Diversified Specialisation – Going One Step Beyond Regional Economics' Specialisation-Diversification Concept

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Abstract

Usually, in economic theory a distinction is made between specialisation and diversification, when characterising the sector structure of an economy. A specialised structure generates localisation advantages and MAR(Marshall-Arrow-Romer) externalities, while urbanisation economies and Jacobs externalities predominate in a diversified environment. In this study, the dichotomy specialisation/diversification is expanded by introducing the concept of diversified specialisation. Cities specialising in several sectors profit from both, MAR as well as Jacobs externalities. In contrast to diversified cities, diversified-specialised cities tend to be smaller and thereby benefit from lower congestion and production costs. As against specialised cities, their advantage lies in a comparatively diversified sector structure which fosters cross-sectoral spillovers and lessens the impact of sector-specific demand shocks on the regional economy. In the present study, an index for the degree of diversified specialisation is proposed and the impact of the regional sector structure on economic growth is assessed empirically by means of regression analyses. A panel data set comprising information on all 118 German kreisfreie Städte (i.e. cities enjoying county status) from 1998 up to 2008 (depending on the respective model setup) is employed. Evidence is found on the positive effects of diversified specialisation on regional economic performance.

1. Introduction

In regional economics, studies inquiring into the consequences of static and dynamic agglomeration effects on regional economic outcomes look back on a long tradition. Yet, a straightforward answer as to whether regional specialisation and MAR externalities (Marshall 1920 (orig. 1890); Arrow 1962; Romer 1986) or a diversified economic structure and Jacobs externalities (Jacobs 1969) foster economic well-being and growth, is still missing. There are several reasons for the lack of clear-cut evidence on this issue, e.g. the differing designs of empirical investigations. Mostly, the analysed regions and sectors vary from one study to another, and different indices for capturing the degree of local specialisation or diversification, as well as variables measuring regional economic growth are employed. This study stands out from the previous literature in that it distinguishes different types of specialisation. The conventional dichotomy “specialised vs. diversified” is expanded by introducing the concept of diversified specialisation. Diversified-specialised cities specialise in a few sectors, whereas conventional specialisation refers to the focus on one single sector.

This study is founded on the thesis that diversified-specialised cities are more productive and experience higher productivity growth rates than merely specialised or diversified cities. There are relatively strong MAR externalities which are complemented by Jacobs externalities. Thus, diversified-specialised cities combine the benefits from higher productivity owed to specialisation with the advantages of a diversified structure, such as cross-fertilisation amongst the sectors a city is specialised in. These theses are confirmed by the empirical results.

Following a review of the relevant literature in part 2, the theoretical argument in favour of diversified specialisation is provided in chapter 3. In chapter 4, the choice of variables for the empirical analysis is explained and the methodological procedure is set out. The theses are tested empirically in chapter 5. The first section of part 5 is dedicated to the static analysis and examines whether the agglomeration of one single sector or rather of several different sectors is more conducive to urban productivity levels. In section two of part 5, the same analysis is carried out for dynamic variables such as employment and productivity growth. Chapter 6 provides a short summary of the results and compares them to the outcomes of previous studies.

2. Emprical Notes on the Link between Sector Structure and Growth in Cities

There are numerous studies inquiring into the interplay, or let us say the correlation, between sector structure and regional economic growth. Most studies find, employment growth rates are higher in regions with a diversified sector structure (e.g. Glaeser et al. 1992, Combes et al. 2004, Frenken et al. 2007 and Blien et al. 2006), whereas productivity growth rates are higher in rather specialised cities (e.g. Henderson et al. 1995, Capello 2002, Cingano/Schivardi 2004, Mukkala 2004).

Empirically, a co-existence of diversified and specialised cities is to be observed (e.g. Duranton and Puga 2000 and 2001 and Neffke et al. 2011). Therefore, it is to be assumed that both structures pose a favourable context for a specific environment, i.e. firms belonging to a certain sector, labour force or consumers.

In specialised cities, MAR externalities which emanate from the concentration of firms of one and the same sector are relatively strong. These cities offer a specialised labour pool, sector-specific infrastructure and proximity to upstream and downstream firms (Marshall 1920 (orig.: 1890)). These assets lead to the assumption of specialised cities being more productive and showing higher productivity growth rates than diversified cities thanks to MAR externalities. Since specialised cities are in general smaller (Duranton and Puga 2000 p. 536), they exhibit lower crowding costs. Due to lower costs of living, wages are lower in smaller cities (Neffke et al. 2011 p. 50 f). This could be conducive to employment growth. On the other hand, specialised cities are dominated by mature industries (Duranton and Puga 2001 p. 1455) and knowledge spillovers occur within sectors. If process innovations occur, they may lead to employment losses if a city is specialised in mature sectors which are at the end of their life cycle and are confronted with an inelastic goods demand. In this case, lower production costs do result in lower prices for goods, but the demand for goods and labour demand rise only slightly because of the low price-elasticity of goods demand. Therefore, the labour-saving effect prompted by the process innovation cannot be fully compensated by the increase in labour demand due to rising goods demand (Schettkat 1997 p. 723 ff). Furthermore, the development of a mono structure poses a certain risk for a region (Haug 2004 p. 178). If a region is only specialising in one sector and this very sector is hit by a negative demand shock, this might lead to high losses of employment depending on the elasticity of goods and labour demand. According to the portfolio theory, a diversified economic structure is preferable, because sector-specific demand shocks can be better absorbed in such a surrounding (Frenken et al. 2007 especially p. 686 und 696). Due to the dependence of employment growth on wage levels, product cycles and local sector structure (portfolio) as well as many other factors, no straightforward prediction with regard to employment growth in specialised cities can be made.

