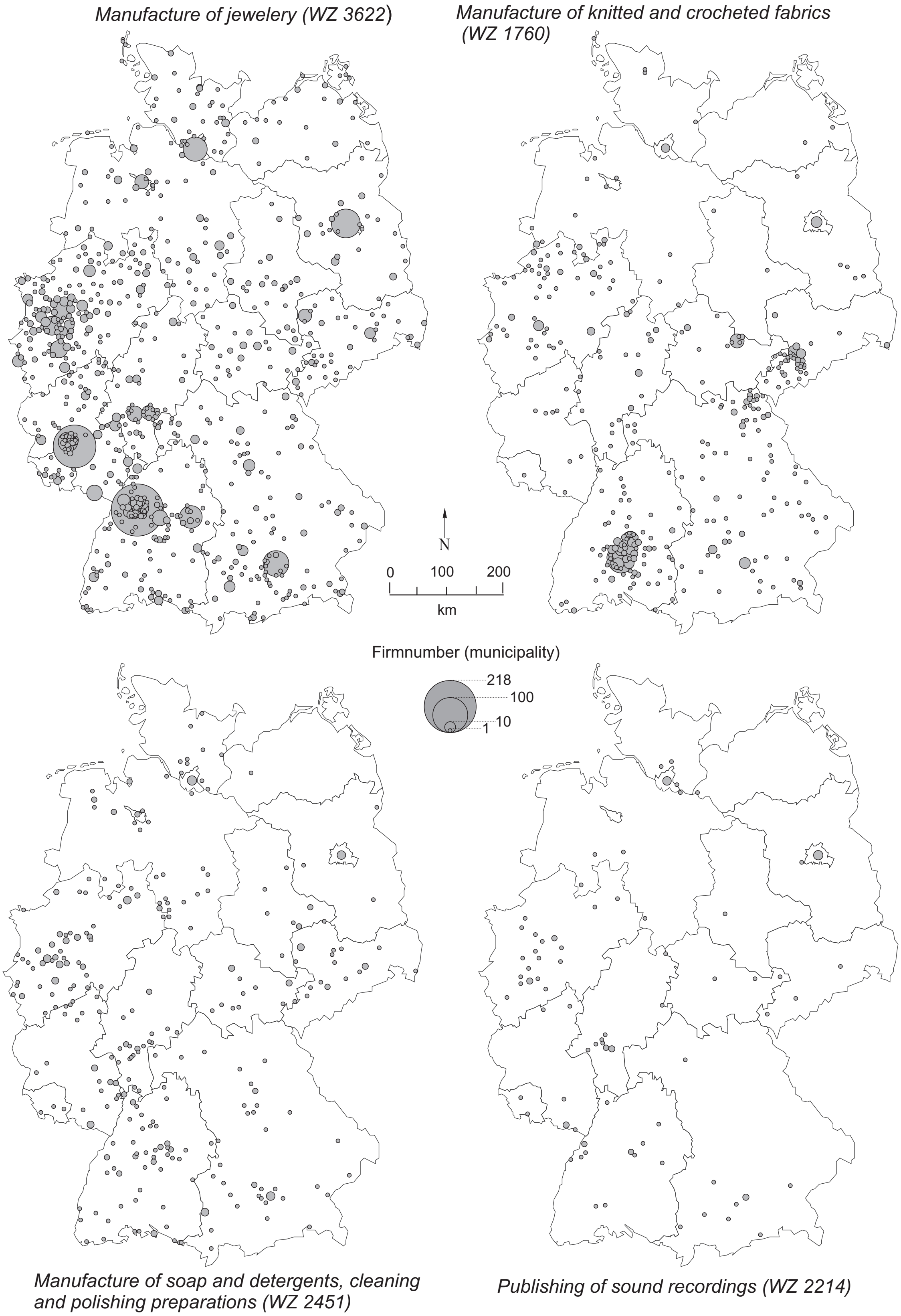


Figure 1.2: Industry location pattern for four illustrative industries

(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.

Table 1.4 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 are 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

Table 1.4: 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

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 such as financial intermediation and entertainment are in general less dependent on natural resources, exhibit lower transport costs and rely more on face-to-face interactions with their customers. 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 1.5.

Table 1.5: 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 thick labor market effects including knowledge spillovers or labor market pooling may be major drivers 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 e.g. Market research and public opinion polling (WZ7413).

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 of 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 1.3 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 1.4 and Table 1.5, 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.

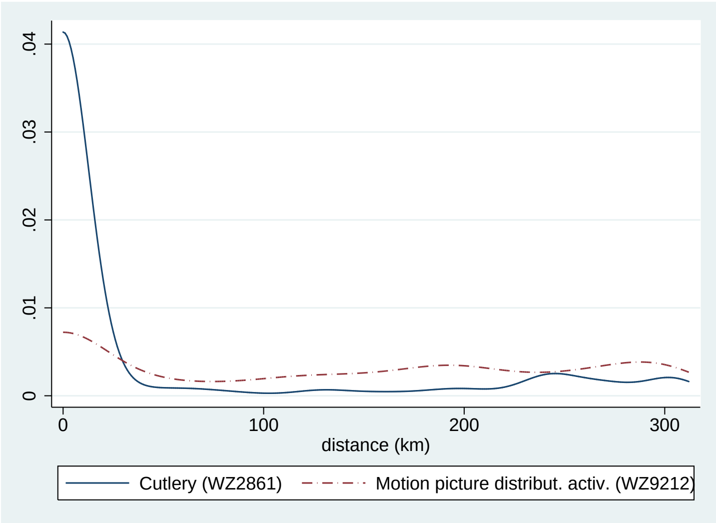


Figure 1.3: Kernel Density Functions for Cutlery (WZ2861) and Motion picture, video distribution activities (WZ9212)

To complete our analysis, we list the most dispersed industries in Table 1.6. 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 to the contrary show that high-tech industries tend to be geographically localized (although with a 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 exceed 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.

Table 1.6: Most Dispersed Manufacturing Industries (DO index)

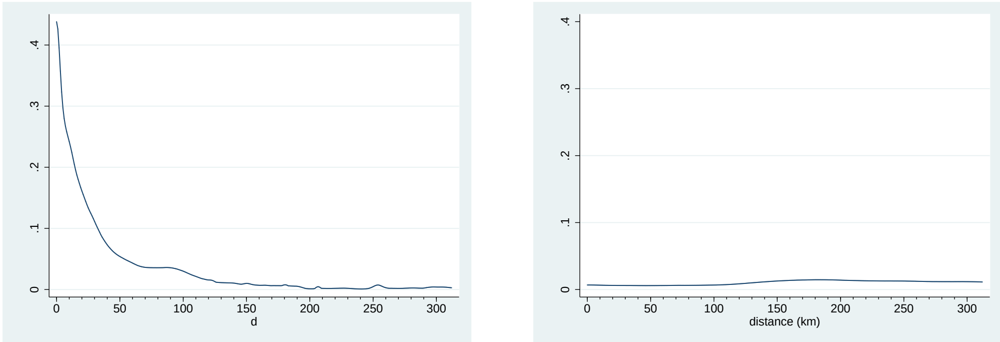
Four-digit industries		Ψ_m
3621	Striking of coins	.098
3543	Manufacture of bicycles and invalid carriages	.083
1588	Manufacture of homogenized food preparations and dietetic food	.075
2744	Copper production	.069
2411	Manufacture of industrial gases	.068
1717	Preparation and spinning of textile fibres	.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

This is illustrated in Figure 1.4 which depicts the distribution for global localization and global dispersion of the industries in our sample across distances.

1.4.1 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



(a) Global localization (b) Global dispersion

Figure 1.4: Γ_m and Ψ_m by distance

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 1.7).[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

[10]To avoid pitfalls that may result from transforming 'dots on a map into unit of boxes', Table 1.7 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.

% 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 (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 be less exposed to transport costs but are on the other hand 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.

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 1.8. 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 re-

[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 1.7: 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

sults 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.

1.5 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

[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.

Table 1.8: Intra-Industry Localization

Two-digit branch		*No. of four-digit industries*	*% of ind. 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	

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 illustrate the methodological shortcomings in depth.

1.5.1 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. First, 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 due to history or general first nature geographies (e.g. one generally expects less economic activity on rugged terrain or at high altitude).

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

[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.

characteristics. The EG index is defined as

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

where 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 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. The authors 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. These threshold values have been commonly applied in various applications of the EG index (see e.g. Rosenthal and Strange (2001)).

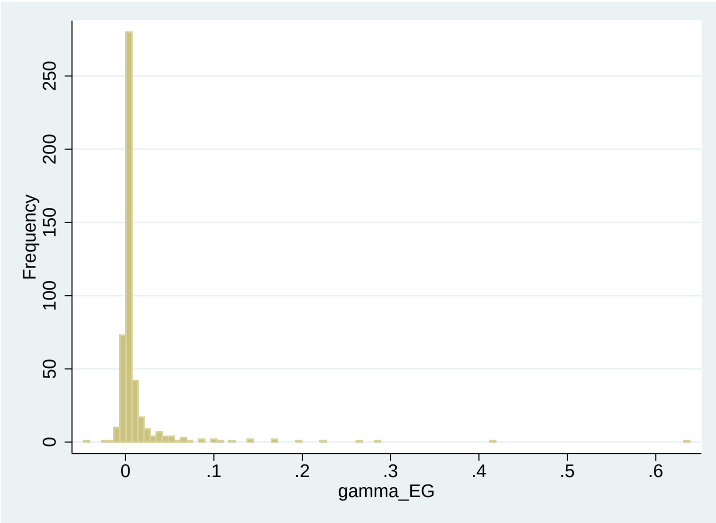


Figure 1.5: Distribution of γ_{EG}

1.5.2 Results with the EG index

Figure 1.5 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 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

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

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[15] 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').[16] Table 9 lists the Herfindahl index (H), the mean raw concentration

[15] This becomes clear after inspecting the raw index of concentration $G \equiv (s_i - x_i)^2$. Recall that G will be low as long as an industry mimics the general tendency of the economy to agglomerated, i.e. as long as s_i and x_i are of similar size. Increasing the scale of spatial aggregation then causes a widening of the gap between an industry's share in a region's employment s_i and a region's share in overall employment x_i.

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

Table 1.9: 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 1.10: 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 %)

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 1.10, 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).[17]

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-country comparisons of agglomeration patterns based on the EG methodology. As the DO approach

[17]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.

Table 1.11: 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

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 the fact that 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. Tables 1.11 and 1.12 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 as 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 1.12 the EG analysis

Table 1.12: 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

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 results 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).[18]

[18]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. DO report that fewer industries are localized when weighting for employment but these industries deviate more strongly randomness.

1.6 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 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 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 (2009b).

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. These are interesting avenues for future research to explore.

Chapter 2

Taxing Agglomeration Rents: The importance of localization and urbanization for local business taxation

2.1 Introduction

One of the most fascinating stylized fact that still allures researchers from various fields is the uneven distribution of economic activity in space. In his principles Alfred Marshall (1890) acknowledges that economic activity tends to cluster in space and that this agglomeration cannot always be explained by exogenous differences in first nature geographies (the physical configuration of the landscape with mountains, coast or natural resources). He formulated three sources of agglomeration economies which are all based on the idea that firms profit from locating geographically close to each other: knowledge spillovers, labor market pooling effects and input-output linkages. Since the advantage of locating in geographical proximity may affect firms within the same industry differently than firms operating in different sectors, the literature distinguishes between so-called *localization* economies which describe the concentration of economic activity on the industry level and *urbanization* economies which describe the overall size of the corporate sector and market respectively.[1]

Several fields in economics have acknowledged the existence of agglomeration externalities such as the new growth theory or new trade theory which led to an extensive body of research initiated by Krugman (1991) known as the New Economic Geography (NEG) literature. The impact of urbanization and localization economies on productivity (Henderson (1986), Henderson (2003) and Combes et al. (2007)), wages (Wheaton and Lewis (2002)) and growth (Glaeser et al. (1992), Henderson et al. (1995)) has been extensively studied. Recent years have moreover seen the development of a flourishing theoretical literature that applies NEG models to questions related to public economics, most notably papers by Andersson and Forslid (2003), Ludema and Wooton (2000), Baldwin and Krugman (2004) and Borck and Pflüger (2006). The key finding of this literature is that the presence of agglomeration economies reduces the mobility of capital and creates taxable location rents. This allows local governments to set higher tax rates without triggering an immediate capital outflow.

[1]See Rosenthal and Strange (2004) for a detailed survey on urbanization and localization economies.

Despite this theoretical interest in the interaction between agglomeration economies and local governments' tax setting behaviour, the theoretical predictions have to the best of our knowledge, not yet been tested in a rigorous empirical framework which, additionally to overall agglomeration effects, distinguishes between different scopes of agglomeration. Our paper aims to provide some answers in this area and to determine if and to what extent jurisdictional tax setting behaviour is affected by the presence of agglomeration rents.

Our testing ground is the German local business tax (*Gewerbesteuer*) which is set autonomously by the approximately 12,000 German municipalities. Precisely, we determine how urbanization and localization economies affect the municipalities' local business tax rate choice. To construct agglomeration measures for urbanization and localization economies, we employ a rich data-set comprising all firms located in Germany. Urbanization economies arise because firms profit from locating near to other firms and thus, they are captured in our estimation strategy by the number of workers employed in a jurisdiction. To construct measures for localization economies, we in a first step identify industries whose localization pattern shows (strong) spatial clustering of activity following the distance-based approach proposed by Duranton and Overman (2005). From this, we in a second step construct several localization measures which account for a community's number of workers in localized industries, the intensity of the industry's localization pattern and the fraction of the overall number of employees in a localized industry which is located in the considered municipality. To the best of our knowledge, our paper is the first to analyze the importance of agglomeration on the industry level separately from overall size effects. Our estimation results suggest a positive effect of urbanization economies and localization economies on tax setting behaviour which is determined to be quantitatively larger for the localization measure. Precisely, we find for our preferred specification that a ten percent increase in the number of localized employees (capturing localization economies) enhances the local business tax by 3 percentage points while an increase in the number of employees (capturing urbanization economies) by ten percentage points induces a rise in the local business tax by 0.6 percentage points.

To avoid a bias in our estimation results driven by unobserved heterogeneity between the municipalities in our sample, we add a large set of control variables to our regression framework. Thus, we account for first-order differences in nature characteristics by including control variables for the jurisdiction's quality of soil and for proximity to rivers, mountains, lakes and the sea. Moreover, we add a full set of fixed effects for commuting areas within Germany to absorb heterogeneity between regions and additionally account for differences in income levels, public good provision, the municipality's fiscal situation and neighboring community's tax setting behaviour. Clustering of the standard errors at the level of the commuting regions moreover takes into account that the communities may be hit by correlated shocks. Additionally, our empirical specifications accounts for potential problems caused by reverse causality as the local business tax rate choice may simultaneously affect the firm agglomeration in a municipality. To overcome this identification problem, we employ an instrumental variable approach which relies on long-lagged historical population data and on historical data on the introduction of railways as exclusion restrictions for the observed agglomeration economies. Both measures include information for years prior to 1936 when the first local business tax act was passed in Germany. We find our instruments to be relevant and valid.

In a final step, we show that a municipality's potential to tax agglomeration rents is determined by its agglomeration characteristics relative to neighboring communities. Since the majority of German municipalities comprise rather small geographical areas, spatial concentration of firms is unlikely to end at the administrative border but in many cases spreads across several municipalities. If municipalities which are close substitutes with respect to their localization and urbanization pattern are located nearby, this might alleviate a jurisdiction's potential to tax agglomeration economies. This pattern is also suggested by anecdotal evidence. For example, Munich which is the only major city in Southern Germany has a local business tax rate of 490 business tax points (or 24.5 percentage points) in our sample period while several large cities in North-Rhine Westphalia are located geographically close and have local business tax rates below 420 business tax points (or 21 percentage points) (see e.g. Cologne, Duesseldorf,...). To test for this effect in an empirical framework, we construct measures which capture size differences between a jurisdiction and its neighboring municipalities (in the urbanization dimension) and employment differences for the set of localized industries located in a jurisdiction compared to its neighbors. Our results confirm this presumption and indicate that jurisdictions set larger tax rates if they host large firm agglomerations *relative* to neighboring communities and if they locate agglomerated industries which are weakly represented in neighboring municipalities.

Summing up, this paper determines the effect of agglomeration economies on the choice of the corporate tax rate in an empirical framework. The main novelty is to assess the role of different agglomeration channels on the choice of the local business tax rate, precisely of localization and urbanization economies in the considered community and neighboring municipalities. The paper extends work by Buettner (2001) and Charlot and Paty (2007) who determine the effect of urbanization economies in the consumer dimension on the jurisdictional tax rate choice. Buettner (2001) analyzes the determinants of the choice of the German local business tax using a panel of jurisdictions within the German state of Baden-Württemberg and finds that jurisdictions with a larger population tend to set higher local business tax rates. Charlot and Paty (2007) equally assess the effects of access to consumer markets on the corporate tax rate choice for French municipalities, where market access is defined as the distance-weighted income of all other municipalities. They find a positive relationship between the local tax rate and the municipality's market access suggesting the existence of taxable agglomeration rents.[2] Both papers, however, neglect urbanization effects in the firm dimension and do not account for localization economies. Moreover, both papers equally do not address potential estimation problems caused by reverse causality, a problem that we circumvent in our analysis by using an instrumental variable approach.

Moreover, our analysis relates to papers which determine corporate tax and agglomeration effects on the location decision of firms. Prominent examples are Devereux et al. (2007), Brülhart et al. (2007) and Jofre-Monseny and Solé-Ollé (2008). All of the

[2]Note that our main results are unaffected by the inclusion of a control variable for the consumer market access as shown in robustness checks.

cited papers find that the location decision of firms becomes less sensitive to corporate tax rate changes in the presence of agglomeration economies. However, although these findings are in line with our results, the papers conceptually differ from our analysis since they do not test whether agglomeration economies exert a causal impact on the choice of the jurisdictional local business tax rate.

Our paper is structured as follows: In section 2, we discuss the main theoretical hypotheses underlying our empirical work. Section 3 describes the data set, in section 4 the estimation strategy is presented. Section 5 gives an overview over our main findings. Section 6 concludes.

2.2 A Simple Theoretical Model

In the following, we construct a simple theoretical model based on Haufler and Wooton (2009) to receive guidance for the specification of our empirical framework. We consider a metropolitan area formed by two jurisdictions $i \in \{a, b\}$ each inhabited by n_i immobile residents and competing for a fixed number of mobile firms. Each jurisdiction hosts two industries, a "localized" industry and a numéraire sector. Firms of the localized industry produce a homogeneous good x under imperfect competition whereas firms in the latter sector produce the numéraire good z under perfect competition. Both goods are produced using labor as the only input. The x commodity is subject to real transport costs whereas the numéraire good is traded freely which also ensures the wage rate w to be equalized across jurisdictions. Residents in both locations have identical preferences

$$u_i = \alpha x_i - \frac{\beta}{2} x_i^2 + z_i, \quad i \in \{a, b\} \tag{1}$$

Each resident receives wage income from inelastically supplying one unit of labor to either sector x or z. Moreover, we assume that total revenues T_i stemming from local business taxation are redistributed to consumers residing in jurisdiction i. Hence, each resident's budget constraint can be expressed as $w + \frac{T_i}{n_i} = z_i + p_i x_i$. Solving the representative consumer's utility maximization problem and aggregating over all consumer yields the aggregate market demand for good x, $X_i = \frac{n_i(\alpha - p_i)}{\beta}$.

A number of k mobile firms of the localized x sector from outside of the metropolitan area are willing to invest in either jurisdiction a or b. Each entrant thereby incurs fixed costs $F_i \equiv f - \gamma h_i - \mu n_i$, where f is assumed to be identical across jurisdictions and incorporates costs e.g. for setting up a production facility or administration costs not further specified in the model. Moreover, we presume that an entrant's set up costs are lowered if it locates in particular close to firms of the same industry due to the existence of agglomeration economies and if it locates where economic activity is most intense (large region size measured through n_i). The term γh_i therefore captures a new firm's benefit from locating close to existing firms h_i of the same industry ("localization economies") whereas the latter term μn_i incorporates the cost lowering effect resulting from the overall scale of economic activity within a jurisdiction ("urbanization economies").[3]

In the spirit of Brander and Krugman (1983)'s reciprocal dumping model firms non-cooperatively choose quantities for each market separately. Hence, pre-tax operating profit of a firm located in i is given by

$$\pi_i = (p_i - w)x_{ii} + (p_j - w - \tau)x_{ji}, \quad i \neq j \tag{2}$$

where p_i is the producer price for sales on the home market, p_j denotes the producer price on the foreign market and x_{ji} is the quantity sold in j by a firm producing in i. Maximizing (2) using market demand X_i yields optimal quantities for both markets of a firm located in i

$$x_{ii} = \frac{n_i(\alpha - w + (k_j + h_j)\tau)}{\beta(1 + k + h)}, \qquad x_{ji} = \frac{n_j(\alpha - w - \tau + (1 + k_j + h_j)\tau)}{\beta(1 + k + h)} \tag{3}$$

[3]The theoretical model in Konrad and Kovenock (2009) argues in a similar direction. The authors assume within a dynamic framework that the fixed costs for FDI will be lower if a region succeeded to attract FDI in the preceding time period. Consequently, the existence of old FDI results in an "agglomeration advantage" for the competing jurisdiction.

Eq. (3) reveals that optimal output levels for the home market depend positively on the number of firms in the other jurisdiction, $(k_j + h_j)$, as this reduces competition on the domestic market. Substituting optimal output levels using in (3) and equilibrium consumer prices into firm's profit function (2) yields the pre-tax operating profit of a firm located in jurisdiction i

$$\pi_i = \frac{n_i[\alpha - \omega + (k_j + h_j)\tau]^2}{\beta(k + h + 1)^2} + \frac{n_j[\alpha - \omega - (1 + k_j + h_j)\tau]^2}{\beta(k + h + 1)^2}, \tag{4}$$

with $k = k_i + k_j$ and $h = h_i + h_j, \quad i \neq j, \quad i, j \in \{a, b\}$. In the absence of transport costs location no longer matters as both jurisdictions form a common market. A higher number of new and initial firms increases the degree of competition and depresses a firm's operating profit. A higher overall number of both initial and new firms increases competition on the product market and reduces a firm's operating profit.

All firms are subject to a local business tax t_i imposed by the host region. The potential k new firms decide on where to set up their production facility based on the comparison of after-tax profits in a and b where the after-tax profit for a firm locating in i, reads

$$\Pi_i \equiv \pi_i - t_i - F_i \tag{5}$$

Solving the condition for a locational equilibrium $\Pi_a - \Pi_b = 0$ with $\Delta \equiv t_a - t_b$ denoting the tax rate differential between region a and b allows us to solve for the equilibrium number of new entrants to the market in jurisdiction a

$$k_a^* = \frac{k - \psi^{loc}}{2} + \frac{\phi(2n_a - n)}{2n\tau} - \frac{\beta(1 + k + h)(\Delta - \mu\psi^{urb} - \gamma\psi^{loc})}{2n\tau^2}, \tag{6}$$

where $\phi \equiv 2(\alpha - \omega) - \tau > 0$. The term $\psi^{urb} \equiv n_a - n_b$ captures jurisdiction a's relative agglomeration advantage with respect to the overall scale of economic activity whereas $\psi^{loc} \equiv h_a - h_b$ reflects the degree of a's uniqueness with respect to its localized industry. A large number of existing firms h_a relative to jurisdiction b intensifies competition in a and deters mobile firms from entering this market. The second term in (6) captures a jurisdiction's pure size effect which vanishes if jurisdictions are equally sized. Differences in tax rates denoted by Δ will affect firms' location decision but less so if a jurisdiction exhibits agglomeration advantages both on the industry and overall level of economic activity. The effect of taxation becomes less decisive in firm's location choice if the respective jurisdiction is larger in absolute terms but also relative to its neighboring jurisdiction and hosts a larger number of firms in the localized sector. Consequently, the model accounts for the empirically well established fact that the existence of agglomeration economies attenuates firms' sensitivity to tax differentials (See e.g. Devereux et al. (2007), Brülhart et al. (2007) and Jofre-Monseny and Solé-Ollé (2008)).

In the first stage of the tax game local governments maximize their residents' wage income and revenues from taxing profits of firms producing within their administrative boundaries, $W_i = t_i(k_i + h_i) + \frac{w}{n_i}$, choosing their tax rates non-cooperatively. Differentiating each government's objective function W_i with respect to its own tax rate taking into account the equilibrium firm number in (6) and solving for the equilibrium Nash tax rate yields

$$t_i^* = \frac{\gamma\psi_i^{loc} + \mu\psi_i^{urb}}{3} + \frac{\tau[3n\tau(k+h) + \phi(n_i - n_j)]}{3\beta(1+k+h)}, \quad i \neq j, \quad i,j \in \{a,b\} \tag{7}$$

In the following we are primary interested in the comparative static results

$$\frac{\partial t_i^*}{\partial h_i} > 0, \qquad \frac{\partial t_i^*}{\partial n_i} > 0. \tag{8}$$

Our comparative static results suggest that both urbanization and localization advantages exert a positive impact on the choice of the local business tax. The equilibrium tax rate chosen by each government will be higher the larger the absolute size of economic activity in general and the economic scale on the sectoral level.

The model also reveals that the capacity of a government to tax away location rents depends on whether the respective jurisdiction hosts a larger economic base and a larger amount of firms in the agglomeration sector than the competing jurisdiction.

This is formally captured by the following comparative static results

$$\frac{\partial t_i^*}{\partial \psi_i^{loc}} > 0, \qquad \frac{\partial t_i^*}{\partial \psi_i^{urb}} > 0. \tag{9}$$

Thus, our analysis predicts a positive effect of urbanization and localization economies on the tax rate choice and stresses that it is not only the jurisdiction's own agglomeration measures which are decisive for the corporate tax decision but also the relative position compared to other jurisdictions. In the following, we will bring this hypothesis to the data.

2.3 Data

The purpose of our paper is to determine how agglomeration economies and industry patterns affect the corporate tax rate choice of jurisdictions. Our testing ground is the German local business tax which is set autonomously by the approximately 12,000 German municipalities. Micro data on the industry classification and employment level of the whole population of German firms enables us to construct agglomeration and industry patterns and to link these variables to the municipalities' tax rate choice.

Our paper draws on various data sources in order to set up a data set which is suitable to test the hypotheses outlined above. Our final data includes information for the years 1999 to 2007. The observational unit is the municipality per year. The dependent variable in our empirical analysis is the local business tax rate which is set at the German municipality level. We restrict our analysis to communities located in Western Germany as communities in the East German states (which joined the Federal Republic of Germany in 1990) were subject to structural reforms which changed their geographical borders within our sample period.[4] This leaves us with a total of 8,464 West German municipalities between 1999 and 2007. The information on the local business tax rate is taken from the German Federal Statistical Office. Table 2.1 shows that the average

[4]Nevertheless, we find largely comparable results to the ones presented in this paper if we account for all municipalities in Germany.

business tax rate set by communities in Germany is determined with 334 business tax points or $16.7\%(= 5\% \cdot 334)$ and shows a considerable cross-sectional variation between a tax rate of 0% to 45%.

To construct measures for the presence of agglomeration economies and for the industry structure at the municipality level, we exploit a comprehensive and detailed data set on the population of German firms between 1999 and 2007 which is provided by the German Employment Agency ('Bundesagentur für Arbeit'). The data includes a detailed industry classification for each firm at the 4-digit level, the firm's number of employees (which are subject to social security payments[5]) and the firm's host community. This firm and employment information is used to construct measures for the municipalities' urbanization and localization economies in absolute and relative terms, i.e. we determine measures capturing the jurisdiction's own agglomeration patterns and its agglomeration pattern relative to neighboring communities. A detailed description of the variable construction can be found in Section 4. As depicted in Table 2.1, the average number of employees in German municipalities is $2,571$ with a strong cross-section variation though between one and $774,869$ employees.

Moreover, we augment our data by information on various municipality characteristics which are used as control variables in our analysis. Thus, we add information on first-order nature differences between the jurisdictions, comprising data for the soil quality (published in the European Soil Database[6]), as well as first nature geographies like the location at a river, lake, the sea or the mountains (obtained from the Bundesamt für Kartographie and Geodäsie). Moreover, we account for information on the inhabitants' average income, the community's financial situation as measured by the lagged deficit per capita in the grants per capita received through the German income redistribution scheme.[7] Furthermore, we control for the level of public good provision by including variables on infrastructure quality as the presence of a railway station, airport, seaport

[5]In Germany, only workers employed in minor contracts (earning less than 400 Euros per month) are not subject to social security contributions.

[6]We thank Gilles Duranton for providing us with this data.

[7]The information on income and the communities' budget variables is retrieved from the German Federal Statistical office and its publications *Statistik Lokal*.

and high-way connection (obtained from the Bundesamt fuer Karthographie and Geodaesie). Last, a distance-weighted average tax rate for the neighboring communities is added. The associated descriptive statistics are found in Table 2.1.

2.4 Empirical Methodology

In our empirical analysis, we estimate a model of the following form

$$t_{it} = \alpha_0 + \alpha_1 U_{it} + \alpha_2 L_{it} + \alpha_3 X_{it} + \epsilon_{it} \tag{10}$$

whereas t_{it} depicts the local business tax rate of community i at time t. U_{it} and L_{it} describe urbanization and localization economies. The urbanization economies U_{it} are reflected by the general economic activity in a community and are captured in our analysis by the municipality's number of employees. Formally, we define a first urbanization measure $U^1_{it} = EMP_{i,t}$ with $EMP_{i,t}$ being municipality i's employment at time t. Firms are presumed to profit from locating close to each other in the same community. If the associated rent is taxable by the municipality, larger firm agglomerations are presumed to exert a positive effect on the tax rate choice. Consequenlty, we presume $\alpha_1 > 0$.

However, as laid out in the theory section, the ability of a community to tax an urbanization rent may not only depend on its own firm agglomeration but also on its relative agglomeration compared to neighboring jurisdictions. Precisely, if other communities with a similar or even larger size than the considered community are located geographically close, mobile firms have an attractive alternative location choice. This competition dimension between communities may restrict their ability to tax urbanization rents. To capture a municipality's relative economic activity, we define a second urbanization measures capturing differences in the number of employees between the considered jurisdiction i and other German communities j

$$U^2_{i,t} = \sum_{j=1}^{N} \left(\frac{EMP_{i,t} - EMP_{j,t}}{DIST_{i,j}} \right), \quad i \neq j, \ \ell \in \{i, j\} \tag{11}$$

whereas $EMP_{i,t}$ and $EMP_{j,t}$ depict the number of employees in the considered jurisdiction i and the neighboring jurisdiction j in year t respectively and $DIST_{i,j}$ stands for the geographic distance between the two jurisdictions. A high positive value for the similarity measure $U^2_{i,t}$ indicates that the respective municipality hosts a large number of workers compared to other (neighboring) jurisdictions. According to our theoretical model, the municipality is then positive differentiated from its neighboring communities with respect to urbanization economies which should allow it to tax arising agglomeration rents, predicting $\alpha_1 > 0$.

Moreover, to determine localization economies $L_{i,t}$, we in a first step exploit our micro data on the population of German firms to identify 4-digit industries in Germany which exhibit strong geographical clustering at small distances. To do so, we follow a methodology developed by Duranton and Overman (2005) (in the following DO). The approach is sketched in Appendix A of this paper whereas a more detailed description of the methodology as well as of the results to this exercise can be found in a companion paper (Koh and Riedel (2009a)). Abstracting from any industries which are clearly not expected to show geographical localization patterns (as e.g. public libraries, retail companies etc.), the DO approach reports that the location pattern of 78% of the remaining German manufacturing and service industries deviates from randomness at any distance. For our purpose, it however seems to be more decisive whether industries are significantly agglomerated at small distances as it is only then that they may be presumed to profit from being geographically very close to other firms within the same jurisdiction and that taxable agglomeration rents arise.[8] We thus identify a first set of industries which are agglomerated at a distance of 0 kilometers (i.e. are agglomerated

[8]If an industry is for example signifcantly agglomerated at a distance of 50 kilometers, then firms appear to profit from being sufficiently close to each other but not necessarily located within the same community. This then does not allow any of our geographically small communities to tax the associated agglomeration rent as the firms are indifferent at which precise community within a certain distance radius to locate.

within the boundaries of German jurisdictions)[9] and a second set of industries which are significantly localized at a distance smaller 10 kilometers according to the Duranton and Overman (2005) approach (73% and 77% of the industries respectively).

As the majority of industries thus observes a significant localization pattern, we face the difficulty that localization measures may be highly correlated with the urbanization measures described above which makes identification of both difficult (the correlation between the number of employees in localized industries at 0 kilometers (10 kilometers) and the overall number of employees is for example determined with 0.898 (0.997)). Moreover, many of the industries exhibit only a weak agglomeration pattern according to the DO index which indicates the intensity of localization (denoted by $\Gamma_m(d)$ in Appendix A). Thus, for an industry to be defined as localized for our analysis, we require it to be signficantly agglomerated at a distance of 0 kilometers (below 10 kilometers) *and* to exhibit a high localization intensity in the sense that the DO index is above the mean of the sample distribution. As this cut-off value is adhoc, we experimented with other cutoff values at the median and different percentiles of the sample distribution which are reported in the result section. Based on this discussion, we define our first localization measure to be the community's number of employees which are employed in localized industries $L^1_{i,t} = \sum_{m=1}^{M} EMP_{i,m,t}$ with $EMP_{i,m,t}$ indicating the number of employees in community i, at time t, in the localized industry m.

