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The Importance of Spatial Autocorrelation for Regional Employment Growth in Germany

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Abstract

In analyzing the disparities of the regional developments in the volume of employment in Germany, in the recent empirical literature so called shift-share-regression-models are frequently applied. However, 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 using spatial autocorrelation in order to analyze regional employment development. Spatial dependency in the form of spatial lag, spatial error and cross regressive model are compared. The results indicate that the exogenous variables' spatial lag 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 differences in 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 thus far is its concentration on estimating shift-share-regression-models when controlling for the influence of sectoral structure on employment growth. However, these models do not account for spatial interdependencies and treat regions as autarkies, despite the fact that on a regional level such effects are likely to occur.

Against this background, this 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 also holds true for major factors of regional employment, such as wages and qualification.

In this paper three different models of spatial interdependence are compared: spatial lag, spatial error and cross regressive model. While the spatial lag model estimates the influence of the endogenous variables' value in neighboring regions (i.e. the spatial lag of the endogenous variable) on the endogenous variable in the observed region, the spatial error model controls for the influence of the error term's spatial lag. Finally, the cross regressive model accounts for 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 following the theoretical background is contrasted 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 the scale of potential spatial interdependencies is identified, in other words the work estimates the strength of interdependencies between regional labor markets and their decline with increasing distance. Subsequently, the regression models and their results are presented. These results are then discussed in the pursuant section. A final section draws conclusions.

2 Theoretical and empirical background

Economic theory discusses several factors influencing (regional) employment development, such as wages, qualification and productivity. In the following, the theoretical background related to these factors is presented and compared to current empirical results.

Wages

Labor market theory often discusses a negative influence of wages on employment development, as the cost argument of wages dominates economic literature. According to this theory, higher wages imply higher costs for the production factor labor so that it becomes less attractive for production and labor demand decreases, leading to lower employment. Conversely, the purchasing power argument recurs in public debate. It is argued that higher wages lead to higher demand and thus, to higher production and higher employment. However, economists are usually 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 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 production 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). Blien et al. (2003) observe a positive effect 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 relatively 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 depends not only on the wage within the region, but also on wages in nearby regions, while the direction of the influence depends on whether the migration of firms or employees dominates. Suedekum and Blien (2007) measure the influence of the wage level of nearby regions on the development of a region's employment and conclude that there is a positive relationship: an increase in the wage level in nearby regions leads to higher employment in the observed region. Accordingly, in Suedekum and Blien (2007) the migration of firms dominates the migration of employees.

Qualification

[1] Actually, 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.

Another factor influencing regional employment is qualification. The labor market for highly qualified people is more flexible and their unemployment rate is lower compared to the unemployment rate of less qualified people (Franz; 2006; Klotz et al.; 1999). Furthermore, through complementarities between highly and poorly qualified labor, poorly qualified benefit from the qualification of highly qualified employees. An increase in the share of the highly qualified accordingly exerts a positive influence on the labor market for the poorly qualified (see Bauer; 1998 and Chiswick; 1982 for an explicit theoretical modeling of these two effects). The positive influence of highly qualified employees on the development in German region's employment situation is widely acknowledged. Empirical evidence is delivered by, among others, 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 oppose each other: With increasing productivity, less labor input is necessary to maintain production levels 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), break down the developments in sectoral employment in order to identify the importance of the sectoral structure to regional employment growth. For example, the empirical studies of Blien et al. (2003) and Blien and Wolf (2002) find that employment growth was stronger in service sectors, as one would expect given the above. However, there is no study directly measuring the influence of growth in productivity, on developments in the employment levels in German regions.

Regional interdependencies

Thus far, interdependencies between regions have only been discussed with reference to migration. However, according to Nijkamp and Poot (1998), interdependencies between regions are also caused by trade, diffusion of technological information and information exchange. The endogenous growth literature discusses similar effects: The Romer (1990) model of endogenous growth explores how knowledge spills over between scientists, and how that 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 place within regions, and may spill over between regions depending on their proximity (Keilbach; 2000). Knowledge spillovers therefore not only generate 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 a 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 furthermore, she reveals that trade between regions leads to interregional dependency of employment development (Niebuhr; 2003). Strong spatial interdependencies in 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 interdependence. 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 the interdependence of regional labor markets remains incomplete.