While strong MAR externalities are generated in specialised cities by focussing on one sector, they only become effective to a limited extent in diversified cities with smaller sectors. Therefore, productivity is expected to be lower in the latter. Jacobs externalities which arise from a manifold sector structure dominate in diversified regions. There, firms benefit from so-called cross-fertilisation. The interplay of firms belonging to different sectors often leads to the combination of ideas through knowledge spillovers by means of which product innovations are generated (Feldman and Audretsch 1999 p. 421 ff). Product innovations may increase employment levels, provided that new products are introduced (additive product innovations) or already available goods undergo such substantial variations that demand moves back in the elastic part of the demand curve (Schettkat 1997 p. 725). In addition, mostly young, innovative sectors in search of the best production process locate in diversified cities (Duranton and Puga 2001 p. 1455 and 1463 ff). These sectors are commonly confronted with an elastic product demand curve, since their products have not reached maturity yet. Consequently, a rise in productivity leads to rising labour demand and employment levels (Schettkat 1997 p. 715). Diversified cities, though, have the drawback of generally being larger than specialised ones (Duranton and Puga 2000 p. 536; Einig and Zaspel 2008 p. 409) and, therefore, production costs tend to be higher in the former. As a result, there are no straightforward expectations regarding employment growth rates in diversified cities, either. Nevertheless, following the reasoning of the portfolio theory, lower variations in employment levels are to be expected as sector-specific demand shocks can be absorbed more easily and result in smaller employment adjustments.

One major weakness is inherent to the dichotomy of specialisation/diversification: Cities are only classified into specialised and diversified ones; other possible sector structures are left aside. This is why, in the present paper, different intensities of specialisation are considered. We name specialisation in more than one, i.e. a few, sectors diversified specialisation. This concept has already been taken up in several studies. Up to now, though, no index for measuring the degree of diversified specialisation has been proposed, and the link between diversified specialisation and economic growth has not been explicitly analysed. Previous studies have only drawn conclusions for a "conducive" sector structure from results on diversification and specialisation.

Referring to Doeringer and Terkla (1995), Dissart (2003) analyses the connection between diversification and a stable regional economy. He argues in favour of promoting more than one branch in a region in order to reduce the risks commonly associated with a mono structure. Consequently, a region should show a diversified structure which combines the productivity advantages generated in each agglomerated branch with a higher shock-resistance of the region (Dissart 2003 p. 438 f). Einig and Zaspel (2008) illustrate the assets of pursuing several specialisations over a very diversified sectoral structure in cities. Sectors of roughly the same size raise average firm size as well as the number of firms. According to Combes et al. (2004 p. 219), spillovers occur across sectors but do not spread out over all sectors. By means of their co-agglomeration index, Ellison and Glaeser (1997 p. 897 ff) show that mainly upstream and downstream industries co-locate. This indicates that sectors benefit from the specialisation of cities in other sectors as well. A region specialising in a certain combination of related sectors is likely to experience higher growth rates than a region specialising in an unrelated portfolio or in one sector only (Frenken et al. 2007 p. 688). Therefore, it has a positive effect on regions to specialise in a few sectors of roughly the same size (Combes et al. 2004 p. 237).

3. The Concept of Diversified Specialisation

Many cities exhibit multiple specialisations, but – apart from specialisation in a few sectors – they show a diversified structure at the same time. Whether those cities are considered to be specialised or diversified is often up to the researcher or the employed indices of specialisation/diversification. Particularly this diversified-specialised structure is of special interest in the present study. In what follows, cities which specialise in a few sectors but are diversified apart from that, are called diversified-specialised.

In diversified cities, companies may benefit from Jacobs externalities. These externalities emanate from a diversified surrounding as new ideas may be generated via knowledge spillovers between different sectors. Jacobs externalities promote product innovations (Feldman and Audretsch 1999 p. 421 ff), as ideas and production processes from different sectors may be combined, leading to the creation of new products. Furthermore, in diversified cities, many different production processes are at work. This is especially helpful for companies in younger sectors still in search of the ideal production process, as it is easier for them to produce prototypes using different technologies in order to find out which production process suits best. Above all, there are many nearby experts in different technologies on whose knowledge they can draw or whom they may cooperate with.

As soon as sectors have found their optimal production process, they benefit from a diverse surrounding only to a lesser extent. Therefore, it may pay off to resettle from a diversified to a specialised city. Firstly, specialised cities tend to be smaller than diversified cities (Duranton and Puga 2000), which is why crowding costs are usually lower in specialised cities, and firms may save on costs in moving. Secondly, MAR externalities gain in importance to firms that have already found their best production process. With MAR externalities, cost-lowering process innovations become more likely, since firms in specialised cities share almost the same knowledge base. This is why MAR externalities boost productivity which, for instance, shows up in the increased number of process innovations (Schettkat 1997 p. 725). Firms may, for example, have an incentive to run research co-operations, fostering the development of the technology jointly used with others. These process innovations may even further lower production costs in specialised cities.

The distinct advantage of diversified-specialised cities is that firms in those cities profit from both MAR and Jacobs externalities. Thus, higher productivity levels and higher productivity growth rates than in diversified and even specialised cities can be realised. Companies benefit from the proximity to upstream and downstream firms, as emphasized in the current debate on the advantageousness of clusters (see e.g. Porter 2000). Moreover, firms profit from tailored infrastructure and a qualified specialised labour pool. Besides, a (limited) variety of sectors generates cross-fertilisation and higher productivity growth rates than in specialised cities. In diversified-specialised cities, spillovers can said to be "co-ordinated", as they occur between related sectors. Related sectors often share the same knowledge base, which is why innovations in one sector may at the same time be beneficial to the other sectors clustered in that very city (Frenken et al. 2004 p. 12). For example, firms in supplier-buyer relationships can benefit from local knowledge spillovers and optimise their respective production processes via the mutual exchange of knowledge. In addition, knowledge is codified in a similar manner, thereby simplifying the exchange of knowledge between sectors.1 As a consequence, the flow of knowledge is boosted, leading to innovations and productivity growth. A further advantage of diversified-specialised cities is that the benefits of specialisation can be enjoyed while, at the same time, the risks going along with a crisis-prone mono-structure are mitigated. However, assumptions can be made concerning employment growth rates. In diversified-specialised cities, the amount of knowledge that spills over increases if related sectors are concentrated. These co-ordinated Jacobs externalities promote product innovations (Feldman and Audretsch 1999 p. 421 ff) and, therefore, employment

[1] For a deeper discussion see Desrochers and Leppälä (2011).