On top of that, the capability of a community to tax the localization rent, however, also depends on the *fraction* of employees in a certain localized sector hosted by the considered municipality. The larger the fraction of the localized industry's activity within a community's borders, the less attractive it is for firms in this industry to leave the community. Thus, we additionally construct a measure for localization rents as the sum of localized industries shares in a considered community $L^2_{i,t} = \sum_{m=1}^{M}(EMP_{i,m,t}/\sum_{m=1}^{M} EMP_{m,t})$. Last, to combine $L^1_{i,t}$ and $L^2_{i,t}$, we define a measure to capture industry cores (i.e. large agglomerations of a localized industry) since we presume that it is mainly those cores which give rise to pronounced local-

[9]Note that we cannot identify the exact geographic location of firms within one community and thus, the geographical distance of firms located in the same community is zero kilometers.

ization economies. Thus, we define a localization measure $L^3_{i,t}$ which captures the number of employees in localized industries if the share of the industry in the considered community is above a defined threshold and hence, $L^3_{i,t} = \sum_{m=1}^{M} EMP_{i,m,t}$ if $EMP_{i,m,t}/\sum_{m=1}^{M} EMP_{m,t} > \alpha$ with α being some positive constant.

Last, following our theoretical predictions, we presume that the capability of the community to tax localization rents does not only depend on its own localization measures but also on its industry agglomeration compared to neighboring jurisdictions which are alternative location choices for mobile firms. Thus, the relative position compared to neighboring communities may be important, i.e. the difference in the number of employees in a certain localized industry compared to neighboring jurisdictions. We calculate the following variable to capture this effect

$$L^4_{i,t} = \sum_{j=1}^{N} \sum_{m=1}^{M} \left(\frac{EMP_{i,m,t} - EMP_{j,m,t}}{DIST_{i,j}} \right), \quad i \neq j \tag{12}$$

whereas $EMP_{i,m,t}$ again depicts the number of jurisdiction i's employees in the localized industry m and $EMP_{j,m,t}$ depicts the neighboring jurisdiction j's number of employees in industry m at year t.

Besides these agglomeration measures, X_{it} depicts a vector of control variables to absorb heterogeneity between the jurisdictions. Thus, we account for first order differences in nature characteristics by including information on the soil quality and proximity to rivers, lakes, mountains and the sea which may affect a jurisdiction's attractiveness as a firm location. This for example takes care of the fact that a fertile soil may have historically attracted the settlement of people and firms (which ultimately might have given rise to agglomerations) and simultaneously induces governments to impose a high corporate tax on firms which exploit the fertile soil in the jurisdiction. Moreover, we include a set of control variables for public good provision (the provision of a railway station, airport and seaport and the connection to highways) and the community's lagged financial situation (e.g. the lagged deficit per inhabitant and the grants per inhabitant received via the German fiscal equalization scheme), the income per employee and the average neighboring communities' tax rate. Following previous papers (see e.g. Overesch and Rincke (2008)), the latter is calculated as a distance weighted average of all other communities in Germany. Moreover, we add a full set of fixed effects for 74 employment regions in Germany ("Raumordnungsregionen") to account for heterogeneity between German regions whereas the employment (commuting) areas are defined according to German commuting patterns (see the definition of the Bundesamt für Bauwesen und Raumordung and Appendix C for a visualization).[10] Last, we control for a full set of year fixed effects to capture common shocks over time. ϵ_{it} stands for the random error term.

Finally, our analysis may be prone to potential reverse causality issues. Precisely, the tax rate choice may affect the agglomeration pattern observed in the community as low tax rates are well established to positively affect firm location. To account for reverse causality, we employ an instrumental variable approach and investigate how exogenous variations in the agglomeration economies affect the municipality's tax rate choice. In the following, we will briefly present the instrumental variables used for this purpose.

Our first set of instruments is constructed from historical population data for German municipalities. Precisely, we employ data from a census in 1910. Although the population information is available for all communities in 1910, we have to address the problem that several jurisdictions have experienced adjustments in their jurisdictional borders since then. Precisely, in 1910 the area which is Germany today has hosted around 70,000 autonomous communities. Today the same area is divided into around 12,000 communities only. Using historical maps, we have linked the population data in 1910 to today's jurisdiction borders and thus constructed information on the long lagged population of today's municipalities.

A central advantage of this long-lagged population data is that it reflects a municipality's inhabitants before the introduction of the local business Tax Act ('Reichsgewerbesteuergesetz vom 1. Dezember 1936') in Germany in 1936. Long-lagged pop-

[10]Note that our framework does not allow to include community fixed effects as the urbanization and localization measures constructed above hardly vary over time and thus do not enable us to determine agglomeration effects on the tax rate choice in a panel framework.

ulation data has been employed by several authors to instrument for the presence of agglomeration economies, see for example Ciccone and Hall (1996) and Combes et al. (2007). In several respects, however, we consider our data to be superior since we obtain long-lagged information for the whole territory of the German state in 1910 and do not have to restrict our analysis to jurisdictions (commonly cities) above a size threshold like earlier work. Based on this long-lagged population information, we construct several instruments for our agglomeration economies measures, precisely the long-lagged number of inhabitants in a community, a long-lagged market potential of the community (defined as the sum of inhabitants of neighboring communities over the geographic distance from the considered municipality) and a long-lagged relative population size measure which is defined analogously to $U^2_{i,t}$.

Moreover, as a second set of instruments we include long-lagged information on the number of train connections which run through a considered municipality. The data is obtained from Handbuch der deutschen Eisenbahnstrecken (1984) includes information on all train connections in Germany between the 1840ies and the early 1930ies (and thus before the introduction of the German local business tax in 1936). We match the long-lagged information on the railway system to the communities in our data set based on historic maps. The idea to use long-lagged information on infrastructure investment in the railway system to explain the agglomeration of (localized) firms follows the perception that infrastructure investment may attract firm agglomeration and affect agglomeration dynamics. Although these past infrastructure investments are themselves driven by determinants at the time of construction (like e.g. population density and the presence of natural resources for example in the mining industry), these infrastructure investments might also have had an impact on location decisions and agglomeration dynamics after their construction. This is, for example, also accounted for in a related framework by Redding et al. (2007) who show that the division of Germany into two states after World War II triggered a relocation of the airport hub from Berlin to Frankfurt (Main) which did not relocate back to Berlin after the reunification of Germany in 1990. This suggests that past infra-structure investments may prevail and may equally determine today's location patterns. The long-lagged information on the German railway system may thereby serve as a particularly good instrument for the localization of industries since in Germany particularly manufacturing firms with high trade costs tend to be localized for which the connection to the railway system may be of particular interest. From this long-lagged railway information, we define two instruments: first, the number of train connections of a municipality before 1935 and a market potential for the train network in neighboring communities (define as the sum of train connectons in neighboring communities normalized on the distance to the considered municipality).

For our instruments to be valid and to deliver unbiased estimates, they have to satisfy two conditions: relevance and exogeneity. Correlation tests indicate a relevant correlation between our instruments and the agglomeration variables. Since we are in the position to construct more instrumental variables from the long-lagged population and railway information than are needed to identify the estimation system, we can apply a Sargan/Hansen test to determine the exogeneity in the instrumental variables. The results for this test will be presented in section 5.

2.5 Results

Our results are depicted in Tables 2.2-2.10. All regressions control for a full set of year fixed effects and a full set of fixed effects for the German employment regions. Moreover, heteroscedasticity robust standard errors allowing for clustering at the commuting area level are presented in parentheses and thus, account for the fact that communities within the same commuting area may experience correlated shocks.

2.5.1 Baseline Results

Table 2.2 depicts our first set of baseline estimations using the number of employees to capture urbanization economies ($U^1_{i,t}$) and the number of employees in industries with significant and above average localization patterns according to DO to capture localization economies ($L^1_{i,t}$). As the distribution of the variables is strongly skewed, we follow previous papers and employ their logarithm as explanatory variable. Specification (1) regresses the tax rate on the agglomeration measures, simultaneously controlling for a full set of commuting area fixed effects and year fixed effects. The coefficient estimates for both variables are positive while, however, only the coefficient estimate for the localization variable gains statistical significance. Controlling for first-order nature characteristics in Specification (2) renders both coefficient estimates to become statistically significant suggesting a positive impact of localization and urbanization economies on the tax rate choice. This result is robust against controlling for the income per capita and the average tax rate in neighboring communities in Specification (3) and various public infrastructure and public budget variables in Specification (4). Quantitatively, a ten-percent increase in the number of employees induces the local business tax rate to rise by 9.3 business tax points (or 0.47 percentage points) while a ten-percent increase in the number of localized employees induces the local business tax rate to rise by 11.5 business tax points (or 0.58 percentage points).

The described specifications base the construction of the localization measure on industries which observe an above average localization intensity according to the DO index. As this cutoff value is adhoc, we reestimated our specification using alternative cutoff values for the localization intensity. In general, we find that - in line with intuition - the coefficient estimate for the localization measure rises the larger the cutoff value for the distribution of the localization intensity. Specifications (5) to (8) depict reestimations of Columns (1) to (4) whereas only industries with a localization intensity in the 90th percentile of the intensity distribution are considered for the construction of our localization measure (note that the 90th percentile is commonly larger than the mean of the intensity distribution). The results are comparable to the previous estimations whereas the coefficient estimate for the localization measure tends to be quantitatively higher though.[11] In Table 2.3, we moreover reestimate the specifications in Table 2.2 including all industries in the construction of the localization measure which exhibit

[11]Note, however, that the difference between the coefficient estimates in Columns (4) and (8) are not statistically different from each other.

significant localization patterns at any distance below 10 kilometers according to DO and find comparable (quantitatively slightly smaller) results.

Following our argumentation in the previous section, we experiment with alternative localization measures. In Table 2.4, we define the localization measure to be the sum of the employment shares of localized industries (at 0 kilometers according to DO) in the considered jurisdiction ($L^2_{i,t}$). Specifications (1) to (4) thereby take all industries with a DO index (and hence localization intensity) above the mean into account when constructing the localization measure whereas Specifications (5) to (8) account for industries with a DO index above the 90th percentile only. The results again indicate a positive effect of both urbanization and localization economies on the municipalities' business tax rate choice. This is confirmed in Table 2.5 which reestimates the Specifications in Table 4 but accounts for all industries which show significant localization patterns according to DO at any distance below 10 kilometers.

Finally, we merge the two definitions of the localization measures discussed so far into our preferred measure which considers the number of employees in a localized industry within the community's border accounting for major firm agglomerations only, i.e. agglomerations which comprise a sufficient share of the industry's employment. The idea behind this approach is that it likely does not pay for communities to host a single firm or a small number of firms in a localized industry (i.e. firms which are located apart from the major industry cores and thus may be spread across several communities). We follow two approaches to define this measure. First, we determine an employee distribution of each localized industry across the communities in our sample and identify the communities above the 99th percentile which host the largest number of employees in that industry. These communities are defined to host industry cores. The localization measure then sums up the number of employees in these industry cores for the communities in our sample. The results of this exercise are found in Table 2.6. In Specification (1), we again regress the local business tax rate on the measures for localization and urbanization economies (the number of employees in the latter case). Note that the coefficient estimate for the urbanization variable and the localization variable are quantitatively larger which may partly be driven by a lower correlation and a more exact identification of the effects but likely also reflect a larger impact of employees in localized industry cores on the tax rate measure. The effects are robust against the inclusion of control variables in Specifications (2) to (4) although the coefficient estimates diminish in size.

In Specification (5), we moreover account for potential reverse causality problems by instrumenting for our agglomeration measures using the information on long-lagged population and long-lagged railway connections. While the coefficient estimate for the employee variable remains largely stable, the coefficient estimate for the localization variable strongly increases in size. This is in line with intuition as reverse causality issues are likely to bias our coefficient estimate downwards if we do not account for potential negative effects of taxes on agglomeration size. Quantitatively, the specification suggests that a ten-percent increase in the number of employees enhances the jurisdiction's local business tax rate by 12 local business tax points or 0.6 percentage points while a ten-percent increase in the number of localized employees increases the local business tax rate by 61 local business tax points or 3 percentage points.

Note moreover that the test statistics indicate our instrumental variable approach to be valid. The Stock Yogo tests suggests that we do not face weak identification while the Sargan/Hansen statistic confirms the instruments to be exogenous and valid. The first-stage regressions are presented in Table 2.8, Specifications (1) and (2). In line with intuition, we find that the long-lagged population exerts a much stronger impact on today's urbanization economies as captured in Specification (1) than on the localization economies as captured in Specification (2). Interestingly, the long-lagged population similarity index capturing the relative size of the community compared enters negatively for the urbanization economy equation and positively for the localization economies. This former effect may be driven by historic satellite jurisdictions to larger cities which grew overproportionally in size. Thus, if the community was located close to a big agglomeration center it is also likely to be large in size today. This is however less true for localization economies which are strongly driven by historic and traditional industries often located in larger population centers. Moreover, as expected the number of train connections exerts a quantitatively larger impact on the localization economies than on urbanization economies and the market potential for the number of train connections (calculated as the sum of number of train connections in neighboring communities normalized on the distance to the considered community) only exerts a significantly positive impact on the localization measure suggesting the importance of a good railway system for the location of industry clusters.

Moreover, in Specifications (6) to (9), we reestimate Specifications (1) to (4) defining the localization measure to be the sum of employees in localized industry clusters with an above average DO index whereas industry cluster is defined to be characterized by the fact that at least two percent of the industry's employees have to be located within the jurisdiction's borders. The results derived are comparable to the previous estimates. As this cutoff value for the industry core definition is adhoc, we moreover reestimated the specifications using one and three percent of the industry share as a cutoff value and found comparable results. Additionally, in Table 2.7 we reestimate the regressions presented in Table 6 but basing the definition of the localization measures on all industries which are localized according to DO at any distance below 10 kilometers. The results derived are comparable to previous estimates.

Last, as suggested by our theoretical model, the municipality's tax setting behavior may not only be affected by its own agglomeration measures but by the relative agglomeration compared to neighboring jurisdictions. In Table 2.9 we regress the local business tax on the jurisdiction's relative urbanization compared to neighboring jurisdictions ($U^2_{i,t}$) and its relative localization compared to neighboring jurisdictions ($L^4_{i,t}$). As both measures are strongly skewed to the right, we shift their distribution upwards so that the smallest index value is just above zero and employ their logarithm as explanatory variable. The results are presented in Table 2.9 and indicate that both, a larger urbanization compared to its neighbors as well as a high localization compared to its neighbors tends to raise the local business tax rate. This result is robust against the inclusion of additional control variables in Specifications (2) to (4) whereas again the coefficient estimates diminish in size. Again, the analysis may be prone to reverse causality problems, as the jurisdiction's tax rate choice may equally affect the agglomeration measures. Thus, we employ an instrumental variables approach in Specification (5) and find large effects of urbanization and localization economies on the tax rate choice. These results are confirmed in Specifications (6) to (10) which reestimates the specifications accounting not only for industries which are localized at 0 kilometers but also for all industries which are localized at any distance below 10 kilometers. Note that the test statistics again indicate the instrumental variable approach to be valid as they report the instruments to be relevant and valid. Moreover, the first stage regressions reported in Table 2.10 are largely in line with intuition, especially note that the market potential variable for the train connections again exhibits a significantly positive effect on the localization measure while the effect is insignificant for the urbanization variable.

2.5.2 Robustness Checks

All specifications reported so far construct the measure for the localization economies on the basis of the DO approach. As a robustness check, we additionally rerun the identification of localized industries based on the Ellison and Glaeser (1997) approach and reconstruct our localization measures on the basis of these results. For a detailed description of the EG results, see the companion paper Koh and Riedel (2009a). In general, we find that the EG index identifies slightly other industries and slightly more industries to be localized. From a methodological point of view, we consider the DO approach to be superior as laid out in Appendix A and Koh and Riedel (2009a). The results are reported in Tables 2.11 to 2.12 and confirm the previous regression results in the sense that urbanization and localization economies are found to exert a positive effect on the municipality's tax rate choice, irrespective of the definition of the agglomeration measures. In particular, the relative agglomeration measures are again found to have a positive tax impact. Moreover, the results are quantitatively comparable. Analogous to our definition of strongly localized employees based on the

DO index, we select those employees which are employed in agglomerated industries according to the Ellison and Glaeser (1997) methodology with an EG index above the mean of the index distribution.[12] Table 2.11 depicts our estimation results. In line with our results reported in Table 2.6, localization economies exert a slightly stronger positive impact on the local business tax rate than urbanization economies. In Specification (4), a ten-percent increase in the number of employees yields to a 12.95 business tax points (0.65 percentage points) increase of the local business tax whereas a ten-percent increase in the number of localized employees brings about an increase of 14.9 business tax points (0.74 percentage points). These numbers are comparable to those reported for localized employees according to the DO methodology. Additionally, reestimating the effects of a municipality's relative position compared to its neighbors with a similarity measure that is based on the Ellison and Glaeser (1997) methodology yields similar results. Again, a municipality which is less substitutable in a firm's location choice in terms of the localization and urbanization pattern is more able to extract location rents. These results are depicted in Table 2.12.

Last, we run robustness checks on our specifications additionally including the market potential (defined as the sum of the income in neighboring jurisdictions over the distance to the considered community) as explanatory variable in our estimation framework. The results are presented in Specifications (1) and (2) of Table 2.13. Most importantly, the inclusion of the market potential as explanatory variable also does not affect our estimation results.

Finally, we redo the same exercise including a measure for the community's diversification in terms of its industry structure. A common measure used in the literature is the inverse Hirschman-Herfindahl index (see also Duranton and Puga (2000)). It is defined as the inverse of a municipality's sum over all industries of squared industry employment shares. A higher index indicates a diversified municipality which holds employment shares across many different industries. The results are reported in Specifications (3) and (4) of Table 2.13 and show that diversification in the industry

[12]We additionally applied the official agglomeration thresholds as reported in Ellison and Glaeser (1997) which yielded similar results.

structure exerts a positive impact on a jurisdictions tax rate choice. Not surprisingly, the coefficient for the effect of diversification on the local business tax rate reverses as we address potential reverse causality problems by instrumenting for agglomeration and diversification as the diversity index is highly correlated with our agglomeration measures.[13] Most importantly, our results are again unaffected by the inclusion of the additional control variable.

2.6 Conclusion

This paper provides empirical evidence for the positive effect of firm agglomeration on the tax setting behaviour of German municipalities. Exploiting a rich data source which comprises all firms located in Germany including the plant's four-digit industry classification we are able to address different scopes of agglomeration. Precisely, we identify agglomeration at the sectoral level ('localization') applying the Duranton and Overman (2005) index and agglomeration based on the overall economic activity within a municipality ('urbanization'). We find that both, the existence of urbanization and localization economies within a municipality's boundary exert a positive impact on the choice of the local business tax rate. The effect of agglomeration on the sectoral level is thereby found to be quantitatively larger.

Moreover, we find that a jurisdiction's capacity to extract location rents depends on the geographical composition of an agglomeration. Precisely, we investigate which factors determine a jurisdiction's capacity to tax away agglomeration rents and apply different measures which all capture a jurisdiction's substitutability with respect to its industry structure and general scale of economic activity. A municipality is found to set higher tax rates if it hosts a larger economic base relative to its neighboring jurisdictions. Moreover, localization that disseminates across jurisdictional boundaries lowers a municipality's capability to extract location rents. Our findings suggest to

[13] Intuitively, a municipality which comprises urbanization and/or localization advantages will also host a large variety of different industries as described in Jacobs (1969).

rethink the desirability to raise local business taxes at the municipality level as the composition of an agglomeration may prevent the taxability of an agglomeration rent at the local level.

Finally, we explicitly address potential reverse causality problems by using an instrumental variable approach. Using long-lagged historical population data and data on the number of train connections prior to 1936 we are able to approach estimation problems which beset previous studies in this research area.

Appendix A: Identifying Agglomerated Industries

The literature has proposed various approaches to identify the geographical location pattern of an industry. The most widely used methodologies have been developed by Ellison and Glaeser (1997) (henceforth EG) and Duranton and Overman (2005) (henceforth DO). Both approaches measure industry agglomeration over and above the overall concentration of economic activity and control for industrial concentration driven by firm-specific characteristics such as the plant size distribution.

The EG index is a discrete measure which compares aggregate industry employment shares within geographical units to the overall share of activity. A shortcoming of the approach is that it does not control for geographical proximity of plants but treat firms equally irrespective of whether they are located close to each other or at the opposite of the geographical unit. Moreover, the EG approach is sensitive to the aggregation level which is employed to determine industry agglomeration which may make its interpretation difficult (for a thorough discussion identifying agglomerated industries in Germany based on the same dataset, see Koh and Riedel (2009a)).

The DO approach in contrast is not prone to these problems. Thus, for the construction of industry agglomeration in our baseline estimates, we follow the DO methodology to identify localized industries in Germany. In sensitivity checks, we however also apply the EG index.

In the following, we briefly outline the methodology and refer to Duranton and Overman (2005) and Koh and Riedel (2009a) for a detailed description of the approach. The basic intuition for the DO index is to estimate the density of bilateral distances between firms of the same industry and to compare the distribution of bilateral distances to the distribution of a hypothetical industry's randomly generated location pattern which has the same number of firms as the actual industry. An industry is considered as being localized at distance d if its distribution of bilateral distances departs significantly from randomness. In the first step, we calculate the bilateral distances of firms within each industry m using Gauss-Krüger coordinates available for each municipality. Defining $d_{i,j}$ as the distance between firm i and j of industry m we estimate the density of distances $\hat{K}_m(d)$ at any distance d with

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

where n is the number of firms in industry m, f is the Gaussian kernel function with bandwidth (smoothing parameter) h. Next, we calculate counterfactual kernel density estimates for this industry by randomly drawing locations from the population of German firms. Repeating this simulation exercise 1000 times, we then compare the industry's actual location pattern to the simulated patterns and thus determine whether it significantly departs from randomness. To test the significance of the result we construct local confidence bands which allow us to make statements about whether the location pattern of an industry deviates significantly from randomness. For each distance d in the interval [0,312], where 312 is the median distance in our sample, we rank the simulated kernel density estimates $\tilde{K}_m(d)$ in ascending order and select the 5th and 95th percentile. This yields a $\overline{\tilde{K}_m(d)}$ which represents an upper 5% and a $\underline{\tilde{K}_m(d)}$ which represents the lower 5% bound. An industry m is said to be localized at distance d if $\hat{K}_m(d) > \overline{\tilde{K}_m(d)}$ and the index of localization is defined as

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

We will concentrate on localized industries at short distances at 0 kilometers[14] or distances below 10 kilometers. The size of the index indicates how much localization occurs at a certain distance. It will serve as a proxy for the intensity of an industry's agglomeration in the following section.

[14] Note that our data does not comprise exact information on the location of a firm within a municipality thus the distance of firms within the same community is zero.

Appendix B: Tables

Table 2.1: Descriptive Statistics

Variables:	*Mean*	*Std. Dev.*	*Min*	*Max*
Local Business Tax Rate (in Local Business Tax Points)	333.99	31.313	0	900
Local Business Tax Rate (in %)	16.700	1.566	0	45
Number of Employees	2571.629	17,042.28	1	774,869
Loc Employee Measures				
Loc Employee, 0 km, DO>Mean	239.549	2622.2	0	149,228
Loc Employee, 0 km, DO>90% Perc	55.159	795.865	0	45,299
Loc Employee, 10 km, DO>Mean	273.136	2933.556	0	166,926
Loc Employee, 10 km, DO>90% Perc	61.227	677.517	0	46,012
Loc Sum Ind. Share, 0 km, DO>Mean	.0064	.0551	0	3.2299
Loc Sum Ind. Share, 0 km, DO>90% Perc	.0022	.0286	0	1.6083
Loc Sum Ind. Share, 10 km, DO>Mean	.0095	.0707	0	3.9211
Loc Sum Ind. Share, 10 km, DO>90% Perc	.0033	.0324	0	1.6462
Core Municipality Variables				
Loc Employee, 0 km, DO>Mean, Core > 99% Perc	106.303	1905.319	0	107,881
Loc Employee, 0 km, DO>Mean, Core > 2%	73.406	1826.169	0	104,924
Loc Employee, 10 km, DO>Mean, Core > 99% Perc	196.166	2992.382	0	165,546
Loc Employee, 10 km, DO>Mean, Core > 2%	132.244	2760.927	0	167,350
Similarity Measures				
Similarity Number of Employees	17,726.97	1001,432	-186,809.7	4.70e+07
Similarity Loc. Employees, 0km	9104.921	12,0481.1	-6232.548	6434,129
Similarity Loc. Employees, 10km	13,869.97	155,189.2	-7649.638	7,523,753

Table 2.1, continued: Descriptive Statistics				
Variables:	*Mean*	*Std. Dev.*	*Min*	*Max*
Control Variables				
Income per Capita	16,816.24	1,719.761	12,838	27,952
Avg. Neighbor Tax Rate	271.101	19.520	239.537	311.299
Administration Grants pC	95.864	564.0004	-67.357	1,490,16.9
Investment Grants pC	37.990	392.074	-201.363	1,017,00.1
Deficit pC	17.520	2,336.273	-574,608	195,236.1
Number of Railway Stations	.5097	.9139	0	16
Number of Airports	.0451	.2172	0	2
Number of Seaports	.0196	.1688	0	7
Instrumental Variables				
Population 1910	3924.109	25,253.54	0	1,345,142
Market Potential 1910	193,901.4	44,940.59	0	440,815.4
Similarity Population 1910	-.000098	.0311	-.0070	1.6142
# Train Connections 1935	.3498	1.712	0	77
Market Potential Train Station 1935	17.9333	6.7554	0	48.5295

Notes: 'Loc Employee, 0 km, DO>Mean' ('Loc Employee, 0 km, DO>90% Perc') depicts the number of employees located in a community which are occupied in industries that are localized at a distance of zero kilometers according to the DO methodology and are strongly localized in the sense that the DO index which indicates the degree of geographical clustering is above the mean (in the 90th percentile of the distribution). Analogous measures were calculated for all industries which are localized at a distance smaller or equal 10 kilometers. Accordingly, 'Loc Sum Ind. Share, 0 km, DO>Mean' ('Loc Sum Ind. Share, 0 km, DO>90% Perc') denotes the sum of industry shares for all those industries in a considered community that are localized at a distance of zero kilometers according to the DO methodology and are strongly localized in the sense that the DO index is above the mean (in the 90th percentile of the distribution). Analogous measures were calculated for all industries which are localized at a distance smaller or equal 10 kilometers. 'Loc Employee, 0 km, DO>Mean, Core > 99th Perc' depicts the number of strongly localized employees (at zero kilometers) in a 'core municipality'. Core municipalities hold a major share in a strongly localized industry and are defined according to two definitions: 'Core > 99th Perc' depicts those municipalities which hold an employment share in the 99th percentile of the localized industry's employment share distribution across municipalities. 'Core > 2%' denotes municipalities which hold a share in a strongly localized industry of at least 2%. 'Similarity Number of Employees' indicates the similarity in the number of employees between a considered community and all other communities in Germany, adjusted for the distance. 'Similarity Loc. Employees, 0km' stands for the sum of the differences of localized employees (at zero kilometer, following DO) between a community and all other communities in Germany, adjusted for the distance. All employee and similarity measures enter in logarithmic form.

Table 2.2: Number of Employees - Localized Industries at 0 kilometers

Region Fixed–Effects								
Model	**DO index > mean**				**DO index > 90th Percentile**			
Explanat. Var.:	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Sum Loc Employees	2.376***	1.890***	1.465***	1.151***	3.481***	2.947***	2.360***	1.542***
	(.366)	(.290)	(.288)	(.292)	(.407)	(.326)	(.342)	(.302)
Sum Employees	.762	1.835***	1.122***	.931**	.801	1.669***	1.066***	1.072***
	(.607)	(.375)	(.378)	(.374)	(.493)	(.325)	(.344)	(.352)
Income per Capita			-27.136***	-8.191			-27.801***	-8.394
			(9.952)	(11.696)			(10.235)	(12.107)
Avg. Tax Neighbor			.362***	.341			.359***	.343
			(.089)	(.225)			(.088)	(.222)
Deficit/10^5				8.550***				8.650***
				(1.90)				(1.920)
Administration Grants				.025***				.024***
				(.002)				(.004)
Investment Grants				-.002				-.002
				(.002)				(.002)
Road Net Work				2.567**				2.396**
				(1.103)				(1.077)
Railway				.534				.470
				(.365)				(.366)
Airport				4.405***				3.998***
				(1.321)				(1.275)
Seaport				9.112***				8.628***
				(2.797)				(2.743)
Capital City			71.710***	44.530***			66.888***	43.118***
			(14.780)	(14.501)			(14.707)	(14.440)
Rural Community			-8.040***	-6.064***			-7.206***	-5.828***
			(1.199)	(1.112)			(1.203)	(1.109)
Border Community			-.125	-.656			-.403	-.881
			(1.838)	(1.509)			(1.781)	(1.489)
First Nature Geographies		√	√	√		√	√	√
# Observations	75,180	60,646	53,972	28,989	75,180	60,646	53,972	28,989
# Commuting Areas	74	74	73	72	74	74	73	72

Notes: Heteroscedasticity robust standard errors adjusted for commuting area clusters in parentheses. *, **, *** indicates significance at the 10%, 5%, 1% level. The observational units are municipalities per year. All regressions include a full set of region fixed effects. 'Sum Loc Employees ' is the sum of employees of localized industries within a municipality. Specifications (1)-(4) define localized industries in the sense that the DO index has to be above the index distribution. Specifications (4)-(8) considers only those industries with a DO index above the 90th percentile of the index distribution.

Table 2.3: Number of Employees - Localized Industries at 10 kilometers

Region Fixed–Effects								
Model	**DO index > mean**				**DO index > 90th Percentile**			
Explanat. Var.:	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Sum Loc Employees	2.175***	1.667***	1.213***	.860***	2.715***	2.230***	1.675***	1.046***
	(.343)	(.245)	(.236)	(.221)	(.372)	(.292)	(.291)	(.263)
Sum Employees	.922	2.013***	1.331***	1.152***	1.172**	2.074***	1.416***	1.288***
	(.618)	(.379)	(.387)	(.383)	(.535)	(.350)	(.366)	(.368)
Income per Capita			-26.298**	-7.174			-26.236**	-7.271
			(10.025)	(11.714)			(10.114)	(11.845)
Avg. Tax Neighbor			.362***	.333			.363***	.333
			(.089)	(.224)			(.089)	(.224)
Deficit/10^5				8.570***				8.60***
				(1.910)				(1.910)
Administration Grants				.025***				.024***
				(.004)				(.004)
Investment Grants				-.003				-.002
				(.002)				(.002)
Road Net Work				2.607**				2.522**
				(1.108)				(1.101)
Railway				.543				.516
				(.362)				(.362)
Airport				4.396***				4.291***
				(1.319)				(1.302)
Seaport				9.166***				8.981***
				(2.809)				(2.759)
Capital City			71.856***	44.711***			69.366***	43.925***
			(14.731)	(14.504)			(14.586)	(14.422)
Rural Community			-8.022***	-6.103***			-7.471***	-5.932***
			(1.191)	(1.112)			(1.210)	(1.122)
Border Community			-.266	-.771			-.325	-.795
			(1.857)	(1.523)			(1.842)	(1.504)
First Nature Geographies		√	√	√		√	√	√
# Observations	75,180	60,646	53,972	28,989	75,180	60,646	53,972	28,989
# Commuting Areas	74	74	73	72	74	74	73	72

Table 2.4: Sum Localized Industry Shares - Localized Industries at 0 kilometers

Region Fixed–Effects								
Model	**DO index > mean**				**DO index > 90th Percentile**			
Explanat. Var.:	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Sum Loc. Ind. Shares	98.109***	88.212***	73.901***	55.362***	138.271***	130.220***	104.043***	75.939***
	(14.406)	(12.729)	(11.792)	(10.916)	(20.701)	(17.577)	(14.873)	(18.037)
Sum Employees	2.156***	2.968***	1.983***	1.729***	2.416***	3.226***	2.135***	1.779***
	(.524)	(.382)	(.408)	(.412)	(.540)	(.380)	(.412)	(.416)
Income per Capita			-22.194**	-3.936			-22.568**	-4.432
			(10.133)	(11.430)			(9.941)	(11.367)
Avg. Tax Neighbor			.368***	.337			.368***	.340
			(.090)	(.227)			(.090)	(.226)
Deficit/10^5				8.580***				8.590***
				(1.940)				(1.950)
Administration Grants				.023***				.024***
				(.004)				(.004)
Investment Grants				-.002				-.002
				(.002)				(.002)
Road Net Work				1.262				1.780
				(1.186)				(1.156)
Railway				.245				.391
				(.394)				(.389)
Airport				4.746***				4.706***
				(1.334)				(1.346)
Seaport				8.045***				8.790***
				(2.562)				(2.613)
Capital City			30.893*	22.506*			46.936***	31.491***
			(16.496)	(11.862)			(14.464)	(11.032)
Rural Community			-8.516***	-6.738***			-8.812***	-6.7996***
			(1.184)	(1.091)			(1.199)	(1.097)
Border Community			.077	-.454			.252	-.402
			(1.805)	(1.516)			(1.829)	(1.508)
First Nature Geographies		√	√	√		√	√	√
# Observations	75,180	60,646	53,972	28,989	75,180	60,646	53,972	28,989
# Commuting Areas	74	74	73	72	74	74	73	72

Notes: Heteroscedasticity robust standard errors adjusted for commuting area clusters in parentheses. *, **, *** indicates significance at the 10%, 5%, 1% level. The observational units are municipalities per year. All regressions include a full set of region fixed effects. 'Sum Loc. Ind. Shares' is the sum of industry shares of localized industries within a municipality. Specifications (1)-(4) define localized industries in the sense that the DO index has to be above the index distribution. Specifications (4)-(8) considers only those industries with a DO index above the 90th percentile of the index distribution.

