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The importance of spatial autocorrelation for regional employment growth in Germany

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Abstract

To analyze the disparities of regional employment development in Germany, in the recent empirical literature so called shift-share-regression-models are frequently applied. These models usually neglect spatial interdependencies, even though such interdependencies are likely to occur on a regional level. Therefore, this paper focuses on the importance of spatial dependencies in form of spatial autocorrelation for regional employment development. Spatial dependency in the form of the spatial lag, spatial error and cross regressive model are compared. The results indicate that the spatial lag of the exogenous variables sufficiently explains the spatial autocorrelation of regional employment growth.

JEL Classification: C21, E24, R11, R23

Keywords: spatial interdependency, spatial autocorrelation, shift-share-regression, regional employment growth

1 Introduction

Regional employment growth in Germany is characterized by huge disparities. Whereas institutional factors might explain disparities of employment growth between nations, they can only account for a minor fraction of regional employment growth. Instead, the sectoral structure of employment is often seen as a major reason for regional disparities. An important attribute of the research conducted so far is that it concentrates on estimating shift-share-regression-models when controlling for the influence of the sectoral structure on employment growth. However, these models do not account for spatial interdependencies and treat regions as autarkies, though on a regional level such effects are likely to occur.

Against this background, the present paper analyzes the role played by spatial interdependencies between regions in explaining their employment growth. By using spatial econometric methods, it emphasizes that regional employment growth is characterized by spatial autocorrelation, pointing to spatial interdependencies between the regions. This holds true also for mayor factors of regional employment such as wages and qualification.

In this paper three different models of spatial interdependencies are being compared: the spatial lag, spatial error and cross regressive model. While the spatial lag model controls for the influence of the value of the endogenous variable in neighboring regions (i.e. the spatial lag of the endogenous variable) on the endogenous variable in the observed region, the spatial error model estimates the influence of the spatial lag of the error term. Finally, the cross regressive model includes the spatial lags of the exogenous variables. The relevant spatial interdependencies are first identified by cross-sectional analysis and then integrated into the framework of the shift-share-regression-model to measure their influence on regional employment growth in Germany.

In the following the theoretical background is confronted to current empirical results, focusing on regional interdependencies. The third section deals with the underlying data and data preparation is performed. In particular an adjusted wage is calculated, correcting for the influence of productivity on wages and furthermore the scale of potential spatial interdependencies is identified, i.e. it is estimated, how strong interdependencies between regional labor markets decline with increasing distance. Subsequently the regression models and their results are presented. These results are discussed in a separate section. A final section draws the conclusions.

2 Theoretical and empirical background

In the economic theory several factors influencing (regional) employment development are discussed, such as wages, qualification and productivity. Furthermore regional interdependencies

are of special interest in this paper. In the following the theoretical background related to these factors is presented and compared to current empirical results.

Wages

In labor market theory a negative influence of wages on employment development is often discussed, as the cost argument of wages dominates economic literature. According to this, higher wages imply higher costs of the production factor labor so that labor becomes less attractive for production and labor demand decreases, leading to lower employment. Conversely, the purchasing power argument is recurring in public debate. It is argued that higher wages lead to higher demand and thus, to higher production and higher employment. However, economists usually are skeptical of this argument (Jerger and Michaelis; 2003). In contrast, Blien et al. (2003) argue that for locally produced and traded goods the purchasing power argument may be of relevance.

The empirical literature regarding the wages' influence on employment does not typically identify net positive effects of wages on employment. However, the influence of wages on employment differs between sectors: While in the secondary sector (the producing sector) wages exert a negative influence on employment, in some branches of the tertiary sector (the service sector) the influence of wages on employment becomes insignificant (Blien et al.; 2005; Suedekum et al.; 2006). Only Blien et al. (2003) observe a positive influence of wages on employment for individual service sectors in eastern German regions.

Beyond that, regional wages may cause migration of employees or firms. Employees migrate to those regions, where there is a relative high wage (i.e. a smoothly running labor market) and employment increases in these regions.¹ Conversely, firms migrate to those regions, where wages (i.e. the costs of labor) are relative low, stimulating labor demand and hence employment in low wage regions. Thus, the employment of a region does not only depend on the wage within the region, but also on the wage of nearby regions, while the direction of the influence depends on whether migration of firms or employees dominates. Suedekum and Blien (2007) measure the influence of the wage level of nearby regions on the employment development of a region and conclude that this influence is positive: an increase of the wage level in nearby regions leads to higher employment in the observed region. Accordingly, in the sample of Suedekum and Blien (2007) the migration of firms dominates the migration of employees.

Qualification

Another factor influencing regional employment is qualification. The labor market for high qualified people is more flexible and their unemployment rate is lower compared to the unemployment

¹Actually, employment will only increase in the in-migration-regions, if the immigrating employees find new employment in these regions. However, it is unlikely that employees will migrate for economic reasons (higher wages) into regions, where they do not find new employment.

rate of less qualified people (Franz; 2006; Klotz et al.; 1999). Furthermore, through complementarities between high and low qualified labor, low qualified benefit from the qualification of high qualified employees. An increase of the share of high qualified accordingly exerts a positive feedback on the labor market for low qualified (see Bauer; 1998 and Chiswick; 1982 for an explicit theoretical modeling of these two effects). The positive influence of the share of high qualified employees on the employment development of German regions is widely acknowledged. Empirical evidence is delivered (among others) by Suedekum and Blien (2004) and Blien et al. (2003).

Labor productivity

The effect of labor productivity on regional employment growth is less obvious. Theoretically, the direction of the influence is not clear, since redundancy- and compensation-effects are opposing each other: With increasing productivity less labor input is necessary to keep the production level and thus employment declines (redundancy-effect). However, increasing productivity leads to lower costs and prices, stimulating demand and production and consequently causes higher employment (compensation-effect). Appelbaum and Schettkat (1993; 1994; 2001) confront these two effects with each other in a theoretical model. According to their theory, the price elasticity of demand determines which of the opposing effects dominates.

When price elasticity is high, the increase in demand due to higher productivity (i.e. lower prices) is large and thus the compensation-effect is large enough to overcompensate the redundancy-effect. Usually high price elasticity (and thus the domination of compensation-effects) is expected to prevail in service sectors, while the opposite is expected in industry sectors. One would thus expect productivity rises to stimulate employment growth in service sectors and to hinder employment growth in industry sectors.

On the regional level, there is no empirical evidence on the influence of productivity growth on employment development in Germany. However, many empirical investigations, inspired by the theoretical models of Appelbaum and Schettkat (1993; 1994; 2001), decompose the sectoral employment development for identifying the importance of the sectoral structure for regional employment growth. For example empirical studies of Blien et al. (2003) and Blien and Wolf (2002) find out that employment growth was stronger in service sectors, as one would expect from the above. However, there is no study directly measuring the influence of productivity growth on employment development in German regions.

Regional interdependencies

So far interdependencies between regions were only discussed with reference to migration. However, according to Nijkamp and Poot (1998), interdependencies between regions are furthermore caused by trade, diffusion of technological information and information exchange. In the endogenous growth literature, similar effects are discussed: The Romer (1990) model of endogenous

growth explores, how knowledge spills over between scientists and how this influences economic growth. Technological knowledge, retained in patents, is used for the production of new technological knowledge, stimulating economic growth. These positive external effects are labeled as ‘knowledge spillovers’.

As technological knowledge cannot be fully formalized and much of the information exchange between scientists rests upon personal communication, distance plays a crucial role in the process of knowledge spillovers. Hence, information exchange largely takes places within a region and may spill over between regions, depending on their distance (Keilbach; 2000). Knowledge spillovers are therefore not only generating positive external effects within a region, but also between regions, depending on the distance between the regions. Thus, the knowledge of a region — incorporated in its qualification level and its labor productivity — will not only influence the labor market of the region itself, but also the labor markets of nearby regions. Regional labor markets cannot be thought of as independent markets, but rather as interrelated markets.