growth. Following Schumpeter's argument, this provides the possibility for sectors which have already passed the maturity phase of their products' life cycle to renew themselves and avoid a decline in employment. In contrast, there may also be negative effects on employment growth due to specialisation: If mature sectors agglomerate, they can profit from local MAR externalities (Duranton and Puga 2000 and 2001) but as a result of an increasingly inelastic goods demand with regard to mature sectors, negative employment effects may be caused by rises in productivity (Schettkat 1997 725). However, caution should be applied when linking expectations on employment growth rates to a certain sector structure, since the connection between labour demand and changes in productivity is of an indirect nature only. Whether labour demand rises, falls or remains constant upon a rise in productivity levels crucially depends on the price elasticity of the respective sector's goods demand (Schettkat 1997 725). Furthermore, labour demand is influenced by uncountable other factors like the thrust of exogenous economic shocks, economic growth (Schmid 2000 11) and the globalisation process (Katz and Autor 1999, Card and DiNardo 2002, Acemoglu 2002). This is why diversified-specialised cities may – but do not necessarily have to – show higher employment growth rates than specialised and diversified cities.

4. Data and Variables

Our data set comprises data from the German Federal Employment Agency, the Federal Statistical Office and the German Patent and Trade Mark Office for all 118 kreisfreie Städte in Germany from 1998 up to 2008.

In this study, like in de Vor and de Groot (2010 p. 413), it is postulated that every kreisfreie Stadt is a closed system which is not influenced by any spillover effects of neighbouring districts. This approach is supported by the study of Duranton and Overman (2005). The results of Jaffe et al. (1993) and Henderson (2007) also point out that externalities are of limited spatial reach.

Data from the Federal Employment Agency on employees subject to social insurance contribution, classified according to 222 3-digit sectors of the 2003 classification system (WZ03), is employed to calculate indices of regional specialisation/diversification. Different studies use a huge variety of indices for measuring regional specialisation. The present work follows Krugman (1991 p. 57 f), Midelfart et al. (2004), Glaeser et al. (1992), Duranton and Puga (2000), and de Vor and de Groot (2010).

Like in Duranton and Puga (2000 p. 535) and de Vor and de Groot (2010), diversification of city j is measured with the help of the Relative Diversity Index (RDI), which is similar to the inverse of the Herfindahl- and Krugman-Specialisation-Index:

$$RDI_j = \frac{1}{\sum_{i=1}^{222} |s_{ij} - s_i|}$$

$$with\ s_{ij} = \frac{E_{ij}}{E_j}\ and\ s_i = \frac{E_i}{E},$$

where E_{ij} is the employment in sector *i* in city *j* and E_j is the total employment in city *j*. In analogy to this, *E* is the total national employment and E_i the national sector employment in sector *i*. The greater the value of *RDI*, the more diversified is city *j*. A city is considered to be diversified, if its sector structure deviates only slightly from the structure of Germany as a whole. That means that diversification is assessed relative to the national average.

For measuring specialisation, the *Krugman Index for Specialisation* (*KSI*) is computed:

$$KSI_j = \sum_{i=1}^{222} |s_{ij} - \bar{s}_{ij}|$$

where $\bar{s}_{ij}$ is the average of s_{ij} over all cities apart from the one considered. See for example Farhauer and Kröll (2010 p. 446) for a detailed treatment of the *KSI*.

The Krugman Index of Specialisation is standardised on values between 0 and 2. The higher the value, the stronger a city is specialised. For this index, no specific threshold values have been set to assess diversification and specialisation. Nevertheless, it is important to distinguish between different forms and varying strength of specialisation. That is why three more measures for specialisation are computed. They provide information on the strength of specialisation in the absolutely biggest, as well as in the three and the five biggest sectors of a city. Specialisation in the biggest sector is measured with the *Specialisation Index* (*ZI*) proposed by Duranton and Puga (2000 p. 534):

$$ZI_j = \max(s_{ij})$$

Duranton and Puga (2000 p. 534) divide s_{ij} by s_i in order to take into account the different sizes of sectors on a nationwide level. This is where the Relative Specialisation Index (RZI) is derived from. This step is left out in the previous setting because our focus lies on the absolute, not relative, specialisation of cities.[2]

Since neither *RDI*, *KSI* nor *ZI* are scaled, it is impossible to set a threshold value for diversification or specialisation. Hence, it is also impossible to define a range of values for those indices, within which a city shows diversified specialisation. That shows the necessity of introducing a further index to measure the extent of diversified specialisation. Following Glaeser et al. (1992), who measure diversity in a similar manner, we operationalise diversified specialisation as the cumulated share of the x largest sectors in total city employment. In the following, this will be the share the three largest sectors have in total regional employment (*ANT3G*). As picking the three largest sectors may seem to be arbitrary, we show that the results do not change importantly, if the share of the five largest sectors (*ANT5G*) is considered instead. Our aim is not to identify the optimum number of sectors in a city, but to simply point out that a specialised mix of sectors can be conducive to city growth. However, the share of the three largest sectors correlates stronger with the dependent variable in every single case and, thus, is preferred as an index for diversified specialisation. Diversified specialisation is all the stronger, the higher the value of *ANT3G* or *ANT5G* respectively.

$$ANT3G_j = \frac{E_{ij\,max} + E_{ij\,max-1} + E_{ij\,max\,-2}}{E_j} * 100$$

$$ANT5G_j = \frac{E_{ij\,max} + E_{ij\,max-1} + E_{ij\,max\,-2} + E_{ij\,max-3} + E_{ij\,max-4}}{E_j} * 100$$

One could argue, as Beaudry and Schiffauerova (2009) do, that the importance of MAR externalities is overestimated when using data at the 3-digit level, since intersectoral spillovers between subsectors of a 3-digit sector are measured as MAR rather than as Jacobs externalities. Therefore, the results in section 5 should be interpreted with this at the back of one’s mind.