3 Data set and data preparation

To measure regional employment, the number of employees subject to social insurance contribution by workplace is taken 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 contributions. The data is very reliable, since it is adopted from a full population survey. This statistic is measured at the industrial level, distinguishing between *agriculture, forestry and fisheries* (AB), *manufacturing* (CE), *construction* (F), *hotel, trade and traffic industries* (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, firms and area of the regions are recorded by 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 the regional level. The variables are measured at the level of labor market regions, given by Eckey et al. (2006), in order not to divide up 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 regional wages and the structure of regional interdependence. Both issues are discussed separately in following.

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 would not be able to determine 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:

$$\left(\frac{W}{P}\right)_{irt} = \alpha_t + \beta_i + \gamma_r + \tau_{rt} + \beta_0 + \beta_1 \pi_{irt} + \beta_2 D_{rt} + \beta_3 G_{rt} + \beta_4 East_r + \epsilon_{irt} \qquad (1)$$

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,

[2] DESTATIS; 2009a; 2009b; 2009c.

population density D and a dummy for eastern German regions, $East$. Additionally the number of employees per plant G is introduced as a control in the regression analysis.

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: Author's own calculations.

To avoid the dummy variable trap, region 1 (Flensburg), year 1999 and sector *agriculture, forestry and fisheries* are defined as reference items. The variation of the region effects over time is captured by the interaction term. Due to heteroskedasticity,[3] 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 $p = 0.00$). By applying the generalized variance inflation factors, especially designed for large sets of dummy variables by Fox and Monette (1992), it becomes clear that multicolinearity is not a problem.[4] The complete set of dummy variables also has significant influence.[5]

The regression coefficients resulting from this analysis then form the basis for building the adjusted wage. This is defined as the wage, not ascribed to productivity, which results from the region, sector, and annual effects, as well as from the interaction term. The interaction term allows for variation in the adjusted wage over the years. This estimation could example a problem with endogeneity, as the wage could be influenced by employment. However, a regression of the

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

[4]The generalized variance inflation factor for correlation between the set of dummy variables with the remaining explanatory variables, corrected for the dimension of the set of dummy variables, is $GVIF^{1/2p} = 1.153$, while it is 1.186 for the correlation of the set of sector dummys 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.

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

adjusted wage on employment and the fixed effects shows that employment does not have a significant influence on the adjusted wage.

3.2 Spatial autocorrelation

Not only is the adjusted wage of interest in estimating developments in regional employment; the influence of spatial interactions also 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 potentially influenced by all other regions, but can also influence 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):

$$w_{ij}^{*} = e^{-d_{ij}\beta} \tag{2}$$

The non-standardized 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:

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

In order to build the spatial weight matrix, these spatial dependencies are calculated for different values[6] 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. Correspondingly, when γ decreases, 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 taken from the 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 for social

[6] γ lies in the range between 0 and 1.

insurance contributions) between 1999 and 2007, small scale spatial interdependencies become obvious, i.e. with increasing γ, the value and significance of the Moran coefficient increases. Given the higher relative weight of nearby regions, spatial interdependencies turn up. Therefore, spatial interactions take place between neighboring 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 interactions[7]. Only for the average monthly wage are the results mixed: in all sectors except *agriculture, forestry and fisheries*, the value and significance of spatial autocorrelation increase in γ. However, the spatial autocorrelation in the sectors *agriculture, forestry and fisheries* and *financing, leasing and business services* is not significant for any value of γ, and in the sectors *manufacturing*, *construction* and *hotel, trade and traffic industries* it is only significant for γ equal or greater than 0.65 (with $\alpha = 0.05$).

Interdependencies between regional labor markets thus take place on a small scale: regions are predominantly influenced by nearby regions — remote regions play only 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

Employment developments within regional labor markets are potentially influenced by interactions between the regional markets, yet they have to a large extent been neglected by recent empirical literature. Currently so called shift-share-regression-models are applied, which disregard spatial interactions (an exception is an unpublished paper by Schanne; 2006). There are regression models using panel structure that account spatial interactions, but shift-share-regression-models incorporate the sector dimension in addition to space and time. A simple transmission of panel models with spatial interactions to shift-share-regression-models is thus not possible. For this reason, this paper measures the relevance of spatial autocorrelation for regional employment development using cross sectional analysis. These established regression

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

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

models can incorporate spatial interactions.