Even though these effects are likely to affect regional employment development, there are only few empirical studies explicitly taking account of these effects. Niebuhr (2000) observes distance-dependent growth relations regarding employment development, based on technological spillovers. For European regions the author reveals furthermore that trade between regions leads to interregional dependency of employment development (Niebuhr; 2003). Strong spatial interdependencies for the development of regional employment and unemployment rates are also found by Kosfeld and Dreger (2006). However, with some exceptions (Schanne; 2006 and Overman and Puga; 2002) empirical studies on the determinants of regional employment development usually neglect the importance of spatial interdependencies.

Schanne (2006) discovers that sectors of nearby regions develop similar (positive spatial autocorrelation) and that the concentration of a sector in nearby regions has a stronger influence on regional employment than the concentration of this sector in the region itself. The author gathers from this that there exists a reciprocal relationship between regions. Overman and Puga (2002) observe a polarization of regional unemployment rates, resulting from similar employment development in nearby regions. However, such studies are still scarce and thus empirical expertise on interdependencies of regional labor markets is still incomplete.

3 Data set and data preparation

To measure regional employment, the number of employees subject to social insurance contribution by workplace is depicted from the German Federal Employment Agency (Federal Employment Agency; 2009) as well as the average monthly wage of full-time employees subject to social

insurance contribution. The data is very reliable, since it is depicted from a full population survey. It is measured at industry level, separating between *agriculture, forestry and fishery* (AB), *manufacturing industry* (CE), *construction industry* (F), *hotel, trade and traffic industry* (GI), *financing, leasing and business services* (JK), and *private and public services* (LP). Additional data on productivity (i.e. gross value added per employee), inhabitants, plants and area of the regions are depicted from the Statistische Ämter des Bundes und der Länder.² Furthermore, the regional price index of Kosfeld et al. (2008) is applied to deflate nominal variables at regional level. The variables are measured at the level of labor market regions, given by Eckey et al. (2006), in order not to cut existing labor markets by using NUTS3-regions.

However, the data cannot be used in its current form for the regression models — some data preparation is necessary regarding the regional wage and the structure of regional interdependency. Both issues are discussed in the following separately.

3.1 Adjusted wage

Wage and productivity are closely interrelated through marginal productivity payment. Rigidities in the labor market influence this relationship, resulting in the wage curve (Blanchflower and Oswald; 1994). If the wage was directly introduced into a regression model for regional employment growth, one could not differ whether the measured effect results from wage or productivity. In this paper, the effects of wage and productivity need to be separated. Therefore one has to identify the wage, which is not already explained by productivity ('excessive wage', see Suedekum and Blien; 2004).

For this purpose, the wage is regressed on a set of explanatory variables following the approach proposal by Suedekum and Blien (2004). In particular the wage is regressed on productivity, yearly varying region effects and additional variables in an integrated framework:

$$\left(\frac{W}{P}\right)_{irt} = \alpha_t + \beta_i + \gamma_r + \tau_{rt} + \beta_0 + \beta_1\pi_{irt} + \beta_2D_{rt} + \beta_3G_{rt} + \beta_4East_r + \epsilon_{irt} \quad (1)$$

The real wage $\frac{W}{P}$ in region r , sector i and year t depends on year α_t , sector β_i and region effects γ_r , an interaction term between region and year effects τ_{rt} , a constant β_0 , real productivity π , population density D and a dummy for eastern German regions $East$. Additionally the number of employees per plant G is introduced as control in the regression analysis.

To avoid the dummy variable trap, region 1 (Flensburg), year 1999 and sector *agriculture, forestry and fishery* are defined as reference items. The variation of the region effects in time

²DESTATIS; 2009a; 2009b; 2009c.

Table 1: Results for the adjusted wage regression

	coefficient	standard error	t-statistic	p-value
π_{irt}	0.0038	0.0005	8.16	0.000
D_{irt}	0.0161	0.0028	5.72	0.000
G_{irt}	0.1727	0.3981	0.43	0.665
$East$	-260.3549	90.9170	-2.86	0.004
α_{2003}	82.9159	39.8115	2.08	0.037
α_{2007}	35.0576	41.5071	0.84	0.398
β_{CE}	788.5188	20.6238	38.23	0.000
β_F	424.6174	13.1896	32.19	0.000
β_{GI}	292.5483	11.7859	24.82	0.000
β_{JK}	494.3127	37.0920	13.33	0.000
β_{LP}	608.5477	13.8907	43.81	0.000
β_{AP}^*	623.5334	15.6945	39.73	0.000
constant	1511.548	58.14924	25.99	0.000

* To increase the number of observations and thus the estimation precision, additionally the sum of all sectors (AP) is added.
Results of the region effects are attached to the appendix (figure 2).
Source: own calculations.

is captured by the interaction term. Due to heteroskedasticity³, robust covariance matrix estimators are applied. The results are presented in table 1. The model explains $R^2 = 86.41$ % of the variance and the explanatory variables together have a significant influence (the F-statistic is 50.23 and significant with $p = 0.00$). Applying the generalized variance inflation factors (especially designed for large sets of dummy variables) by Fox and Monette (1992), it becomes clear that multicollinearity is not a problem.⁴ The complete set of dummy variables has also a significant influence.⁵

The resulting regression coefficients of this analysis form the basis for building the adjusted wage. This is defined as the wage, which is not ascribed to productivity and thus results from the region, sector and year effects as well as from the interaction term. Through the interaction term a variation of the adjusted wage over the years is allowed. A problem of the upcoming estimation might be endogeneity, since the wage could be influenced by employment. However, a regression of the adjusted wage on employment and the fixed effects shows that employment has not a significant influence on the adjusted wage.

³The Breusch-Pagan-test statistic is $\chi^2 = 6.01$, which is significant at $\alpha = 0.05$.

⁴The generalized variance inflation factor for the correlation between the set of dummy variables with the remaining explanatory variables, corrected for the dimension of the set of dummy variables is $GVIF^{1/2p} = 1.153$, whereas it is 1.186 for the correlation of the set of sector dummies and 1.152 for the set of interaction terms (including year and region effects) with the respectively remaining explanatory variables and corrected for the dimension of the respective set of dummy variables.

⁵The F-statistic for the F-test between the full model and the reduced model, not including the dummy variables, is 16.501.

3.2 Spatial autocorrelation

For the estimation of the regional employment development not only the adjusted wage is of interest, but also the influence of spatial interactions plays an important role. As opposed to time series analysis, where a variable can only be influenced by past values of itself, in spatial econometrics multi-directional dependencies occur: A region is not only influenced by potentially all other regions, but also potentially influences all other regions. To model such multi-directional interdependencies, spatial weight matrices are applied. It is assumed that the spatial dependence between two regions decreases with increasing distance between the regions according to an exponential function (following Niebuhr; 2000):

$$w_{ij}^* = e^{-d_{ij}\beta} \quad (2)$$

The unstandardized spatial dependence w_{ij}^* between two regions i and j is a function of the travel time d_{ij} between these regions and a parameter β , which is a function of the average distance between all regions \bar{d} and the distance decay parameter γ :

$$\beta = -\frac{\ln(1 - \gamma)}{\bar{d}} \quad (3)$$

In order to build the spatial weight matrix, these spatial dependencies are calculated for different values⁶ of γ and the matrix is row-standardized (the matrix is recalculated so that the row sums equal one). When γ increases, the relative weight of nearby regions increases and small scale spatial structures result. Vice versa, with decreasing γ , the relative weight of remote regions converges to the weight of nearby regions and large scale spatial structures result. The travel time d_{ij} is depicted from RRG (2009). However, the spatial weight matrix only models potential interactions between the regions. To measure the empirical relevance of these potential interactions for different variables, the Moran coefficient (a measure of spatial autocorrelation) is applied.