For every kreisfreie Stadt in Germany, we use data from the Federal Statistical Office on gross value added and gross national product for the time period 1998-2007. With this data, a partial productivity measure for operationalising productivity is constructed. For using a multifactorial productivity measure such as total factor productivity (TFP), with which the influence of various production factors on productivity could be isolated (OECD 2001 p. 20),

[2] When using *RZI* instead of *ZI*, distortions may arise; e.g. a city having a large employment share in a nationwide small branch could have a higher value of *RZI* than a city in which the majority of citizens work in a sector with high total national employment – even though the latter is much more specialised. Regional concentration of a sector would be confused with specialisation. This problem is evaded when using the *ZI*.

data on the capital stock for the kreisfreie Städte (NUTS 3-level) would be needed. Since this data is only available on NUTS 2-level, a partial productivity measure – labour productivity – is computed following Sveikauskas (1975), Partridge and Rickman (1999), Capello (2002) and Mukkala (2004). Apart from indicating the capacity and effort of a worker, labour productivity also reflects the efficiency of resource allocation, e.g. capital on the labour force, as well as technological progress (OECD 2001 p. 14 f and 20). A higher capital stock per employee and technological progress therefore show up as a rise in labour productivity. What is more, Ciccone and Hall (1996) note that differences in capital stocks only account for small differences in productivity levels in the USA. The present paper aims at estimating the impact of the sector structure on productivity, not at isolating the impact of various production factors on productivity. Thus, using labour productivity as an operationalisation for productivity seems to be perfectly justified.

Partridge and Rickman (1999 p. 321) take account of business cycles and long-term nationwide trends in productivity growth in the USA by dividing state labour productivity by the same for the whole country. Along with this, there goes a problem which can be illustrated with the help of a simple example: Given the national growth rate of labour productivity equalling 5% and the growth rate of any state amounting to 1%, the resulting coefficient (0.2) indicates that the respective state has developed worse than the reference region. If the national growth rate is -5% and the regional figure reaches -1%, the resulting coefficient is the same, namely 0.2, although the considered region experiences a less severe slow-down of growth than the country as a whole. In order to avoid such ambivalence, we subtract average labour productivity per hour worked in all kreisfreie Städte from the local labour productivity per hour worked.

Productivity regressions are estimated on the basis of gross value added (GVA) per hour worked by the working population, which can be calculated using data of the Federal Statistical Office. The results vary only negligibly when the gross national product (GNP) is employed instead. Therefore, the results reported in the current paper are exclusively on gross value added per hour worked (bwsa). During the survey period, the borders of some NUTS 3-regions in Sachsen have been changed. This is why data on GNP and GVA for the cities of Plauen, Zwickau, Görlitz and Hoyerswerda is not available with respect to consistent demarcation lines, and these cities have to be excluded for analyses based on data from the Federal Statistical Office.

GNP and GVA per employee do not account for changes in working hours resulting, for instance, from restructuring from full-time to part-time jobs or from the loss of working hours due to illness (OECD 2001 p. 39). Hence, GNP and GVA are calculated per hour worked. Information on the number of working hours in kreisfreie Städte is only available from 1999 onwards. Therefore, the number of working hours in 1998 is approximated by the values of 1999, because it changes only slightly over the course of one year. Both dependent variables have advantages as well as downsides. Using value added is inaccurate for several reasons, e.g. due to the difficulty to separate material from immaterial inputs and quantify them in statistics (Denny and May 1978 p. 54 ff). This problem can be avoided by considering gross national product. If, however, labour productivity is calculated on the basis of GNP, it is more sensitive to the degree of vertical integration3 and outsourcing (OECD 2001 p. 29 f), which is an argument for using GVA instead. Consequently, the productivity regressions are run twice with GNP and GVA as regressands (with only the results of the latter being reported). It turns out that the results differ only negligibly. Previous empirical studies mostly use output as dependent variable, e.g., Mody and Wang (1997), Partridge and Rickman (1999), Lee et al. (2005), Dekle (2002) and Frenken et al. (2007), whereas Henderson (1986), for example, employs production value for the United States and value added for Brazil, due to the availability of data. Mukkala (2004) and Neffke et al. (2011) also measure productivity by value added.

One independent variable is the level of gross wages and salaries (blga) from 1998 to 2007, as reflected by data from the Federal Statistical Office. In order to increase the comparability between different cities, wages like GNP and GVA are also calculated per hour worked. The link between the level of gross wages and salaries and employment growth is presumably negative: High wages dampen growth as they lead to higher production costs. If the share of highly qualified workers in a city is particularly high, it could happen that the coefficient of the wage variable turns positive because highly qualified workers typically foster employment growth but earn higher wages at the same time. To avoid this effect, the share of highly qualified workers is considered as an additional control variable in regressions using the wage level as independent variable. A further reason for taking into account the qualification structure is that productivity and wages are measured per working hour. Labour is a heterogeneous factor, though, and one hour worked by a highly qualified workers is to be assessed differently than one hour worked by a qualified or unqualified worker (OECD 2001

[3] If the degree of vertical integration rises, so does the share of intermediate inputs in production while the share of labour input decreases. If output stays the same, the data show a rise of output per unit of labour input – even though labour productivity has not changed by the substitution of inputs (OECD 2001 p. 29).

p. 40). Thus, the share of highly qualified workers (ant_hq) is included in the data set. The data containing information on the qualification structure of employees at their respective workplaces from 1998-2008 is provided by the Federal Employment Agency. A positive influence of the share of highly qualified workers on productivity as well as on employment growth is to be expected. Following the theory of endogenous growth, human capital and knowledge spillovers are the driving forces of growth and are decisive for the successful economic development of regions. On the one hand, highly qualified workers are apt to be more productive and generate positive externalities (Partridge and Rickman 1999 p. 325). Rauch (1993) shows that a metropolitan region where the average number of educational years is one year higher than elsewhere, has a productivity advantage of about 3%. On the other hand, a likewise positive influence of university graduates on research and development activities in a region, the innovation potential involved (e.g. approximated by the number of patent registrations) as well as employment growth is assumed (Blien et al. 2003 p. 28 f).

Furthermore, the data of the Federal Employment Agency contain information on firm sizes. We calculate the share of employees working in small enterprises with fewer than 20 employees subject to social insurance contribution (ant_ku_20). Data on firm size is only available from 1999 onwards. Hence, the structure of firm sizes in cities in 1998 is approximated by data for 1999, since this structure varies only slightly in the course of one year.