Table 2.5: Sum Localized Industry Shares - Localized Industries at 10 kilometers

Region Fixed–Effects								
Model	**DO index > mean**				**DO index > 90th Percentile**			
Explanat. Var.:	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Sum Loc. Ind. Shares	79.994***	71.020***	59.870***	43.656***	131.364***	122.901***	98.508***	72.898***
	(11.767)	(10.438)	(9.622)	(8.245)	(19.132)	(16.250)	(13.665)	(14.285)
Sum Employees	2.068***	2.885***	1.937***	1.710***	2.342***	3.149***	2.085***	1.762***
	(.519)	(.380)	(.406)	(.409)	(.537)	(.382)	(.411)	(.415)
Income per Capita			-22.147**	-3.994			-22.035**	-3.938
			(10.177)	(11.4997)			(10.036)	(11.403)
Avg. Tax Neighbor			.368***	.334			.369***	.338
			(.090)	(.226)			(.090)	(.226)
Deficit/10^5				8.580***				8.590***
				(1.930)				(1.950)
Administration Grants				.023***				.024***
				(.004)				(.004)
Investment Grants				-.002				-.002
				(.002)				(.002)
Road Net Work				1.186				1.587
				(1.184)				(1.165)
Railway				.211				.319
				(.391)				(.393)
Airport				4.683***				4.704***
				(1.347)				(1.338)
Seaport				8.073***				8.591***
				(2.549)				(2.608)
Capital City			28.060*	21.420*			45.032***	30.572***
			(16.796)	(12.045)			(14.683)	(10.959)
Rural Community			-8.344***	-6.645***			-8.732***	-6.798***
			(1.189)	(1.093)			(1.196)	(1.095)
Border Community			.-.013	-.522			.183	-.420
			(1.804)	(1.520)			(1.846)	(1.516)
First Nature Geographies		√	√	√		√	√	√
# Observations	75,180	60,646	53,972	28,989	75,180	60,646	53,972	28,989
# Commuting Areas	74	74	73	72	74	74	73	72

Table 2.6: Number of Employees in Core Regions - Localized Industries at 0 kilometers

Region Fixed–Effects										
Model	**Core > 99th Percentile**					**Core > 2%**				
Explanat. Var.:	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
Sum Loc Employees	3.561***	3.251***	2.734***	1.760***	6.114***	3.145***	2.849***	2.173***	1.160***	7.972***
	(.340)	(.327)	(.324)	(.261)	(1.256)	(.517)	(.497)	(.452)	(.348)	(2.025)
Sum Employees	1.615***	2.344***	1.594***	1.432***	1.206**	2.244***	3.042***	2.033***	1.695***	1.708***
	(.477)	(.348)	(.375)	(.384)	(.576)	(.530)	(.369)	(.404)	(.412)	(.623)
Income per Capita			-26.776**	-7.731	-14.397			-24.169**	-5.617	-7.676
			(10.511)	(12.240)	(15.294)			(10.082)	(11.610)	(13.277)
Avg. Tax Neighbor			.366***	.331	.360			.364***	.330	.329
			(.089)	(.223)	(.236)			(.090)	(.228)	(.252)
Deficit/10^5				8.490***	8.170***				8.550***	8.310***
				(1.850)	(1.470)				(1.930)	(1.610)
Administration Grants				.023***	.022***				.024***	.024***
				(.004)	(.003)				(.004)	(.004)
Investment Grants				-.002	-.002				-.003	-.002
				(.002)	(.002)				(.002)	(.002)
Road Net Work				1.824	-1.113				2.427**	-.297
				(.984)	(.870)				(1.116)	(1.223)
Railway				.446	-.366				.547	-.192
				(.352)	(.441)				(.363)	(.466)
Airport				3.578***	.807				4.445***	3.368**
				(1.229)	(1.570)				(1.344)	(1.637)
Seaport				7.751***	2.226				8.765***	4.204*
				(2.658)	(2.550)				(2.731)	(2.559)
Capital City			56.021***	38.999***	23.756			57.007***	38.181**	-3.527
			(14.511)	(14.318)	(18.216)			(14.397)	(14.507)	(20.571)
Rural Community			-7.059***	-5.960***	-2.749**			-8.483***	-6.564***	-4.564***
			(1.126)	(1.044)	(1.367)			(1.165)	(1.075)	(1.227)
Border Community			-.547	-.792	-1.276			-.292	-.663	-1.013
			(1.859)	(1.545)	(1.759)			(1.832)	(1.542)	(1.789)
First Nature Geographies		√	√	√	√		√	√	√	√
Stock Yogo					30.693					14.503
Sargan-Hansen (dof)					2.844 (3)					2.720 (3)
Sargan-Hansen (p-value)					0.416					0.437
# Observations	75,180	60,646	53,972	28,989	26,384	75,180	60,646	53,972	28,989	26,384
# Commuting Areas	74	74	73	72	72	74	74	73	72	72

Notes: Heteroscedasticity robust standard errors adjusted for commuting area clusters in parentheses. *, **, *** indicates significance at the 10%, 5%, 1% level. The observational units are municipalities per year. All regressions include a full set of region fixed effects. 'Sum Employees' is the number of employees in the respective core municipality. 'Sum Loc Employees' is the number of localized employees in a core municipality localized at less than 0 km according to the DO index. These employees are defined as strongly localized in the sense that the DO index has to be above the mean of its distribution. 'Core municipalities' are classified according to two definitions: in specification (1)-(5) a core municipality has to hold a share in a localized industry in the 99th percentile of the industry share distribution. In specification (6)-(10) a core municipality has to hold a more than 2 % of a localized industry's share.

Table 2.7: Number of Employees in Core Regions - Localized Industries at 10 kilometers

Region Fixed–Effects										
Model	**Core > 99th Percentile**					**Core > 2%**				
Explanat. Var.:	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
Sum Loc Employees	3.005***	2.728***	2.266***	1.502***	5.418***	2.211***	1.912***	1.348***	.553**	6.643***
	(.283)	(.275)	(.265)	(.222)	(1.055)	(.368)	(.354)	(.303)	(.241)	(1.540)
Sum Employees	1.535***	2.277***	1.574***	1.405***	1.035*	2.133***	2.957***	2.018***	1.715***	1.539**
	(.481)	(.353)	(.379)	(.387)	(.589)	(.541)	(.372)	(.408)	(.422)	(.641)
Income per Capita			-26.581**	-7.229	-13.125			-24.065**	-5.706	-7.133
			(10.366)	(11.994)	(14.222)			(9.941)	(11.507)	(13.060)
Avg. Tax Neighbor			.361***	.331	.349			.364***	.330	.318
			(.090)	(.225)	(.246)			(.091)	(.228)	(.271)
Deficit/10^5				8.520***	8.210***				8.560***	8.270***
				(1.890)	(1.520)				(1.940)	(1.60)
Administration Grants				.023***	.023***				.024***	.024***
				(.004)	(.003)				(.004)	(.004)
Investment Grants				-.002	-.002				-.003	-.003
				(.002)	(.002)				(.002)	(.002)
Road Net Work				1.944*	-.827				2.585**	-.133
				(.993)	(.793)				(1.106)	(.964)
Railway				.451	-.398				.552	-.698
				(.356)	(.445)				(.360)	(.528)
Airport				3.187**	-.590				4.439***	1.909
				(1.221)	(1.696)				(1.334)	(1.618)
Seaport				7.896***	2.274				8.859***	2.040
				(2.719)	(2.566)				(2.806)	(3.015)
Capital City			59.731***	40.777***	29.417*			63.941***	42.385***	11.509
			(14.407)	(14.295)	(17.742)			(14.407)	(14.391)	(17.125)
Rural Community			-6.790***	-5.731***	-1.894			-8.243***	-6.482***	-2.899*
			(1.113)	(1.030)	(1.472)			(1.143)	(1.060)	(1.518)
Border Community			-.817	-1.022	-2.190			-.423	-.757	-2.515
			(1.849)	(1.548)	(1.796)			(1.876)	(1.553)	(1.934)
First Nature Geographies		√	√	√	√		√	√	√	√
Stock Yogo					30.943					26.109
Sargan-Hansen (dof)					2.340 (3)					1.697 (3)
Sargan-Hansen (p-value)					0.505					0.638
# Observations	75,180	60,646	53,972	28,989	26,384	75,180	60,646	53,972	28,989	26,384
# Commuting Areas	74	74	73	72	72	74	74	73	72	72

Table 2.8: First Stage Regressions Employees - Localized Industries in Core Regions

Region Fixed–Effects - Core > 99th Percentile				
Model	**0 km**		**10 km**	
Explanat. Var.:	*(1)*	*(2)*	*(3)*	*(4)*
Population 1910	1.105***	.144***	1.105***	.186***
	(.051)	(.041)	(.051)	(.049)
Market Potential Pop 1910	1.559***	2.197 ***	1.559 ***	2.446***
	(.505)	(.651)	(.505)	(.680)
Population Similarity 1910	-7.279***	19.072***	-7.279***	19.511***
	(1.644)	(3.962)	(1.644)	(4.284)
Market Potential Train 1935	.004	.022*	.004	.026*
	(.009)	(.012)	(.009)	(.013)
Number of Train Connections 1935	.090***	.288***	.090***	.457***
	(.027)	(.070)	(.027)	(.086)
Dep. Variable	# Emp. All	# Loc. Emp.	# Emp. All	# Loc. Emp.
# Observations	26,384	26,384	26,384	26,384
Partial R-Squared of Excl. IVs	0.429	0.077	0.429	0.080

Notes: Heteroscedasticity robust standard errors adjusted for commuting area clusters in parentheses. *, **, *** indicates significance at the 10%, 5%, 1% level. The observational units are municipalities per year. All regressions include a full set of region fixed effects. '# Emp. All' is the number of employees in the core municipality, where core municipalities are defined to hold a share in a localized industry in the 99th percentile of the industry share distribution. '# Loc. Emp. ' is the number of localized employees in a core municipality. These employees belong to an industry that is geographically agglomerated according to the DO methodology and where its DO index lies above the mean of its distribution.

Table 2.9: Similarity - Localized Industries - DO index

Region Fixed–Effects										
Model	**DO index at 0 km**					**DO index at 10 km**				
Explanat. Var.:	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
Similarity # Emp	7.203***	7.570***	6.475***	5.961***	7.379***	7.309***	7.836***	6.731***	6.003***	6.796**
	(.920)	(.939)	(1.164)	(1.285)	(2.750)	(.951)	(.973)	(1.198)	(1.290)	(2.978)
Similarity # Loc Emp	5.799***	5.630***	5.234***	3.697***	7.6997**	5.062***	4.665***	4.326***	2.912***	8.312**
	(.831)	(.858)	(.906)	(.762)	(3.544)	(.800)	(.841)	(.859)	(.662)	(3.786)
Income per Capita			-23.609*	-2.617	-5.736			-22.351*	-.931	-5.320
			(12.644)	(13.751)	(14.722)			(12.963)	(13.844)	(15.297)
Avg. Tax Neighbor			.363***	.274	.287			.353***	.239	.282
			(.099)	(.235)	(.228)			(.101)	(.240)	(.245)
Deficit/10^5				8.220***	7.920***				8.240***	7.850***
				(1.610)	(1.340)				(1.680)	(1.350)
Administration Grants				.028***	.028***				.029***	.029***
				(.004)	(.004)				(.005)	(.004)
Investment Grants				-.001	-.001				-.001	-.001
				(.002)	(.002)				(.002)	(.002)
Road Net Work				.585	-1.301				.704	-1.393
				(.955)	(.893)				(.924)	(.890)
Railway				-.092	-.745				.008	-.705
				(.425)	(.484)				(.416)	(.483)
Airport				2.081	.761				2.195*	.594
				(1.297)	(1.534)				(1.317)	(1.566)
Seaport				5.561**	2.116				5.421**	.712
				(2.440)	(2.287)				(2.465)	(2.5996)
Capital City			37.812***	30.131**	17.644			40.940***	32.123**	17.460
			(14.046)	(13.479)	(16.499)			(13.760)	(13.492)	(16.401)
Rural Community			-2.728**	-2.973**	.165			-2.722**	-3.040**	.220
			(1.245)	(1.245)	(1.639)			(1.258)	(1.235)	(1.609)
Border Community			-.708	-1.270	-1.611			-.698**	-1.139	-1.594
			(1.855)	(1.633)	(1.546)			(1.838)	(1.602)	(1.551)
First Nature Geographies		√	√	√	√		√	√	√	√
Stock Yogo					21.474					23.009
Sargan-Hansen (dof)					0.323 (3)					0.052 (3)
Sargan-Hansen (p-value)					0.9556					0.997
# Observations	42,705	37,551	33,036	20,797	18,960	49,338	43,324	38,672	21,623	19,741
# Commuting Areas	74	74	73	72	72	74	74	73	72	72

Table 2.10: First Stage Regressions - Similarity Index

Region Fixed–Effects				
Model	**0 km**		**10 km**	
Explanat. Var.:	*(1)*	*(2)*	*(3)*	*(4)*
Population 1910	.366***	.106***	.363***	.112***
	(.036)	(.019)	(.034)	(.020)
Market Potential Pop 1910	.205	.634**	.165	.686**
	(.248)	(.268)	(.253)	(.260)
Population Similarity 1910	3.817***	10.082***	3.814***	9.442***
	(1.183)	(1.431)	(1.192)	(1.542)
Market Potential Train 1935	.008	.013***	.009	.011*
	(.006)	(.005)	(.007)	(.006)
Number of Train Connections 1935	.143***	.110***	.147***	.140***
	(.022)	(.029)	(.023)	(.032)
Dep. Variable	Simi All	Simi Loc	Simi All	Simi Loc
# Observations	18,960	18,960	19,741	19,741
Partial R-Squared of Excl. IVs	0.296	0.145	0.285	0.126

Table 2.11: Employees in Core Regions - Localized Industries - EG index

Region Fixed–Effects										
Model	**Core > 99th Percentile**					**Core > 2%**				
Explanat. Var.:	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(4)*	*(10)*
Sum Loc Employees	2.721***	2.452***	2.031***	1.485***	7.622***	2.835***	2.637***	2.131***	1.228***	6.60***
	(.271)	(.260)	(.236)	(.230)	(1.238)	(.390)	(.377)	(.338)	(.303)	(1.609)
Sum Employees	1.773***	2.543***	1.695***	1.295***	.160	2.134***	2.901***	1.904***	1.632***	1.715***
	(.4997)	(.354)	(.382)	(.379)	(.696)	(.518)	(.363)	(.395)	(.408)	(.609)
Income per Capita			-25.638**	-9.311	-27.161			-24.409**	-6.550	-13.669
			(10.085)	(12.182)	(17.216)			(10.054)	(11.777)	(13.698)
Avg. Tax Neighbor			.397***	.345	.407			.370***	.338	.384
			(.090)	(.227)	(.263)			(.090)	(.226)	(.251)
Deficit/10^5				8.550***	8.320***				8.580***	8.40***
				(1.930)	(1.660)				(1.950)	(1.710)
Administration Grants				.023***	.021***				.024***	.024***
				(.004)	(.003)				(.004)	(.004)
Investment Grants				-.002	-.002				-.003	-.002
				(.002)	(.002)				(.002)	(.002)
Road Net Work				1.925*	-2.311**				2.316**	-.492
				(.9997)	(1.041)				(1.080)	(1.021)
Railway				.366	-1.007**				.507	-.404
				(.346)	(.447)				(.357)	(.458)
Airport				3.420***	-2.558				4.135***	1.373
				(1.294)	(1.867)				(1.325)	(1.761)
Seaport				8.347***	2.495				8.253***	1.830
				(2.716)	(2.587)				(2.730)	(2.722)
Capital City			61.304***	42.449***	30.787*			58.303***	39.136***	11.577
			(14.593)	(14.376)	(17.890)			(14.271)	(14.129)	(16.532)
Rural Community			-7.157***	-5.212***	2.595			-8.364***	-6.523***	-4.374***
			(1.142)	(1.029)	(2.020)			(1.140)	(1.057)	(1.226)
Border Community			-.719	-1.155	-3.381**			-.108	-.566	-.314
			(1.136)	(1.438)	(1.724)			(1.794)	(1.511)	(1.513)
First Nature Geographies		√	√	√	√		√	√	√	√
Stock Yogo					17.172					25.090
Sargan-Hansen (dof)					1.615 (3)					3.466 (3)
Sargan-Hansen (p-value)					0.656					0.325
# Observations	75,180	60,646	53,972	28,989	26,384	75,180	60,646	53,972	28,989	26,384
# Commuting Areas	74	74	73	72	72	74	74	73	72	72

Notes: Heteroscedasticity robust standard errors adjusted for commuting area clusters in parentheses. *, **, *** indicates significance at the 10%, 5%, 1% level. The observational units are municipalities per year. All regressions include a full set of region fixed effects. 'Sum Employees' is the number of employees in the respective core municipality. 'Sum Loc Employees' is the number of employees in a core municipality localized according to the EG index. These employees are defined as strongly localized in the sense that the EG index has to be above the mean of its distribution. 'Core municipalities' are classified according to two definitions: in specification (1)-(5) a core municipality has to hold a share in a localized industry in the 99th percentile of the industry share distribution. In specification (6)-(10) a core municipality has to hold more than 2% in a localized industry's employment.

Table 2.12: Similarity - Localized Industries - EG index

Region Fixed–Effects					
Model	**EG index > mean**				
Explanat. Var.:	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
Similarity # Emp	8.063***	8.620***	7.648***	6.773***	6.857**
	(.875)	(.872)	(1.201)	(1.408)	(2.730)
Similarity # Loc Emp	4.892***	4.573***	4.399***	3.199***	8.840**
	(1.067)	(1.068)	(1.072)	(.975)	(3.909)
Income per Capita			-31.063**	-9.763	-12.187
			(13.916)	(14.343)	(15.072)
Avg. Tax Neighbor			.384***	.327	.328
			(.098)	(.227)	(.220)
Deficit/10^5				257.470***	213.320**
				(.001)	(84.240)
Administration Grants				.028***	.028***
				(.006)	(.006)
Investment Grants				-.001	-.002
				(.002)	(.002)
Road Net Work				.707	-1.143
				(.997)	(.914)
Railway				-.233	-.860*
				(.428)	(.504)
Airport				2.058	.736
				(1.362)	(1.547)
Seaport				5.003**	.341
				(2.350)	(2.452)
Capital City			39.356**	31.262**	17.600
			(15.104)	(15.943)	(16.333)
Rural Community			-2.039	-2.813**	-.701
			(1.408)	(1.402)	(1.536)
Border Community			-1.129	-1.375	-2.084
			(2.156)	(1.948)	(2.099)
First Nature Geographies		√	√	√	√
Stock Yogo					35.576
Sargan-Hansen (dof)					0.199 (3)
Sargan-Hansen (p-value)					0.9779
# Observations	37,533	33,638	29,944	16,946	15,467
# Commuting Areas	74	74	73	72	72

Table 2.13: Robustness Check - Market Potential and Diversification

Region Fixed–Effects				
Model	**Core > 99th Percentile - 0km**			
Explanat. Var.:	*(1)*	*(2)*	*(3)*	*(4)*
Sum Loc Employees	1.739***	7.254***	1.771***	4.925**
	(.262)	(1.208)	(.263)	(1.983)
Sum Employees	1.546***	1.155**	1.274***	17.013
	(.410)	(.583)	(.399)	(11.534)
Market Potential	-5.402	-15.059*		
	(7.542)	(8.063)		
Diversity Index			.974**	-35.172
			(.547)	(25.274)
Income per Capita	-5.206	-9.714	-9.697	-22.596
	(12.586)	(14.927)	(12.039)	(23.695)
Avg. Tax Neighbor	.200	.145	.269	-.032
	(.242)	(.243)	(.218)	(.3999)
Deficit/10^5	13.550***	13.290***	8.440***	8.460***
	(1.50)	(1.189)	(1.790)	(2.570)
Administration Grants	.022***	.020***	.022***	.067**
	(.004)	(.003)	(.004)	(.031)
Investment Grants	-.004*	-.003**	-.002	-.013
	(.002)	(.003)	(.002)	(.008)
Road Net Work	1.989*	-1.488*	1.785*	-1.377
	(1.013)	(.879)	(.999)	(1.188)
Railway	.344	-.525	.270	-1.413
	(.347)	(.463)	(.350)	(.979)
Airport	3.553***	-.033	3.734***	-2.976
	(1.225)	(1.664)	(1.212)	(3.914)
Seaport	8.361***	1.370	8.534***	-7.714
	(2.631)	(2.741)	(2.605)	(8.352)
Capital City	43.528***	18.925	40.633**	17.731
	(14.570)	(17.641)	(16.519)	(15.881)
Rural Community	-5.635***	-1.943	-5.682***	4.138
	(1.037)	(1.303)	(1.065)	(4.789)
Border Community	-1.184	-2.129	-.804	-4.470
	(1.524)	(1.947)	(1.608)	(2.876)
First Nature Geographies	√	√	√	√
Stock Yogo		16.532		1.174
Sargan-Hansen (dof)		0.402 (2)		0.326 (2)
Sargan-Hansen (p-value)		0.818		0.850
# Observations	22,987	20,971	28,795	26,240
# Commuting Areas	72	72	72	72

Notes: Heteroscedasticity robust standard errors adjusted for commuting area clusters in parentheses. *, **, *** indicates significance at the 10%, 5%, 1% level. The observational units are municipalities per year. All regressions include a full set of region fixed effects. 'Market Potential' is the distance weighted sum of per capita income of all neighboring communities and measures a location's market access (see also Head and Mayer (2004)). 'Diversity Index' denotes the inverse Hirschman-Herfindahl and measures the degree of diversification within a municipality (see also Duranton and Puga (2000)). It is defined as the inverse of a municipality's sum over all industries of squared industry employment shares, where a higher index therefore indicates a diversified municipality.

Appendix C

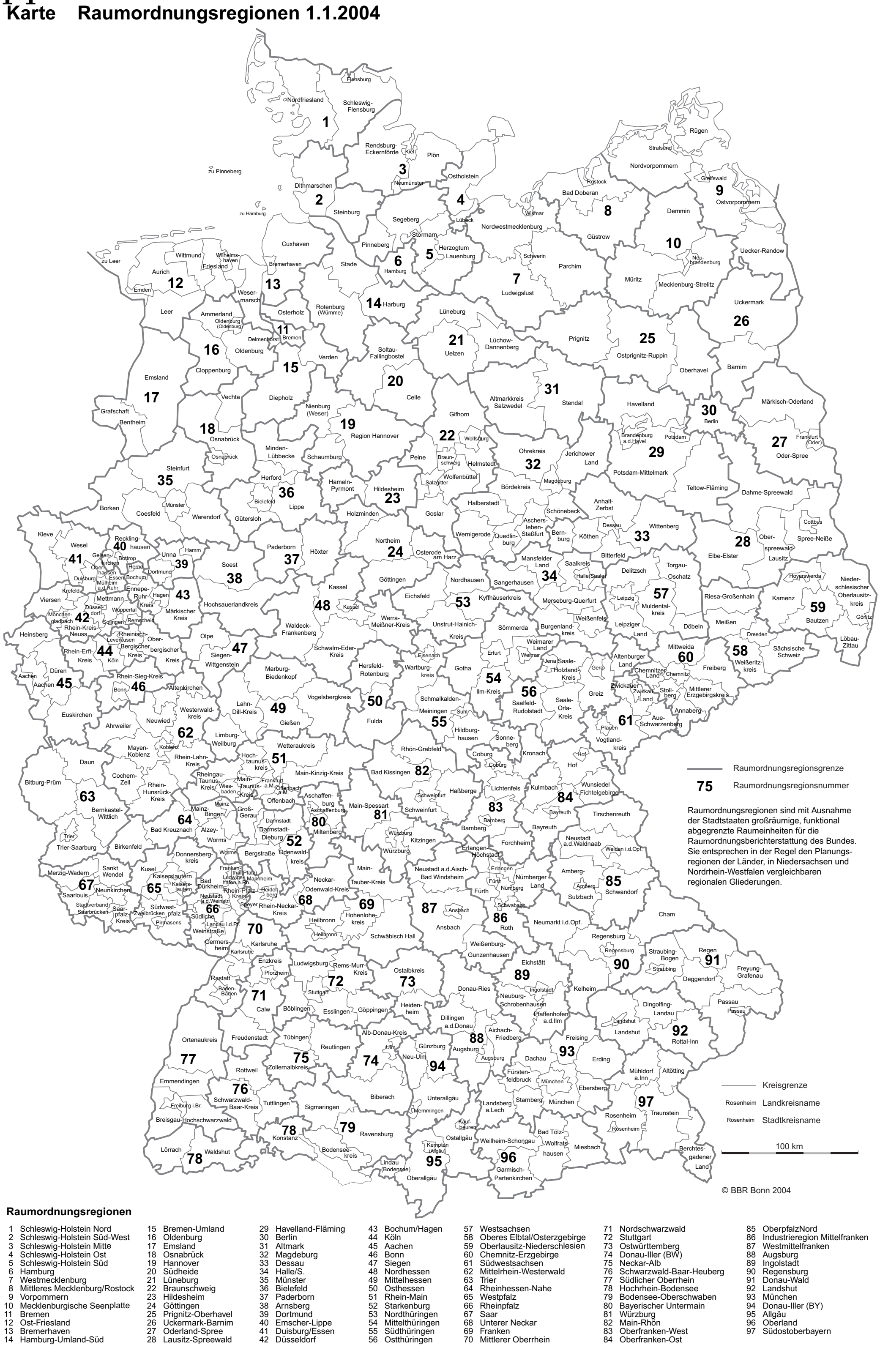


Figure 2.1: Raumordnungsregionen

Appendix D: Constructing historical data sets

The long lagged population data was derived from the population census in 1910 which was conducted by the Kaiserliches Statistisches Amt (1915). The basic historical data contained around 80.000 observations which had to be matched to around 8.000 West German municipalities that exist today. Two major challenges had to be overcome during the construction of the data set. Firstly, in 1910 the German Kaiserreich comprised a much larger territory than today, notably Prussia which stretched north earth (todays Poland) and north comprising many nowadays Danish cities. Secondly, todays municipality borders do not coincide with those back in 1910 which were much more disaggregated at that time. A majority of jurisdictions which formed an autonomous municipality back in 1910 were consolidated during several municipal reforms to one municipality with several suburbs and villages. The single historical municipalities were matched manually according to their name and the region. Fortunately, names of historic municipalities did merely change over time and they could be precisely located as the data set was partitioned into single provinces which simplified the matching substantially. This two stage procedure avoided pitfalls, e.g. from multiple municipality names that would have otherwise bothered the matching process. Our final matching rate amounts to 97%.

The construction of the historical railway data proceeded similarly except for 'filling' up todays municipalities with historic jurisdictions. We assigned the number of train stations to the respective municipality which we identified according to the name and region.

Chapter 3

Inefficient Lock-in and Subsidy Competition

3.1 Introduction

The many merits and drawbacks of capital tax competition and other forms of locational or jurisdictional competition have been established in a by now sizable literature.[1] This paper advances a novel argument in favor of tax competition: inefficient lock-ins of industry can potentially be overcome, and a shift to a more efficient equilibrium be induced, through competition in capital subsidies.

Inefficient lock-in situations are well-known from the field of technology adoption (David, 1985; Arthur, 1989). Arguably the most famous example is the computer keyboard, which despite technologically superior systems today still has the same layout – a succession of letters beginning with QWERTY in the topmost row – as the old typewriter.

Decreasing unit costs and multiple equilibria are also a hallmark of the new trade theory and of economic geography. This research has unveiled that 'history matters' for national or regional specialization, and that it cannot be assured that the best equilibrium is chosen. Krugman and Obstfeld (2009) provide a simple textbook example that countries can get locked into undesirable specialization patterns when industries are competitive and there are external economies of scale at the country level: two countries, Switzerland and Thailand, are both (potentially) able to supply the world demand for watches at decreasing average costs. Although Thailand could (by assumption) do so more cheaply at any scale, the Swiss industry, has (historically) established its industry first. This head start and the associated scale of production implies that the Swiss industry has lower unit costs compared to a Thai watch firm which considers to enter the market, but realizes that it could not competitively produce the first unit in isolation (i.e. given that a watch industry is yet non-existing in Thailand). Path dependencies and hysteresis effects in location have similarly been shown to arise in the more recent economic geography models (see e.g. Fujita et al., 1999; Baldwin et al., 2003). Anecdotal evidence documenting that agglomeration patterns may persist even

[1] Recent surveys of this literature are provided in Wilson and Wildasin (2004) and in Wilson (1999).

though the initial factors have vanished over time have been presented early on by Krugman (1991b,c). More recent econometric evidence documented in Redding et al. (2007) reinforces the hypothesis that history may matter: they find that the temporary shock of the division of Germany after World War II had a permanent effect on industry location in the sense that there are no signs that the associated shift of the German air hub from Berlin to Frankfurt is only temporary.

These lock-in effects – in the fields of technology adoption, international trade and economic geography or other fields – have in common that a shift from (say) an inefficient equilibrium to a potentially more efficient equilibrium is prevented by a coordination failure among the agents. The starting point of our analysis is a situation of an inefficient lock-in of industry, where no single firm finds it profitable to shift location even though a coordinated move would make all of them better off. Following Martin and Rogers (1995), we develop a simple two region model of monopolistic competition. The commercial relations between regions consist of intra-industry trade based on love-of-variety on the part of consumers and mobility of physical capital. We make two key assumptions. First, as in Martin and Rogers (1995), regions may differ in size. Given the assumption that firms produce with internal increasing returns, and in the absence of other differences between regions, this has the well-known implication that the larger region attracts a more than proportionate share of firms (the 'home market effect'). Second, there are localized intra-industry spillovers (e.g. knowledge spillovers) among monopolistic producers and also inter-industry spillovers from the modern sector to the other sector.[2] Accordingly, local marginal production costs are lower, the more numerous local firms are. Taken together, these two key assumptions imply that, given a suitable set of parameters, the model has two stable equilibria which can unambiguously be welfare-ranked. One equilibrium has all firms concentrated in the larger region, exploiting both the advantages of the large market and the advantages asso-

[2] Localized external economies of scale have obtained strong empirical evidence. See the surveys by Audretsch and Feldman (2004) and Rosenthal and Strange (2004) and the recent paper by Badinger and Egger (2008), which finds strong empirical evidence in favor of intra-industry spillovers and also, though less strong, inter-industry spillovers for OECD manufacturing. Indirect evidence of intra-industry spillovers is provided by Devereux et al. (2007) who find that firms of a specific industry respond to subsidies only in the region which already hosts a critical share of the respective industry.

ciated with the external economies. However, quite intuitively, if the intra-industry spillovers are strong enough there also exists a second, inefficient equilibrium where all firms concentrate in the smaller region but are unable to coordinate on a shift to the more efficient equilibrium.

Our subsidy game starts from such an inefficient equilibrium, where all the industry is located in the smaller region (say region 2). Governments are assumed to dispose of one instrument, direct capital payments, which are financed through non-distortionary taxes, and which can be offered to the capital owners. Following a recent literature, we assume that the subsidy game is in three stages (e.g. Baldwin and Krugman, 2004; Borck and Pflüger, 2006): in the first stage, the core region (the government in region 2) sets its subsidy, in the second stage, the government in the periphery (region 1) chooses its capital subsidy and the market allocation then unfolds in the third stage. The welfare functions of the regional governments are utilitarian with possibly different weights attached to workers and capital owners in their region.