Adopting this procedure, different spatial weight matrices, resulting from different values of γ and thus representing a different scale of potential spatial interactions, can be compared with regard to their empirical relevance for particular variables. It is hence possible to identify the scale of spatial interdependencies (i.e. small or large scale spatial structures).

When calculating the Moran coefficient for the growth rate of employees (liable to social insurance contribution) between 1999 and 2007, small scale spatial interdependencies become obvious, i.e. with increasing γ , the value and significance of the Moran coefficient increases.

⁶ γ lies in the range between 0 and 1.

With higher relative weight of nearby regions, spatial interdependencies turn up. Therefore spatial interactions take place between close regions. This is not only true for the sum of all sectors, but also for all individual sectors: the spatial autocorrelation is always positive (i.e. the Moran coefficient is greater than its mean) and significant (for $\gamma \geq 0.05$), while its value and significance increases in γ .

The same result can be observed for the growth rate of real productivity between 1999 and 2007. Here there is also significant positive spatial autocorrelation, while value and significance of the spatial autocorrelation increases in γ , pointing to small scale spatial interactions⁷. Only for the average monthly wage the results are mixed: in all sectors except *agriculture, forestry and fishery*, value and significance of spatial autocorrelation increase in γ . However, the spatial autocorrelation in sector *agriculture, forestry and fishery* and *financing, leasing and business services* is not significant for any value of γ and in sectors *manufacturing industry, construction industry* and *hotel, trade and traffic industry* it is only significant for γ equal or greater 0.65 (with $\alpha = 0.05$).

Interdependencies of regional labor markets thus take place on a small scale: regions are predominantly influenced by nearby regions — remote regions play solely a minor role. To model these small scale spatial interdependencies and hence to calculate the spatial weight matrix for the following analysis a γ of 0.9 is applied.⁸

4 Regression models and results

The employment development of regional labor markets is potentially influenced by interactions between the regional labor markets, which are, however, to a large extent neglected by the recent empirical literature. Currently so called shift-share-regression-models are applied, which disregard spatial interactions (an exception is an unpublished paper of Schanne; 2006). There exist regression models in panel structure accounting for spatial interactions, but shift-share-regression-models incorporate the sector dimension additionally to the space and time dimension. A simple transmission of panel models with spatial interactions to shift-share-regression-models is thus not possible. For this reason, in this paper the relevance of spatial autocorrelation for regional employment development is measured by cross sectional analyses. For these established regression models incorporating spatial interactions exist.

Conversely, in cross sectional analyses only the growth rate of employment between two points

⁷An exception is sector *financing, leasing and business services*, where there is no significant spatial autocorrelation for any value of γ .

⁸In some sectors, the significance of the spatial autocorrelation decreased for $\gamma > 0.9$

in time can be analyzed — results are thus influenced by the choice of these points in time. Furthermore the number of observations is considerably lower than in shift-share-regression-models and results are therefore less robust. Additionally, the sectors have to be analyzed individually. Due to these differing advantages and disadvantages of cross sectional models and shift-share-regression-models, both models will be adopted in the following.

4.1 Cross sectional analyses

To investigate the importance of spatial interdependencies for regional employment development, cross sectional regressions are applied. Therefore, individual sectors are analyzed using the growth rates of employment between 1999 and 2003, 2003 and 2007, and 1999 and 2007.

Methodology

The determinants (explanatory variables) of regional employment growth \hat{L}_r can be depicted from the theoretical background: Hence the growth rate of the adjusted wage $\left(\frac{\hat{W}}{P}\right)_r$ and productivity $\hat{\pi}_r$, the share of medium/high qualified employees (q_r^M and q_r^H) as well as the spatial lags of these variables (i.e. the average value of these variables in the neighboring regions, weighted by the spatial weight matrix) influence the growth rate of regional employment. Additionally the spatial lag of the employment growth rate is introduced: The employment growth rate of a region depends not only on the exogenous variables mentioned above, but also on the average employment development in nearby regions (weighted by the spatial weight matrix \mathbf{W}). Furthermore the location coefficient⁹ LQ_r , the population density D_r , the number of employees per plant G_r and a dummy variable for eastern German regions $East_r$ are introduced as controls.

For each sector and growth rate, a basic model is estimated, incorporating only the variables of the region itself:

$$\begin{aligned} \hat{L}_r = & \beta_0 + \beta_1 \left(\frac{\hat{W}}{P}\right)_r + \beta_2 \hat{\pi}_r + \beta_3 q_r^H + \beta_4 q_r^M + \beta_5 LQ_r + \beta_6 D_r \\ & + \beta_7 G_r + \beta_8 East_r + \epsilon_r \end{aligned} \quad (4)$$

The model is extended to the cross regressive model by introducing the spatial lags of the exogenous variables:

⁹The location coefficient is the share of employees of sector i and region r in the number of employees in region r , divided by the share of employees of sector i in the number of employees in the reference region (Germany).

$$\begin{aligned}\hat{L}_r = & \beta_0 + \beta_1 \left(\frac{\hat{W}}{P} \right)_r + \beta_2 \hat{\pi}_r + \beta_3 q_r^H + \beta_4 q_r^M + \beta_5 LQ_r + \beta_6 D_r + \beta_7 G_r \\ & + \beta_8 East_r + \beta_9 \mathbf{W} \left(\frac{\hat{W}}{P} \right)_r + \beta_{10} \mathbf{W} \hat{\pi}_r + \beta_{11} \mathbf{W} q_r^H + \beta_{12} \mathbf{W} q_r^M + \epsilon_r\end{aligned}\quad (5)$$

Where \mathbf{W} represents the spatial weight matrix and thus \mathbf{W} times a variable denotes the spatial lag of the particular variable (i.e. the spatially weighted mean of the variable in nearby regions).

The basic model is extended to the spatial lag model by introducing the spatial lag of the endogenous variable:

$$\begin{aligned}\hat{L}_r = & \beta_0 + \beta_1 \left(\frac{\hat{W}}{P} \right)_r + \beta_2 \hat{\pi}_r + \beta_3 q_r^H + \beta_4 q_r^M + \beta_5 LQ_r + \beta_6 D_r \\ & + \beta_7 G_r + \beta_8 East_r + \rho \mathbf{W} \hat{L}_r + \epsilon_r\end{aligned}\quad (6)$$

Alternatively the basic model is extended to the spatial error model by introducing the spatial lag of the error term to the model:

$$\begin{aligned}\hat{L}_r = & \beta_0 + \beta_1 \left(\frac{\hat{W}}{P} \right)_r + \beta_2 \hat{\pi}_r + \beta_3 q_r^H + \beta_4 q_r^M + \beta_5 LQ_r + \beta_6 D_r \\ & + \beta_7 G_r + \beta_8 East_r + \epsilon_r \text{ where } \epsilon_r = \lambda \mathbf{W} \epsilon_r + v_r\end{aligned}\quad (7)$$

whereas v_r represents a normally distributed error term. In order to get unbiased results, the spatial lag and error models are estimated using maximum likelihood.

Results

All models are estimated using the full range of explanatory variables and, if necessary due to heteroscedasticity, robust estimators are applied. In the next step the individual models are reduced to the significant explanatory variables and tests for spatial dependence are calculated for the basic model and the cross regressive model (these tests do not apply to the spatial lag and error model). The results can be depicted from table 2, they will be discussed in detail below. Since all tolerance coefficients exceed 0.1 (and most exceed 0.2), multicollinearity is not a problem.