Often, spillovers are approached by the number of patent registrations, like in Baptista and Swann (1998), Andersson et al. (2005) and Boschma and Weterings (2005). A positive influence is expected, both on employment as well as on productivity growth. For one, patents may lead to product innovations which raise labour demand and, consequently, employment (Schmid 2000 p. 85). On the other hand, patents may lead to process innovations which show up in the form of higher productivity (Schettkat 1997 p. 725). The present data set contains the number of patent registrations per employee subject to social insurance contributions, from 2000 to 2005. The data originate from the patent atlas of the German Patent and Trade Mark Office. Calculating the number of patents per employee takes into consideration that probably more patents are registered in large cities because of their higher total employment.

A further independent variable is city size. Productivity is assumed to be higher in larger cities, as inputs can be used more efficiently there (Moomaw 1981 p. 675). Contrary to this, specialised cities are supposed to be more productive (see above); they are, however, comparatively small (Duranton and Puga 2000 p. 536). Therefore, the effect of city size on productivity is ambiguous. In a static view, Partridge and Rickman find higher population numbers result in higher productivity. This effect is outweighed by a less productive sector structure in larger cities, though (Partridge and Rickman, 1999 p. 333). Qutub and Richardson (1986) find productivity is highest in small and medium-sized specialised industrial cities. This result is in line with those obtained by Henderson (1986). Depending on whether the advantage of more efficient usage of inputs or the drawback of having a less productive sector structure in large cities predominate, either a positive or a negative influence of city size on productivity will be found in the present study.

No clear-cut influence of city size on productivity levels and growth rates is to be made out from the theory: Smaller cities tend to be specialised and, as a result, more productive which indicates a negative influence of city size on productivity. However, in large cities inputs can be utilised more efficiently – i.e. put to the best possible use – by means of which productivity is higher. Additionally the correlation between city size (svpb) and the number of patent registrations per employee (pat) is significantly positive (r = 0.2169, significant at the 1% level). Since more patents per employee are registered in large cities than in small ones, productivity growth is expected to be higher in the former. It cannot be said in advance which of these effects dominates.

In order to account for still prevailing differences between the “old” and the “new” Länder, a regional dummy variable (reg_dum) is introduced which takes on the value of one if a city is situated in the former East. Table 1 shows descriptive statistics of the employed variables.

Table 1: Descriptive statistics of the employed variables

Variable	Obs	Mean	Std. Dev.	Min	Max
ksi	1298	0.65	0.15	0.34	1.31
zi	1298	11.43	7.86	5.29	64.95
ant3g	1298	23.54	8.36	11.96	70.72
ant5g	1298	32	8.38	19.31	74.26
rdi	1298	1.54	0.29	0.72	2.77
svpb	1298	101253.7	149307.2	10616	1139096
bwsa	1140	33.85	6.25	20	56.42
blga	1140	16.68	2.45	10.62	27.24
pat	590	0.0011	0.0008	0.0001	0.0048
ant_hq	1298	10.03	4.16	3.41	25.34
ant_ku_20	1298	23.19	4.43	8.31	40.1
reg_dum	1298	0.23	0.42	0	1

Source: authors’ calculations.

5. Models and Results

In order to linearise non-linear relationships and to simplify the interpretation of the estimated coefficients, the independent variables enter the regression models in logarithms. In the static regression models, the estimated coefficients multiplied by 0.01 show the effect on the regressand if an independent variable changes by 1%, and, in the dynamic models, the estimated coefficients are to be interpreted as elasticities. Besides simplifying the interpretation of the regression coefficients, taking logarithms facilitates comparisons between our different sector structure variables, as we consider only percentage changes in these variables. Thus, comparability is ensured even though most of the indices are not scaled. The models are estimated using OLS and heteroscedasticity-consistent White standard errors.

5.1 Static Analysis

In a first step, we test the hypothesis of specialised cities being more productive compared to diversified cities, but the most productive cities being diversified-specialised ones. For this, the following model for the level of gross value added per working hour (German: Bruttowertschöpfung pro Arbeitsstunde, BWSA) in city j is estimated:

$$BWSA_j = \beta_0 + \beta_1 \ln(B_j) + \beta_2 \ln(svpb_j) + \beta_3 \ln(ant\_hq_j) + \beta_4 reg\_dum_j + \ln(u_j)$$

Due to strong multicollinearity between the measures of the sector structure (see Table 2, significance values (p-values) being below the correlation coefficients), several models are estimated. Each of them includes only one measure of the sector structure Bj. Following this procedure, KSI, ZI, ANT3G, ANT5G and RDI are substituted for Bj one after the other. Control variables are city size svpbj measured by the number of employees subject to social insurance contributions, the share of academics (ant_hq), as well as a dummy variable (reg_dum) taking on the value 1 if a city is situated in the East. β0 is the model’s constant, and u the error term. The model is estimated with yearly data from 1998 to 2007 for n=1440 observations.

Table 2: Correlogram of variables capturing city sector structure

	ksi_ln	zi_ln	ant3g_ln	ant5g_ln	rdi_ln
ksi_ln	1				
zi_ln	0.6518	1			
	0.0000				
ant3g_ln	0.7365	0.9376	1		
	0.0000	0.0000			
ant5g_ln	0.7604	0.8949	0.9838	1	
	0.0000	0.0000	0.0000		
rdi_ln	-0.9706	-0.6821	-0.7623	-0.7858	1
	0.0000	0.0000	0.0000	0.0000	

Source: authors' calculations.