Our main results are the following. If governments attach equal weight to capital owners and workers, then region 2 will never defend the core. Rather, it will accept that the more populous region 1 snatches the core by offering a capital subsidy which is just high enough to induce all capital to relocate. Intuitively, the larger region has an advantage in the competition game, because the agglomeration rent accruing to capital owners is larger when all capital is located in the larger region. Although residents of the smaller region benefit from a lower price index and higher wages when the core is located in their region, given that subsidies to capital accrue to capital owners in both regions, it becomes too costly for the government of the (smaller) core region to hold on to the core once the (larger) periphery actively bids for firms. Joint welfare as well as welfare in the two regions then increases. If, by contrast, governments assign a higher weight to workers' than to capital owners' welfare, there is a set of parameters where the smaller region defends the core, the inefficient lock-in persists, the periphery gains and the core loses in comparison with the situation before the start of this subsidy game. Intuitively, although allowing capital to relocate would allow capital owners to benefit from subsidies paid by the new core, this benefit would weigh less than the loss incurred in the form of lower wages and higher prices when the core region lets its industry go. Hence, in this case, the core will want to defend the core, even though global efficiency would rise if all industry were located in the larger region.

Our paper is related to several strands of previous research, neither of which has come up with the argument in favor of subsidy competition advanced here, however.

First, our paper is related to the literature on tax competition. The traditional literature in this field is based on models with perfectly competitive markets and stresses that, as a result of fiscal externalities, taxes and government expenditures are bid down by benevolent governments to sub-optimal levels. There are circumstances, however, when tax competition may be favourable, notably when without such competition tax rates are inefficiently high. In this spirit, Edwards and Keen (1996) show that tax competition max help tame Leviathan governments, and Kehoe (1989) shows that tax competition may alleviate excessive capital taxation in the absence of government commitment. However, lock-in situations do not arise in this traditional literature.

Second, a more recent literature reconsiders tax competition in the presence of market power on goods markets.[3] Research in the tradition of the new economic geography (typically) uses models of monopolistic competition and shows that the government in the core region is able to maintain a higher tax on capital than the government in the periphery.[4] A result similar in spirit has been obtained by Haufler and Wooton (1999). They show that in the competition to attract a foreign-owned monopolist, the government of the larger region is able to achieve this at a lower cost than the small region government. This result is based on the fact that the monopolist – similar to the firms in the differentiated goods sector in models of the new economic geography – has a locational preference for the larger market. Different market sizes are also studied by Ottaviano and van Ypersele (2005) who analyse monopolistic competition with mobile capital but without endogenous agglomeration, to show that, under certain conditions

[3]Important work in this area is by Janeba (2000). See also the surveys cited in footnote 1.
[4]See Andersson and Forslid (2003), Baldwin and Krugman (2004), Borck and Pflüger (2006), Kind et al. (2000) and Ludema and Wooton (2000). See also Janeba (1998).

(notably when trade costs are low enough) tax competition is efficiency enhancing.

Even though our model has much in common with these studies, there are important differences, the most important one being that an inefficient lock-in – our starting point – has not been considered in this literature. The papers on tax competition and economic geography analyze symmetric-identical regions which are endogenously driven into a core-periphery constellation. Due to this fundamental symmetry, from a welfare perspective it is immaterial which region ends up being the core – hence there is no welfare improvement associated with a switch of the core.[5] Haufler and Wooton (1999) and Ottaviano and van Ypersele (2005) allow for different market sizes, but they do not consider local external economies. Hence, the tension between local intra-industry spillovers and market size considerations, which gives rise to an inefficient lock-in is not present in their models.

Finally, there is a literature which addresses the coordination failure that emerges in models with decreasing average costs. In the context of city-industry equilibria considered in urban economics, the sustainability of inefficient lock-ins is contested by the idea of profit-seeking 'land developers'. The idea, put forward by Henderson (1975), holds that the existence of more efficient city sites can be exploited by forward-looking developers, who, by this efficiency differential, are able to profitably organize 'city corporations', and, hence to restore an overall efficient allocation. This idea has been revived by Rauch (1993) who shows that discriminatory pricing of land over time on the part of developers is key to the removal of such inefficiencies. Another mechanism to overcome multiple equilibria and coordination failures arising under external economies of scale has recently been worked out by Grossman and Rossi-Hansberg (2008). They analyze a model where production of final goods uses a continuum of tasks, each of which has a zero weight, and which can possibly be performed in two locations. They show that, by becoming external suppliers for these tasks, even 'small' agents can alleviate coordination problems.

[5]Note, however, that this does not imply that the a core-periphery constellation is necessarily the welfare optimum. See e.g. Ottaviano and Thisse (2002) and Pflüger and Südekum (2007).

Our analysis relates to these works insofar as we also address the coordination issue. In a non-technical paper, (Duranton, 2008, p.40) has recently put forward the intuitive notion that territorial competition can improve the spatial allocation of plants because "the places for which the external effects are the strongest are expected to bid the most". We provide a formal analysis which is much in this spirit, but where the interaction of external economies and market size is key.

The remainder of the paper is organized as follows. The next section describes the model and the locational equilibria. A welfare analysis is conducted for symmetric and asymmetric region size. Section 3.3 analyzes the outcomes of subsidy competition between asymmetrically sized regions. The last section concludes.

3.2 The Model

3.2.1 Basic Set Up

The model builds on Martin and Rogers (1995). The world consists of two regions, indexed by $i = 1, 2$, which are symmetric in preferences and technology. There are two sectors. The modern sector (M), characterized by increasing returns, monopolistic competition and iceberg trade costs, produces a composite of industrial varieties. Spatial distance is modeled using iceberg trade costs. To consume one unit of a variety produced abroad, $\tau > 1$ units have to be shipped; the remainder melts away in transit.

The perfectly competitive traditional sector (A) produces a homogenous good under constant returns to scale. The A-good is taken as the numéraire good and hence, its price is normalized to one, $p_i^A = 1$. We assume that the traditional good is produced in both regions and is traded without costs across regions.

There are two input factors, capital and labor. Each worker owns of one unit of labor and each capitalist one unit of capital, which they both supply inelastically. The mass of workers and the mass of capitalists are both normalised to unity. Region 1 hosts the share s_l of workers and the share s_k of capital owners. Labor is immobile across regions and employed in both sectors. Capital is employed in the modern sector only, and each firm requires one unit of capital. Capital can be freely moved across the two regions, but capital owners are immobile. We assume perfect portfolio diversication: each capitalist owns an equal share of the international portfolio which delivers the return $s_n r_1 + (1 - s_n) r_2$, where r_i is the return to capital invested in region i and s_n is the share of capital (and, hence, firms) installed in region 1. The capital income of region 1 is therefore given by $s_k(s_n r_1 + (1 - s_n) r_2)$.

3.2.2 Preferences and Demand

Households derive utility from consuming a range of differentiated modern goods and the traditional good. Preferences are represented by a two tier utility function, where the upper tier function is logarithmic quasi-linear and the lower tier utility function is CES. The utility function of a type-h individual (capitalist or worker) in region i is[6]

$$U_i(A_i, M_i) = \alpha \ln M_i + A_i \tag{1}$$

A type-h individual in region i receives income y_{ih}. We assume $0 < \alpha < y_{ih}, i = 1, 2, h = K, L$, to assure that both types of goods are consumed by all individuals in each region. A_i denotes consumption of the numéraire good and α the amount of income spent on the composite good (see below). Consumption of the modern good M_i consists of all differentiated varieties v:

$$M_i = \left(\int_0^{n_i} m_{ii}(v)^{\frac{\sigma-1}{\sigma}} dv + \int_{n_i}^{n_i+n_j} m_{ji}(v)^{\frac{\sigma-1}{\sigma}} dv \right)^{\frac{\sigma}{\sigma-1}}, \qquad \sigma > 1, \quad i \neq j, \tag{2}$$

where m_{ii} denotes consumption of a variety produced domestically and m_{ji} denotes consumption of a variety produced abroad. The constant elasticity of substitution between any two varieties is denoted by σ. The budget constraint of a representative

[6]To simplify notation, we use the fact that – due to quasilinear utility – all individuals consume the same amount of modern goods.

household reads

$$\int_0^{n_i} p_i(v)m_{ii}(v)dv + \int_{n_i}^{n_i+n_j} \tau p_j(v)m_{ji}(v)dv + A_{ih} = y_{ih}, \tag{3}$$

where p_i and p_j denote the producer prices of a respective variety. Solving the utility maximization problem yields the following demand functions, $m_{ii}(v)$, $m_{ji}(v)$, M_i^* and A_{ih}^* and indirect utility V_{ih}:

$$M_i^* = \alpha/P_i, \qquad A_{ih}^* = y_{ih} - \alpha, \quad h = K, L \tag{4}$$

$$m_{ii} = \alpha p_i(v)^{-\sigma} P_i^{\sigma-1}, \qquad m_{ji} = \alpha(\tau p_j(v))^{-\sigma} P_i^{\sigma-1},$$

$$P_1 \equiv [s_n p_1^{1-\sigma} + (1-s_n)(\tau p_2)^{1-\sigma}]^{\frac{1}{1-\sigma}}, \tag{5}$$

$$V_{ih} = y_{ih} - \alpha \ln P_i, \tag{6}$$

where P_1 denotes the CES price index in region 1 which already takes symmetry of producer prices into account. An analogous expression holds for the CES price index of region 2.

3.2.3 Production

We will henceforth derive all expressions for region 1 only. The corresponding expressions for region 2 are analogous.

Traditional sector

The A-good is produced using labor as the only input according to $q_1^A = (1 + \mu s_n)L_1^A$, where L_1^A is labor input and q_1^A is output. The term μs_n captures inter-industry spillovers, with $\mu > 0$. The larger the domestic share of firms, s_n, the higher is the marginal productivity of labor and the more units of the A-good can be produced with a given labor force. Due to perfect competition labor is paid its marginal product. Hence, we get $w_1 = 1 + \mu s_n$.[7]

Modern sector

The representative firm in region 1 produces one variety using one unit of capital (the fixed input requirement) and $1/(1 + \gamma s_n)$ units of labor according to the total cost function

$$TC_1 = \left(\frac{1 + \mu s_n}{1 + \gamma s_n}\right) q_1 + r_1, \tag{7}$$

where q_1 is a firm's output in region 1. Its fixed costs are given by r_1 and its marginal costs are determined by the variable input requirement and by the wage as previously determined. Intra-industry spillovers γ have a positive effect on the productivity of a firm. The proximity to other producers in the same industry generates knowledge spillovers which lower firms' variable costs. Inter-industry spillovers, on the other hand, drive up wages in the region and hence, the firm's variable costs. In line with the empirical evidence we assume that spillovers are stronger within an industry than between different industries, i.e. spillovers increase industry specific skills of a worker more than general skills.[8] The profit function of the representative firm in region 1 is given by

$$\Pi_1 = \left(p_1 - \frac{1 + \mu s_n}{1 + \gamma s_n}\right) q_1 - r_1. \tag{8}$$

Market clearing requires a firm's supply q_1 to be equal to aggregate demand, which consists of domestic and export demand, including the indirect demand associated with

[7] Note that contrary to previous economic geography models which assume that the immobile factor earns the same reward irrespective of whether employed in the concentrated or in the peripheral region we allow for a higher wage rate in the region where industry is agglomerated.

[8] See Rosenthal and Strange (2004) for a survey of the evidence.

the iceberg trade costs:

$$q_1 = m_{11}(s_l + s_k) + \tau m_{12}((1 - s_l) + (1 - s_k)). \tag{9}$$

Equation (9) uses the familiar result that mill pricing is optimal in the Dixit Stiglitz model. Profit maximization yields optimal mill prices which are constant markups on marginal costs:

$$p_1 = \frac{\sigma}{\sigma - 1}\left(\frac{1 + \mu s_n}{1 + \gamma s_n}\right). \tag{10}$$

Using the zero pure profit condition and applying mill prices from (10) yields the break even output q_1 of a firm:

$$q_1 = r_1(\sigma - 1)\left(\frac{1 + \gamma s_n}{1 + \mu s_n}\right). \tag{11}$$

Short run equilibrium

In the short run, the allocation of capital and hence the allocation of firms is exogenous. Eqs. (10) and (11) then immediately imply $r_i = (p_i q_i)/\sigma$, i.e. the capital reward captures operating profits. Using this result as well as the mill prices from (10) and the market clearing condition (9), we find:

$$r_1 = \frac{\alpha}{\sigma}\left(\frac{s_l + s_k}{s_n + (1 - s_n)\phi\chi} + \frac{\phi((1 - s_l) + (1 - s_k))}{\phi s_n + (1 - s_n)\chi}\right), \tag{12}$$

$$r_2 = \frac{\alpha}{\sigma}\left(\frac{\phi(s_l + s_k)\chi}{s_n + (1 - s_n)\phi\chi} + \frac{((1 - s_l) + (1 - s_k))\chi}{s_n\phi + (1 - s_n)\chi}\right), \tag{13}$$

where

$$\chi \equiv (\frac{p_2}{p_1})^{1-\sigma} = \left(\frac{1 + \mu(1 - s_n)}{1 + \mu s_n}\frac{1 + \gamma s_n}{1 + \gamma(1 - s_n)}\right)^{1-\sigma}$$

and $\phi \equiv \tau^{1-\sigma}$ is the level of trade freeness, with $0 \leq \phi \leq 1$.

3.2.4 Long run equilibrium and welfare: the symmetric case

In the long run, capital is mobile and moves to the location where it earns the highest return. We assume that this movement is governed by the ad-hoc adjustment equation:

$$\dot{s_n} = (r_1 - r_2)(1 - s_n)s_n.$$

A long run equilibrium is defined as a situation where capital no longer moves across regions. In this model, there are two types of locational long-run equilibria. Depending on the relative strength of centripetal and centrifugal forces industry will be either dispersed (symmetric interior equilibrium, where $r_1 = r_2$) or agglomerated in one single region (a core-periphery equilibrium) at $s_n = 0$ (with $r_1 < r_2$) or $s_n = 1$ (with $r_1 > r_2$).

The different locational equilibria which emerge for different levels of trade costs are depicted in Figure 3.2 for the case where regions are equal sized. The parameters are $\alpha = 0.3$,$\sigma = 4$, $\mu = 0.5$, $s_l = s_k = 0.5$,$\gamma = 1$.[9]

A symmetric equilibrium is stable for low trade freeness, e.g. $\phi = 0.17$. Starting from $s_n = 1/2$, increasing region 1's industry share lowers the capital reward gap $(r_1 - r_2)$ implying that firms will have an incentive to move back to region 2. A core-periphery outcome is stable for high trade freeness ($\phi = 0.75$) but unstable for low trade freeness. For intermediate trade freeness ($\phi = 0.24$), all three allocations, the symmetric interior equilibrium and the two core-periphery equilibria are stable.

Locational forces

The market allocation is driven by different agglomeration and dispersion forces which can be identified by making use of (12) and (13).[10]

[9] Unless otherwise noted, all figures will use the same basic parameters.
[10] A formal exposition of the forces of the model can be found in Appendix 3.5.3.

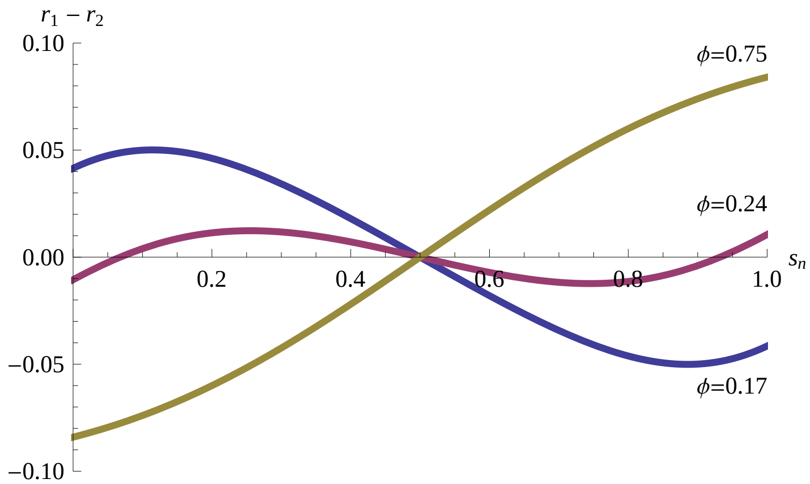


Figure 3.1: Locational equilibria

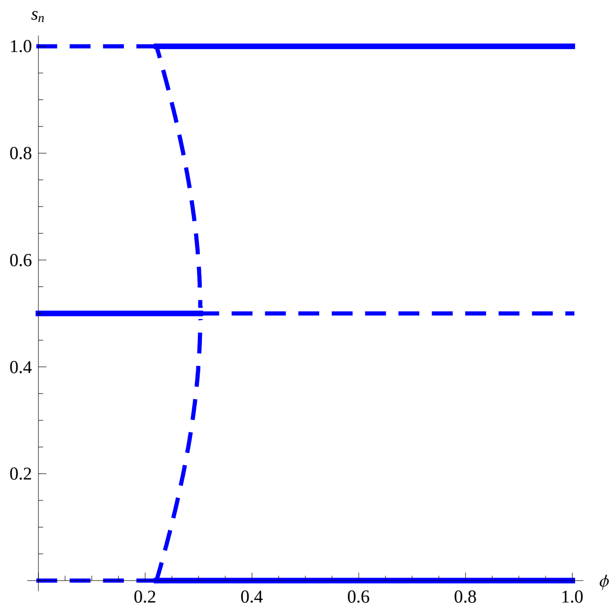


Figure 3.2: Bifurcation diagram

Intra-industry spillovers are an agglomeration force. A higher local industry share lowers the variable input requirement and raises firms' operating profits. Thus, more capital is attracted to that region.

The local competition effect (also termed crowding effect) and inter-industry spillovers act in favor of a dispersed outcome. The competition effect describes the tendency of firms to produce in regions with only few competitors. Starting from a symmetric allocation of industry, increasing the share of industry in one region (for given production costs) drives down operating profits in that region. This will in turn discourage capital owners to supply their capital there. The second dispersion force works through the worker's wage rate. A higher number of firms lowers variable costs but, due to inter-industry spillovers, the wage paid to workers in the core exceeds the wage paid in the periphery. Higher production costs in turn lower firms' operating profits which discourages a movement of capital into that region.

Symmetry Breaking

To assess the stability of the different long-run equilibria we derive the market break point, ϕ^B, which is the threshold level of trade freeness above which the symmetric equilibrium becomes unstable.

Figure 3.2 depicts the stability of long run equilibria for symmetric region size. The model exhibits a subcritical pitchfork. As soon as ϕ exceeds the critical break point ϕ^B, the only stable equilibrium is the core-periphery outcome. The expression for ϕ^B is given in Appendix 3.5.1. The break point depends in intuitive ways on the parameters: when agglomeration forces become stronger, ϕ^B falls, so that the range of trade freeness levels at which the symmetric equilibrium is stable shrinks. This is the case when intra-industry spillovers increase (higher γ), inter-industry spillovers decrease (lower μ) or σ decreases, which means higher economies of scale at the firm level.

Agglomeration rent and sustain point

Next, we assess the stability of the core-periphery equilibria and derive the level of trade freeness ϕ^S (the 'sustain point'), up to which a core-periphery equilibrium can be sustained.

When all industry is agglomerated, say, in region 2, capital earns an agglomeration rent, $\Omega_2(\phi, \cdot) \equiv (r_2(\phi, \cdot) - r_1(\phi, \cdot)) \mid_{s_n=0}$:

$$\Omega_2(\phi, \cdot) = \frac{\alpha}{\sigma}\left[2 - \left(\frac{1+\gamma}{1+\mu}\right)^{1-\sigma}\left(\frac{s_k + s_l}{\phi} + [(1-s_k) + (1-s_l)]\phi\right)\right]. \qquad (14)$$

which is the loss that a firm would incur if it were to relocate from region 2, the core, to the periphery region 1, given that all other firms stay in the core.

The sustain point solves $\Omega_2(\phi, \cdot) = 0$. At this level of trade freeness, the agglomeration rent is zero so that full agglomeration is viable for $\phi > \phi^S$. The expression for ϕ^S is presented in Appendix 3.5.2. Again, stronger agglomeration forces decrease the sustain point, which means full agglomeration can be sustained for smaller levels of trade freeness. This is the case when intra-industry spillovers increase, inter-industry spillovers decrease, or σ decreases.

Moreover, the overlap between the sustain and market break point depicted in Figure 3.2 reflects the range of levels of trade freeness at which both types of equilibria, the symmetric as well as the core-periphery outcome are stable.

Welfare Analysis

To study the welfare effects of a reallocation of industry, we first derive the indirect utility functions of workers and capital owners in region i:

$$V_{K_i} = -\alpha \ln P_i + s_n r_1 + (1-s_n) r_2, \qquad V_{L_i} = -\alpha \ln P_i + w_i, \qquad (15)$$

where $w_1 = (1 + \mu s_n)$ and $w_2 = (1 + \mu(1 - s_n))$. Regional welfare is assumed to be the weighted sum of indirect utilities of capital owners and workers residing in the respective region. We let the government attach a weight λ to workers' welfare. Then regional welfare is given by:

$$W_1 = \lambda s_l V_{L_1} + (1 - \lambda) s_k V_{K_1}, \qquad W_2 = \lambda(1 - s_l) V_{L_2} + (1 - \lambda)(1 - s_k) V_{K_2}. \qquad (16)$$

For weak γ and low ϕ, residents of any region unambiguously lose as the share of industry in their region declines, since to consumer prices rise and wage rates fall. Residents of the agglomerating region experience a welfare increase since they save on transport costs on imported varieties and workers earn a higher wage rate. By contrast, the effect of a reallocation of firms on regional welfare is ambiguous for strong intra-industry spillovers and high ϕ. For instance, for high γ, at $s_n = 0$ even residents of region 1 may benefit from an agglomeration in region 2, since consumer prices are low due to strong spillovers. If at the same time ϕ is sufficiently high, the benefit from lower producer prices exceeds the cost of importing industrial goods. However, with an ongoing reallocation of industry towards region 1 the gains from intra-industry spillovers decline, increasing consumer prices, thereby hurting households in both regions.

Next, to check whether the arising location pattern is socially desirable (i.e. whether there is too much or too little agglomeration), we compare the social planner's choice of industry allocation to the market outcome. Since conflicting interests among residents of different regions make the Pareto criterion unapplicable, we apply a utilitarian concept and assume the social welfare function to be the sum of household's indirect utilities $W = W_1 + W_2$. We assume that the social planner takes market prices as given and only decides over the allocation of industry.[11] Figure 3.3 depicts the social welfare function for different levels of trade freeness and symmetric region size.

While partial agglomeration is never optimal for the social planner, a symmetric allo-

[11] Pflüger and Südekum (2007) show that the resulting allocation is the same as when the planner can implement first-best welfare, which also corrects for the price distortion in the industrial sector stemming from imperfect competition.

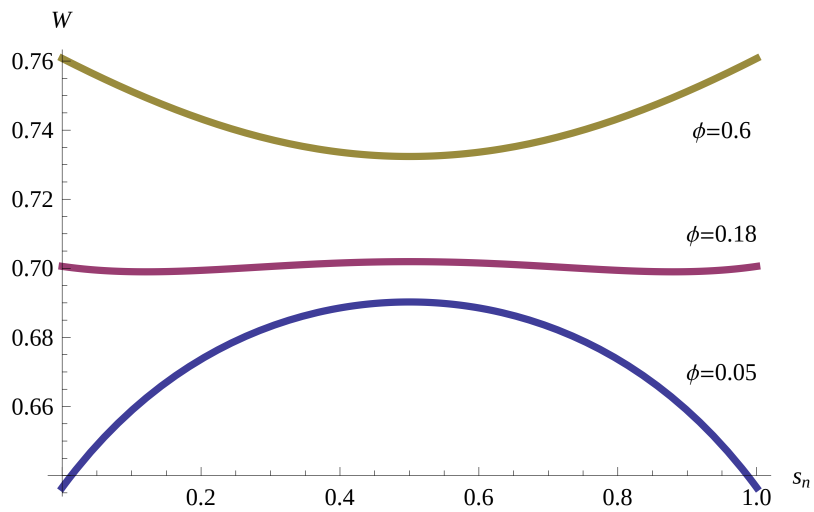


Figure 3.3: Social welfare: symmetric region size

cation is chosen at low ϕ and a core periphery equilibrium at high ϕ. We denote by ϕ^{SB} the level of trade freeness at which the social planner is just indifferent between implementing a symmetric allocation or a core periphery outcome. Formally ϕ^{SB} solves $W|_{s_n=\frac{1}{2}} = W|_{s_n=1} = W|_{s_n=0}$. Comparing ϕ^{SB} with ϕ^{B} allows us to detect whether the market outcome is socially desirable. It turns out that the social break point lies below the market breakpoint for our parameter restrictions,[12] which implies that for $\phi^{SB} < \phi < \phi^{B}$ the market exihibits under-agglomeration (see also Figure 3.2). Given that our model includes external economies, this is not really surprising.

3.2.5 Long run equilibrium and welfare: the asymmetric case

So far we have assumed regions to be equally endowed with the immobile factor. In this section, we generalise the model to allow for differences in regional workforces. In particular, we consider region 1 to host more workers than region 2, so that $s_l \geq \frac{1}{2}$.

[12]The full expression for ϕ^{SB} is suppressed here but is available upon request.

Region size effect

Recall that capital moves in search of the highest nominal reward where the capital reward rates are given by (12) and (13). For simplicity we will assume that regions are equally rich in capital, i.e. each region owns half of the world capital stock ($s_k = 1/2$) but they may differ in the number of workers. This gives rise to another agglomeration force, which we term region size effect. This describes the tendency of firms to produce in the larger market and to export to the smaller market.[13] Formally, the market size effect is derived by differentiating the capital reward gap with respect to the share of immobile workers in region 1, s_l, evaluated at the symmetric equilibrium in the absence of inter-and intra-industry spillovers:

$$\left.\frac{\partial(r_1 - r_2)}{\partial s_l}\right|_{s_n=\frac{1}{2},\mu=\gamma=0} = \frac{4\alpha}{\sigma}\left(\frac{1-\phi}{1+\phi}\right) \geq 0. \tag{17}$$

Bifurcation diagram and agglomeration rent

Once we allow regions to differ, the symmetric equilibrium can no longer be stable. The blue curve in the bifurcation diagram in Figure 3.4 identifies stable equilibria for different levels of ϕ, assuming $s_l = 0.8$. For low levels of trade freeness a stable asymmetric interior equilibrium emerges, where the larger region (region 1) hosts more than half of the total industry. However, for high ϕ, both the core in the large region as well as the core in the smaller region constitute stable equilibria.

Both core-periphery equilibria, $s_n = 1$ and $s_n = 0$ are stable, since all firms, once agglomerated in the region, earn a positive agglomeration rent. As Figure 3.5 shows, however, for $\phi < 1$, the agglomeration rent is clearly higher when all industry is in the larger region.

Our model then allows for the possibility that the entire industry is concentrated in the smaller region, despite the fact that firms could earn a higher agglomeration rent

[13] The region size effect is actually made up of two effects: the market size effect described above, and the factor proportions effect: the larger region has larger relative supply of labour.

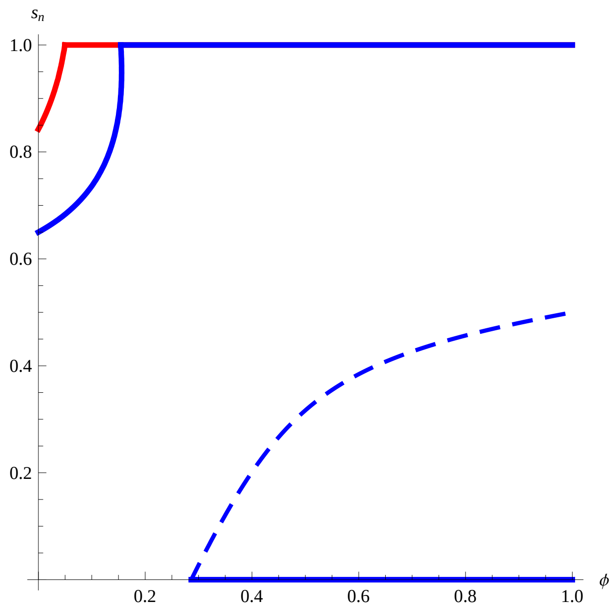


Figure 3.4: Bifurcation diagram for asymmetric region size

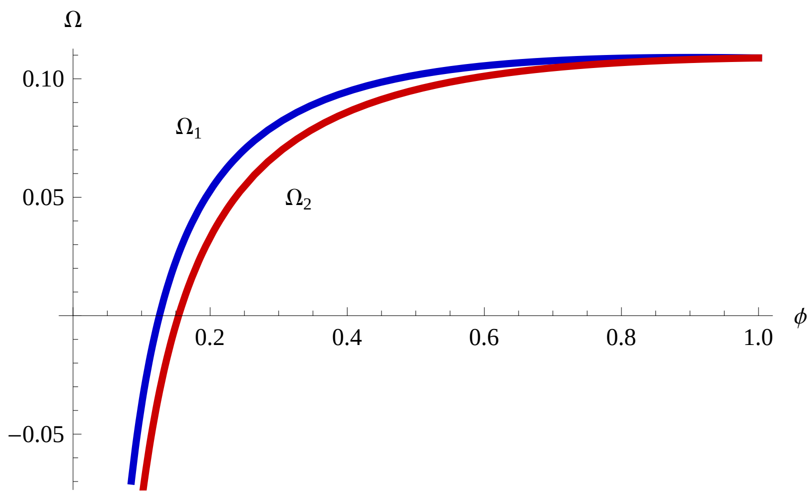


Figure 3.5: Agglomeration rent for asymmetric region size

if all industry were located in the larger region.[14] This new feature of the asymmetric model is in contrast to the 'footloose capital' model described in Baldwin et al. (2003) and used by Ottaviano and van Ypersele (2005)[15] where the larger region always hosts a larger share in industry irrespective of the underlying level of trade freeness.

Welfare

We stick to our definition of global welfare as the sum of regional welfare levels, where W_1 and W_2 are given by (16). Figure 3.6 depicts the social welfare function for asymmetric region size and different levels of trade freeness.

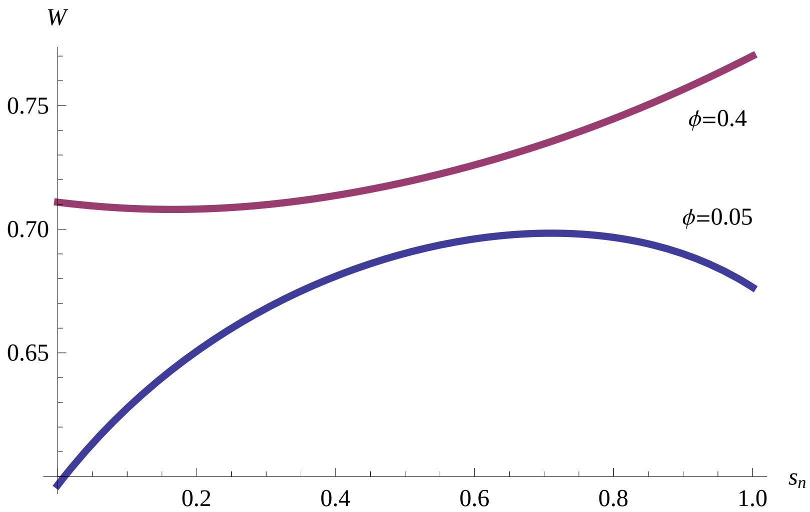


Figure 3.6: Social welfare: asymmetric region size

Note that for low ϕ (e.g. $\phi = 0.05$ in the Figure), partial agglomeration, with the larger region hosting a larger share in industry, is socially desirable. For sufficiently high ϕ, global welfare is maximized when all industry is agglomerated in the large region:

[14]The literature typically assumes that there exists some coordination failure or absence of rational expectations (e.g. lack of information or costs that hinder firms to relocate) which makes firms unable or unwilling to commit to relocate (see Baldwin et al. (2003) or Krugman (1991d)). Without this assumption it becomes difficult to justify the existence of multiple equilibria. Krugman (1991b) argues that rational expectations are hard to justify since they call for a degree of information and sophistication that is unreasonable.

[15]In Ottaviano and van Ypersele (2005), for high trade costs there is a stable interior asymmetric equilibrium, where the larger region hosts a larger industry share, whereas for low trade costs all industry will be agglomerated in the larger region.

Proposition 1 *For $\phi > \phi^{SB}$, we have $W(1) > W(0)$ iff $s_l > \frac{1}{2}$.*

Proof. See Appendix 3.5.4. ■

The intuition for the result is that when the core is in the larger region, the majority of households benefit from a lower cost-of-living index and higher wages.

However, as outlined above, our model allows for a stable core-periphery equilibrium in the smaller region. It therefore allows for an inefficient but stable allocation of industry. Figure 3.4 shows the welfare optimal allocation of industry as the red curves: The figure also shows that whenever there is an equilibrium with full agglomeration, this is also socially optimal.