Five tests for spatial dependency are applied. The Moran test (i.e. the test of significance for the Moran coefficient) delivers an overall test for the importance of spatial dependence of the error terms. If the Moran coefficient significantly deviates from zero spatial autocorrelation (i.e. the mean of the Moran coefficient), this is an indicator for spatial dependency. However, it still

Table 2: Tests for spatial dependency in cross sectional regressions

model	growth rate	sector	Moran	LMERR	LMERR (robust)	LMLAG	LMLAG (robust)
basic	1999-2003	AB	—	0.278	0.188	0.817	0.435
cross regressive	1999-2003	AB	—	0.278	0.188	0.817	0.435
basic	2003-2007	AB	0.002	0.257	0.067	0.979	0.150
cross regressive	2003-2007	AB	—	0.210	0.054	0.748	0.133
basic	1999-2007	AB	0.009	0.587	0.774	0.626	0.877
cross regressive	1999-2007	AB	0.000	0.060	0.104	0.295	0.659
basic	1999-2003	CE	0.011	0.571	0.235	0.119	0.060
cross regressive	1999-2003	CE	0.430	0.644	0.878	0.619	0.811
basic	2003-2007	CE	0.000	0.205	0.094	0.598	0.225
cross regressive	2003-2007	CE	—	0.150	0.385	0.250	0.993
basic	1999-2007	CE	0.000	0.169	0.015	0.024	0.002
cross regressive	1999-2007	CE	0.599	0.482	0.967	0.300	0.445
basic	1999-2003	F	0.000	0.000	0.043	0.000	0.000
cross regressive	1999-2003	F	0.000	0.012	0.985	0.000	0.000
basic	2003-2007	F	0.537	0.661	0.060	0.124	0.017
cross regressive	2003-2007	F	0.792	0.451	0.438	0.752	0.713
basic	1999-2007	F	0.000	0.001	0.300	0.000	0.000
cross regressive	1999-2007	F	0.000	0.101	0.891	0.000	0.001
basic	1999-2003	GI	0.002	0.337	0.644	0.017	0.025
cross regressive	1999-2003	GI	0.077	0.932	0.328	0.556	0.255
basic	2003-2007	GI	0.000	0.020	0.251	0.002	0.022
cross regressive	2003-2007	GI	0.679	0.550	0.106	0.097	0.025
basic	1999-2007	GI	0.005	0.406	0.608	0.037	0.048
cross regressive	1999-2007	GI	0.771	0.509	0.615	0.668	0.975
basic	1999-2003	JK	0.442	0.763	0.643	0.958	0.721
cross regressive	1999-2003	JK	0.017	0.831	0.322	0.544	0.253
basic	2003-2007	JK	0.042	0.404	0.166	0.493	0.193
cross regressive	2003-2007	JK	0.042	0.404	0.166	0.493	0.193
basic	1999-2007	JK	0.000	0.109	0.343	0.196	0.915
cross regressive	1999-2007	JK	0.434	0.609	0.607	0.774	0.771
basic	1999-2003	LP	0.000	0.019	0.106	0.028	0.160
cross regressive	1999-2003	LP	0.000	0.033	0.158	0.030	0.145
basic	2003-2007	LP	0.021	0.660	0.374	0.058	0.040
cross regressive	2003-2007	LP	0.763	0.555	0.987	0.366	0.494
basic	1999-2007	LP	0.000	0.005	0.082	0.002	0.036
cross regressive	1999-2007	LP	0.019	0.797	0.734	0.936	0.814

The table contains the p-values of the tests for spatial dependency: Moran-test, spatial error and spatial lag test (including the robust variants of the latter two tests) for the basic and cross regressive models. Source: own calculations.

remains to be clarified, which is the underlying form of spatial dependency. Spatial dependency may occur in the form of the spatial lag model — i.e. the endogenous variable depends on its own spatial lag. Alternatively spatial dependency may be based on the spatial error model — i.e. the spatial lag of the error term may exert a significant influence. To differ between these two cases, the LMLAG (test of significance for the spatial lag model) and LMERR tests (test of significance for the spatial error model) are applied, as well as their robust versions.

The test statistics for spatial dependency show for the basic models that in some cases (sectors/growth rates) spatial autocorrelation, measured by the Moran coefficient, is significant. However, if the spatial lags of the exogenous variables are introduced — i.e. the cross regressive model is estimated — the degree and significance of spatial autocorrelation reduces. This relationship varies over sectors (see table 2). If the spatial lags of the exogenous variables are

accounted for, the (robust) LMERR and LMLAG tests show no significant autocorrelation (with only few exceptions). The cross regressive models (sometimes the basic model) are additionally preferred over the spatial lag and error models by the AIC and BIC statistics (see table 5). Only for sector *construction industry*, the spatial lag model seems to deliver better results than other models.

Thus, except for sector *construction industry*, the spatial autocorrelation results from the neglect of the spatial lags of the exogenous variables. Expressed differently, the cross regressive model is preferred — introducing the spatial lags of the exogenous variables to the basic model sufficiently explains the spatial dependency of the endogenous variable (i.e. the employment development). However, the spatial lags of the exogenous variables can be introduced into the shift-share-regression-models without any further adjustment. Thus the main disadvantage of the shift-share-regression-model over cross sectional regressions — i.e. the inability of introducing a spatial lag or error term — does not apply in the case of employment development. The advantages in form of more robust estimators and a larger number of observations still hold. Therefore the shift-share-regression-models dominate cross regressive models here and the following discussion only refers to the shift-share-regression-model.

4.2 Shift-share-regression-model

In the recent literature on regional employment development in Germany, the shift-share-regression-framework is frequently applied.¹⁰ Though these models do not allow to introduce spatial lags of the error term or the endogenous variable, they do allow for introducing spatial lags of the exogenous variables which is the relevant case here.

Methodology

Shift-share-regression-models estimate the influence of region γ_r , sector β_i and year effects α_t and additional explanatory variables \mathbf{X}_{irt} on an endogenous variable y_{irt} (here the employment growth rate), similar to a panel model with fixed effects. Since here the employment growth rate is estimated, the regression has to be weighted by the employment share of each region-sector-combination in total employment (for every year) g_{irt} . Thereby the model accounts for both, the heterogeneity as well as the interpretation of the estimation as the average employment growth rate. For a better interpretation of the fixed effects, the sums of the sector, region and respectively year effects are constrained to zero. Additionally the sum of the region effects of region type j (e.g. eastern Germany) is constrained to the effect of the region type j . Hence the

¹⁰The framework was developed by Patterson (1991).

model in general can be written as:

$$y_{irt}g_{irt} = \alpha_t g_{irt} + \beta_i g_{irt} + \gamma_r g_{irt} + \delta_j g_{irt} + \mathbf{X}_{irt} g_{irt} \beta^* + \epsilon_{irt} g_{irt} \quad (8)$$

whereas g_{irt} represents the share of the sector-region-combination ri in the total employment of Germany in year t and ϵ_{irt} is the error term. The constraints are:

$$\begin{aligned} \sum_{i=1}^m \sum_{r=1}^n \sum_{t=1}^o \alpha_t g_{irt} &= 0 \\ \sum_{i=1}^m \sum_{r=1}^n \sum_{t=1}^o \beta_i g_{irt} &= 0 \\ \sum_{i=1}^m \sum_{r=1}^n \sum_{t=1}^o \gamma_r g_{irt} &= 0 \\ \sum_{i=1}^m \sum_{r=1}^n \sum_{t=1}^o \varphi_j g_{irt} \gamma_r &= \delta_j \end{aligned} \quad (9)$$

whereas φ_j has value one, if region r is of regiontype j and zero otherwise.