Table 3: Gross value added per working hour – Static regression results

bwsa_0	1	2	3	4	5
ksi_ln	5.7464***				
	0.0000				
zi_ln		2.6963***			
		0.0000			
ant3g_ln			4.6349***		
			0.0000		
ant5g_ln				6.1784***	
				0.0000	
rdi_ln					-5.9717***
					0.0000
svpb_0_ln	1.8698***	1.6376***	1.898***	2.0544***	1.8292***
	0.0000	0.0000	0.0000	0.0000	0.0000
ant_hq_ln	3.3811***	2.9866***	2.915***	2.8922***	3.1498***
	0.0000	0.0000	0.0000	0.0000	0.0000
reg_dum	-11.5755***	-11.1066***	-11.1587***	-11.1106***	-11.6990***
	0.0000	0.0000	0.0000	0.0000	0.0000
C	10.7328	5.1829	-5.6902	-14.1763	11.5445
R^2	0.6088***	0.6060***	0.6126***	0.6151***	0.6055***
adj. R^2	0.6074***	0.6046***	0.6112***	0.6137***	0.6042***
Prob. > F	0.0000	0.0000	0.0000	0.0000	0.0000

Source: authors' calculations.

All estimated models shown in Table 3 are significant at the 1 % level and explain between 60.42 and 61.37 % (adj. R^2) of variations in the data. The table shows that an increase in specialisation of 1 %, measured by the Krugman Index of Specialisation, goes along with an increase in gross value added of 5.7 Cent per working hour. Increasing specialisation in the most prominent sector of a city by 1 % goes along with a rise in GVA per working hour of 2.7 Cent, whereas an increase in diversified specialisation even enhances GVA by 4.6 Cent per working hour. This illustrates the advantageousness of a sector structure with certain priorities. In contrast, a diversified sector structure exerts a negative influence on the level of GVA per working hour. Accordingly, a rise in diversification by 1 % results in a fall of GVA per working hour by 6 Cent.

All models show a weak, but significant, positive influence of city size on GVA per working hour. This may be due to inputs being used more efficiently and put to the best use in bigger cities (Moomaw 1981 p. 675). The share of academics positively contributes to the level of GVA as well, since the productivity of highly qualified workers is higher than the one of unqualified workers. It shows that location plays a decisive role in determining the level of gross value added per working hour. In Eastern cities, GVA per working hour, on average, is between 10 to 12 Cent lower than in Western cities. The study of Fischer et al. (2007 p. 15 ff) confirms that the Eastern Länder still lag behind in productivity. The inclusion of ant5g instead of ant3g only slightly changes the results. Moreover, there are hardly any deviations in case productivity is not approximated by gross value added, but by gross national product.

5.2 Dynamic Analysis

In the previous section, the link between sector structure and productivity levels was analysed in a static sense. Now it is to be examined which sector structure is best for employment and productivity growth. For this, separate regression models are estimated for the growth rate of the number of employees subject to social insurance contributions and the growth rate of labour productivity in cities.

By means of the following regression model, the link between sector structure and employment growth is modelled:

$$W_{SvpB_j} = \beta_{0+}\beta_1 \ln(B_j) + \beta_2 \ln(blga_j) + \beta_3 \ln(pat_j) + \beta_4 \ln(ant\_hq_j) + \beta_5 \ln(ant\_ku\_20_j) + \beta_6 reg\_dum_j + \ln(u_j)$$

The dependent variable WSvpBj is the growth rate of employment subject to social insurance contributions. Depending on the lag structure of the employed model, this is the growth rate over a period of one to six years, corrected for the average growth of all kreisfreie Städte in the considered time span. As the qualitative results remain almost the same, only the models with a growth rate over a period of six years are presented in the current paper. All independent variables take their values at the starting point of the observed period. This means that the regressors, such as the sector structure, the level of gross wages and salaries, the number of registered patents, the share of academics and the share of employees in small enterprises (with < 20 employees) represent the situation at the starting point of the observed six-year period.

In nearly all empirical studies on the connection between sector structure and economic growth, different time lags are employed. However, arguments for the choice of a specific time lag are missing in most cases. Henderson (1997) estimates the temporal reach of agglomeration economies. The results vary markedly, depending on the examined sector: For some sectors, agglomeration economies seem to be rather static, while for others they turn out to be of a more dynamic nature. Blien et al. (2006 p. 447) find that static effects are more important than dynamic ones, whereas Combes (2000) even employs a time lag of nine years. Following the empirical literature, the models would have to be estimated with time lags from one to nine years, and the optimal lag length would have to be determined according to information criteria for the selection of the proper lag length, such as the BIC- or AIC-criterion (e.g. Lütkepohl 2005 p. 148 ff). However, in order to do so, the sample needed to be downsized to two years for ensuring all models were estimated with the same number of observations. Thereby, a large amount of the available information would be disregarded.

That is why we only estimate models with a lag length from one to six years (with only the results of the latter being shown in the following). To make sure all models are estimated with the same number of observations (n = 570), the sample does not include current observations and the regressions are only run with data from 1998 to 2008. This way it is possible to analyse the link between sector structure and employment growth for time spans from one to six years at the most.

Table 4: Employment growth – Dynamic regression results

wsvpb(6)	1	2	3	4	5
ksi_ln	2.2370**				
	0.022				
zi_ln		2.2245***			
		0.001			
ant3g_ln			3.5196***		
			0.0000		
ant5g_ln				4.1392***	
				0.0000	
rdi_ln					-3.4652***
					0.001
blga_0_ln	-13.1462***	-14.5863***	-14.7788***	-14.5002***	-12.9764***
	0.005	0.002	0.002	0.002	0.006
ant_ku_20_ln	-7.6969***	-5.9710**	-6.1786***	-6.4593***	-6.8463***
	0.002	0.013	0.009	0.006	0.006
pat_ln	0.9229**	0.9093**	0.9108**	0.9387***	0.8810**
	0.012	0.012	0.012	0.01	0.017
ant_hq_ln	0.9522	1.3487	1.6132*	1.6115*	1.1287
	0.257	0.108	0.052	0.052	0.179
reg_dum	-10.0850***	-10.4803***	-10.7968***	-10.6774***	-10.3755***
	0.0000	0.0000	0.0000	0.0000	0.0000
C	68.3944	60.0021	54.9189	51.9411	65.0532
R²	0.2573	0.2679	0.2708	0.2693	0.2624
adj. R²	0.2493	0.2601	0.2631	0.2615	0.2545
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000

Source: authors' calculations.

The dependent variable in the models presented in Table 4 is the growth rate of employment subject so social insurance contributions over a six-year period. Column 1 shows that specialisation in general (measured by the Krugman Index for Specialisation) has a positive influence on employment growth. This impact is significant at the 5 % level. If the degree of specialisation in the starting period increases by 1 %, employment growth in the following six-year period will be higher by 2.2 % than otherwise.