3.3 Subsidy Competition

3.3.1 Basic Setup

We are interested in the outcome of subsidy competition in the presence of technological spillovers. Assume that the level of trade freeness is sufficiently high such that originally, industry is agglomerated in one region. Each regional government maximizes welfare of its residents by using subsidies to influence capital owners' investment decision. The core region, say region 2, as well as the periphery benefit from retaining or attracting firms since hosting the industry core increases welfare of immobile factor owners residing in the core through lower transport cost ('cost-of-living effect') and a higher wage rate. In order to derive analytical expressions for the different subsidy levels we model subsidies z_i in their simplest form, namely as a direct lump-sum payment to capital owners. Firms move according to the highest post-subsidy capital reward rate, $r_i^s = r_i + z_i$. Laborers' and capital owners' endowment is taxed in a lump sum fashion to finance subsidy payments. The regional budget constraints are:

$$z_1 s_n = T_1(s_k + s_l), \qquad z_2(1 - s_n) = T_2((1 - s_k) + (1 - s_l)). \tag{18}$$

For region 1, total subsidy payments are the subsidy times the share of firms s_n, while tax payments are lump-sum taxes paid by the s_k capitalists and s_l workers.

Government expenditure and tax revenue are zero once the region happens to become the periphery, since there are no firms to subsidize. Inserting the price indices from (5) as well as the post-subsidy capital reward rates, wage rates and tax payments into the indirect utility functions, using (16) allows us to derive regional welfare both for the case where region 1 hosts the industry core and for the case where region 1 is the periphery (the expressions for region 2 being analogous):

$$\begin{aligned} W_1^C(z_1) = W_1\Big|_{s_n=1} &= \lambda s_l(1+\mu) + (1-\lambda)s_k\left(z_1 + \frac{2\alpha}{\sigma}\right) \\ &\quad -\big(\lambda s_l + (1-\lambda)s_k\big)\left(\alpha \ln P^C + \frac{z_1}{s_l + s_k}\right) \end{aligned} \tag{19}$$

$$\begin{aligned} W_1^P(z_2) = W_1\Big|_{s_n=0} &= \lambda s_l + (1-\lambda)s_k\left(z_2 + \frac{2\alpha}{\sigma}\right) \\ &\quad -\big(\lambda s_l + (1-\lambda)s_k\big)\big(\alpha \ln P^P\big) \end{aligned} \tag{20}$$

where $P^C \equiv \left(\frac{1+\mu}{1+\gamma}\right)$ and $P^P \equiv \phi^{\frac{1}{(1-\sigma)}}\left(\frac{1+\mu}{1+\gamma}\right)$ are the price indices for the core and periphery case, respectively. Whereas welfare of a peripheral region is increasing in the subsidy level offered in the core region, it decreases in its own subsidy level as soon as it hosts the industry core. This is due to the ownership structure of capital and the regional financing scheme. Since capital income is repatriated to the region of origin and subsidies are financed via regional taxes, each capital owner residing in the periphery benefits from a subsidy distributed in the core region. Welfare of the core is falling in its own subsidy level, since it is entirely financed by residents of the core, but part goes to capital owners residing in the periphery.

We adopt the same game structure as Baldwin and Krugman (2004) and apply a sequential move game. In the first stage the government of the core (Govt 2) sets its subsidy level, the periphery (Govt 1) then chooses its subsidy in the second stage. In the third stage firms choose their location of production dependent on the gross capital reward rates. Production and consumption take place as described in the preceding sections. We continue to assume that $s_k = 1/2$ but allow for asymmetries in region size in terms of the number of workers and in particular allow for the possibility that the initial core region is smaller than the periphery. As before, we suppose that $s_l \geq \frac{1}{2}$, so that region 1 is larger, but region 2 is the core, so that the equilibrium without subsidies is inefficient since the core is in the smaller region. Hence, in contrast to the previous literature, we allow for a situation where the initial factors (e.g. market size) which caused this agglomeration have vanished over time but where locational hysteresis has led to a persisting inefficient agglomeration, where firms continue to produce in the smaller region. Differences in region size are only allowed to the extent to which welfare of the smaller core region, $W_2^C(z_2) \equiv W_2\big|_{s_n=0}$ still exceeds the welfare level in the periphery case, $W_2^P(z_1) \equiv W_2\big|_{s_n=1}$ such that the outcome of the subsidy competition game does not become trivial.[16]

Stage Two: Periphery's Decision

In stage two Govt 1 (the periphery) decides whether to induce a relocation of the industry core or to stay out of the competition and leave the allocation of industry unchanged. However, due to the existence of agglomeration forces Govt 1 will not achieve any movement of capital if it sets its subsidy too low. In order to induce firms to relocate, the subsidy level has to be at least as high as the agglomeration rent accruing to firms in the core plus the core's subsidy rate, i.e. $z_1^{min}(z_2) = \Omega_2 + z_2$. This would make a capital owner indifferent between staying in the core – realising the agglomeration rent Ω_2 – and being paid a subsidy of z_2, or moving to the periphery

[16]Otherwise the benefits of hosting the industry core in the form of lower living costs and higher wage rates would not suffice for the government of the core region to engage in a costly subsidy competition.

and being paid z_1. Inserting Ω_2 using (14) and $s_k = 1/2$ yields

$$z_1^{min}(z_2) = \frac{\alpha}{\sigma}\left[2 - \frac{(\frac{1+\gamma}{1+\mu})^{1-\sigma}(1 + 2s_l - (2s_l - 3)\phi^2)}{2\phi}\right] + z_2. \tag{21}$$

Any subsidy level below $z_1^{min}(z_2)$ will fail to induce a relocation of firms. Clearly, whether Govt 1 decides to enforce a relocation by setting a subsidy level equal to z_1^{min} depends on the subsidy level set by the core government in the first stage. Govt 1 chooses its subsidy level according to the following decision rule:

$$z_1 = \begin{cases} z_1^{min}(z_2) & \text{if} \quad W_1^C(z_1) > W_1^P(z_2), \\ 0 & \text{otherwise.} \end{cases}$$

Intuitively, for Govt 1 to engage in the competition, welfare after having successfully attracted all industry ($W_1^C(z_1)$) has to exceed the welfare level for the case where region 1 remains the periphery ($W_1^P(z_2)$). Using this decision rule, we are able to derive the maximum subsidy level z_1^{max} that Govt 1 would be willing to incur. This subsidy level solves $W_1^P(z_2) = W_1^C(z_1^{max})$. To enhance intutition we evaluate the resulting subsidy levels at $\lambda = 1/2$ for the time being and turn later to the case of unequal welfare weights. Using (19) and (20) yields

$$z_1^{max}(z_2)\big|_{\lambda=1/2} = 2\mu s_l + \frac{\alpha(1 + 2s_l)}{1 - \sigma} \ln \phi - z_2. \tag{22}$$

The first term in (22) captures the potential 'wage effect' for region 1's workers that will occur if Govt 1 succeeds in attracting the industry core. The second term captures the 'cost-of-living effect' which enters through the price index prevailing in the respective region.[17] This term is positive since σ >1 and $\ln \phi$ <0. Finally, the last term expresses the 'subsidy effect' for each of region 1's capital owners. The higher z_2 set in the first stage, the lower will be z_1^{max}, i.e. the lower will be the willingness of Govt 1 to attract the core. It follows that as soon as $z_1^{min}(z_2) \geq z_1^{max}(z_2)$ Govt 1 will no longer be willing

[17] Due to symmetric spillovers both regions benefit from high intra-industry spillovers through lower prices. Hence, any disparity in consumer prices between core and periphery stems from trade costs only.

to attract the core, since the necessary subsidy is so high that the gain from attracting the core is lower than the cost.

Stage One: Core's Decision

Turning to the first stage, Govt 2 acts as a Stackelberg leader, foreseeing the implications of its choice on the choice of Govt 1 in the following stage. Since Region 2 welfare falls in its own subsidy, Govt 2 will want to set the lowest subsidy level consistent with defending the core, if it wants to defend at all. This subsidy level, z_2^d, is that at which the periphery in the second stage will no longer be willing to snatch the core. Formally, z_2^d solves $z_1^{min}(z_2^d) = z_1^{max}(z_2^d)$. Using (21) and (22), we get:

$$z_2^d\big|_{\lambda=1/2} = \frac{1}{2}\left\{2\mu s_l + \frac{\alpha(1+2s_l)}{1-\sigma}\ln\phi - \frac{\alpha}{\sigma}\left[2 - \frac{(\frac{1+\gamma}{1+\mu})^{1-\sigma}(1+2s_l-(2s_l-3)\phi^2)}{2\phi}\right]\right\} \tag{23}$$

Therefore, Govt 2 will set its subsidy at z_2^d if its welfare when it defends the core exceeds the welfare it receives when becoming the periphery. Otherwise, it would set a subsidy of $z_2^d - \varepsilon$, where ε is a small positive number. The reason is that by raising its subsidy, Govt 2 raises the subsidy which Govt 1 has to pay in order to attract industry. This benefits region 2's capital owners via the repatriation externality. Hence, we have the following decision rule:

$$z_2^* = \begin{cases} z_2^d & \text{if} \quad W_2^C(z_2^d) \geq W_2^P(z_1^{min}(z_2)), \\ z_2^d - \varepsilon & \text{otherwise.} \end{cases}$$

3.3.2 Equilibrium

Having derived the decision rules of the respective players and the according subsidy levels, this section identifies the outcomes of the game.

Equilibrium 1: Relocation of industry

Whether Govt 2 decides to defend the industry core depends on how much Govt 2 values workers' relative to capitalists' welfare in region 2. We start with the case where workers and capitalists' welfare is equally weighted.

Proposition 2. *For equal welfare weights, $\lambda = 1/2$, Govt 2 will never defend the core for any $s_l \geq \frac{1}{2}$. The equilibrium subsidy levels are given by $z_2^* = z_d^2 - \varepsilon$, $z_1^* = z_1^{min}(z_d^2 - \varepsilon)$ with some small $\varepsilon > 0$.*

Proof. See Appendix 3.5.4. ■

By setting $z_2 = z_2^d - \varepsilon$, Govt 2 ensures that region 1 snatches the core offering $z_1^{min}(z_2^d - \varepsilon)$, thereby restoring an efficient allocation of industry. At the same time, since z_2 raises z_1^{min}, Govt 2 realizes the highest possible repatriation externality by setting $z_2 = z_2^d - \varepsilon$, which will benefit region 2's capitalists via the repatriation of capital income. This result is rather intuitive, in the sense that the larger region has a 'natural advantage' in the subsidy game: when the core region is small, the agglomeration rent is small too. This implies that the periphery government has to offer capital owners a relatively small subsidy to induce a relocation. It also implies that the periphery government will be more willing to snatch the core, since the payoff to doing so increases with s_l. Hence, defending the core will be more costly for the core government. In fact, it becomes so costly that for a symmetric welfare function, the core will only be defended if it is located in the larger region. In other words, subsidy competition restores an efficient allocation of industry. The next result states that welfare is then higher if it would be without subsidies and the core located in the smaller region.

Proposition 3. *For* $z_2^d > 0$,

(i) overall welfare is higher in the equilibrium with than without subsidies,

$$W(z_1^{min}(z_2^d - \varepsilon), z_2^d - \varepsilon) > W(0, 0),$$

(ii) region 1's residents experience a welfare gain after having successfully attracted all industry compared to the initial regional welfare level:

$$W_1^C(z_1^{min}(z_2^d - \varepsilon)) > W_1^P(0).$$

Proof. See Appendix 3.5.4. ■

What cannot be unambiguously determined is whether the new periphery region (region 2) will be worse or better off after the relocation of industry compared to the initial welfare. On the one hand, a relocation of industry induced by a positive subsidy level set by Govt 1 imposes a positive externality on capital owners' income in the new periphery. Half of the subsidy payment promised to industrial firms by Govt 1 accrues to capital owners of region 2. On the other hand, region 2 loses all industry thereby suffering from a lower wage rate and a higher cost-of-living index. Overall welfare however, will be higher after the relocation of industry towards an efficient industry allocation. This is an important result, since it shows that fiscal competition can help redress an inefficiency stemming from increasing returns to scale.

Equilibrium 2: Persistent inefficient industry allocation

In this subsection, we look at the case where the welfare function assigns a higher weight to workers than to capitalists. We may think of a government which leans towards representing worker interests, for distributional or political reasons.

Once we allow for $\lambda > 1/2$, region 2's welfare differential $W_2^C(z_2^d) - W_2^P(z_1^{min}(z_2^d - \varepsilon))$ is no longer unambiguously negative for $s_l > 1/2$. This opens up the possibility that the core region will defend the core even if it is smaller and efficiency would require locating all industry in the larger region. Intuitively, for $\lambda = \frac{1}{2}$ and $s_l > \frac{1}{2}$, we have just shown that the benefit capitalists incur through the repatriation of subsidies when the core moves to region 1 more than outweighs the loss to workers and capitalists through lower wages and a higher price index. When $\lambda > \frac{1}{2}$, then, the core government weighs the loss to workers from falling wages and rising consumer prices after industry relocation more heavily than the gain to capitalists from the subsidies paid by the foreign government. In particular, we can show the following:

Proposition 4. *There exists a region size $\tilde{s}_l = s_l(\gamma)$ such that region 2 defends the core if and only if $s_l < \tilde{s}_l$. Further, $\tilde{s}_l$ satisfies*

$$(i)\tilde{s}_l = \frac{1}{2} \quad for\ \lambda = \frac{1}{2} \tag{24}$$

$$(ii)\frac{d\tilde{s}_l}{d\gamma} > 0 \quad for\ \lambda > \frac{1}{2}. \tag{25}$$

Proof. See appendix 3.5.4. ■

Figure 3.7 plots $\tilde{s}_l$ for $\lambda = 0.8$ in order illustrate the effect of region size and localization economies on core's decision. For all s_l, γ-combinations above $\tilde{s}_l$, the core government will not defend the core and industry will relocate towards the larger region 1; for all s_l, γ-combinations on and below $\tilde{s}_l$, the core government defends the core and the allocation of industry remains inefficient. Most importantly, note that there are s_l, γ-combinations for which Govt 2 decides to defend the industry core against region 1 despite region 1 being larger in terms of workers (the shaded region in Figure 3.7). Hence, the disadvantage from becoming the periphery which predominantly affects workers via reduced real wage income exceeds the benefit of a relocation (the subsidy effect) for governments acting in workers' interests. Figure 3.7 also shows $\tilde{s}_l$ for $\lambda = \frac{1}{2}$, which is horizontal at $s_l = \frac{1}{2}$: in this case, the core defends if and only if it is the larger region.

Intuitively, the figure shows that an inefficient industry allocation can persist only if the difference in region sizes is small and if spillovers are relatively large. On the one hand, for given γ, a larger s_l implies that it will be more and more difficult for the (smaller) core to keep the industry from leaving. Larger spillovers imply that the core will be more willing to hang on to the core. On the one hand, the costs of retaining the core are reduced, since the agglomeration rent increases and Govt 2 therefore has to pay higher subsidies to snatch the core. On the other hand, this means that if Govt 2 defends, capital owners do not benefit from the higher subsidy paid by region 1. But this second effect is dominated by the first (see the Proof of Proposition 4), so that the core government will be more willing to defend the core when spillovers increase.

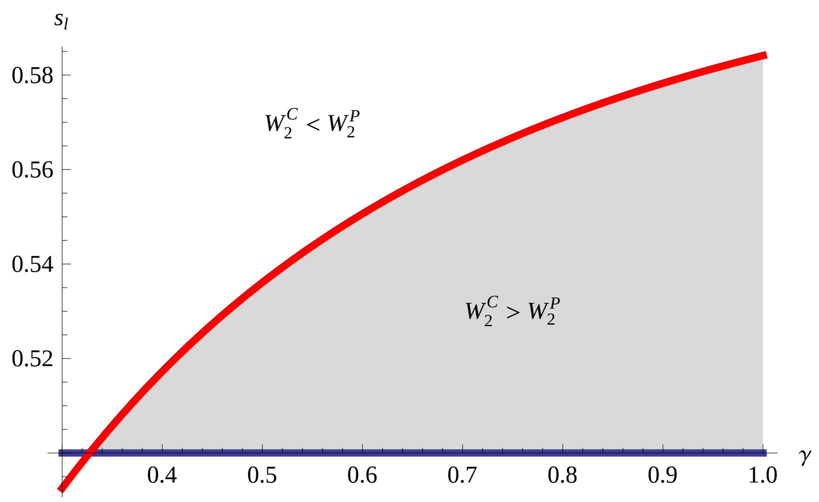


Figure 3.7: Govt 2's Decision ($z_2^d > 0$)

Proposition 5. *If Govt 2 defends the core by setting $z_2 = z_2^d$, compared to a situation without subsidies,*

(i) aggregate welfare falls,

(ii) region 2 welfare decreases for $z_2^d > 0$, and

(iii) region 1 welfare increases.

Proof. See appendix 3.5.4. ■

This is intuitive, since the allocation of industry is not changed by subsidies. The only effect relevant for welfare is the payment of subsidies. Since these are paid by region 2 residents but part of the subsidy accrues to residents of region 1, subsidies redistribute from region 2 to region 1. Overall welfare falls since the subsidy redistributes from workers to capitalists, and this reduces welfare for $\lambda > \frac{1}{2}$.

3.4 Conclusion

The paper studies subsidy competition among asymmetric regions in a model with mobile capital and agglomeration forces. We start from a situation where industry is agglomerated in the smaller region for historic reasons, and ask whether subsidy competition can lure industry to the larger region. When governments maximize a weighted welfare function, we find the answer is yes when the welfare weights of workers and capital owners are equal. In this instance, the smaller region does not prevent the larger region from paying subsidies which lures all capital to that region. However, when workers' welfare is weighted more heavily, the smaller region might pay subsidies to capital owners that are just large enough to prevent them from shifting their capital to the other region. In this case, if the size difference between the regions is not too large, an inefficient industry location prevails. Our paper thus provides a formalization of the intuitive argument that, when external economies are prevalent, jurisdictional competition can improve the spatial allocation of economic activity (e.g. Duranton, 2008). Unless territorial welfare functions are skewed towards immobile workers and size differences between regions are small, this notion is shown to be correct.

3.5 Appendix

3.5.1 Break point

Solving

$$\frac{d(r_1 - r_2)}{ds_n}|_{s_n=\frac{1}{2}} = 0, \tag{A.1}$$

using (12) and (13) gives the 'break point'

$$\phi^B = \frac{4 + 6\mu - 4\mu\sigma + \gamma(4\sigma + \mu - 2) - 2\sqrt{2}\sqrt{(\gamma - \mu)(\sigma - 1)(4 + \mu(4 + \gamma - 2\sigma) + 2\gamma\sigma)}}{(2 + \gamma)(2 + \mu)} \tag{A.2}$$

3.5.2 Sustain point

Solving (14) gives the sustain point

$$\phi^S = \frac{(\frac{1+\gamma}{1+\mu})^\sigma \left(1 + \mu - \sqrt{(1+\mu)^2 - (1+\gamma)^2(\frac{1+\mu}{1+\gamma})^{2\sigma}}\right)}{1+\gamma}. \tag{A.3}$$

Differentiating ϕ^S gives:

$$\frac{\partial \phi^S}{\partial \gamma} = -\frac{(1+\mu)(\sigma - 1)}{(1+\gamma)\sqrt{(1+\mu)^2 - (1+\gamma)^2(\frac{1+\mu}{1+\gamma})^{2\sigma}}} \cdot \phi^S < 0 \tag{A.4}$$

$$\frac{\partial \phi^S}{\partial \mu} = \frac{\sigma - 1}{\sqrt{(1+\mu)^2 - (1+\gamma)^2(\frac{1+\mu}{1+\gamma})^{2\sigma}}} \cdot \phi^S > 0 \tag{A.5}$$

3.5.3 Locational Forces

The locational forces are obtained by evaluating the different forces at $s_n = \frac{1}{2}$ for the symmetric region case, i.e. $s_l = s_k = \frac{1}{2}$.

Intra-Industry Spillovers

To isolate the intra-industry spillover force we differentiate the capital reward gap with respect to s_n, holding fixed the market crowding effect (the direct effect of the industry share on r_i) and inter-industry spillovers.

$$\left.\frac{d(r_1 - r_2)}{ds_n}\right|_{s_n=\frac{1}{2},\mu=0} = \frac{\partial(r_1 - r_2)}{\partial\chi_\gamma}\frac{\partial\chi_\gamma}{\partial s_n} = -\frac{32\alpha\gamma(1-\sigma)}{(2+\gamma)\sigma}\frac{\phi}{(1+\phi)^2} > 0. \tag{A.6}$$

This expression is positive for our parameter specifications and captures the agglomerative intra-industry spillover force.

Inter-Industry Spillovers

Holding fixed the market crowding effect and intra-industry spillovers yields the deglomerative inter-industry spillover force

$$\left.\frac{d(r_1 - r_2)}{ds_n}\right|_{s_n=\frac{1}{2},\gamma=0} = \frac{\partial(r_1 - r_2)}{\partial\chi_\mu}\frac{\partial\chi_\mu}{\partial s_n} = \frac{32\alpha\mu(1-\sigma)}{(2+\mu)\sigma}\frac{\phi}{(1+\phi)^2} < 0. \tag{A.7}$$

Market Crowding Effect

The second dispersion force denoted as the market crowding effect works through the direct effect of s_n on r_1 in (12). Holding fixed inter-and intra-industry spillovers yields

$$\left.\frac{\partial(r_1 - r_2)}{\partial s_n}\right|_{s_n=\frac{1}{2},\mu=\gamma=0} = -\frac{8\alpha}{\sigma}\frac{(-1+\phi)^2}{(1+\phi)^2} \leq 0. \tag{A.8}$$

which is unambiguously non-positive.

3.5.4 Proofs

Proof of Proposition 1.

We show that irrespective of the welfare weight λ, an industry allocation where all firms are located in the larger region is preferred by the social planner to an allocation with all firms in the smaller region. Comparing the sum of regional welfare for the case where the core is located in the larger region with the sum of regional welfare for the case where the small region hosts the core yields

$$W\big|_{s_n=1} - W\big|_{s_n=0} = \frac{(2s_l-1)[\mu(\sigma-1)-\alpha\ln\phi]\lambda}{\sigma-1} \tag{A.9}$$

which is unambiguously positive for $s_l > \frac{1}{2}$. ■

Proof of Proposition 2.

Plugging in the respective subsidy levels z_2^d and z_1^{min} from (23) and (21) into region 2's welfare function, respectively yields

$$W_2^C(z_2^d) - W_2^P(z_1^{min}(z_2))\big|_{\lambda=1/2} = -\frac{(2s_l-1)}{2}\big[\mu - \frac{\alpha}{\sigma-1}\ln\phi\big], \tag{A.10}$$

which is negative for $s_l > \frac{1}{2}$. It follows that Govt 2 sets $z_2 = z_2^d - \varepsilon$ implying that $W_1^C(z_1^{min}(z_2^d-\varepsilon)) > W_1^P(z_2)$. ■

Proof of Proposition 3.

(i) From Proposition 1, we know that without subsidies, welfare is higher if the core is in the larger region. Evaluating the effect of subsidies on welfare in the case where the core is in region 1 gives:

$$(1-\lambda)z_1^{min} - \frac{(1-\lambda)s_k + \lambda s_l}{s_k + s_l} z_1^{min}. \tag{A.11}$$

For $\lambda = \frac{1}{2}$, this is zero. The same holds for the welfare effect of subsidies if the core is in region 2. Hence, welfare with subsidies is still highest if the core is in the larger region.

(ii) From the proof above we know that $W_1^C(z_1^{min}(z_2^d - \varepsilon)) > W_1^P(z_2)$ holds. Since $\frac{\partial W_1^P}{\partial z_2} > 0$ implies $W_1^P(z_2) > W_1^P(0)$ for $z_2^d > 0$ it follows that $W_1^C(z_1^{min}(z_2^d - \varepsilon)) > W_1^P(0)$, i.e. Govt 1 is better off after successfully snatching the core compared to the baseline welfare level. ■

Proof of Proposition 4.

The locus $\tilde{s}_l = s_l(\gamma)$ is implicitly defined by

$$\Delta(s_l, \gamma, \cdot) \equiv W_2^C(z_2^d, s_l, \gamma, \cdot) - W_2^P(z_1^{min}(z_2^d - \epsilon), s_l, \gamma, \cdot) = 0.$$

Part(i) follows immediately from setting $\lambda = \frac{1}{2}$ in (A.10). To prove (ii), differentiatiation of Δ gives the slope:

$$\frac{d\tilde{s}_l}{d\gamma} = -\frac{d\Delta/d\gamma}{d\Delta/ds_l}, \tag{A.12}$$

where

$$\frac{d\Delta}{d\gamma} = \frac{\alpha(2\lambda-1)(\sigma-1)\phi(1+\mu)^{\sigma-1}\left(\lambda\left(1-2s_l\right)^2-1\right)\left(\frac{2s_l+1}{\phi^2}-2s_l+3\right)}{2(1+\gamma)^\sigma\sigma\left(2s_l-3\right)\left(\lambda\left(2s_l-1\right)+1\right)} > 0 \tag{A.13}$$

for $s_l, \lambda > \frac{1}{2}$.

The expression for $d\Delta/ds_l$ is rather messy and therefore omitted. However, we can show numerically that it is negative for the parameters used in the paper. Intuitively, when region 2 becomes smaller, it will be less willing to defend. Formally, we can show that differentiating $\frac{d\tilde{s}_l}{d\gamma}$ and evaluating at $\lambda = \frac{1}{2}$ gives

$$\left.\frac{d(\frac{d\tilde{s}_l}{d\gamma})}{d\lambda}\right|_{\lambda=1/2} = \frac{\alpha(\sigma-1)^2\left(4\left(s_l-1\right)s_l-1\right)(1+\mu)^{\sigma-1}\phi^{\frac{\sigma+1}{1-\sigma}}\left(\left(2s_l+1\right)\phi^{\frac{2}{\sigma-1}}+\left(3-2s_l\right)\phi^{\frac{2\sigma}{\sigma-1}}\right)}{\sigma(1+\gamma)^{\sigma}\left(2s_l-3\right)\left(2s_l+1\right)\left(\alpha\log(\phi)+\mu(1-\sigma)\right)} > 0 \tag{A.14}$$

Hence, $\frac{d\tilde{s}_l}{d\gamma} > 0$ for $\lambda, s_l > \frac{1}{2}$. ■

Proof of Proposition 5.

(i) Since the industry allocation is not affected, we need to consider only the effect of subsidies on welfare. This is given by:

$$Z = (1-\lambda)z_2 - \frac{(1-\lambda)(1-s_k)+\lambda(1-s_l)}{1-s_k+1-s_l}z_2 = \frac{(1-2\lambda)(1-s_l)}{1-s_k+1-s_l}z_2.$$

This expression is negative for $\lambda > \frac{1}{2}$, so subsidies decrease welfare.

(ii) and (iii). From $\frac{\partial W_2^C(z_2)}{\partial z_2} < 0$ and $\frac{\partial W_1^P(z_2)}{\partial z_2} > 0$ it follows that $W_2^C(z_2^d) < W_2^C(0)$ and $W_1^P(z_2) > W_1^P(0)$ for $z_2^d > 0$. Residents of region 2 will unambiguously experience a welfare decline whereas households in region 1 experience an unambiguous welfare gain. ■

Chapter 4

The winner gives it all: Unions, tax competition and offshoring

4.1 Introduction

In January 2008, Nokia's Executive Vice president Veli Sundbäck announced the closure of its handset factory in Bochum in North Rhine-Westphalia (NRW) and the relocation of Nokia's manufacturing activity to Cluj (Romania) as a response to changes in market conditions and an increased requirement for cost effectiveness. However, as Nokia had received investment subsidies from the state of NRW for its production site in Bochum and will be exempt from the real estate tax in Romania, the decision to relocate its production facility to a low-labour-cost country reignited an old debate on the distribution of state subsidies. As a matter of fact, the latest case of production delocation is just another example of what has been common practice long before the enlargement of the European Union: Governments exploiting firms' responsiveness to subsidies and engaging in subsidy races.[1] Accordingly, Germany may have lost the latest race for a large manufacturer, but has come off as the winner in the past at the cost of subsidy payments when bidding for a BMW plant in 2001 against Kolin (Czech Republic) or averting Volkswagen's threats to relocate towards Hungary in 1996.

Against this background, the present paper assesses the outcome and welfare implications of a subsidy race between countries with different degrees of labor market distortions. Our analysis builds on a model in which industrial activity is inefficiently locked-in in a unionized core country. What we have in mind is that a certain region historically emerged as an industrial center which sparked the emergence of trade unions, capturing some of the location rents earned in such an agglomeration. Our most important result is that tax competition among a leading unionized industry core and a challenging emerging country is efficiency enhancing as it leads to relocation of industry towards the country with a non-distorted labor market. A government of an industrial core whose objective it is to maximize residents' welfare will find it optimal

[1] As more than three quarters of subsidies to industry in the OECD are investment subsidies (see Fuest and Huber, 2000, Table 1) there is hardly any doubt that local governments use subsidies as an instrument to influence the location decision of capital. Biesebroeck (2008) gives an overview of bidding wars between the Canadian and the US government for the automotive industry. See also Greenstone and Moretti (2003).

to let its competitor attract mobile capital so as to benefit from increased efficiency and the competing location's tax regime.

Local labor markets are typically thought of as important determinants of subsidy policies, disregarding alternative employment opportunities of local workers and the fact that consumers across the country as well as shareholders of locally owned companies may benefit hugely from real capital moving to low-wage or low-tax regions. Our at first sight somewhat surprising result suggests that what we observe in everyday political discussions and decisions may, in some respects, be in contrast to what would be optimal policy once general equilibrium effects are taken into account.

Moreover, disentangling the welfare effects of industry relocation to factor groups reveals that capitalists are the clear winners of the subsidy race as they benefit from lower consumer prices and the repatriation of subsidy income. Workers of the non-unionized competitive industry in the winning country benefit from their government's action only if union wages have been way above the competitive wage rate such that the benefit from lower consumer prices compensates the financing costs of attracting an industry cluster. The opposite holds for non-unionized workers in the former industrial core country. Surprisingly, they suffer, together with former unionized workers, from a delocation of industry and in particular when union wages were high. Since union wages depend on the same parameter as consumers' love for variety a loss of industry will be more severe if the valuation for the industry good is high as this will have a strong impact on the country's consumer price index.

Our modelling approach has various advantages. Firstly, the monopolistic competition framework allows us to be consistent with empirical findings by Stewart (1990), Abowd and Lemieux (1993) and Nickell and Wadhwani (1994) who give evidence for unions' wage setting behavior to depend on firms' market power next to their own bargaining power. Secondly, the model which follows recent work by Borck et al. (2009) is able to reflect the stylized fact that economic activity is not evenly distributed across space but tends to cluster according to certain agglomeration mechanisms as outlined by Marshall (1890), creating location rents for each individual firm. These location rents can to a certain extent be extracted, e.g. by governments or unions without changing the spatial allocation of firms instantaneously.

Our work draws on different strands of the literature. Recent years have seen an increasing interest in the interaction of agglomeration economies and local government tax setting behaviour (Kind et al. (2000), Ludema and Wooton (2000), Baldwin and Krugman (2004), Borck and Pflüger (2006)) with one major insight being that the presence of agglomeration economies reduces the mobility of capital and creates taxable location rents. These models, however, do not incorporate labor market frictions as an additional factor in the competition for mobile capital. Picard and Toulemonde (2006) examine the role of trade unions on the allocation of firms across two regions. They describe how the existence of union wages reinforce the home market effect supporting the concentration of firms in one location.

A parallel strand in the literature has focused on the deterring effects of unionization on foreign direct investment (Leahy and Montagna (2000); Naylor and Santoni (2003); Lommerud et al. (2003)).[2] These papers, however, consider only trade unions and firms while ignoring government tax policies. A notable exception is recent work by Haufler and Mittermaier (2008) who show that a unionized country with additional location disadvantages (such as a smaller market) may end up attracting mobile foreign capital, whereby taxes have a strategic effect on the union's behavior. Our model however differs conceptually as it explicitly accounts for agglomeration tendencies which are empirically well established[3] and explain the co-existence of industrialized core and lagging regions as empirically outlined in Redding and Venables (2004). Moreover, our paper, by contrast, examines the role unions plays for tax competition without their behavior being controllable (directly or indirectly so) by governments.

The remainder of this paper is organized as follows. Section 2 describes the general setup of the model. Section 3 illustrates the impact of tax competition on the allocation

[2] These contributions are part of a more general literature that analyzes the interaction between unionization, imperfect competition in goods markets, and economic integration. See e.g. Brander and Spencer (1988), Huizinga (1993), Driffill and van der Ploeg (1995), and Naylor (1999).

[3] For an overview of the empirical literature on agglomeration economies see Rosenthal and Strange (2004).

of industrial firms. Section 4 demonstrates the welfare effects on each single factor group. Section 5 discusses the outcomes of the game for an alternative government objective. Section 6 concludes.

4.2 The basic model

The theoretical model follows the model proposed by Borck et al. (2009). We consider two countries $i \in \{h, f\}$ (h and f being mnemonic for 'home' and 'foreign') where one of the two production factors, labor (L), is immobile, whereas the other, capital (K), is mobile across countries such that it can be employed in one region while its owners (who do not move) spend its return in the other region. Countries are symmetric in technology, preferences and size, but are allowed to differ in labor market rigidity as measured by a parameter of union power. There are two sectors, an 'A' sector with perfect competition, and an industrial 'M' sector displaying differentiated goods, increasing returns to scale and monopolistic competition. Trade in the competitive good is costless, whereas the increasing returns sector faces per unit 'iceberg' transport costs τ à la Samuelson (1954) which means that for each unit to arrive at location j, $\tau > 1$ units have to be shipped from location i. The A sector produces a homogeneous traditional good which we choose to be the numéraire using labor only. Units are scaled such that one unit of labor produces one unit of output, so that the competitive wage also equals one.