Results

In a first step, all explanatory variables and their spatial lags are incorporated to the model. However, as multicollinearity results, adjustments are necessary. First, the share of high qualified and medium qualified employees is aggregated. The qualification is then represented by the share of medium and high qualified employees.¹¹ Furthermore there is a strong correlation between the growth rate of the adjusted wage and its spatial lag. While the introduction of the spatial lag into a model with only the growth rate of the adjusted wage does not significantly deliver additional explanation (measured by the F-test), the opposite is true for the opposite case. Therefore only the growth rate of the adjusted wage is incorporated into the model, while its spatial lag is neglected.

As well there is a strong correlation between the share of qualified employees and its spatial lag. While the introduction of the spatial lag into a model with only the share of qualified employees significantly delivers additional explanation, the opposite is true for the opposite case. Therefore the share of qualified employees is not incorporated into the model, while its spatial lag is. An explanation for this result is that the qualification of the employees of a region already

¹¹Hence the variable actually controls for the influence of low qualified. A problem that may result is that in regions where there is a favorable development of the labor market, it will be easier for low qualified to find employment so that their share may be higher. Furthermore the share of medium qualified is a heterogeneous group, blurring the results. However, due to multicollinearity this adjustment is necessary — otherwise the sign of the coefficients was unsure.

is measured by the productivity of the region. Furthermore this result may follow from the aggregation of medium and high qualified, which is, however, a necessary adjustment to avoid multicollinearity. The previous controls (population density, number of employees per plant and location coefficient) are dropped due to multicollinearity; they represent foremost regional features, whose time invariant parts are captured by the region effects. Even though the assumption of exogeneity of the productivity growth in the estimation of employment growth cannot be dropped by the Wu-Hausman-Test (the p-value is 0.15, see appendix A.1), the productivity growth rate is introduced into the model with a time-lag of one year to assure exogeneity. Thus, the following model is estimated:

$$\begin{aligned}\hat{L}_{irt} = & \alpha_t + \beta_i + \gamma_r + \beta^0 + \beta^1 East_r + \beta^2 \mathbf{W}q_{rt}^{M+H} + \beta_i^3 \hat{\pi}_{ir(t-1)} + \beta_i^4 \mathbf{W}\hat{\pi}_{ir(t-1)} \\ & + \beta_i^5 \left(\frac{\hat{W}}{P} \right)_{ir} + \epsilon_{irt}\end{aligned}\tag{10}$$

whereas \hat{L}_{irt} represents the yearly growth rates of employment, α_t , β_i and γ_r are the year, sector and region effects, β^0 is a constant, $East_r$ is a dummy variable for eastern German regions, $\mathbf{W}q_{rt}^{M+H}$ is the spatially weighted average share of qualified employees in the neighboring regions, $\hat{\pi}_{ir(t-1)}$ is the time-lagged yearly growth rate of real productivity, $\mathbf{W}\hat{\pi}_{ir(t-1)}$ its spatial lag and $\left(\frac{\hat{W}}{P} \right)_{ir}$ is the growth rate of the adjusted wage between 1999 and 2007. Weights and constraints are applied to the model as discussed above (for a more compact illustration both were not introduced to the above equation). Results are presented in table 3 and figures 1 and 3.

The coefficient of determination is comparatively high with $R^2 = 0.76$. Multicollinearity is, according to the generalized variance inflation factors by Fox and Monette (1992), not a problem (after the above discussed elimination of variables).¹² Heteroscedasticity is controlled for by weighting the regression. The F-test for omitted spatially lagged exogenous variables (Florax and Folmer; 1992) shows that all included spatially lagged exogenous variables are relevant for the model.

A significant spatial lag of the endogenous variable appears in the cross sectional analysis for sector *construction industry* (see above). Therefore sector *construction industry* is excluded for comparison: The (significant) coefficients of both shift-share-regression-models (with and without sector *construction industry*) only change marginally — the mean absolute deviation between the significant coefficients of both models is 1.7 %. For the other sectors no spatial dependence (in form of the spatial lag or error model) is expected due to the results from the cross sectional analyses. To assure these results the Moran test is applied to the residuals of all

¹²The generalized variance inflation factor (corrected for the dimension of the set of dummy variables) only amounts to 1.03.

Table 3: Shift-share-regression-model

	coefficient	standard error	t-statistic	p-value
Wq^{M+H}	-0.8351	0.0371	-22.49	0.000
$East$	0.7744	0.0367	21.11	0.000
$\pi_{\hat{A}B}$	-0.0192	0.2162	-0.09	0.929
$\pi_{\hat{C}E}$	0.0004	0.0125	0.03	0.977
$\pi_{\hat{F}}$	0.1314	0.0616	2.13	0.033
$\pi_{\hat{G}I}$	-0.0171	0.0073	-2.35	0.019
$\pi_{\hat{J}K}$	-0.0830	0.0299	-2.77	0.006
$\pi_{\hat{L}P}$	0.1660	0.0444	3.74	0.000
$W\pi_{\hat{A}B}$	-0.0829	0.2539	-0.33	0.744
$W\pi_{\hat{C}E}$	-0.0128	0.0381	-0.34	0.736
$W\pi_{\hat{F}}$	0.1449	0.1611	0.90	0.368
$W\pi_{\hat{G}I}$	0.0424	0.0206	2.06	0.040
$W\pi_{\hat{J}K}$	-0.1807	0.0473	-3.82	0.000
$W\pi_{\hat{L}P}$	0.3527	0.0780	4.52	0.000
$(W/\hat{P})_{AB}$	-34.2544	1.6020	-21.38	0.000
$(W/\hat{P})_{CE}$	-50.1806	2.3124	-21.70	0.000
$(W/\hat{P})_F$	-42.8920	1.9667	-21.81	0.000
$(W/\hat{P})_{GI}$	-39.8613	1.8381	-21.69	0.000
$(W/\hat{P})_{JK}$	-43.9880	2.0312	-21.66	0.000
$(W/\hat{P})_{LP}$	-46.4709	2.1415	-21.70	0.000
constant	3.47E-06	6.15E-07	5.64	0.000

The table contains the results for selected variables of the model. Results for the region effects are illustrated in figure 3 and for the sector and year effects in figure 1.
Source: own calculations.

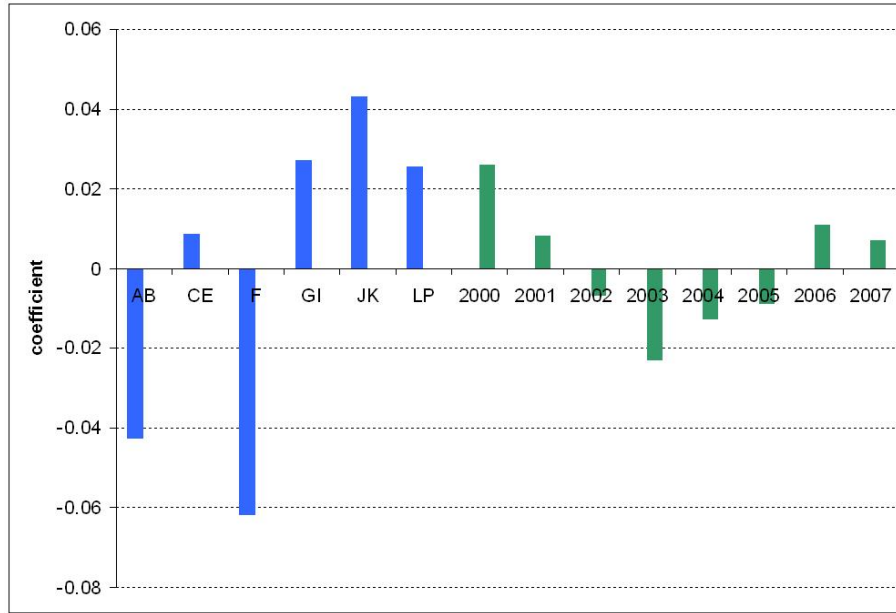
sector-year-combinations of the shift-share-regression-model. In only 2 of 48 cases (4.17 %), there appears significant spatial autocorrelation. Thus there is no systematic spatial autocorrelation — spatial autocorrelation is sufficiently captured by the spatial lags of the exogenous variables.