Again, the question arises whether specialisation in one single sector or rather in a small pool of sectors is more conducive to employment growth. Probably, employment growth in diversified-specialised cities is even higher than in specialised ones because sector-specific negative demand shocks can be better cushioned by other strong sectors (see above). This thesis is corroborated by columns 2, 3 and 4 in Table 4. The estimated coefficients of specialisation (ZI) and diversified specialisation (ANT3G) are significant at the 1 % level and the coefficient of ANT3G is greater than the one of ZI. If ANT3G is substituted by the share of the five biggest sectors in total city employment, this effect becomes even stronger: The coefficient of ANT5G is even greater than that of ANT3G. An increase by 1 % of specialisation in a city's most prominent sector (ZI) in the base period is associated with a 2.2 % higher employment growth rate in the following six-year period. If specialisation in the three most prominent sectors rises by 1% in the base year, the employment growth rate in the following six-year period rises by 3.5 % and an increase of ANT5G by 1 % even leads to a growth rate higher by 4.1 %. Hence, employment growth is higher in cities focussing on more sectors than in cities specialising in only one sector. Furthermore, specialisation in five sectors generates even stronger growth impulses than specialisation in only three sectors.

Obviously, the majority of specialised cities focus on sectors which have not reached the maturity stage in their product life cycle yet (Schettkat 1997 p. 715 ff) and have either not been hit by demand shocks in the observation period at all or were only hit by positive ones. In specialised cities, negative demand shocks on the most prominent sector(s) cannot be absorbed as easily as in diversified cities. Therefore, it is assumed that the variance of employment growth within the group of specialised cities is higher than within the group of diversified cities, since a positive or negative demand shock has larger impacts on the former. In order to check this, the median of KSI-values is determined. The group of specialised (diversified) cities comprises those which show stronger (weaker) levels of specialisation than the median value. A test on the equality of variances of the two groups' city employment growth rates over the period of one to six years (again, only the latter is shown in the following, as the qualitative results are the same for shorter periods) is conducted. Table 5 shows the standard deviations of employment growth rates from the group mean value for the specialised and the diversified group for a six-year growth period, as well as the corresponding F- and p-values.

Table 5:Test for equality of employment growth rate variances in specialised and diversified cities (KSI)

sector structure (KSI)	Std.Dev	F(295,295)	p-value
specialised	7.851306	2.113	< 0.001
diversified	5.401258		

Source: authors' calculations.

The null hypothesis of the equality of variances can be rejected at the 1 % level in favour of the alternative hypothesis that specialised cities show a higher variance with respect to the employment growth rate. If cities are not classified into specialised and diversified ones by their KSI-values but by their RDI-values instead, the results are not altered at all. Thus, specialisation is basically conducive to employment growth, even though it goes along with a higher risk of being severely impacted by demand shocks. On the other hand, if a city has got a rather diversified sector structure, employment growth is inhibited. The significance of this influence grows with the length of the period over which growth is monitored. It is only from a growth period of two years onwards that employment growth is significantly influenced by diversification at the 10 % level. From a growth period of three years onwards, the significance of the diversification variable rises steadily, with only one exemption. Although diversified cities can absorb negative demand shocks comparatively easily, they obviously lack growth poles which generate impulses for employment growth.

The estimation of the above model goes along with a major methodological issue: The connection between sector structure and employment growth is dependent on the elasticity of goods demand and, hence, on a sector's position in its product life cycle. Therefore, a more direct approach to empirically investigate the link between sector structure and regional growth is to analyse the impact of the sector structure on productivity growth. In order to do so, the following base model is estimated:

$$W_{BWSA_j} = \beta_{0+}\beta_1 \ln(B_j) + \beta_2 \ln(svpb\_0_j) + \beta_3 \ln(bwsa\_0_j) + \ln(u_j)$$

The growth rate of productivity per working hour (W_{BWSAj}) serves as a regressand. Depending on the lag structure of the respective model, this is the one- to six-year growth rate, corrected for the average growth rate of all kreisfreie Städte over the considered period. Again, only the results for a six-year growth period are reported, since the results vary only sligthly for different growth periods. Whether productivity is approximated by gross value added or gross national product hardly affects the results at all. The estimations presented in this text rely on gross value added per working hour. To ensure that all models are estimated with the same number of observations (n = 456), the sample is downsized and current observations are neglected; the regressions are estimated with data from 1998 to 2008. This way, the link between sector structure and productivity growth can be analysed for time spans from one to six years at the most. The results are reported in Table 6.

Table 6: Productivity: Dynamic regression results

wbwsa(6)	1	2	3	4	5
ksi_ln	3.8156**				
	0.023				
zi_ln		2.0239*			
		0.067			
ant3g_ln			2.87703*		
			0.096		
ant5g_ln				3.9686*	
				0.075	
rdi_ln					-3.5127**
					0.043
svpb_0_ln	1.5664***	1.4975***	1.6024***	1.7196***	1.4527***
	0.0000	0.0000	0.0000	0.0000	0.0000
bwsa_0_ln	-19.9631***	-21.0214***	-20.6678***	-20.7814***	-19.7301***
	0.0000	0.0000	0.0000	0.0000	0.0000
C	52.9786	51.08	44.4611	38.8875	53.1825
R^2	0.258	0.2593	0.2566	0.258	0.2554
adj. R^2	0.2531	0.2544	0.2517	0.2531	0.2505
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000

Source: authors' calculations.

Specialisation as measured with the KSI exerts a significantly positive influence on productivity growth in all observed periods: For a time span of six years, the city growth rate of gross value added per working hour rises by 3.8 % if the value of the KSI increases by 1 %. If a differentiation between different kinds of specialisation is made, the corresponding coefficients (ZI, ANT3G, ANT5G) are only significant (at the 10 % level) when looking at the productivity growth rate over a six-year period. Nevertheless, it becomes obvious that specialisation in a portfolio of sectors exerts a stronger positive influence on growth than considering specialisation only in the biggest sector. Productivity growth rises by 2 % if the value of ZI increases by 1 %, but even by 2.9 % (4 %) as a result of a 1 %-increase of ANT3G (ANT5G). Thus, we conclude that diversified-specialised cities profit from higher productivity growth rates, whereas diversification alone has a negative impact on productivity growth, in the short as well as in the long run. A 1 % increase of diversification goes along with a fall of the growth rate of gross value added per working hour of 3.5 % over a six-year period.