4.2.1 Preferences

There are two types of households in each country, inelastically supplying their factor endowment, labor and capital, respectively. In country i, there is a total of K_i+L_i households, whose utility stems from consumption of the traditional as well as the differentiated, industrial varieties. Those preferences are reflected by a two-tier utility function, whereby the upper tier is quasi-linear and the lower tier is of the C.E.S. type.

The upper tier utility function of a household is

$$U_i(M_i, A_i) = \alpha \ln M_i + A_i - \alpha[\ln \alpha - 1], \tag{1}$$

where the last term is a constant that disappears when indirect utility is derived, A_i denotes consumption of the traditional good and M_i stands for differentiated industrial varieties v according to the lower-tier function

$$M_i = \left(\int_0^{n_i} m_{ii}(v)^{\frac{\sigma-1}{\sigma}} dv + \int_{n_i}^{N} m_{ji}(v)^{\frac{\sigma-1}{\sigma}} dv \right)^{\frac{\sigma}{\sigma-1}}, \quad \sigma > 1, \quad N = n_i + n_j. \tag{2}$$

Here σ denotes the constant elasticity of substitution between any two varieties and n_i the mass of varieties produced in i. m_{ii} and m_{ji} denote the quantity consumed by a household in country i of a variety produced in i and j, respectively. Assuming $0 < \alpha < y_{is}$, $(i = h, f;\ s = K, L)$ it is ensured that both goods will be consumed. Utility maximization yields the following demand functions:

$$\begin{aligned} &M_i = \tfrac{\alpha}{P_i}, \quad A_{is} = y_{is} - \alpha, \quad s = K, L \\ &m_{ii} = \alpha p_i(v)^{-\sigma} P_i^{\sigma-1}, \quad m_{ji} = \alpha(\tau p_j(v))^{-\sigma} P_i^{\sigma-1}, \end{aligned} \tag{3}$$

where

$$P_i \equiv \left(n_i p_i^{1-\sigma} + n_j(\tau p_j(v))^{-\sigma} \right)^{\frac{1}{1-\sigma}} \tag{4}$$

denotes the perfect C.E.S. price index[4] where we take into account that firms within one country are identical and charge identical producer prices.[5] Indirect utility is

$$V_{is} = y_{is} - \alpha \ln P_i, \qquad s = K, L \tag{5}$$

where income is either labor ('L') income or capital ('K') income.

[4]This is the expenditure needed to purchase a unit-level of welfare.

[5]However, producer prices across regions are no longer equal once we allow for labor market frictions.

4.2.2 Industrial production

The perfectly competitive A sector has already been described above. Every firm in the industrial sector produces one variety[6] with a fixed input, namely one unit of capital, and labor. Moreover, a higher concentration of industry in the country lowers the labor input requirement, according to the following specification: For each unit of output, $\gamma_i \equiv 1/(1+\theta n_i)$ units of labor are needed as a variable input, where $\theta > 1$ measures the local knowledge spill-over occurring between workers of the M sector. This way of modelling spill-overs is obviously a short-cut for considering the various channels through which industry concentration may benefit each and every single firm. It can be rationalized in the present setting by knowledge exchange or thick labor markets.[7] Using this specification, the firms' profit function in i reads

$$\pi_i = (p_i - w_i \gamma_i) q_i - r_i, \tag{6}$$

where p_i denotes the consumer price, w_i is the wage rate, and r_i is the capital reward rate. Equilibrium in the goods market requires total (world) demand for a domestic industrial good to equal supply of this variety. The market clearing condition reads

$$q_i = m_{ii}(L_i + K_i) + \tau m_{ij}(L_j + K_j) \tag{7}$$

This latter term shows that part of demand is indirect due to iceberg trade costs which are fully borne by consumers. Straightforward profit maximization gives us the firm's mill price

$$p_i = \frac{\sigma}{\sigma - 1} w_i \gamma_i, \tag{8}$$

whereby the same price, multiplied by τ, is charged to customers abroad. Now, since capital supply is fixed, so is the number of firms which will bid for capital; hence, its compensation adjusts so as to ensure zero profits in equilibrium. Using this zero-profit

[6] Note that this is not an assumption, but a result. For details, refer to Baldwin et al. (2003).

[7] For a thorough analysis on the micro-foundations of agglomeration economies, see Duranton and Puga (2004).

condition and (8), we obtain the output level which allows a firm to break even

$$q_i = \frac{r_i(\sigma - 1)}{w_i \gamma_i}. \tag{9}$$

Labor demand of an industrial firm reads

$$l_i^M = \gamma_i q_i. \tag{10}$$

4.2.3 Mobile factor's reward

In the short run the allocation of capital and hence the location of M firms is exogenous. To derive capital's reward note that, due to the fact that one unit of capital is needed to run a firm, its reward is bid up to the point where it equals operating profit. To ease notation, we will henceforth use the share notation where $s_n \equiv n_h/N$ denotes region h's share of the world's industry, $\lambda \equiv L_h/L$ is region h's share of world labor and $\kappa \equiv K_h/K$ denotes the share of world capital region h owns. With (8) and (9), it follows immediately that the capital reward rate r_i reflects operating profit, i.e. $r_i = (1/\sigma)p_i q_i$. Using this, the demand functions (3) and market clearing (7) and normalizing $N = L = K = 1$, yields

$$\begin{aligned} r_h &= \frac{\alpha}{\sigma}\left(\frac{\kappa + \lambda}{s_n + \phi\chi\,(1 - s_n)} + \frac{((1-\kappa) + (1-\lambda))\phi}{\phi s_n + \chi\,(1 - s_n)}\right), \\ r_f &= \frac{\alpha}{\sigma}\left(\frac{\phi\chi(\kappa + \lambda)}{s_n + \phi\chi\,(1 - s_n)} + \frac{((1-\kappa) + (1-\lambda))\chi}{\phi s_n + \chi\,(1 - s_n)}\right); \end{aligned} \tag{11}$$

where $0 < \phi \equiv \tau^{1-\sigma} \leq 1$ stands for the level of trade freeness and $\chi \equiv (\frac{p_f}{p_h})^{1-\sigma} = (\frac{w_f \gamma_f}{w_h \gamma_h})^{1-\sigma}$.

In the long run capital is mobile and seeks for the highest nominal return. Local technological spillovers on the sectoral level support a locational equilibrium where all industrial activity is clustered in one region since, all else equal an increase in the number of firms in h increases operating profit in h and hence the capital reward gap $(r_h - r_f)$ which induces a further capital inflow into h. On the other hand, firms in h will face intense local competition as s_n increases which deters other firms to enter the market. However, for ongoing trade integration ϕ firms compete with other firms irrespective of their location which entails that the opportunity cost of agglomerating in one country and serving the foreign market from abroad become low. Consequently, for a sufficiently high level of trade freeness firms will be agglomerated in one region as they benefit from the spatial proximity to other firms through local industry spill-over effects. The critical level of trade freeness at which the benefit of agglomeration begins to exceed the cost of serving from one location is typically denoted as the break point level of trade freeness, ϕ^B and derived solving $\frac{\partial r_h - r_f}{\partial s_n}\Big|_{s_n=1/2} = 0$ for ϕ.[8]

For the purpose of our later analysis which assesses the outcome of a tax competition game between an industrialized country hosting an industry cluster ('core') and a lagging region ('periphery'), we describe a locational equilibrium where the level of trade freeness is sufficiently high ($\phi > \phi^B$) such that all industry is agglomerated in one region, say h.[9] This could be due to historical reasons, just as the story goes in Krugman (1991e)'s seminal paper. For instance, one could think of a highly industrialized country in Western Europe versus an emerging market in Eastern Europe. As said in the introduction, we think that historically determined agglomeration patterns then may have sparked labor's organization, giving rise to asymmetric unionization. Firms in the industrial core earn an agglomeration rent (Ω) which is defined as the loss a single firm would incur if it relocated to the periphery, given that all other firms stay in the core. In other words, capital is tied to the core and capital owners will have no incentive to relocate their capital unit as long as they earn positive location rents

[8] A formal expression of the break point is available upon request. For a more detailed model exposition see Borck et al. (2009).

[9] Tax competition within agglomeration models where trade costs are so high that no agglomeration occurs yield results that are closer in nature to the 'basic tax competition model' (see Baldwin et al. (2003)). For an analysis of such interior cases in a New Trade Theory model, refer to Egger and Seidel (2007) who show that a country with a stronger labor market distortion will find it optimal to choose a lower Nash tax rate in competition for mobile capital.

which can be expressed as

$$\Omega \equiv r_h - r_f\big|_{s_n=1} = \frac{\alpha}{\sigma}\left(2 - \frac{1}{\phi}\left(\frac{w_f(1+\theta)}{w_h}\right)^{1-\sigma}(1+\phi^2)\right). \tag{12}$$

Obviously, the agglomeration rent is increasing in θ the intensity of local industry spill-overs, the level of trade integration ϕ and foreign's wage rate w_f, whereas it is decreasing in core's wage, w_h.

4.2.4 Union wage setting

As noted earlier the emergence of an industrial cluster may have sparked labor's organization, giving rise to asymmetric unionization. We find it therefore natural to choose the industrialized core to be the unionized country whereas periphery's labor market is perfectly competitive. Hence, whereas the immobile factor's reward in the periphery is equal to the competitive wage rate, we allow firm-specific unions (which are conceptually identical to sector-specific unions in this model) in the core to set the nominal[10] reward for unionized workers using a decentralized wage setting approach for two reasons: Nationwide unions are hardly observed in reality and, more importantly, the feature of our model that unions, much like competing firms, try each to get the highest rent possible without internalizing consequences for the overall price level, tax policies and industry location, is one that makes it plausible as a stylized description of many OECD countries' union behavior.

Workers employed in unionized firms will enjoy higher nominal wages than those working in the non-unionized sector of the economy. Consequently, as firms set their prices according to a fixed mark-up rule (8), consumer prices will, of course, be higher under unionization, which implies that A sector employees and capital owners will lose from it, as will foreign country's residents who buy imported differentiated goods from core's industry. The non-unionized traditional A industry serves as a 'buffer' sector

[10] Obviously, we do not use a monetary model here. We use the term 'nominal' as opposed to 'real' in the sense that the latter means taking the price index into account.

for those who do not find employment in the industrial M sector, so there will be no unemployment.

We employ a monopoly union approach,[11] where the union maximizes the nominal wage bill of its members over and above the competitive one, $(w_h - 1)l_i^M$. The firm then exerts its 'right to manage', i.e. it chooses optimal output given the wage rate. From here on, w_h denotes the union-sector wage in h (whereas the competitive wages in core and periphery are equal to 1, see above). Using (7), (10) and the demand functions from (3), we rewrite union's objective function,

$$(w_h - 1)\,\gamma\, q_h = (w_h - 1)\gamma_h \left(\frac{\sigma}{\sigma - 1}\,\gamma_h\, w_h\right)^{-\sigma} \alpha\psi, \tag{13}$$

where $\psi \equiv [P_h^{\sigma-1}(\kappa + \lambda) + P_f^{\sigma-1}((1-\kappa) + (1-\lambda)]$.[12] The left hand side of (13) reveals how each union equally weighs the factors 'wage rate above competitive wage rate' and 'employment' so as to maximize the excess wage bill. The iso-elasticity of both labor demand (that stems from the iso-elasticity of product demand and constant per unit labor input requirement) and the firm's part of the Nash bargaining lead to the wage that maximizes (13)

$$w_h = 1 + \frac{1}{\sigma - 1} \tag{14}$$

which is simply a fixed mark-up on the competitive wage. Intuitively, the union wage rate falls in the elasticity of substitution which measures a firm's mark-up in the monopolistically competitive industry.[13]

[11]This is a special case of Nash bargaining between the representative union and the firm where all the bargaining power is with the union. We are aware that this is only one out of many ways to model industrial relations; however, it seems to be the most widely used one due to its tractability. For an exhaustive overview of collective bargaining and some empirical evidence, we refer to Cahuc and Zylberberg (2004).

[12]Note that each union neglects the effects on the economy's consumer price index.

[13]It is worth noting that we get an only quantitatively different result with the more general Nash bargaining approach. The union's outside option is zero, and the firm's outside option is to produce nothing, having already sunk the fixed cost which is the same whether an agreement is reached or not and hence cancels from the Nash maximand (This point is parallel to Picard and Toulemonde (2006). They emphasize that this assumption is implicitly made in many models where fixed costs are set to zero). Adding weights of β and $1 - \beta$ to the union's and firm's objectives in the Nash product, respectively, and maximizing yields $w_h = 1 + \beta/(\sigma - 1)$. Since this does not provide us with additional insights, we do not pursue this further.

A natural question that arises within a core-periphery equilibrium and unions' mark-up wages in the core is whether, in the absence of government intervention, this allocation of capital remains stable. This is a straightforward problem to tackle, which leads us to

Proposition 1 *Agglomeration rents earned in the core can partially be reaped by trade unions, up to a wage level of* $w_b = (1+\theta)\left(\frac{2\phi}{1+\phi^2}\right)^{\frac{1}{\sigma-1}}$. *Beyond this point, the core-periphery equilibrium becomes unstable as the rents in* f *are higher.*

For the proof, we simply set r_h equal to r_f and solve the equation for w_h, evaluating the expression at $s_n = 1$. This is the 'break wage rate' above which each and every unit of capital is better off in country f than in the core h. The first derivatives are straightforward: w_b rises in local technological spill-over (θ) and falls with market integration (ϕ). Figure 4.1 illustrates the stability of the core-periphery equilibrium under asymmetric unionization.[14]

Figure 4.1: Stability of core-periphery equilibria under asymmetric unionization

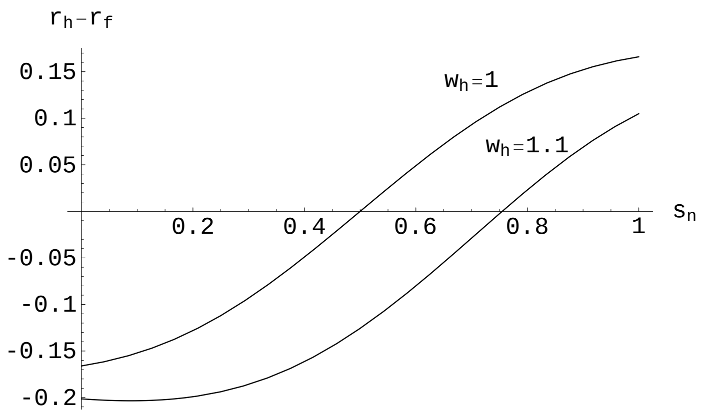


Figure 4.1 reveals that as long as the union wage rate set in the core does not exceed the break wage rate w_b, capital will be tied to the region where it earns an agglomeration

[14]Parameter values $\sigma = 4; \alpha = 0.5; \theta = 0.3; \phi = 0.6$.

rent. Of course, with the presence of unions in the agglomerated core part of the location rent which, in the absence of labor market distortion fully accrued to capital owners are now redirected to unionized workers.

4.3 Tax competition

Governments maximize residents' welfare and deploy lump-sum taxes on factor endowment, using the revenues for a direct subsidy to capital employed within their borders.[15] In accordance with the models in this literature (see Baldwin and Krugman (2004), Borck and Pflüger (2006)), we assume that the core is a Stackelberg leader in that it gets to set its tax rate first. In our framework, this assumption can be rationalized in the following way: The country that disposes of the unionized industries knows that it may face competition from a challenger and will essentially play an 'entry-deterrence' game.

Letting z_i denote a subsidy to capital employed in i and $r_i + z_i$ the return to capital including subsidies, we end up with the government budget constraints

$$s_n z_h = T_h(\kappa + \lambda); \quad (1 - s_n) z_f = T_f((1 - \kappa) + (1 - \lambda)), \tag{15}$$

with T_i denoting the tax rate. To best disentangle the effects of asymmetric unionization on the location of capital we assume that countries are of equal size ($\kappa = \lambda = 0.5$).[16] Governments are utilitarian and maximize the sum of residents' indirect utility, where welfare of unionized M and non-unionized A workers as well as capitalists, in h reads

$$V_h^M = L_h^M(w_h - \alpha \ln P_h - T_h), \tag{16}$$

$$V_h^A = (L - L_h^M)(1 - \alpha \ln P_h - T_h), \tag{17}$$

[15] Tax competition here is modelled in a very simple way: Given that the *owners* of both factors are immobile, they are simply taxed on their endowment, i.e. residence-based taxes are employed.

[16] The interested reader is referred to Borck et al. (2009) who consider inefficiencies arising through asymmetrically sized countries.

$$V_h^K = K_h(y_K - \alpha \ln P_h - T_h), \tag{18}$$

where y_K denotes capitalist's income and $L_h^M = l_h^M n_h$ is the core's industrial sector's labor demand. Observe that since the world is a lumpy place in this model, both parties will effectively compare two situations: being the core (henceforth indicated by the superscript 'c') or the periphery (indicated by 'p'). At this point, the simple structure of the model gives us a lot of mileage when it comes to optimal policy analysis as we get a closed-form welfare function. Taking the example of country h being the core,[17] welfare is derived adding up (16)-(18) evaluated at $s_n = 1$

$$WF_h^c = \frac{1}{2}\big(1 - z_h + \frac{2\alpha}{\sigma}\big) + L_h^{Mc}(w_h - 1) - \alpha \ln P_h^c, \tag{19}$$

where $L_h^{Mc} \equiv \frac{2\alpha}{\sigma}\frac{(\sigma-1)}{w_h}$. Country f's welfare in this case is

$$WF_f^p = \frac{1}{2}\big(\frac{2\alpha}{\sigma} + z_h + 1\big) - \alpha \ln P_f^p. \tag{20}$$

If, by contrast, all industry locates in f, the welfare terms are

$$WF_h^p = \frac{1}{2}\big(\frac{2\alpha}{\sigma} + z_f + 1\big) - \alpha \ln P_h^p \tag{21}$$

$$WF_f^c = \frac{1}{2}\big(\frac{2\alpha}{\sigma} - z_f + 1\big) - \alpha \ln P_f^c \tag{22}$$

The simplified price indices are obtained using (8) and (14) in (see (4))

$$\begin{aligned} P_h^c &= \tfrac{\sigma}{\sigma-1} w_h \gamma, \qquad & P_h^p &= \tfrac{\sigma}{\sigma-1}\phi^{1/(1-\sigma)}\gamma, \\ P_f^c &= \tfrac{\sigma}{\sigma-1}\gamma, \qquad & P_f^p &= \tfrac{\sigma}{\sigma-1}\phi^{1/(1-\sigma)} w_h \gamma. \end{aligned} \tag{23}$$

where $\gamma \equiv 1/(1+\theta)$. Note that part of core's union wage rate is borne by consumers abroad ('wage cost exporting').

Moreover, given our assumption that the labor market distortion occurs only in h, we

[17] Note that $r_h|_{s_n=1} = r_f|_{s_n=0} = 2\alpha/\sigma$.

can show that global welfare $WF^{glob} = WF_h + WF_f$ could be enhanced if the industry core shifted towards the non-unionized periphery:

Proposition 2 *For high levels of trade freeness and $w_f < w_h < w_b$ the core-periphery equilibrium $s_n = 1$ is stable but globally inefficient,*

$$WF^{glob}|_{s_n=1} < WF^{glob}|_{s_n=0}.$$

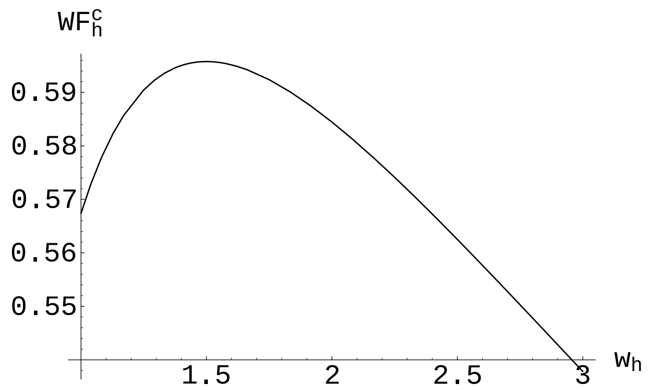
Proof: See Appendix 4.7.1. ■

The obvious question then is whether core will defend its industry cluster and prevent the shift of industry towards an efficient allocation, using a generous tax regime to compensate capital for high union wages and at the same time ensuring higher nominal wages for its industrial workers. Hosting the industry core is attractive since local production avoids consumer-borne trade costs for one's residents ('cost-of-living effect').

Moreover, whereas the benefit of higher nominal wages accrues to unionized workers in the core only, part of the resulting higher consumer prices is borne by consumers abroad ('wage cost exporting'). However, the latter effect enhances welfare in the core only up to a certain union wage level after which consumer prices become so high that less workers will be employed in the unionized sector as less of the industrial good is demanded. This is illustrated in Figure 4.2 which depicts core's welfare as a function of union wages in the absence of subsidies[18]

[18]Parameter values: $\sigma = 4; \alpha = 0.3; \theta = 0.3; \phi = 0.6$.

Figure 4.2: Core's welfare function for different union wages



4.3.1 Second Stage: Periphery's government

Solving the game via backward induction, we start with the government of the periphery at stage two of the tax game. As all firms are alike, this is a straightforward exercise: The government of the periphery, government f, has a maximum subsidy/minimum tax it is willing to offer. This can be found at the point where its overall welfare level is the same no matter if it hosts the industry or not, $WF_f^c = WF_f^p$. Solving this for the subsidy, we obtain 'z_f^{max}':

$$z_f^{max} = -z_h + 2\alpha \left(\ln w_h - \frac{\ln \phi}{\sigma - 1} \right) \tag{24}$$

The first term denotes the foregone repatriation of subsidy income from c for periphery's capitalists once p attracts the industry. The second term captures the benefits of industry relocation towards the non-unionized country. Residents in the periphery benefit from lower consumer prices since wages are competitive and transport costs are absent for them once industry locates in the periphery. On the other hand, the government of the periphery knows that it has to offer each firm at least what core's government offers, in addition to the agglomeration rent Ω. We call this subsidy level

'z_f^{min}' which is obtained solving $\Omega + (z_h - z_f) = 0$ for z_h using (12):

$$z_f^{min} = z_h + \frac{\alpha}{\sigma}\left(2 - \frac{1}{\phi}\left(\frac{1+\theta}{w_h}\right)^{1-\sigma}(1+\phi^2)\right). \quad (25)$$

Now, as long as z_f^{max} is greater than z_f^{min}, periphery can profitably attract the capital from the core. Note that these terms depend only on core's tax policy (z_h) and exogenous parameters (as the monopoly unions' wage, w_h, only depends on the parameter σ). The next step is to examine government h's behavior.

4.3.2 First Stage: Core's government

The core's government is aware of the influence its policy exerts on the ability and willingness of the periphery to attract capital. To determine core's optimal behavior, we first determine the policy at which periphery's government will not be able to profitably attract the mobile capital. In a next step we check whether core's government will actually want to hold on to the industrial core.

From inspection of (24) and (25), it can easily be seen how we can work out the 'knife-edge' level of subsidy, say z_h^d, at which the core can make it unprofitable for the periphery to attract the industry which will be the case whenever z_f^{min} is at least as large as z_f^{max}. We set (24) equal to (25) and solve for z_h:

$$z_h^d = \frac{\alpha}{2\sigma}\left(\frac{1}{\phi}w_h^{\sigma-1}(1+\theta)^{1-\sigma}(1+\phi^2) + 2\sigma \ln w_h - \frac{2\sigma \ln \phi}{\sigma - 1} - 2\right). \quad (26)$$

This means that core's offer has to be at least z_h^d to make sure that the periphery's government will not be a threat to the pre-existing allocation.[19]

It is however not immediately obvious what core's government opts for: Production in its part of the world leads to a lower price index for all of its consumers ('cost-of-living effect'). Moreover, industrial workers in the core earn higher wages than they otherwise

[19] Obviously, every better offer will do the trick, but will never be optimal since the subsidies do not alleviate any distortion. Rather, they amount to a transfer to the other country which will be kept as tiny as possible.

would - whereby part of this excess wage bill is paid, via higher prices, by foreigners ('wage cost exporting effect'). On the other hand, allowing the industry to delocate to f means h's capitalists would benefit from the repatriation of subsidy income and also that its consumers would be able to buy goods produced in a low-wage region. So, in the case where core holds on to its industry, it will set $z_h = z_h^d$. In the case where it does not, it will set the subsidy level marginally smaller, $z_h = z_h^d - \epsilon$, where ϵ is some small but positive number. To see this latter point, note that this guarantees the highest possible subsidy transfer from the periphery (remember, $z_f^{min} = z_h + \Omega$). Core's optimal policy can therefore be summarized by

$$z_h^* = \begin{cases} z_h^d & \text{if} \quad WF_h^c(z_h^d) \geq WF_h^p(z_f^{min}(z_h)), \\ z_h^d - \epsilon & \text{otherwise.} \end{cases}$$

This gives us also f's optimal policy when it attracts all industry: As the second mover, it takes the given z_h^*. So we plug z_h^d for z_h into (25), which is optimal by a similar argument to the one above: It is the cheapest way to attract the industry. On the contrary, in case of no industry delocation it is simple to conclude that the subsidy to capital and hence the tax on L and K will be zero as being the periphery implies not hosting any industry.

Now that we derived each countries' optimal policies in the two cases, we proceed to the equilibrium outcome of the game. The reduced-form equations can be obtained by plugging the optimal policies for each case into the region's respective welfare functions (19)-(22) using (25) and (26). It is then a straightforward exercise to compare welfare levels. Core's government will simply compare the difference between $WF_h^c(z_h^*)$ and $WF_h^p(z_f^*)$. If it is positive, then the country as a whole is better off holding on to its industry; if it is negative, the opposite holds true. Using (19) and (21) the welfare differential can be written as

$$WF_h^c - WF_h^p = L_h^{Mc}(w_h - 1) - \frac{z_h^*}{2} - \frac{z_f^*}{2} - \alpha \ln\left(\frac{P_h^c}{P_h^p}\right). \tag{27}$$

The excess wage bill in the first term reflects the benefits of keeping all industry whereas the second and third term reflect the financing cost and the foregone subsidy payment of doing so, respectively. The last term's sign is ambiguous as both P_h^c and P_h^p will exceed one. Hence, depending on the level of trade freeness and the union wage the last term will be positive or negative. Note that both governments take into account all general equilibrium effects. Specifically, all tax and wage effects as well as trade cost and price effects are taken into account. We can now state

Proposition 3 *A welfare-maximizing government in the unionized core will find it in its best interest to let the industrial core move to the periphery i.e.,*

$$WF_h^c(z_h^d) - WF_h^p(z_f^{min}) < 0.$$

Proof: See Appendix 4.7.2. ■

This result is striking at first sight. After all, the core acts as a Stackelberg leader and maximizes welfare within its border. So one might have expected it to hold on to its industry via a generous tax regime since the costs of higher union wages are partly borne by consumers abroad while the benefits of higher wage income accrue solely to workers within the country. Upon closer inspection, however, our result is quite intuitive: By letting its capital relocate to f, while still owning it, country h gets rid of the labor market distortion[20] and, at the same time, makes sure capital owners get a favorable tax regime abroad, leading to repatriated subsidies.

This makes a nice case why governments may, in bidding for mobile factors, make favorable offers: They may have in mind the preferential regimes their countrymens' businesses will get abroad. Furthermore, the presence of a challenging emerging market, i.e. tax competition leads to increased global welfare via restoring an efficient allocation of industry.

[20] Trade costs will, at a certain point, counteract the 'lower-wage' effect on prices. However, high trade costs undermine stability of the core-periphery equilibrium in the first place, which is why we concentrated on lower levels of τ from the outset.

4.4 Winners and losers of the subsidy race

The above analysis showed that unionized core benefits from inducing a relocation of firms towards the periphery country f. It chooses a subsidy level at which the periphery can profitably attract all industry. Hence, both countries are clearly winners of the game and benefit from delocating industry towards a country with a non-distorted labor market. This section identifies the winners and the losers of the subsidy race within the different income groups. We begin with country h's and f's capital owners.

Proposition 4 *Capitalists in both locations are the clear winners of the subsidy race. Capitalists in h win due to the repatriation of capital income whereas capitalists in f benefit from a lower cost-of-living index.*

Proof: See Appendix 4.7.3. ■

For core's capital owners, the benefits from repatriating subsidies exceed the cost of incurring transport costs for imported varieties. Capitalists in f benefit from a lower cost-of-living index while the financing cost for subsidies are shared between capitalists and workers.

The impact on workers in the new core country is however ambiguous. To begin with workers of the new core the indirect utility ($V_{f,w}$) differential of workers in f before and after reads

$$V^p_{f,w} - V^c_{f,w} = L_f\bigg(\alpha(\ln P^c_f - \ln P^p_f) + z^{min}_f\bigg). \tag{28}$$

The difference in price indices is negative since $P^c_f < P^p_f$, indicating that workers are better off with firms producing in their country. The last term, however, indicates that workers might be better off in a periphery when financing costs are high. Figure 4.3 illustrates the welfare differential in (28).[21]

[21]Parameter values: $\phi = 0.6$; $\alpha = 0.3$; $\theta = 1.$.

Figure 4.3: Foreign workers' welfare differential

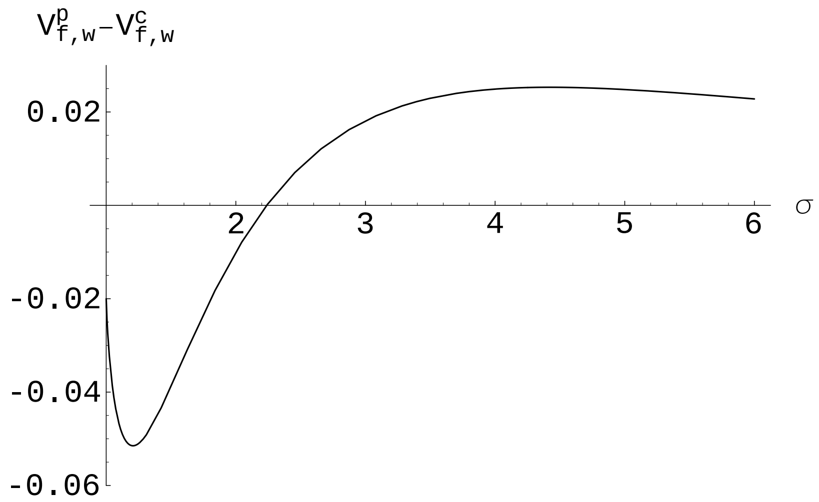


Figure 4.3 reveals that workers in f will only benefit from an industry relocation for low σ. Put differently, workers in f win only if they have severely suffered from wage cost exporting, i.e. for high union wages (low σ) such that it becomes worthwhile to incur the financing costs of attracting firms.

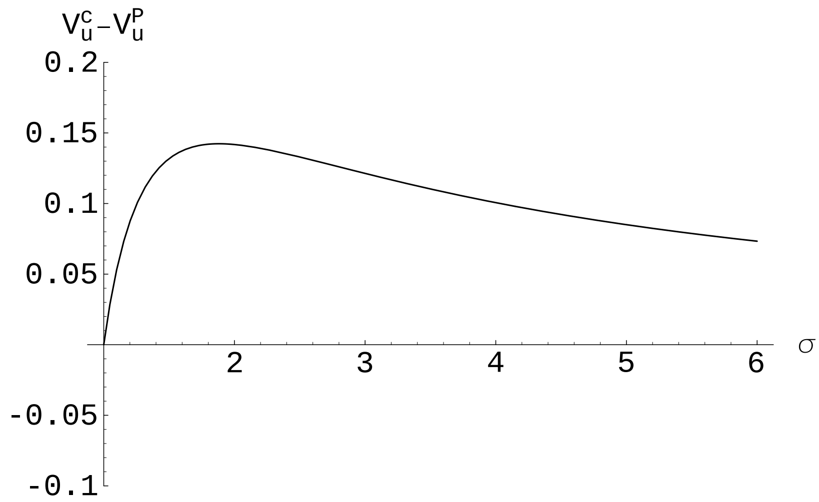
Intuitively, union members as a whole lose as industry shifts towards f. Their real income unambiguously falls on two counts, the decline of the nominal wage and the increase of the price index. The difference of before and after welfare of union workers denoted as V_u^c and V_u^p, respectively is derived using (16) and (23) for the core and periphery case

$$V_u^c - V_u^p = \frac{2\alpha}{\sigma}\left(\frac{\sigma-1}{\sigma}\right)\left(1+\alpha[(\sigma-1)\ln(\frac{\sigma-1}{\sigma}) - \ln\phi]\right). \tag{29}$$

Figure 4.4 depicts union workers' welfare differential in (29) for different σ which confirms that union workers particularly suffer from subsidy competition for low σ, i.e. high union wages.[22]

[22]Parameter values: $\phi = 0.6$; $\alpha = 0.3$.