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

4.1 Cross sectional analyses

To investigate the importance of spatial interdependencies for regional employment development, cross sectional regressions are applied. 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 in light of 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 average/highly 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 coefficient LQ_r,[9] 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:

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

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

[9] The 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).

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

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:

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

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

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

where υ_r represents a normally distributed error term. In order to provide for 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 as in table 2, and they will be discussed in detail below. Since all tolerance coefficients exceed 0.1 (and most exceed 0.2), multicollinearity does not present a risk to the quality of the results.

Five tests for spatial dependency are applied. The Moran test (i.e. the test of significance for the Moran coefficient) provides for an overall test of the importance of the error terms' spatial dependence. When the Moran coefficient significantly deviates from zero spatial autocorrelation (i.e. the mean of the Moran coefficient), it functions as an indicator for spatial dependency.

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: Author's own calculations.

However, it still 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 differentiate 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 combinations of sectors and 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 is reduced.

This relationship varies over sectors (see table 2). If the spatial lags of exogenous variables are accounted for, the (robust) LMERR and LMLAG tests show no significant autocorrelation, with few exceptions. The cross regressive models (sometimes the basic model) are equally preferred over the spatial lag and error models by the AIC and BIC statistics (see table 5). Only for the *construction* sector does the spatial lag model seem to deliver better results than other models.

Thus, except in the case of the *construction* sector, 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. employment development). However, the exogenous variables' spatial lags 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 — their inability to introduce spatial lag or error term — does not apply in the case of employment development. The advantage in the form of more robust estimators and a larger number of observations still holds. 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 has frequently been applied.[10] Though these models do not allow for the introduction of spatial lags in the error term or the endogenous variable, they do allow for the introduction of spatial lags in the exogenous variables, relevant to the 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}. The model thereby 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 regional effects of region type j (e.g. eastern Germany) is constrained to the effect of the region type j. Hence the

[10]The framework was developed by Patterson (1991).

model in general can be written as:

$$y_{irt}g_{irt} = \alpha_t g_{irt} + \beta_i g_{irt} + \gamma_r g_{irt} + \delta_j g_{irt} + \mathbf{X_{irt}} g_{irt} \beta^* + \epsilon_{irt} g_{irt} \tag{8}$$

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:

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

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

Results

In a first step, all explanatory variables and their spatial lags are incorporated into the model. However, this results in multicollinearity, and adjustments are thus necessary. First, the share of highly qualified and average qualified employees is aggregated. The qualification is then represented by the share of average and highly 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 converse 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.

There is also a strong correlation between the share of qualified employees and its spatial lag. While the introduction of the spatial lag into a model which accounts for only the share of qualified employees offers the researcher a model capable of additional explanatory power, the opposite is true for the converse case. Therefore the share of qualified employees is not incorporated into the model, while its spatial lag is. The explanation for this result lies in the

[11] Hence the variable actually controls for the influence of poorly qualified. This may result in a problem, given the fact that, in regions where there is favorable development in the labor market, it will be easier for the poorly qualified to find employment, providing them with a larger share of the total employment. Furthermore the share of average qualified is a heterogeneous group, blurring the results. However, due to multicollinearity this adjustment is necessary — otherwise the sign of the coefficients would be indeterminate.

fact that the qualification of a region's employees is already measured by the productivity of that region. Furthermore this result may follow from the aggregation of average and highly 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 aspects are captured by the regional effects. Even though the assumption of exogeneity of the productivity growth in the estimation of employment growth cannot be expunged via 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:

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

wher $\hat{L}_{irt}$ 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 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 (in order to allow for a more compact illustration neither was introduced to the above equation). The 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 concern (according to 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.