The results point to a negative influence of the share of qualified employees of nearby regions on the employment development of the observed region, while the share of qualified employees of a region doesn't exert any influence on the employment development of the region beyond its indirect influence through productivity increases. The latter result may be due to the aggregation of qualification, which is however necessary in consequence of multicollinearity.

Furthermore it follows from the results, that employment development in eastern Germany would have been more favorable than in western Germany, if all other variables (in particular productivity and wage development) were the same. In other words, the relative worse development of eastern German regions as compared to western German regions is due to productivity and wage development, qualification level, and sectoral structure.

The influence of the time-lagged yearly growth rate of productivity on employment growth differs between sectors, as predicted by theory. However, the signs of the coefficients don't deliver the results expected by theory. In sector *agriculture, forestry and fishery* and *manufacturing industry*, no significant influence of productivity growth on employment development is visible. In

Figure 1: Sector and year effects of the shift-share-regression-model



Except for sector CE, all sector and year effects are significant at $\alpha = 0.01$.

Source: own calculations.

contrast, employment development in sector *construction industry* is stimulated by productivity growth, while it is hindered in sectors *hotel, trade and traffic industry, financing, leasing and business services* and *private and public services*. It should be kept in mind, that productivity growth is positive in all sectors except sector *financing, leasing and business services*.

The influence of the time-lagged yearly growth rate of productivity in nearby regions on employment growth also differs between the sectors. While there is no significant influence in sectors *agriculture, forestry and fishery, manufacturing industry* and *construction industry*, the employment development of a region in sector *financing, leasing and business services* is hindered by productivity growth and enhanced in sectors *hotel, trade and traffic industry* and *private and public services*.

The influence of the growth rate of the adjusted wage between 1999 and 2007 on employment development is significantly negative in all sectors. ‘Excessive wages’ negatively affect employment growth of a region. Illustrating the region effects in a map, it becomes clear that especially agglomerations (such as Berlin, Hamburg or Munich) are affected negatively. The relative better employment development in these regions is thus due to other effects such as productivity, qualification, wages or the sectoral structure.

The sector effects clearly mirror the structural change from the primary and secondary sector to the tertiary. Similarly, the year effects reflect the business cycle with upturns between 2000 and 2001, 2006 and 2007, and a downturn between 2002 and 2005.

5 Discussion

In the following the empirical results are compared to theory and previous empirical research to incorporate them into the existing body of literature. First of all, it becomes apparent that regional employment development is characterized by spatial autocorrelation. However, the main result of the cross sectional analysis is that this spatial autocorrelation is due to the influence of spatially lagged exogenous variables. These can be introduced into a shift-share-regression-model, which potentially delivers more robust results than cross sectional analyses. Therefore the following discussion on the determinants of regional employment development rests upon the shift-share-regression-model and is organized into the individual determinants.

Adjusted wage growth

Theoretically both, a positive and a negative influence of (adjusted) wages on employment is imaginable, depending on whether purchase power arguments are sufficient to overcompensate cost arguments — even though purchase power arguments are usually negated in economic theory. Previous empirical research accordingly usually observes a negative influence of (adjusted) wages on employment growth. Only for individual, regionally oriented service sectors cost and purchase power arguments seem to cancel each other out. In this paper, a significant negative influence for all sectors is observed: A wage growth, which is not ‘justified’ by productivity increases, leads to significant reductions in employment growth.

In contrast to the findings of Suedekum and Blien (2007), no significant influence of the wage of nearby regions on the employment development of the observed region occurs. Suedekum and Blien (2007) discover a positive relationship between the wage of nearby regions and employment development in the observed region, pointing to the dominance of migration of firms. However, the authors only included western Germany while in this paper all German regions are included. This paper covers additionally migration flows of employees from eastern to western Germany, potentially compensating the positive influence of the wage of nearby regions on the employment development of the observed region due to migration of firms. Thus the insignificant influence of the spatial lag of the adjusted wage growth rate points to migration of firms and employees canceling each other out.

Qualification

In theory, the share of qualified employees exerts a positive influence on employment (in a region) for two reasons: Firstly, the labor market chances of qualified people are higher and secondly due to complementarities between low and high qualified employees low qualified benefit from the qualification of high qualified employees. Previous empirical studies confirm the positive influence of the share of qualified employees on the employment development of a region. The results of this paper in contrast indicate that the share of qualified employees does not exert any influence on employment growth beyond the indirect influence through productivity. However, it has to be kept in mind that in the present paper the share of medium and high qualified employees had to be aggregated in order to avoid multicollinearity. The explanatory power of the qualification variable is hence reduced.

The results of this paper instead point to a negative influence of the share of qualified employees of neighboring regions on the employment development of the observed region. Positive human capital spillovers between regions thus do not occur — rather there seems to be competition among regional labor markets with respect to qualification level.

Productivity growth

On the basis of the Appelbaum and Schettkat (1993) model, a sectorally varying influence of productivity on employment growth appears plausible. An elastic demand in the branches of the tertiary sector is assumed to lead to a positive relationship between productivity growth and employment development, while the opposite is assumed in the branches of the primary and secondary sectors. Previous empirical research on German regional labor markets often cites this model to argue, why a sectoral decomposition is necessary. However, there is no study for German regions directly measuring the influence of productivity increases on employment growth. These studies measure the influence of the sectoral structure on employment growth and conclude that employment growth is higher in branches of the tertiary sector, while it is lower in branches of the primary and secondary sector, reflecting structural change.

This paper directly estimates the (sectoral varying) influence of productivity increases on regional employment growth. Significant sectoral differences in the influence become apparent. However, the influence only partly reflects the expectations drawn from the Appelbaum and Schettkat (1993) model. Structural change towards the tertiary sector is only partly reflected by the relationship between productivity increases and employment growth, but instead strongly by the sector effects. The underlying influences for the sector effects remain subject to research though.

Productivity Spillover

In the endogenous growth theory literature, knowledge spillovers are discussed. As these are re-

lated to distance, due to their tacit characteristics, regional knowledge spillovers seem plausible: The productivity of a region is likely to influence labor markets of nearby regions through knowledge spillovers. Currently, there is no empirical evidence on the significance of inter-regional knowledge spillovers for regional employment growth. This paper, instead, focuses on these interdependencies and finds different results for different sectors.

While there is no significant influence of productivity growth of nearby regions on the observed region in sectors *agriculture, forestry and fishery, manufacturing industry* and *construction industry*, the employment development in sector *financing, leasing and business services* is positively and in sectors *hotel, trade and traffic industry* and *private and public services* negatively influenced by the productivity growth of nearby regions. Only in sectors *hotel, trade and traffic industry* and *private and public services* there are indications of positive knowledge spillovers between regional labor markets. However, as there is a negative influence of productivity on employment growth in sector *hotel, trade and traffic industry*, the result cannot be interpreted as positive knowledge spillovers. For sector *financing, leasing and business services* the underlying theory does not deliver explanation approaches for the observed effects, too.

6 Conclusions

The employment development in Germany is characterized by considerable regional disparities. At regional level often the sectoral structure is used as an explanation approach. To measure this influence empirically, in the recent literature shift-share-regression-models are frequently applied. These regression models control for the sectoral structure by sectoral fixed effects. However, they don't account for regional interdependencies. Regions are (with only few exceptions) treated as autarkies. The aim of this paper is to identify the determinants of regional employment growth, controlling for regional interdependencies.