Figure 4.4: Welfare of h's union workers before and after industry relocation

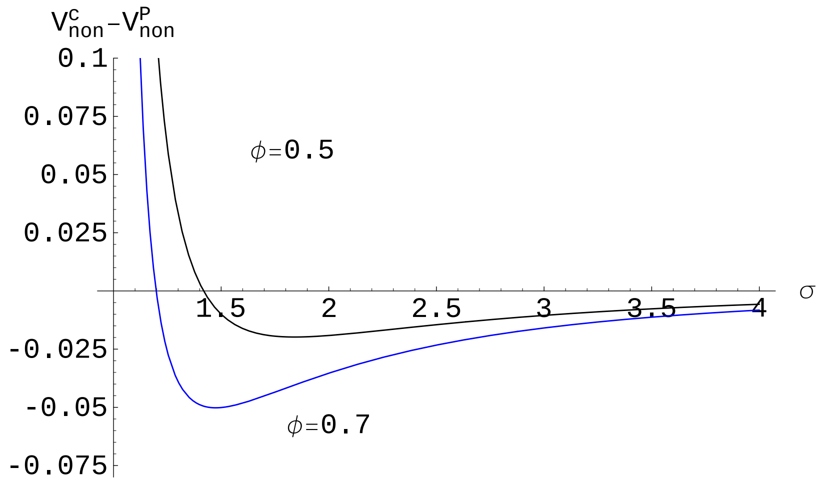


Turning to non-union workers in h, their welfare differential is obtained after inserting the respective price indices into h's non-union workers' indirect utilities using (17) for both cases

$$V_{non}^c - V_{non}^p = -\alpha(\lambda - L_h^{Mc})(\ln w_h - \frac{1}{1-\sigma}\ln\phi) \quad (30)$$

From inspection of (30) it is not ex ante clear whether non-union workers unambiguously benefit from industry relocation towards a country with no labor market distortion. More precisely, non-union workers benefit from industry delocation as they no longer bear high consumer prices resulting from asymmetric unionization (this effect is captured in '$\ln w_h$') whereas they suffer from losing all industry as they have to bear transport costs for imported varieties which is reflected through '$\ln\phi$'. To learn whether the overall effect is positive or negative Figure 4.5 displays non-union workers' before and after welfare differential at different levels of σ evaluated at different degrees of trade freeness.

Figure 4.5: Welfare of h's non-union workers (before and after industry relocation)



Surprisingly, non-union workers were *better off* for low σ, i.e. under (high) union wages and experience higher welfare from industry relocation only for higher σ (low union wages). This seems to be counterintuitive at first sight as we would expect non-union workers to gain (like workers in f) especially for low σ, i.e. for high union wages. To understand the result, first note that non-union workers face a trade off between higher consumer prices due to union wages and higher consumer prices because of shipping costs. However, recall that a low elasticity of substitution σ implies high union wages but at the same time indicates a high love for variety. Consequently, consumers in h suffer from industry delocation especially if their valuation for the industrial good is high as this leads to a strong increase in the cost-of-living index P_h which depresses households' purchasing power in h. Formally, this effect reads

$$\frac{\partial P_h^p}{\partial \sigma} = \frac{\phi^{\frac{1}{1-\sigma}}(\sigma \ln \phi + 1 - \sigma)}{(1+\theta)(\sigma-1)^3} < 0, \qquad \frac{\partial^2 P_h^p}{\partial \sigma \partial \phi} = \frac{\phi^{\frac{\sigma}{1-\sigma}}(\sigma^2 - 1 - \sigma \ln \phi)}{(1+\theta)(\sigma-1)^4} > 0. \tag{31}$$

which reflects that an increasing elasticity of substitution (a declining 'love for variety' and lower union wages) attenuates the loss arising from a high peripheral cost-of-living index. This effect is amplified by decreasing levels of trade freeness.

4.5 Discussion

Obviously, our strong main result arises out of two specific assumptions: Firstly, governments are true welfare-maximizers and weigh workers' and capital owners' utility equally. Then, the most efficient solution prevails, which is offshoring production to a location where the labor market is not distorted.[23] A straightforward extension here is to assume a government that only cares about workers, which could be due to its preferences or the fact that capital ownership is concentrated in very few hands, whereas the by far biggest share of households are labor households. In this case, the core will not find it optimal to get rid of its industry up to a certain union wage, but will rather accept the distortion which is partially borne by periphery's residents. We briefly illustrate the case of a government that does not care about capital owners: Such a government's objective function has as its arguments only A- and M-sector workers' utility. Apart from that, we proceed in perfect analogy to the analysis above, i.e., we compare price indices and welfare levels with all industrial activity in h and f, respectively, and work out the critical tax/subsidy levels $\hat{z}_h^{max}$, $\hat{z}_h^d$ under this alternative scenario. Finally, inserting the optimal policies under the revised scenario into the government objective function and conducting government h's welfare comparison, like before leads to the welfare differential

$$\tilde{WF_h}^c - \tilde{WF_h}^p = L_h^{Mc}(w_h - 1) - \frac{z_h}{2} - \alpha \ln\left(\frac{P_h^c}{P_h^p}\right). \tag{32}$$

Inserting the new subsidy levels $\hat{z}_h^d$ and the corresponding price indices finally yields

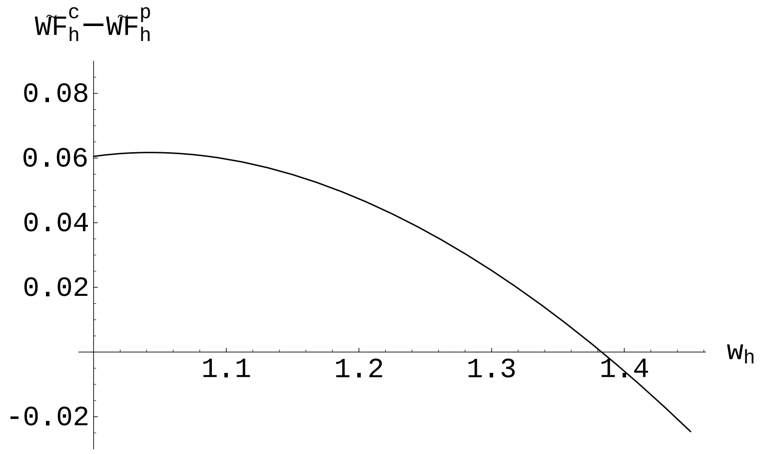
$$\tilde{WF_h}^c - \tilde{WF_h}^p = 2\alpha - \frac{1}{w_h}\frac{2\alpha(\sigma-1)}{\sigma} - \frac{\alpha}{\sigma}\left(1 + \frac{(1+\phi^2)}{2\phi}\left(\frac{1+\theta}{w_h}\right)^{1-\sigma}\right) - \alpha \ln w_h. \tag{33}$$

As one would expect, it is rising in the agglomeration force (θ) and in trade freeness (ϕ). Since technological spillovers as well as the level of trade integration increase the agglomeration rent, it also decreases the cost of financing a subsidy level necessary to defend the core. These familiar effects notwithstanding, core's optimal decision in this

[23] The tax game here has, as is true of many of the models in this literature, an auction-like character - hence the globally efficient outcome.

alternative 'leftist' scenario is no longer as clear cut as it was in Section 3. To see this Figure 4.6 illustrates the welfare difference as a function of the union wage rate w_h.[24]

Figure 4.6: Home's welfare difference for different union wages



For moderate union wages a 'leftist' government that represents workers' interests will set a subsidy level low enough to prevent a relocation of industry towards an efficient outcome. This may not seem too surprising as unionized workers benefit from the distortion, but remember that non-union workers and home capitalists equally enter the government's welfare calculus. Even though the model is highly stylized, we think the model and its predictions have intuitive appeal: Due to the quasi-linearity of the utility function, the M-sector can be thought of as one specific industry producing differentiated goods, whereas the competitive sector represents the ('big') rest of the economy. If such a sector suffers from a labor market distortion, it may not be ex ante clear that a government will find it in its best interest to compensate mobile factors for high wages. Rather, it may well be welfare-enhancing to use tax instruments or other government action to get industries offshored to low-wage countries, which benefits consumers with low consumer prices and shareholders with higher dividends. Thinking of particular industries such as consumer electronics, it may well be that industrialized countries' governments have understood that it can be in their best

[24]Parameter values: $\sigma = 4; \alpha = 0.5; \theta = 0.3; \phi = 0.6$.

interest to allow production and assembling to be shifted to places with lower labor costs. Then, downward pressure on taxes benefits them as national shareholders gain from them. Thinking of the car industry, on the contrary, one typically has in mind that jurisdictions do a lot to hold on to it, which may show the importance of local interest groups as decisions on industry- or even firm-specific tax breaks or subsidies will not only, in general, be based on national welfare-maximizing behavior, but also on the interests of local politicians.

4.6 Conclusion

In a simple model of tax competition between countries with asymmetric union power and agglomeration tendencies, we have shown that the government of the agglomerated and unionized country may not have an incentive to try to hold on to its industry. Instead of realizing the benefits from higher wage income while exporting part of the wage burden to foreign consumers via higher prices, it rather allows the competing country to attract industry and benefit from the other country's generous tax regime as well as low production costs, leading to low consumer prices. Tax competition is welfare enhancing as it leads to a relocation of industry towards a country with a non-distorted labor market. In contrast to the previous literature which focused on the agglomeration-holding country's ability to hold on to the core, we show why its willingness to do so may be curtailed. The finding has intuitive appeal when one thinks of the fact that welfare is, after all, driven by consumption, which in this case is increased by two facts: Lower prices because of the circumvented labor market distortion, and higher income because of capitalists' repatriated income. We highlight the way in which winners and losers are generated in tax competition and leave it for future work to look into this in more depth empirically. In terms of theory, it seems promising to examine the role of special interest groups and their organization when it comes to influencing governments in their choice of policy variables in the presence of international tax competition.

4.7 Appendix

4.7.1 Proof of Proposition 2

Global welfare is derived adding up the indirect utility functions of A sector workers, unionized and non-unionized M workers as well as capital owners across countries. Taking the difference of global welfare evaluated at $s_n = 1$ and global welfare at $s_n = 0$ gives, after inserting $w_h = \frac{\sigma}{\sigma-1}$,

$$WF^{glob}\big|_{s_n=0} - WF^{glob}\big|_{s_n=1} = -1 - \frac{\sigma^2}{\sigma-1}\ln\left(\frac{\sigma-1}{\sigma}\right). \tag{A.1}$$

one can easily see that the expression above is non-negative for $\sigma > 1$. ■

4.7.2 Proof of Proposition 3

Setting $z_h = z_h^d$ and $z_f = z_f^{min}(z_h)$ in equation (27), as well as inserting the respective price indices from (23) reduces to

$$WF_h^c(z_h) - WF_h^p(z_f) = \frac{2\alpha(\sigma-1)}{w_h\sigma}(w_h - 1) - 2\alpha\ln w_h. \tag{A.2}$$

Note that the first term is simply union's objective which is the excess wage bill of its members whereas the second term denotes the potential benefit of a relocation, namely getting rid of the distortion. This equals, after substituting $w_h = \frac{\sigma}{\sigma-1}$,

$$WF_h^c(z_h) - WF_h^p(z_f) = \frac{2\alpha(\sigma-1)}{\sigma^2} - 2\alpha\ln\left(\frac{\sigma}{\sigma-1}\right). \tag{A.3}$$

This term is smaller than zero for any $\alpha > 0, \sigma > 1$, indicating that the government in h will always be better off when the core is in f. The equilibrium subsidy levels are given by $z_h^* = z_h^d - \epsilon$ and $z_f^* = z_f^{min}(z_h^*)$, for some small ϵ. ■

4.7.3 Proof of Proposition 4

The indirect utility differential of capitalists in h reads

$$V^{c}_{h,\,cap} - V^{p}_{h,\,cap} = K_h\big(\alpha(\ln P^{p}_{h} - \ln P^{c}_{h}) - z^{min}_{f}\big) \tag{A.4}$$

Inserting the respective price indices, (23), and the union wage yields

$$V^{c}_{h,\,cap} - V^{p}_{h,\,cap} = \frac{\alpha}{4\sigma^2}\frac{(1+\theta)^{1-\sigma}(\sigma-1)^{1-\sigma}\sigma^{\sigma}(1+\phi^2)}{\phi} + \frac{\alpha[2\sigma(\ln(\sigma-1)-\ln\sigma)-1]}{2\sigma}. \tag{A.5}$$

This expression will be infinitely negative for $\sigma \to 1$ and approaches zero for $\sigma \to \infty$. Hence, capitalists in h gain from firms' relocation towards the union-unionized country. The welfare differential of capital owners in f reads simply

$$V^{c}_{f,\,cap} - V^{p}_{f,\,cap} = K_f\big(\alpha(\ln P^{p}_{f} - \ln P^{c}_{f})\big). \tag{A.6}$$

After inserting the respective price indices and w_h simplifies to

$$V^{c}_{f,\,cap} - V^{p}_{f,\,cap} = \frac{\alpha}{2}\big(\ln\sigma - \ln(\sigma-1) - \frac{1}{\sigma-1}\ln\phi\big), \tag{A.7}$$

which is unambiguously positive for any $\alpha > 0$, $\sigma > 1$ and $0 < \phi < 1$. ■

Chapter 5

The merits and pitfalls of co-agglomeration: Vertical linkages and regional competition

5.1 Introduction

Inspired by the success of economic clusters such as Silicon Valley, California or Sophia Antipolis, France the focus of regional policies has gradually shifted away from equity considerations to objectives enhancing the competitiveness of lagging regions. In its latest report on national cluster strategies the OECD points to countries like Germany, Finland, Norway and Italy that formerly engaged predominantly in preserving employment in declining industries and only recently launched regional policy programs supporting particulary high-technology industries (OECD (2007)).[1] To justify the distribution of funds to selected firms of a specific industry, policy makers commonly emphasize the interrelated nature of firm location decisions. More precisely, it is argued that the attraction and formation of a key industry cluster is essential for the subsequent attraction of establishments from related industries. This cluster strategy has significantly shaped the funds allocation process e.g. in the UK, where funds are distributed exclusively to those firms which demonstrate credibly substantial linkages between research institutions and industry (OECD (2007)).

The interdependent nature of firm location decisions has equally encouraged the development of the industrial park in Cluj-Napoca, Romania and the actions taken by local Romanian officials concerning the attraction of inward FDI. By means of state subsidies it successfully persuaded Nokia to delocate its production facility from Germany to Romania in 2008. Whether the official's strategy to induce a self-supporting process of firm location will be successful still remains to be seen. In any case, the latest incident of publicly funded FDI attraction has triggered a lively debate on the desirability of such industry specific policies between politicians and researchers. Whereas supporters highlight positive first round and second round employment effects, economists prevalently cast doubt on the efficiency of industry specific industrial policy programs. So do Leslie and Kargon (1996), who present anecdotal evidence on the non-transferability of economic clusters and the failure of applying the concept of existing clusters to other locations.

[1] For instance, the InnoRegio program designated to the Eastern Länder in Germany is to facilitate the transformation process from traditional manufacturing to research oriented sectors.

We develop a simple true vertical linkage model à la Venables (1996) where firm agglomeration occurs through production linkages between upstream and downstream firms.[2] Depending on the level of economic integration, final and intermediate good suppliers locate evenly across regions or agglomerate in one of the two locations. The interrelated production structure entails that a region which hosts all upstream industry attracts more than half the share of final goods producers which benefits core and hurts peripheral residents on two counts as trade in both types of goods is costly. Residents incur lower consumer prices as final goods producers incur lower transport costs when purchasing intermediate varieties. Additionally, core residents save directly on transport costs when purchasing the industrial final good. Starting from an agglomerated equilibrium we explore the effectiveness and desirability of selective financial assistance in a setting where local authorities compete for firms of a certain key industry.

We find that the amount of subsidy payments required to enforce an industry delocation from a core to a peripheral region exceeds the maximum amount of resources that a government of a peripheral region is willing to invest to increase its residents' welfare. An industry cluster will remain in the location where it emerged prior to any government intervention. At the end of the game a subsidy is distributed to owners of these firms ensuring that the neighboring jurisdiction is not tempted to snatch the industry cluster. Except for owners of the subsidized industry cluster, residents of the agglomeration are worse off than before as they incur the costs of financing subsidy payments. Our findings therefore particularly highlight the pitfalls associated with the competition for a key industry and suggest to rethink current cluster strategies which selectively distribute funds to industries which are assumed to be the drivers of industrial agglomeration.

The recent empirical contribution by Ellison et al. (2007) who explore the sources

[2] The literature on production linkages between firms can be divided into two types of input-output models. Krugman and Venables (1995) apply the idea of 'horizontal linkages' in the spirit of Ethier (1982) who assumes final goods to enter private consumption and at the same time enter final good production as intermediate goods. Contrary to this modelling type, Venables (1996) assumes a 'vertical linkage' structure where upstream and downstream firms form two distinct industries which are interrelated through production linkages.

of agglomeration formulated by Marshall (1890), i.e. the importance of knowledge spillovers, labor market pooling effects and cost linkages for firm agglomeration, reveal the decisive nature of input-output linkages for the co-agglomeration of economic activity in space. Similarly, Duranton and Overman (2008) find evidence for the relevance of input-output linkages at the regional level and Midelfart-Knarvik et al. (2000) empirically show that central locations have attracted industries which are dependent on intermediate inputs. However, despite the rich empirical evidence on the importance of production linkages for firm agglomeration and the reassessment of regional policy goals as reported by the OECD, the number of studies that apply vertical linkage models to questions related to regional cluster policies and subsidy competition is small. Notable exceptions are Forslid and Midelfart (2005) who look at optimal industrial cluster policy to upstream or downstream firms in a model where agglomeration occurs through cost linkages ignoring however the pressures arising from competing governments. Similarly, Wildasin (1993) assesses the question of how changes of the own tax policy affect wages and welfare of the neighboring jurisdiction. The author considers a model of two jurisdictions that are interrelated through interindustry trade but abstract from co-agglomeration tendencies. Most closely related to our paper is the work by Kind et al. (2000) who analyze tax competition in a model with input-output linkages. Nevertheless, our model set up is slightly different as their two-sector model builds on the assumption that production linkages occur within the same sector ('horizontal linkages'). The model ranges in the family of true 'vertical linkages' models as it displays two distinct industrial sectors, a final and intermediate goods industry next to a traditional sector and accounts for the empirically observed co-agglomeration patterns. Furthermore, the assumption of vertical linkages has also implications for the tax competition game. In contrast to the horizontal linkage model developed by Kind et al. (2000), holding the industry cluster in the current model becomes more attractive with intense production linkages as strong input-output linkages raise the share of downstream firms in the core which benefits core residents via low consumer prices.

The paper is organized as follows. We present the model and the equilibrium analysis in Section 2 and 3. The subsidy competition game where local governments who maximize their residents' welfare intend to attract a key industry by means of sector specific subsidies is analyzed in Section 4. Section 5 concludes.

5.2 The Model

5.2.1 Basic Set Up

The world consists of two regions $i \in \{1, 2\}$ with symmetric technology. Each region is inhabited by $L_i + K_i + H_i$ households with identical preferences. There are three sectors. The perfectly competitive numéraire sector produces a homogenous good A under constant returns to scale. It is produced in both regions using immobile labor as the only input and is traded without costs across regions. The two industrial sectors, M and X produce under Dixit-Stiglitz monopolistic competition and are subject to iceberg trade costs $\tau \geq 1$.[3] The downstream sector (M) produces a final industrial good using one unit of sector specific capital K and a composite of industrial varieties which are purchased from firms of the upstream sector X. Each firm of the upstream industry produces one intermediate variety using one unit of capital H which is specific to the upstream sector and labor.[4] Hence, whereas demand for M-goods stems from households residing in both locations, intermediate inputs are purchased by downstream firms only. Sector specific capital K and H can move freely across regions but capital owners are assumed to be immobile which implies that the reward of capital is repatriated to the region of residence. We denote $s_k \equiv K_1/K$ as the share of world capital owned by downstream capital owners residing in region 1 with $K = K_1 + K_2 = 1$. Analogously, $s_m \equiv m_1/m$ denotes the share of downstream capital employed in region 1 (or more precisely, the mass of downstream varieties produced in region 1). With full employment of downstream capital the total mass of downstream firms m is determined by the total mass of downstream capital owners in

[3]For simplicity we assume that both sectors incur the same level of transport costs.
[4]Upstream specific capital are e.g. patents allowing to produce a particular X variety.

the economy $m = m_1 + m_2 = K = 1$. The share of capital owners who supply capital to the upstream firms are denoted as $s_h \equiv H_1/H$ with $H = H_1 + H_2 = 1$. Analogously, $s_n \equiv n_1/n$ denotes the share of capital employed in region 1 (the mass of varieties produced in region 1) with $n = n_1 + n_2 = H = 1$. The share of workers in region 1 is denoted as $s_l \equiv L_1/L$, with $L = L_1 + L_2 = 1$. We assume regions to be equal in their overall market size i.e. $s_h = s_k = s_l$.

5.2.2 Preferences and Demand

The representative household inelastically supplies one unit of its factor endowment and derives utility from consuming a range of differentiated industrial M-varieties and the traditional sector's A-good. Household's preferences are represented by a two tier utility function, where the upper tier function is quasi-linear which eliminates the income effect on the M-good. The lower tier utility function is of the CES form displaying a household's love for industrial varieties. The upper tier utility function reads

$$U_i(A_i, M_i) = \alpha \ln M_i + A_i - \alpha[\ln \alpha - 1] \tag{1}$$

We assume $0 < \alpha < y_{if}$, $f \in \{H, K, L\}$ to assure that both types of goods are consumed. $\alpha[\ln \alpha - 1]$ is a constant which will cancel out when deriving the indirect utility function. A_{if} denotes consumption of the numéraire good and α the amount of income spent on the composite good M_i which consists of all differentiated varieties v of the industrial good

$$M_i = \left(\int_0^{m_i} D_{ii}(v)^{\frac{\sigma-1}{\sigma}} dv + \int_{m_i}^{m_i+m_j} D_{ji}(v)^{\frac{\sigma-1}{\sigma}} dv \right)^{\frac{\sigma}{\sigma-1}}, \qquad \sigma > 1, \quad i \neq j. \tag{2}$$

D_{ii} denotes consumption of a downstream variety produced domestically and D_{ji} denotes consumption of a downstream variety produced abroad. The constant elasticity of substitution between any two varieties is denoted by σ. The budget constraint of a representative household reads

$$\int_0^{m_i} p_{Mi}(v)D_{ii}(v)dv + \int_{m_i}^{m_i+m_j} \tau p_{Mj}(v)D_{ji}(v)dv + A_i = y_{if}, \quad f \in \{H, K, L\} \tag{3}$$

where p_{Mi} and p_{Mj} denote the producer prices of a respective variety and $\tau \geq 1$ iceberg trade costs. y_{if}, $f \in \{H, K, L\}$ denotes income of the respective household. Solving the two stage budgeting problem yields the following demand functions, $D_{ii}(v)$, $D_{ji}(v)$, M_i and A_i and indirect utility V_{if}

$$M_i^* = \alpha/P_i, \qquad A_{if}^* = y_{if} - \alpha, \tag{4}$$

$$D_{ii} = \alpha p_{Mi}(v)^{-\sigma} P_i^{\sigma-1}, \qquad D_{ji} = \alpha p_{Mj}(v)^{-\sigma} P_i^{\sigma-1},$$

$$P_i \equiv [m_i p_{Mi}^{1-\sigma} + m_j p_{Mj}^{1-\sigma}]^{\frac{1}{1-\sigma}}, \tag{5}$$

$$V_{if} = y_{if} - \alpha \ln P_i, \quad f \in \{H, K, L\} \tag{6}$$

where P_i denotes consumers' cost-of-living index in region i which takes symmetry of producer prices already into account.

5.2.3 Production

Traditional Sector

The A-good is traded at zero costs among regions and is produced using labor only according to $q_i^A = L_i^A$, where L_i^A denotes labor input and q_i^A denotes output. Due to perfect competition labor is paid its marginal product. Free trade ensures that wage rates are equalized across regions. Hence, with $p_i^A = 1$ and from $p_i^A q_i^A = wL_i^A$ and $q_i^A = L_i^A$ it follows $w = 1$ for both regions.

Final goods production (downstream industry)

A firm of the M-sector produces a variety using sector specific capital K a composite intermediate good X with price P_{xi} entering as a CES aggregate and labor. More precisely, output of an upstream firm only enters production of a final good variety, i.e. the M-good serves as a final consumption good whereas the X-good is used as an intermediate input only. A representative downstream firm in region i has to employ one unit of capital K as the fixed input requirement which costs R_i before starting to produce a final good variety. Production of the variety itself follows a Cobb-Douglas technology where a_M units of the intermediate input per unit of output is employed. Hence, a typical downstream firms in region i produces q_{Mi} units of output with total costs TC_{Mi} given by

$$TC_{Mi} = a_M P_{xi}^{\eta} q_{Mi} + R_i, \qquad 0 < \eta < 1 \tag{7}$$

The parameter η denotes the share of expenditures which are devoted to the purchase of the composite X-good with producer price $P_{xi} = [n_i p_{xi}^{1-\rho} + n_j p_{xj}^{1-\rho}]^{\frac{1}{1-\rho}}$.[5] It also indicates the intensity of vertical linkages between upstream and downstream firms. The profit function of a downstream firm reads

$$\pi_{Mi} = (p_{Mi} - a_M P_{xi}^{\eta}) q_{Mi} - R_i, \tag{8}$$

and the profit maximizing final goods producer price is a constant mark up over marginal costs $p_{Mi} = \frac{\sigma}{\sigma-1} a_M P_{xi}^{\eta}$. Choosing units $a_M = \frac{\sigma-1}{\sigma}$ then yields

$$p_{Mi} = P_{xi}^{\eta}, \tag{9}$$

i.e. the price of the final industrial good depends on the cost of purchasing the whole available range of intermediate inputs. Note that the per unit producer price is identical on the two markets. This is due to the familiar result that mill pricing in the Dixit

[5] P_{xi} is derived solving the lower expenditure minimization problem $\int_0^{n^w} p_{xi}(s) x_i(s) ds$ s.t. $X_i = [\int_0^{n^w} x_i(s)^{\frac{\rho-1}{\rho}}]^{\frac{\rho}{\rho-1}}$.

Stiglitz monopolistic competition framework is optimal for firms.[6] Trade costs are fully borne by consumers implying that part of the demand is indirect due to transport losses.

Using the zero pure profit condition and applying mill prices from (9) yields output q_{Mi} that allows a downstream firm to break even

$$q_{Mi} = \frac{R_i \sigma}{P_{xi}^{\eta}}. \tag{10}$$

Finally, the condition for market clearing in the final goods sector reads

$$q_{Mi} = D_{ii}\mu_1 + \tau D_{ij}\mu_2. \tag{11}$$

Would-be entrepreneurs bid for downstream capital K until operating profit equals the capital reward rate for this sector, $R_i = \frac{p_{Mi} q_{Mi}}{\sigma}$.[7] Inserting households' demand function using (4) into (11) and applying the share notation yields the reward for downstream capital K in each location

$$R_1 = \frac{\alpha}{\sigma}\left(\frac{\mu_1}{s_m + \phi(1-s_m)\chi} + \frac{\phi\mu_2}{\phi s_m + (1-s_m)\chi}\right) \tag{12}$$

$$R_2 = \frac{\alpha}{\sigma}\left(\frac{\chi\mu_2}{\phi s_m + (1-s_m)\chi} + \frac{\chi\phi\mu_1}{s_m + \phi(1-s_m)\chi}\right), \tag{13}$$

where $\phi \equiv \tau^{1-\sigma}$ is the level of trade freeness with $\phi \in [0,1]$. $\chi \equiv \left(\frac{p_{M2}}{p_{M1}}\right)^{1-\sigma} = \left(\frac{P_{x2}}{P_{x1}}\right)^{\eta(1-\sigma)}$ is the ratio of producer price indices for intermediate varieties.

[6] This is due to the constant markup, or more precisely due to the constant elasticity of substitution (see Dixit and Stiglitz (1977)).

[7] Operating profits in the Dixit Stiglitz monopolistic competition framework are equal to a constant share of firm's sales.

Intermediate goods production (upstream industry)

The representative firm of the upstream sector produces one variety using one unit of sector specific capital H and a_x units of labor according to the total cost function

$$TC_{xi} = a_x q_{xi} + r_i \tag{14}$$

where r_i denotes capital H's reward rate, q_{xi} firm's output in region i and a_x the unit input requirement of labor. With the profit function of the representative firm in region i, $\pi_{xi} = \big(p_{xi} - a_x\big)q_{xi} - r_i$, the profit maximizing price of an upstream firms is given by

$$p_{xi} = (\frac{\rho}{\rho - 1})a_x \tag{15}$$

where ρ is the elasticity of demand perceived by upstream firms whose demand stems from M-good producers. In equilibrium firms make zero profits and equilibrium firm size is equal to

$$q_{xi} = \frac{r_i(\rho - 1)}{a_x} \tag{16}$$

which by choosing units $a_x = \frac{\rho-1}{\rho}$ is simply $q_{xi} = r_i\rho$. For simplicity we will assume that the perceived elasticity of demand of downstream firms equals the perceived elasticity of demand of upstream, $\sigma = \rho$, i.e. upstream and downstream firms neglect to the same amount the effect of their pricing behavior on the overall sectoral price index P_{xi} and P_{Mi}, respectively. Total demand of the downstream sector producing in region i for the upstream composite good X is derived using Shepard's Lemma on (7)

$$\frac{\partial TC_{Mi}}{\partial P_{xi}} = \eta a_M q_{Mi} P_{xi}^{\eta-1} = \frac{\eta VC_{Mi}}{P_{xi}} \tag{17}$$

with ηVC_{Mi} denoting expenditure on the composite good X of a single M firm producing in i with variable costs

$$VC_{Mi} = a_M P_{xi}^{\eta} q_{Mi}. \tag{18}$$

Let $x_{ii}(s)$ denote the quantity of an intermediate variety s produced in i and demanded by M firms in i. $x_{ii}(s)$ is derived applying Shepard's Lemma on (18) which yields

$$x_{ii}(s) = \frac{\partial VC_{Mi}}{\partial p_{xi}(s)} = \frac{\partial VC_{Mi}}{\partial P_{xi}} \frac{\partial P_{xi}}{\partial p_{xi}(s)} = \frac{p_{xi}^{-\rho} \eta VC_{Mi}}{P_{xi}^{1-\rho}}. \tag{19}$$

The market clearing condition for an upstream firm reads

$$q_{xi} = x_{ii} m_i + \tau x_{ij} m_j. \tag{20}$$

In a goods market equilibrium supply of an intermediate variety must be equal to downstream firms' demand for the variety. Note that we assume the intermediate good to be exposed to the same level of trade costs as the final good. Analogously to the M sector, reward to owners of capital H is equal to operating profit of an intermediate good producer, $r_i = \frac{p_{xi} q_{xi}}{\rho}$. After inserting market demand for the intermediate variety using (19) and the producer price using (15) then yields

$$r_1 = \frac{\eta(\sigma - 1)}{\sigma} \left(\frac{R_1 s_m}{s_n + \phi(1 - s_n)(\frac{p_{x2}}{p_{x1}})^{1-\rho}} + \frac{\phi R_2 (1 - s_m)}{\phi s_n + (1 - s_n)(\frac{p_{x2}}{p_{x1}})^{1-\rho}} \right) \tag{21}$$

$$r_2 = \frac{\eta(\sigma - 1)}{\rho} \left(\frac{R_2 (1 - s_m)}{\phi s_n + (1 - s_n)} + \frac{\phi R_1 s_m}{s_n + \phi(1 - s_n)} \right), \tag{22}$$

where we use the share notation and $\rho = \sigma$. As producer prices for upstream varieties are equal across regions we can write $(\frac{p_{x2}}{p_{x1}})^{1-\rho} = 1$.

5.3 Locational equilibria

In the short run both types of capital are immobile. Consequently, the share of downstream industry s_m as well as the share of upstream industry in region 1, s_n, are both exogenous and capital owners K and H earn rewards equal to (12), (13) and (21), (22), respectively. In the long run capital owners of both industries seek for the highest nominal reward which is measured in terms of the numéraire. The location of upstream and downstream capital is determined by its respective capital reward differential. In the following, we verbally describe the locational forces of the final goods industry and the intermediate goods sector and leave a formal analysis to Appendix 5.6.