The estimated coefficient of city size is steadily positive and significant. Hence, productivity growth is higher in bigger cities. Conversely, the level of gross value added in the base year of the six-year growth period exerts a markedly negative influence on productivity growth which is also significant. This leads us to assume that a convergence process is going on, and cities with lower productivity levels are characterised by higher growth rates.

Up to this point, effects emanating from spillovers generated by a specific sector structure on city productivity have been analysed. One channel through which knowledge spillovers lead to higher productivity is via patent registrations (Simonen and McCann 2010 p. 297). To capture the extent of knowledge spillovers, it would be better to employ patent citations instead, as in Jaffe et al. (1993). Unfortunately, there is no data available on patent citations in Germany which is why we use patent registrations instead. The occurrence of spillovers in a region encourages the development of product and process innovations which can be, at least for some time, protected by patent application. Thus, the number of patent registrations serves as an indicator for innovation activity, which again serves as a proxy for the existence or the importance of spillovers. Table 7 displays the estimation results of the following model:

$$\ln(pat_j) = \beta_0 + \beta_1 \ln(B_j) + \beta_2 \ln(ant\_ku\_20_j) + \beta_3 \ln(ant\_hq_j) + \beta_4 reg\_dum_j + \ln(u_j)$$

The dependent variable is the annual number of patent registrations per employee subject to social insurance contributions from 2000 to 2005. The model is estimated with n = 590 observations and three control variables – the share of employees in businesses with fewer than 20 employees, the share of academics and a region dummy variable.

Table 7: Operationalisation of spillovers through patent registrations – Regression results

pat_ln	ksi_ln	zi_ln	ant3g_ln	ant5g_ln	rdi_ln
sector structure variable	0.7344***	0.2631***	0.3689***	0.413***	-0.6685***
	0.0000	0.0000	0.0000	0.0000	0.0000
ant_ku_20_ln	0.6146***	0.6143***	0.554***	0.4998***	0.5952***
	0.0000	0.002	0.004	0.009	0.001
ant_hq_ln	0.9946***	0.9274***	0.9404***	0.9405***	0.9525***
	0.0000	0.0000	0.0000	0.0000	0.0000
reg_dum	-1.3148***	-1.2149***	-1.2342***	-1.2294***	-1.3023***
	0.0000	0.0000	0.0000	0.0000	0.0000
C	-10.5034	-11.3067	-11.6832	-11.7791	-10.4082
R²	0.4017	0.3758	0.3745	0.3718	0.388
adj. R²	0.3976	0.3715	0.3702	0.3675	0.3838
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000

Source: Source: authors' calculations.

The findings of this regression analysis comply with those of the productivity regressions: An increase in specialisation reinforces spillovers; which shows up as an increase in patent registrations per employee. More precisely, an increase of specialisation (KSI) by 1 % results in a rise of patent registrations per employee of 0.73 %. It should be stressed that the elasticity between patent registrations and specialisation is all the higher, the more sectors a city specialises in. With regard to specialisation in one single sector, the elasticity is 0.26 and increases to 0.37 (0.41) when considering specialisation in the three (five) biggest sectors. Conversely, a 1 % increase in diversification is accompanied by a 0.67 % decrease of patent registrations. These values are all highly significant at the 1 % level. So, once more, the propitiousness of specialisation in a few sectors as against focussing on only one single sector or having a diversified sector structure is corroborated.

6. Conclusion

The present paper introduces the concept of diversified specialisation. The propitiousness of a diversified-specialised sector structure for regional economic performance is confirmed for all considered dependent variables, namely productivity levels, productivity growth, the number of patent registrations per employee and employment growth. Apparently, specialisation as such does generate positive effects as well. They are, however, markedly weaker than those generated by diversified specialisation, whereas a diversified sector structure even exerts a negative influence on the considered variables. Whether productivity is approximated via GNP or GVA hardly affects the results at all. Caution should be applied when interpreting the results on employment growth, as it is dependent on regional productivity, as well as on the sector-specific price-elasticity of goods demand. Therefore, the relationship between sector structure and employment growth is of indirect nature. Apart from that, we obtain evidence for a higher variance of the employment growth rate in specialised cities compared to diversified cities, as sector-specific demand shocks cannot be easily cushioned and prompt comprehensive adjustments in employment levels and employment growth.

Diversified-specialised cities have the huge advantage of offering both, MAR and Jacobs externalities. They are commonly smaller than diversified cities, as a result of which crowding and production costs are generally lower. Furthermore, they are not that severely affected by sector-specific demand shocks, since they focus on a wider portfolio of sectors than specialised cities do.

The results regarding the positive influence of specialisation (especially diversified specialisation) on productivity and productivity growth are in line with the majority of previous studies, e.g., with Cingano and Schivardi (2004), Nakamura (1985), Henderson (1986), Dekle (2002), Mukkala (2004), Capello (2002) and Partridge and Rickman (1999). Furthermore, we find a positive effect of specialisation on the number of patent registrations per employee subject to social insurance contributions through which spillovers can be approximated. The results lead to the assumption that spillovers bringing about patent registrations are strongest in diversified-specialised cities, while spillover-effects tend to be comparatively weak in diversified regions.

Due to the positive impact of a diversely specialised sector structure on regional economic growth, there is a need for further research in this field. For instance, a scientific discussion on further measures for determining the degree of diversified specialisation or differentiating diversified specialisation from specialisation and diversification would be desirable. Also, the concept of diversified specialisation constitutes an attractive approach for regional politics as an alternative to the cluster concept. The advantage of diversified specialisation lies in it fostering economic growth, but at the same time abstaining from establishing a mono structure with its well-known risks. Instead, the focus on a few branches which benefit from each other is promoted.

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