The results indicate strong spatial autocorrelation of regional employment growth, i.e. the employment development of a region is interrelated with the employment development of nearby regions. Cross sectional analyses show, that this spatial autocorrelation is due to the influence of spatially lagged exogenous variables, e.g. productivity growth of nearby regions influences employment development of the observed region. These spatial lags of the exogenous variables can be introduced into the framework of shift-share-regression-models without any further adjustment.

In this paper, such a shift-share-regression-model, accounting for the influence of the spatially lagged exogenous variables is estimated. Moran tests for the residuals indicate that the spatial autocorrelation of regional employment growth is sufficiently captured by the spatially lagged

exogenous variables of the model.

The results of the model point to a negative influence of the adjusted wage on regional employment growth: ‘excessive’ increases in wages negatively affect regional employment development. Additionally a negative influence of the share of qualified employees in nearby regions on the employment development of the observed region appears, pointing to a competitive relationship between nearby regional labor markets.

Structural change is explained by the Appelbaum and Schettkat (1993) model through sectorally varying influences of productivity increases on employment development. However, even though this influence is observed to vary between sectors, the estimated direction of influence doesn’t point to the structural change hypothesis for all sectors. Instead structural change is captured by sectoral fixed effects. What these fixed effects are based on remains subject to research, though.

Regional interdependencies are visible for productivity growth: The productivity growth of nearby regions influences employment development in the observed region. Yet the direction of the influence may only be interpreted as positive knowledge spillovers in sector *private and public services*. For sectors *hotel, trade and traffic industry* and *financing, leasing and business services* the reasons for observed relationship remain subject to research and for the remaining sectors no influences occur.

The main finding of this paper is that regional interdependencies are important for regional employment growth and that they are sufficiently captured by the spatial lags of the exogenous variables.

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A Appendix

A.1 Tests for endogeneity

When employment is regressed on productivity, it is not evident, whether productivity denotes an exogenous variable: productivity could be influenced by employment itself. In the latter case, productivity would be introduced to the regression model as an endogenous variable and lead to inconsistent estimators. Therefore the Wu-Hausman-Test for endogeneity is applied to the relevant regression models (see Johnston and DiNardo; 1996, S. 257-259 for the Wu-Hausman-Test).

The primary model is:

$$y = \beta_0 + \beta_1 X_{ex} + \beta_2 X_{end} + \epsilon \quad (11)$$

where X_{ex} is a set of variables, which is assumed to be exogenous, while X_{end} is tested for endogeneity. Under the null hypothesis, X_{end} is exogenous:

$$H_0 : plim \left(\frac{1}{n} (X_{end})' \epsilon \right) = 0 \quad (12)$$

Next the regressor X_{end} is estimated by the set of exogenous variables X_{ex} and additional controls Z :

$$X_{end} = \gamma_0 + \gamma_1 X_{ex} + \gamma_2 Z + \varepsilon \quad (13)$$

The estimated values \hat{X}_{end} are included in the primary regression:

$$y = \beta_0 + \beta_1 X_{ex} + \beta_2 X_{end} + \beta_3 \hat{X}_{end} + \epsilon \quad (14)$$

When the null hypothesis H_0 is true, β_3 doesn't significantly deviate from zero. The test statistic of β_3 is (where X_{end} contains l variables):

$$\frac{\hat{\beta}_3^2}{var(\hat{\beta}_3)} \sim \chi^2(l) \quad (15)$$

The tests for endogeneity are applied to those cross sectional analyses, where productivity exerts a significant influence. In these cases, the test for endogeneity is applied to the basic model. The auxiliary regression for the estimated values of productivity X_{end} rests upon the regressors $\left(\frac{\hat{W}}{P}\right)$, q^M , q^H , G , D , LQ and $East$. In the case of the shift-share-regression-model the set of regressors is based on $\left(\frac{\hat{W}}{P}\right)$, q^{M+H} , $W\hat{\pi}$ and the region, sector and year effects.

None of the test statistics points to a significant deviation of the coefficient $\hat{\beta}_3$ from zero: the

null hypothesis of exogeneity cannot be rejected.

Table 4: Wu-Hausman-Test for endogeneity

model	sector	growth rate	$\hat{\beta}^3$	χ^2	p-value
basic	JK	1999-2003	-0.3357	1.7826	0.1818
basic	F	2003-2007	0.0872	0.4315	0.5113
basic	JK	2003-2007	0.4937	0.9280	0.3354
basic	LP	2003-2007	0.1749	0.2684	0.6044
basic	JK	1999-2007	0.2955	0.7165	0.3973
Shift-share-model*			-0.9008	2.0531	0.1519

* without time-lag of productivity growth. Source: own calculations.