As firms of the final goods industry face immobile household demand in each region they will want to locate where market demand is highest which minimizes transport costs ('demand linkage effect'). On the other hand, firms of the final goods sector use intermediate varieties in the production of the M good. Consequently they will want to locate close to upstream firms which minimizes the cost of purchasing intermediate goods ('cost linkage effect'). Firms of the upstream industry face no cost linkages but locate where demand for intermediate varieties is highest. Both industries are subject to the local competition effect in their sector which acts as a dispersion force. The equilibrium location of upstream and downstream firms will be determined by the interplay of these agglomerative and dispersive forces. To derive the equilibrium share of final good firms in region 1 we exploit the no-delocation condition $R_1 - R_2 = 0$ which characterizes a locational equilibrium in this sector. Using (12) and (13) and solving for s_m, yields

$$s_m = Min[1, Max(0, \hat{s}_m)], \quad \text{with} \quad \hat{s}_m = \frac{1}{2}\left[2 + \frac{\phi}{\chi - \phi} + \frac{1}{\chi\phi - 1}\right] \tag{23}$$

where we assume symmetric market size and impose $\mu_1 = \mu_2 = \frac{3}{2}$. Equation (23) reveals that the share of downstream firms depends on the level of trade freeness ϕ and on the ratio of cost indices χ for purchasing intermediate X-varieties which themselves depend on the share of upstream firms, s_n. The equilibrium of upstream firms can be described by the following proposition.

Proposition 1 *X-industry exhibits only two stable spatial equilibria. Firms of the X-sector are either symmetrically dispersed ($s_n = 1/2$) across regions or agglomerated in one of the region. A partial equilibrium is never a stable equilibrium.*

Proof. See Appendix 5.7. ■

Proposition 1 states that upstream firms locate either symmetrically across locations or agglomerate in one region. The critical level of trade freeness (commonly denoted as the 'break point' level of trade freeness) at which the allocation of upstream industry changes from a symmetric distribution to a full agglomeration equilibrium is obtained solving $\frac{\partial(r_1 - r_2)}{\partial s_n}\Big|_{s_n=\frac{1}{2}} = 0$ for ϕ.[8]

$$\phi^B = 1 + 2\eta - 2\sqrt{\eta(1+\eta)}, \qquad \frac{\partial \phi^B}{\partial \eta} = 2 - \frac{(1+2\eta)}{\sqrt{\eta(1+\eta)}} < 0. \tag{24}$$

The second expression unveils that agglomeration of intermediate goods suppliers occurs at lower levels of trade freeness as production linkages get more intense.

Clearly, under autarky ($\phi \to 0$), downstream and upstream industry will be evenly distributed across regions, $s_m = s_n = \frac{1}{2}$.[9] For cases where trade costs are positive, the vertical production structure has some interesting implications for the allocation of downstream and upstream firms. This can be easily seen after differentiating s_m using (23) with respect to s_n and evaluating the expression at the symmetric equilibrium

$$\frac{\partial \hat{s}_m}{\partial s_n}\bigg|_{s_n=1/2} = \frac{4\eta\phi}{1-\phi^2} > 0. \tag{25}$$

Bearing in mind that $s_n = 1/2$ implies $s_m = 1/2$ implies that as soon as the region holds all upstream firms it also enjoys more than half the share of downstream firms, $s_m|_{s_n=1} > 1/2$, as long as trade is not completely free. This effect is amplified with

[8]See Appendix 5.8 for a detailed derivation of ϕ^B.

[9]For upstream industry, insert the equilibrium share of downstream firms, s_m and downstream capital reward rates R_1 and R_2 into (21) and (22) and evaluate $(r_1 - r_2)$ at $\phi = 0$. Solving $r_1 - r_2\big|_{\phi=0}$ for s_n yields $s_n = \frac{1}{2}$.

higher input-output linkages and freer trade. Figure 5.1 illustrates upstream capital's reward gap for different s_n and the corresponding share of downstream firms in a scissors diagram (Figure 5.2)[10]

Figure 5.1: Upstream industry (X)

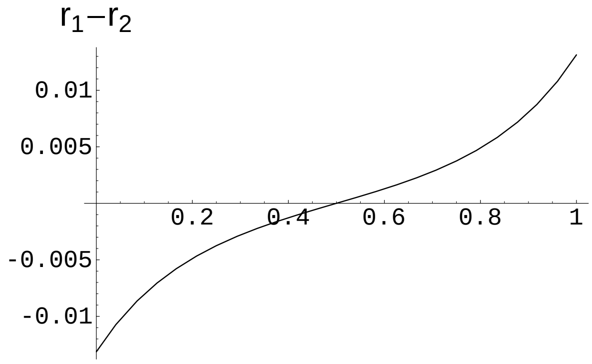
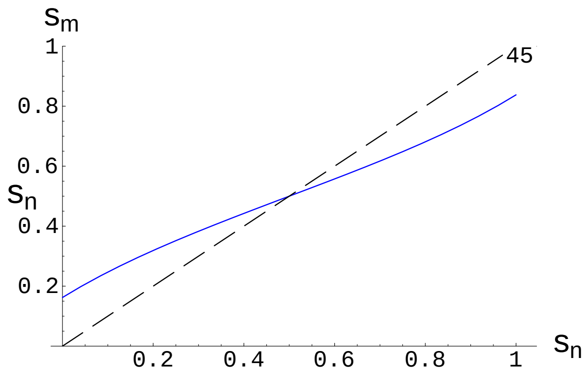


Figure 5.2: Downstream industry (M)



The stability of the agglomerated equilibrium for upstream firms is best explained with a thought experiment commonly used in this literature (e.g. Baldwin et al. (2003)). Starting from the symmetric allocation at $s_n = \frac{1}{2}$ in Figure 5.1 and increasing the share of upstream firms in region 1 marginally widens the capital reward gap $r_1 - r_2$ which makes region 1 relatively more profitable to upstream capitalists. Consequently, region 1 will experience an inflow of upstream firms as along as the capital reward gap remains positive. The adjustment process will come to an end after all upstream firms have set up their production facility in region 1. Figure 5.2 illustrates the location of downstream firms in a scissors diagram for parameter values at which upstream firms concentrate in one region. In this case, downstream industry are asymmetrically distributed across regions ($1/2 < s_m < 1$) and not fully agglomerated as firms in this industry face demand from (immobile) households residing in each region.

Agglomeration rent

According to Proposition 1 and (25), economic activity of both industries will be unevenly distributed across regions if the level of trade integration is sufficiently high, i.e.

[10]Parameter values: $\alpha = 0.3; \sigma = 4; \phi = 0.4; \eta = 0.3$

if ϕ exceeds ϕ^B. In that case, cost and demand linkages ensure that one region will holds all intermediate suppliers and according to (25) a larger fraction of final goods producers. As already described in the introduction, our paper intends to consider a scenario where local authorities pursue a cluster strategy which focuses on a particular key industry. It seems therefore most natural to let upstream firms which are decisive for the clustering of economic activity to represent a key industry and firms belonging to the downstream sector to characterize those industries that are affected by the location decisions of firms belonging to the key industry. Then, if intermediate goods suppliers are agglomerated in one region, say region 1, upstream capitalists earn an agglomeration rent Ω, which is defined as the loss that a single X firm incurs if it relocates towards the peripheral region given that all other X firms stay in the core. Formally, the agglomeration rent prevailing in region 1 is given by

$$\Omega \equiv r_1 - r_2\big|_{s_n=1} = \frac{3\alpha\eta(\sigma-1)(1-\phi)[s_m^c(1+\phi)-1]}{\phi\sigma^2} \tag{26}$$

where $s_m^c \equiv Min[1, Max(0, \hat{s}_m^c)]$ with

$$\hat{s}_m^c \equiv \hat{s}_m|_{s_n=1} = \frac{1}{2}\left(2 + \frac{\phi}{P^{\eta(1-\sigma)} - \phi} + \frac{1}{\phi P^{\eta(1-\sigma)} - 1}\right), \tag{27}$$

and $P \equiv P_{x2}|_{s_n=1} = P_{x1}|_{s_n=0} = \phi^{\frac{1}{1-\sigma}} > 1$.

Accordingly, we can write $s_m^p \equiv Min[1, Max(0, \hat{s}_m^p)]$ with

$$\hat{s}_m^p \equiv \hat{s}_m|_{s_n=0} = \frac{1}{2}\left(2 + \frac{\phi}{P^{-\eta(1-\sigma)} - \phi} + \frac{1}{\phi P^{-\eta(1-\sigma)} - 1}\right) \tag{28}$$

as the share of region 1's downstream firms for the case where all upstream industry is agglomerated in region 2.

To summarize, the section showed that the model exhibits only two possible stable allocations of economic activity. Whether each location holds an equal share of each industry depends on the level of trade integration as well as on the intensity of vertical production linkages which both affect the relative strength of agglomerative and dispersive forces. Moreover, equation (25) unveiled that the location of downstream industry is linked to the location decision of intermediate goods suppliers. A concentration of upstream firms in one location entails an uneven distribution of final goods producers across locations where the agglomerated location will attract more than half the share of final goods producers. This benefits core and hurts peripheral residents on two counts as trade in both types of goods is costly. Residents incur lower consumer prices as final goods producers incur lower transport costs when purchasing intermediate varieties. Additionally, core residents save on direct transport costs when purchasing the industrial final good.

5.4 Competition for a key industry

The true vertical linkage nature of the model allows us to consider a cluster policy which is targeted at one specific sector as described in the introduction.[11] Each region his run by a local government which decides on the distribution of funds. It maximizes regional welfare W_i which consists of the unweighted sum of indirect utilities of households residing within a jurisdiction's boundaries. Moreover, we consider a scenario where local authorities compete for an industrial cluster, and presume that the two regions initially differ in their level of economic activity. Whereas both regions are active in the traditional sector, region 1, the core, is assumed to host all upstream firms and consequently also a larger share in downstream industry. We denote region 2 the periphery with $s_n = 0$ and $(1 - s_m^c) < \frac{1}{2}$. We apply a three stage sequential move game in the spirit of Baldwin and Krugman (2004), where the core region acts as a Stackelberg leader and chooses her subsidy level z_1 in the first stage. The periphery decides whether to attract upstream industry in the second stage. The equilibrium allocation of economic activity unfolds in the third stage where production and consumption take place as described in the preceding sections. Subsidy payments to upstream capital owners are financed through a lump sum tax on each factor owner's endowment.

[11] E.g. Germany's BioRegio program focuses exclusively on the biotech sector and was launched to catch up with successes of UK and US biotech firms (OECD (2007)).

Government's budget constraint in region 1 and region 2 then reads

$$z_1 s_n = \mu_1 T_1, \qquad z_2(1 - s_n) = \mu_2 T_2, \tag{29}$$

where z_i, $i \in \{1, 2\}$ is the subsidy payment prevailing in region i and offered to upstream capitalists. Indirect utility of each households now reads

$$V_{if} = s_f[-\alpha \ln P_i + y_f^* - T_i], \quad f \in \{H, K, L\}, \quad i \in \{1, 2\} \tag{30}$$

where P_i is given in (5) and T_i denotes the per capita residency based lump sum tax. Workers' income in both regions is simply the wage rate which is equal to one. Derivation of capital owners' income is equally straightforward. Irrespective of the equilibrium allocation of downstream capital (either an interior equilibrium where capital rates equalize or a corner equilibrium where downstream capital follows the location of upstream firms) income of downstream capital owners is the same, i.e. $y_K^* \equiv \frac{3\alpha}{\sigma}$, $i \in \{1, 2\}$.[12] Similarly, upstream capitalists earn an income equal to $y_H^* \equiv \frac{3\alpha\eta(\sigma-1)}{\sigma} + z_i$, $i \in \{1, 2\}$. Noting that $\mu_1 \equiv s_k + s_h + s_l$ and $\mu_2 \equiv (1 - s_k) + (1 - s_h) + (1 - s_l)$ regional welfare in the two economic states, $s_n = 0$ and $s_n = 1$ can be expressed as

$$W_1^C = -\alpha\mu_1 \ln P_1^C + s_h y_H^* + s_k y_K^* + s_l - z_1, \tag{31}$$

$$W_1^P = -\alpha\mu_1 \ln P_1^P + s_h y_H^* + s_k y_K^* + s_l, \tag{32}$$

$$W_2^C = -\alpha\mu_2 \ln P_2^C + (1 - s_h)y_H^* + (1 - s_k)y_K^* + (1 - s_l) - z_2, \tag{33}$$

$$W_2^P = -\alpha\mu_2 \ln P_2^P + (1 - s_h)y_H^* + (1 - s_k)y_K^* + (1 - s_l), \tag{34}$$

where $W_2^C \equiv W_1|_{s_n=0}$, $W_2^P \equiv W_1|_{s_n=1}$ and $P_2^C \equiv P_2|_{s_n=0}$.[13]

[12] For the proof, we simply insert the equilibrium number of downstream firms, s_m using (23) into R_i using (12)-(13). The same equilibrium capital reward rate is obtained after evaluating R_1 at $s_m = 1$ or R_2 at $s_m = 0$, respectively.

[13] A detailed derivation of the cost-of-living indices is conducted in Appendix 5.9.

5.4.1 Stage 2 - Periphery's decision

We begin with periphery's choice of z_2. Upstream capital owners earn an (after subsidies) agglomeration rent, $\hat{\Omega} \equiv (z_1 - z_2) + \Omega$, where Ω is denoted in (26). If periphery's regional policy program is to attract the target industry it must offer a subsidy payment which is high enough to make each upstream capitalist indifferent between employing her capital in region 1 or 2 given that the rest of upstream capital remains in region 1. Formally, this critical subsidy level is derived setting $\hat{\Omega} = 0$ and solving for z_2 which yields $\underline{z_2} = z_1 + \Omega$. Hence, to induce a delocation of upstream firms periphery must pay a subsidy high enough to compensate upstream capitalists for the agglomeration rent prevailing in the core plus the subsidy payment which is offered by the core government.

Proposition 2. *Tighter production linkages increase periphery's cost of attracting the cluster ('Rent-increasing effect of linkages')*

$$\frac{\partial \underline{z_2}}{\partial \eta} = \frac{\partial \Omega}{\partial \eta} = \gamma \left[s_m^c (1+\phi) + \eta(1+\phi) \frac{\partial s_m^c}{\partial \eta} \right] \geq 0 \qquad (35)$$

with $\gamma \equiv \frac{3\alpha(\sigma-1)(1-\phi)}{\phi\sigma^2} > 0$.

Proof. See Appendix 5.10.1. ■

Consequently, stronger interindustry linkages stabilize an existing agglomeration which makes it more costly for a challenging periphery to snatch the industry core.

Aside from the subsidy level that periphery has to offer at least in order to persuade upstream capitalists to invest in the region, we need to know how much periphery is actually willing to pay for the industry cluster. Intuitively, periphery will increase her subsidy offer as long as residents' welfare after successfully attracting the industry core is higher than welfare without the cluster. Note that periphery's upstream capitalists benefit from a subsidy paid by the foreign government due to the repatriation of capital income and the residency based financing scheme. Inserting capital owners' income y_H, and y_K into (33),(34) and solving $W_2^C = W_2^P$ for z_2 yields the threshold level of z_2 at which periphery is no longer willing to attract the agglomeration.

$$\overline{z_2} = -\frac{(1-s_h)}{s_h} z_1 - \frac{\alpha\mu_2}{s_h} \ln\left(\frac{P_2^C}{P_2^P}\right) \tag{36}$$

$\overline{z_2}$ will be lower the higher the foregone subsidy payment z_1 that periphery's upstream capitalists have to incur in case her government decides to attract the cluster. It will be higher the larger the potential gain from saving on transport costs on imported final goods since a side effect of attracting the agglomeration is a relocation of downstream firms towards the new core.[14] The latter effect will be amplified with rising interindustry linkages which is summarized in Proposition 3.

Proposition 3. *Stronger linkages increase the attractiveness of hosting the industry cluster for the periphery ('Cost-of-living effect').*

$$\frac{\partial \overline{z_2}}{\partial \eta} = -\frac{\alpha\mu_2}{s_h}\left[\frac{\partial P_2^C}{\partial \eta}(P_2^C)^{-1} - \frac{\partial P_2^P}{\partial \eta}(P_2^P)^{-1}\right] \geq 0 \tag{37}$$

Proof. See Appendix 5.10.2. ■

Proposition 3 is not confined to the periphery but applies equally to residents in the core region. To confirm that the industry cluster becomes more attractive with stronger vertical production linkages for core residents we derive the threshold level of core's willingness to retain the agglomeration analogously to $\overline{z_2}$ by solving $W_1^C = W_1^P$ for $\overline{z_1}$. By symmetry of the model, core's willingness to hold on to the cluster increases with an increase in vertical production linkages, $\frac{\partial \overline{z_1}}{\partial \eta} \geq 0$. This result emphasizes a

[14]Appendix 5.9 shows that $\ln\left(\frac{P_2^C}{P_2^P}\right) < 0$.

notable difference to the model employed in Kind et al. (2000). In a model with horizontal production linkages as outlined in Kind et al. (2000), industrial varieties are used for private consumption but also enter as intermediate inputs in the production of the industrial good. Consequently, the share which industrial varieties take on in the production of the final industrial good (in our model denoted as η) next to labor also determines the degree to which varieties enter private consumption. It follows that a larger intensity of production linkages lowers the share of industrial varieties in household's consumption basket. As a result, hosting an industrial cluster becomes less attractive to a region with increasing input-output linkages as the output of this sector then denotes only a small share in private consumption.

Hence, whereas the attractiveness of holding an agglomeration declines with stronger production linkages in Kind et al. (2000) it increases in our model for both, the core and the periphery. Stronger production linkages affect consumer prices of final good varieties since downstream firms are reliant on intermediate goods varieties. Holding the industrial core is therefore associated with lower consumer prices for residents of the core as they benefit from savings in direct transport costs of the final good since the core holds a larger share of final goods industry. Secondly, final goods producers save on transport costs when purchasing intermediate varieties and will therefore charge lower consumer prices.

5.4.2 Stage 1 - Core's decision

At the first stage of the subsidy game the government of the core region foresees the implications of her choice on the periphery's choice in the second stage. Core decides according to the decision rule

$$z_1 = \begin{cases} \hat{z}_1 & \text{if} \quad W_1^C(\hat{z}_1) \geq W_1^P(\underline{z_2}), \\ \hat{z}_1 - \delta & \text{otherwise.} \end{cases}$$

where δ is some small but positive number. If core decides to retain the agglomeration she has to set a subsidy level at which inducing a relocation of upstream firms becomes too costly for the periphery. Solving $\underline{z_2} = \overline{z_2}$ for z_1 yields the level of subsidy payment at which core ensures that the industry cluster stays in the region

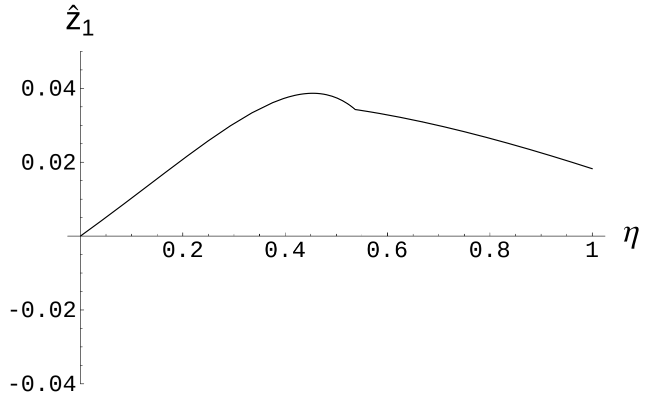
$$\hat{z_1} = -\mu_2 \alpha \ln\left(\frac{P_2^C}{P_2^P}\right) - s_h \Omega \tag{38}$$

The subsidy level necessary to prevent a delocation will be higher if periphery faces a large potential benefit from attracting the core. A large agglomeration rent reduces core's cost of preventing a delocation. If core is not interested in holding on to the industry cluster it simply offers a subsidy level marginally below $\hat{z}_1$. This ensures that periphery can profitably attract all industry while core's upstream capitalists benefit from high subsidy payments financed by residents of the periphery. As only capital is mobile while its owners reside in the region of residence, repatriation of capital income benefits region 1's upstream capitalists.

Inspection of the critical subsidy levels $\underline{z_2}$ and $\overline{z_2}$ unveiled two opposing effects of higher input-output linkages which influences core's choice of subsidy payment in (38). On the one hand, stronger linkages stabilize the agglomeration rent Ω which lowers core's cost of retaining all industry. On the other hand, stronger linkages also promise higher benefits from holding the core which increases periphery's threshold level up to which she will make an offer to upstream capitalists. Figure 5.3 depicts $\hat{z}_1$ evaluated at $\phi = \phi^B$ for parameter values $\alpha = 0.3; \sigma = 4; \mu 2 = 3/2; s_h = 1/2$.

Figure 5.3 illustrates that slightly altering the underlying model by assuming vertical instead of horizontal linkages affects the interpretation and direction of subsidy levels. Contrary to earlier work by Kind et al. (2000) where the taxing capacity increases monotonically with increasing production linkages, the subsidy cost (taxing capacity) of retaining the core in the current model increase (decreases) for weak production linkages and only decrease (increase) when vertical linkages between both sectors become sufficiently strong.

Figure 5.3: Core's subsidy necessary to defend industry core



The equilibrium outcome of the game is summarized in Proposition 4.

Proposition 4 *(Equilibrium outcome) Core retains all industry and sets* $z_1 = \hat{z}_1$ *which increases periphery's cost of attracting upstream firms to the level where* $\underline{z_2} = \overline{z_2}$.

$$W_1^C(\hat{z}_1) - W_1^P(\underline{z_2}) \geq 0. \tag{39}$$

Proof. See Appendix 5.10.3. ■

Proposition 4 states that a welfare maximizing government of a periphery abstains from offering funds to upstream capitalists as the underlying financing costs would make her residents, particularly worker households and downstream capital owners who do not belong to the subsidy recipients, worse off. To trigger a delocation of the key industry periphery would have to offer a subsidy level which exceeds her threshold level $\overline{z_2}$ as soon as core chooses to set $\hat{z}_1$. Moreover, although upstream firms will not relocate, maintaining the industry cluster becomes less attractive if subsidies accrue to capital owners abroad. Global welfare remains unaffected as subsidies are distributed in a lump-sum fashion. Compared to the welfare level prior to the subsidy competition game, core residents experience an overall welfare decline whereas periphery residents benefit from subsidy payments financed by core residents.[15] Welfare of core's upstream capital owners increases whereas core's workers and downstream capitalists are worse off compared to a situation without any subsidies.

The outcome of the subsidy game highlights an often postulated concern that regional policy programs targeted at one specific industry do not affect the allocation of industry as intended and are associated with high financing costs for the core region. These are mainly borne by non-recipients whereas capitalists of the subsidized industry benefit from the distribution of subsidy payments irrespective of the region of residence.

5.5 Conclusion

This paper recognizes the recent shift in several national industrial policy strategies as outlined in the latest OECD report on regional policies (OECD (2007)). We consider a cluster strategy where public funds are distributed to firms of an industry of which local authorities believe that it fosters an ongoing agglomeration process attracting further establishments of related industries. Welfare maximizing governments compete for firms of this core industry as attracting the core industry is associated with higher regional welfare. The underlying model differs from earlier work by Kind et al. (2000) who similarly deal with questions of interjurisdictional competition in the presence of agglomeration economies. We employ a vertical linkage model with final and intermediate goods producers and account for the stylized fact that cost linkages are an important source of agglomeration. Altering the assumptions on the production structure of the model in this way has implications for the tax competition game. More precisely, the taxing capacity of a region hosting an industrial agglomeration no longer monotonically increases with increasing cost linkages but depends on the level of initial input-output linkages. The equilibrium outcome of the subsidy game reveals that a welfare maximizing periphery will abstain from attracting an industrial core as the fi-

[15] The exact amount to which core residents lose compared to a situation without subsides is $(1 - s_h)z_h^*$, i.e. the amount that accrues to foreign subsidy recipients which is financed by domestic core residents.

nancing costs exceed the benefits of attracting a core industry. Whereas the allocation of economic activity remains unchanged, core residents suffer from financing subsidy payments that are necessary to prevent a relocation of industry. Except for capital owners of the subsidized industry, residents of the industrial core will suffer from the distribution of sector specific subsidies.

Appendix

5.6 Locational forces of the model

5.6.1 Final goods sector

Cost-linkage effect

Given symmetric region size downstream firms will agglomerate indirectly due to cost linkages. Indirect because the concentration of M-firms depends on the number of upstream firms in a region. Selling in the region with a high number of upstream firms lowers the cost of purchasing intermediates. Formally,

$$\left.\frac{\partial(R_1 - R_2)}{\partial s_n}\right|_{s_m=s_n=1/2} = \frac{\partial(R_1 - R_2)}{\partial \chi}\frac{\partial \chi}{\partial s_n} = \frac{48\alpha\eta(1-\phi)\phi}{\sigma(1+\phi)^3} \geq 0. \tag{A.1}$$

Downstream local competition effect

On the other hand the local competition effect deters firms to produce in a region with many competitors.

$$\left.\frac{\partial(R_1 - R_2)}{\partial s_m}\right|_{s_m=s_n1/2} = -\frac{12\alpha(\phi-1)^2}{\sigma(1+\phi)^2} < 0. \tag{A.2}$$

5.6.2 Intermediate goods sector

Demand linkage effect

Demand linkages in the upstream industry support the agglomeration of suppliers in one region. The intensity of demand linkages depends on the share of intermediates denoted as η that enter the variable cost of a downstream firm. Inspecting the expression for s_m reveals that it depends on the share of upstream industry as well as exogenous parameters. Holding the market competition constant we insert the expression for R_i, $i \in \{1,2\}$ and s_m into the upstream capital reward differential and differentiate with respect to s_n. This yields the isolated demand linkage effect

$$\left.\frac{\partial(r_1 - r_2)}{\partial s_n}\right|_{s_n=1/2} = \frac{48\alpha\eta^2(\sigma-1)\phi}{(1+\phi)^2\sigma^2} \geq 0 \tag{A.3}$$

The demand linkage effect is positive but decreasing in the level of trade freeness as location becomes less important with ongoing economic integration. The second order derivative reads

$$\left.\frac{\partial^2(r_1 - r_2)}{\partial s_n \partial\phi}\right|_{s_n=1/2} = \frac{96\alpha\eta^2(\sigma-1)(\phi-2)}{(1+\phi)^4\sigma^2} < 0 \tag{A.4}$$

Upstream local competition effect

The local competition effect for upstream firms is derived similarly to above. Holding the demand linkage effect constant it can be expressed as

$$\left.\frac{\partial(r_1 - r_2)}{\partial s_n}\right|_{s_n=1/2} = -\frac{12\alpha\eta(\phi-1)^2(1+\phi(2-4\eta+\phi))(\sigma-1)}{(1+\phi)^4\sigma^2} \leq 0. \tag{A.5}$$

5.7 Proof of Proposition 1

As $\partial^2(r_1-r_2)/\partial s_n^2 = 0$ and $\partial^3(r_1-r_2)/\partial s_n^3 > 0$ at the symmetric equilibrium $s_n = 1/2$ and $\phi = \phi^B$ with

$$\frac{\partial^3(r_1 - r_2)}{\partial s_n^3} = \frac{96\alpha\eta^3(1+2\eta)(\sigma-1)}{(1+\eta)\sigma^2}$$

the formal conditions for a subcritical pitchfork diagram are fulfilled which implies that partial equilibria such as $0 < s_n < 1/2$ and $1/2 < s_n < 1$ are unstable equilibria (Grandmont (2008), pp.33.). ■

5.8 Derivation of ϕ^B

To derive the level of trade freeness at which the slope of the capital reward gap curve is just zero, i.e. where agglomeration and dispersion force do just offset each other, we insert the expression for R_1 and R_2 using (12) and (13) as well as s_m using (23) into (21) and (22) and partially differentiate $(r_1 - r_2)$ with respect to the share of upstream firms s_n and evaluate at the symmetric equilibrium. This yields

$$\left.\frac{\partial(r_1 - r_2)}{\partial s_n}\right|_{s_n=1/2} = \frac{12\alpha\eta(\sigma-1)[\phi(2+4\eta-\phi)-1]}{(1+\phi)^2\sigma^2} \tag{A.6}$$

Note that this expression is simply the sum of the market crowding and the demand linkage effect derived above. Solving (A.6) for ϕ yields the break point expressed in (24).

5.9 Cost-of-living indices

The producer price indices for region 1 and 2 read

$$P_{x1} = \left[s_n + \phi(1-s_n)\right]^{\frac{1}{1-\sigma}} \qquad P_{x2} = \left[(1-s_n) + \phi s_n\right]^{\frac{1}{1-\sigma}} \tag{A.7}$$

Noting that $P^C_{xi} = 1$ and $P = P^P_{xi} = \phi^{\frac{1}{1-\sigma}}$, the cost-of-living-indices for final goods for both possible states (core and periphery) read

$$P^C_1 = [s^c_m + (1-s^c_m)\phi P^{\eta(1-\sigma)}]^{\frac{1}{1-\sigma}}, \quad P^P_1 = [s^p_m P^{\eta(1-\sigma)} + (1-s^p_m)\phi]^{\frac{1}{1-\sigma}}, \tag{A.8}$$

$$P^C_2 = [(1-s^p_m) + s^p_m \phi P^{\eta(1-\sigma)}]^{\frac{1}{1-\sigma}}, \quad P^P_2 = [(1-s^c_m)P^{\eta(1-\sigma)} + s^c_m\phi]^{\frac{1}{1-\sigma}}. \tag{A.9}$$

To prove that $\ln\left(\frac{P^C_2}{P^P_2}\right) < 0$ we use the fact that $s^c_m = 1 - s^p_m$ (for equal overall market size). Consequently, $P^C_1 = P^C_2$ and $P^P_1 = P^P_2$. To show that $P^C_1 < P^P_1$ it must be true that

$$s_m^c + (1 - s_m^c)\phi P^{\eta(1-\sigma)} > (1 - s_m^c)P^{\eta(1-\sigma)} + s_m^c\phi \tag{A.10}$$

which after some rearrangements and inserting $P = \phi^{\frac{1}{1-\sigma}}$ can be written as

$$s_m^c - (1 - s_m^c)\phi^\eta$$

This expression is positive since $s_m^c > (1-s_m^c)$ due to (25) and $\phi^\eta < 1$ for our parameter specifications.

5.10 Proofs

5.10.1 Proof of Proposition 2

Partially differentiating s_m^c with respect to η yields

$$\frac{\partial s_m^c}{\partial \eta} = \frac{1}{2}P_{x2}^{\eta(1-\sigma)}(1-\sigma)\phi \ln P_{x2}\left(-\frac{1}{(P_{x2}^{\eta(1-\sigma)} - \phi)^2} - \frac{1}{(\phi P_{x2}^{\eta(1-\sigma)} - 1)^2}\right) > 0 \tag{A.11}$$

which is positive since $\sigma > 1$. ■

5.10.2 Proof of Proposition 3

To prove that $\frac{\partial P_2^C}{\partial \eta}$ is non-negative it must be true that $\frac{\partial P_2^C}{\partial \eta} \leq 0$ and $\frac{\partial P_2^P}{\partial \eta} \geq 0$. We begin with the first expression

$$\frac{\partial P_2^C}{\partial \eta} = \frac{1}{1-\sigma}(P_2^C)^\sigma \left(\frac{\partial s_m^c}{\partial \eta}(1 - \phi^{1+\eta}) + (1 - s_m^c)\phi^{1+\eta}\ln\phi\right) \tag{A.12}$$

Increasing vertical production linkages will have no effect on the consumer price index for the case where $s_m^c = 1$. In this case it follows $\frac{\partial s_m^c}{\partial \eta} = 0$ and $\frac{\partial P_2^C}{\partial \eta} = 0$. For the case of an interior stable equilibrium of downstream industry, $\frac{1}{2} < s_m^c < 1$ we insert the expression for $\frac{\partial s_m^c}{\partial \eta}$ from (A.11) which yields

$$\frac{\partial P_2^C}{\partial \eta} = \frac{1}{1-\sigma}\left(\frac{\phi^{1+\eta}(\phi^2-1)}{2(\phi-\phi^\eta)^2}(P_2^C)^\sigma \ln\phi\right) \tag{A.13}$$

This expression is unambiguously negative since $0 < \phi, \eta < 1$ and $\sigma > 1$. The benefit from a lower cost-of-living index therefore increases with stronger production linkages. It remains to be shown that $\frac{\partial P_2^P}{\partial \eta} \geq 0$.

$$\frac{\partial P_2^P}{\partial \eta} = \frac{1}{1-\sigma}(P_2^P)^\sigma\left((1-s_m^c)\phi^\eta \ln\phi - \frac{\partial s_m^c}{\partial \eta}(\phi^\eta - \phi)\right) \geq 0 \tag{A.14}$$

This expression is non-negative for $\sigma > 1$ since $\frac{\partial s_m^c}{\partial \eta} \geq 0$ and $(\phi^\eta - \phi) > 0$. ■

5.10.3 Proof of Proposition 4

Inserting $\hat{z}_1$ and $\underline{z_2}(\hat{z}_1 - \delta)$ into $W_1^P(z_1)$ and $W_1^P(z_2)$ yields

$$\begin{aligned} W_1^C(\hat{z}_1) - W_1^P(\underline{z_2}) &= s_h\delta - \mu_1\alpha\ln\left(\frac{P_1^C}{P_1^P}\right) + \mu_2\alpha\ln\left(\frac{P_2^C}{P_2^P}\right) \\ &= s_h\delta > 0, \end{aligned} \tag{A.15}$$

since $P_1^C = P_2^C$ and $P_1^P = P_2^P$ and $\mu_1 = \mu_2$. ■

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