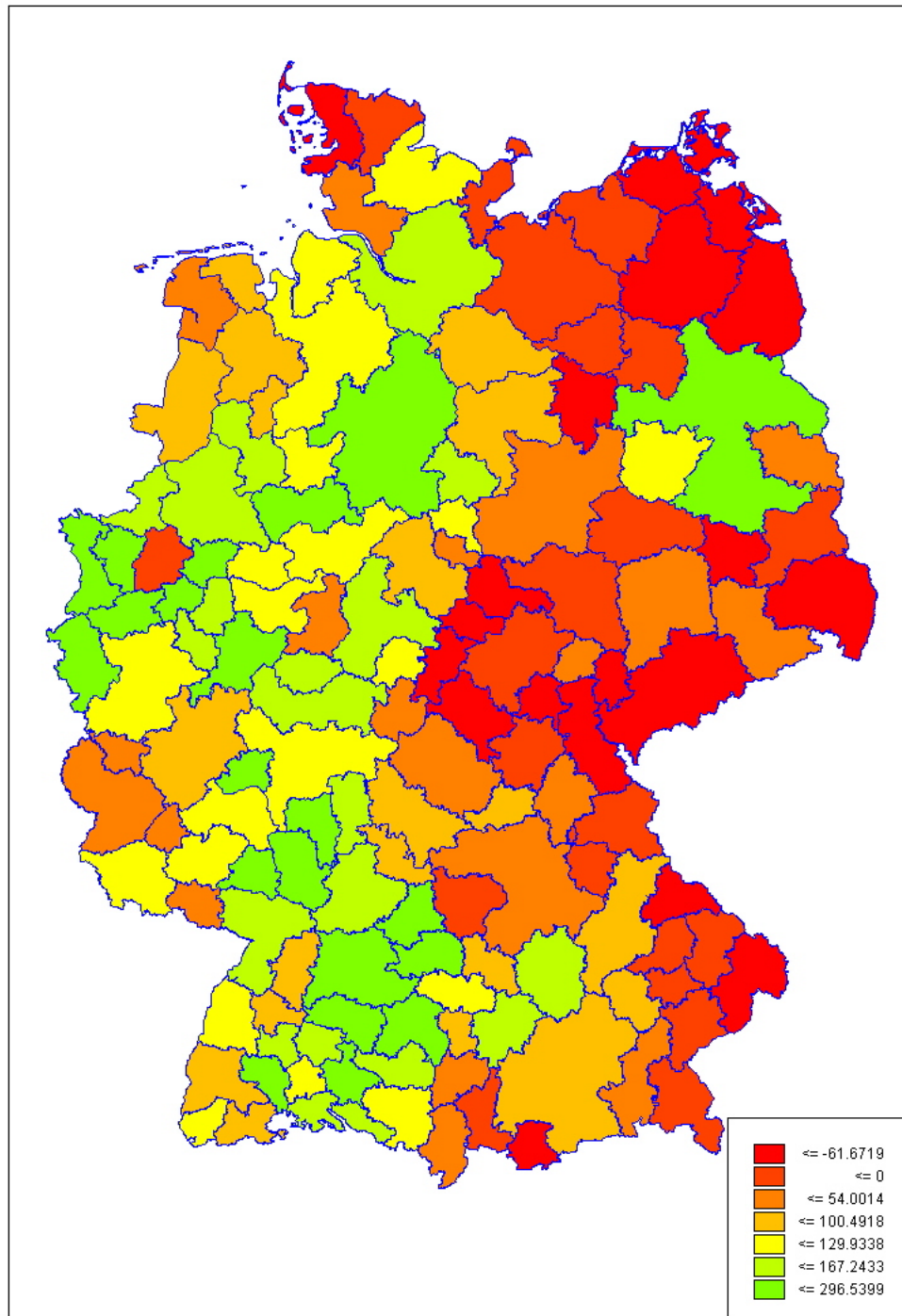
A.2 Tables and figures

Table 5: AIC and BIC for the cross sectional models

AIC					
growth rate	sector	basic	spatial lag	spatial error	cross regressive
1999-2003	AB	-299.5297	-295.6033	-298.7497	-299.5297
1999-2003	CE	-426.5078	-424.2861	-422.9316	-443.8496
1999-2003	F	-447.3313	-477.8496	-456.4904	-459.7341
1999-2003	GI	-460.4102	-462.2685	-458.7365	-465.8334
1999-2003	JK	-342.7373	-338.7407	-338.9097	-344.635
1999-2003	LP	-540.7765	-537.3366	-538.9883	-540.3141
2003-2007	AB	-210.3603	-206.3613	-207.3574	-216.6977
2003-2007	CE	-352.3254	-349.5683	-351.6678	-373.9903
2003-2007	F	-428.5826	-426.6811	-426.8033	-436.917
2003-2007	GI	-515.9178	-516.9715	-515.4027	-535.0533
2003-2007	JK	-294.7292	-291.1859	-291.3539	-294.7292
2003-2007	LP	-614.7225	-612.2883	-606.3847	-626.4783
1999-2007	AB	-153.94	-150.7137	-150.6948	-140.4106
1999-2007	CE	-241.7391	-240.642	-239.2765	-277.385
1999-2007	F	-375.3586	-396.3625	-380.2476	-390.2365
1999-2007	GI	-357.9454	-356.9319	-354.6634	-358.6181
1999-2007	JK	-179.5439	-177.3964	-176.1271	-187.7904
1999-2007	LP	-435.8159	-449.5492	-449.6671	-448.0229
BIC					
growth rate	sector	basic	spatial lag	spatial error	cross regressive
1999-2003	AB	-284.7505	-274.9126	-278.0589	-284.7505
1999-2003	CE	-411.7287	-403.5953	-402.2408	-426.1146
1999-2003	F	-432.5522	-451.2472	-432.8438	-436.0875
1999-2003	GI	-445.6311	-438.6219	-435.0898	-445.1426
1999-2003	JK	-330.914	-321.0057	-321.1747	-329.8558
1999-2003	LP	-528.9532	-522.5574	-524.2091	-525.535
2003-2007	AB	-201.4928	-191.5822	-192.5782	-198.9627
2003-2007	CE	-340.5021	-334.7892	-336.8887	-353.2995
2003-2007	F	-413.8034	-405.9903	-406.1125	-416.2262
2003-2007	GI	-507.0503	-502.1924	-500.6235	-523.23
2003-2007	JK	-288.8175	-279.3626	-279.5306	-288.8175
2003-2007	LP	-599.9434	-594.5534	-591.6056	-614.655
1999-2007	AB	-139.1609	-127.0671	-127.0482	-128.5873
1999-2007	CE	-232.8717	-225.8628	-224.4973	-259.6501
1999-2007	F	-360.5794	-372.7159	-359.5568	-369.5457
1999-2007	GI	-343.1663	-336.2411	-333.9726	-343.839
1999-2007	JK	-167.7206	-159.6614	-158.3921	-175.9671
1999-2007	LP	-423.9926	-431.8142	-431.9321	-436.1996

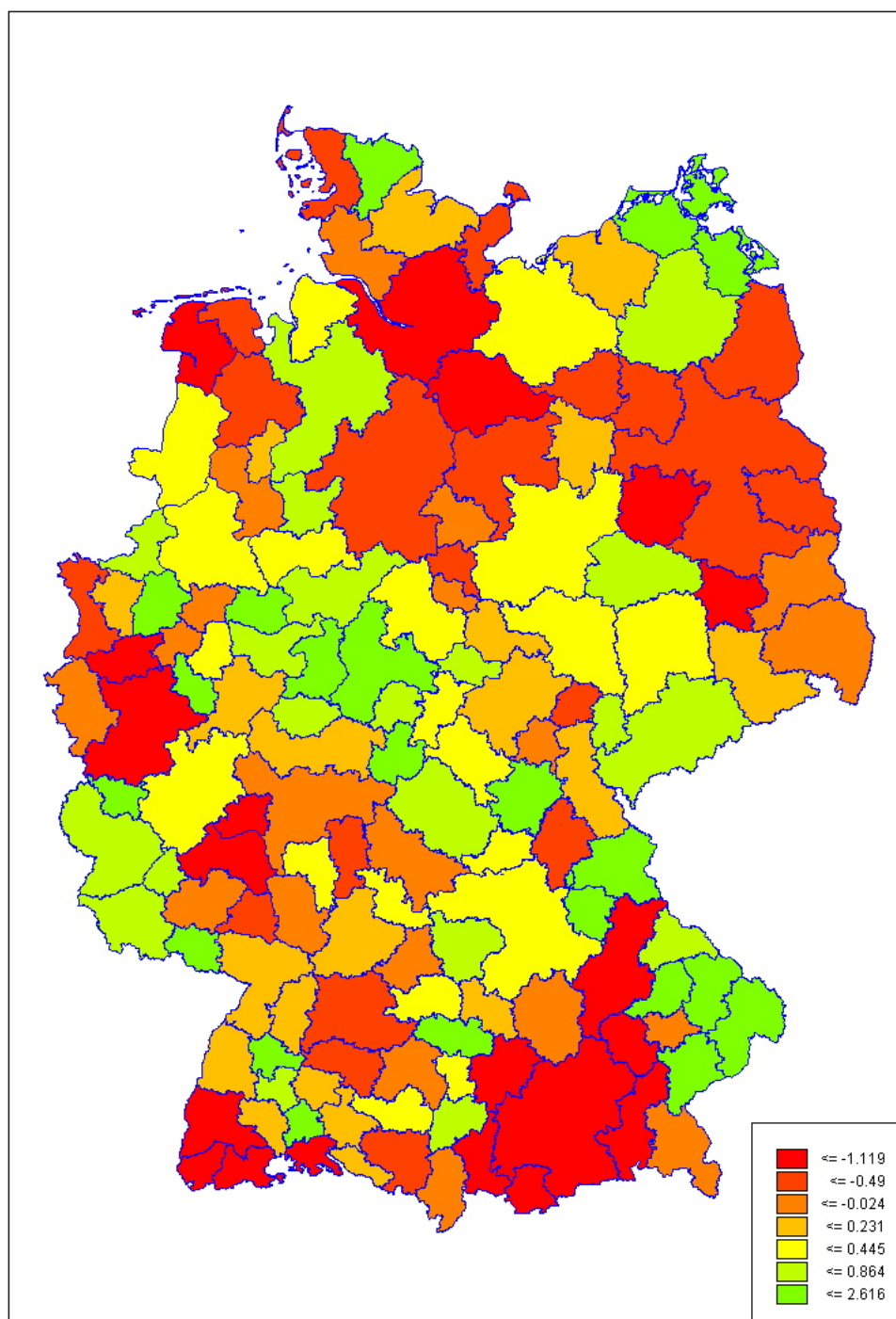
Source: own calculations.

Figure 2: Region effects of the adjusted wage regression



Source: own calculations.

Figure 3: Region effects of the shift-share-regression-model



Except for labor market region 111 (Donau-Ries), all region effects are significant at $\alpha = 0.01$.
Source: own calculations.