The endogenous variable's spatial lag is significant in the cross sectional analysis for the *construction* sector (see above). Therefore, the *construction* sector is excluded to compare the results: The (significant) coefficients of both shift-share-regression-models (with and without the *construction* sector) 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 the form of spatial lag or the error model) is expected due to the results from the cross sectional

[12] The 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
$\hat{\pi_{AB}}$	-0.0192	0.2162	-0.09	0.929
$\hat{\pi_{CE}}$	0.0004	0.0125	0.03	0.977
$\hat{\pi_F}$	0.1314	0.0616	2.13	0.033
$\hat{\pi_{GI}}$	-0.0171	0.0073	-2.35	0.019
$\hat{\pi_{JK}}$	-0.0830	0.0299	-2.77	0.006
$\hat{\pi_{LP}}$	0.1660	0.0444	3.74	0.000
$W\hat{\pi_{AB}}$	-0.0829	0.2539	-0.33	0.744
$W\hat{\pi_{CE}}$	-0.0128	0.0381	-0.34	0.736
$W\hat{\pi_F}$	0.1449	0.1611	0.90	0.368
$W\hat{\pi_{GI}}$	0.0424	0.0206	2.06	0.040
$W\hat{\pi_{JK}}$	-0.1807	0.0473	-3.82	0.000
$W\hat{\pi_{LP}}$	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

Results for selected variables in the model.
Source: Author's own calculations.

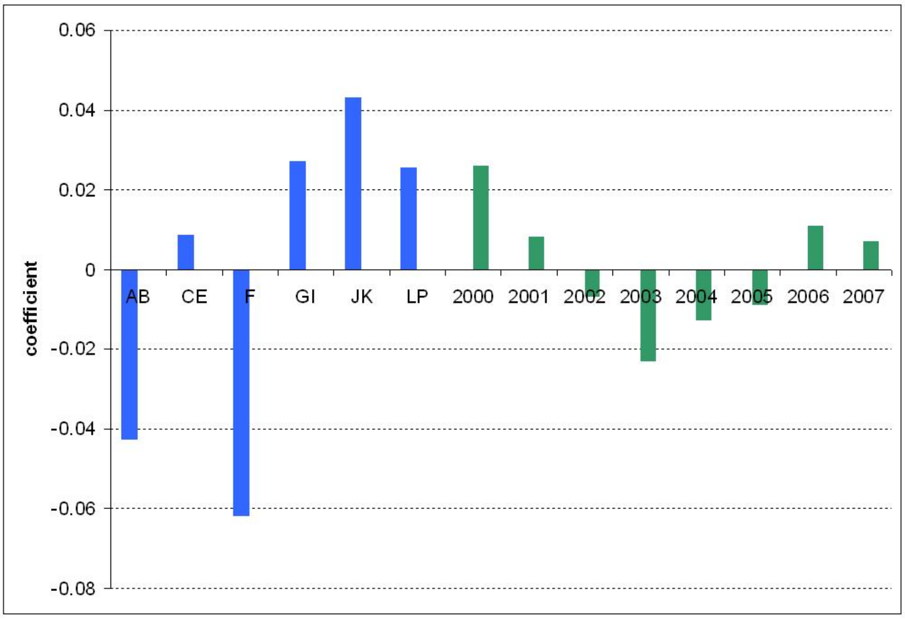
analyses. To verify these results the Moran test is applied to the residuals of all sector-year-combinations of the shift-share-regression-model. Significant spatial autocorrelation appears in only 2 of the 48 cases studied (4.17%). Thus there is no systematic spatial autocorrelation, rather it is sufficiently captured by the spatial lags of the exogenous variables.

The results point to a negative influence resulting from the share of qualified employees in nearby regions on the observed regions's employment development, while the share of a region's qualified employees does not exert any influence on the development of employment in the region, beyond its indirect influence through increases in productivity. The latter result may be due to the aggregation of qualification, however that represents a necessary statistical measure to avoid 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 relatively worse-off 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 in the theory. However, the signs of the coefficients don't deliver the results expected by the theory. In the *agriculture, forestry and fisheries*, as well as

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: Author's own calculations.

in the *manufacturing* sector, productivity growth appears to have no significant influence on employment development. In contrast, employment development in the *construction* sector is stimulated by productivity growth, while the latter hinders employment growth in the in sectors *hotel, trade and traffic industries*, *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 the *financing, leasing and business services* sector.

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 the *agriculture, forestry and fisheries* sector, the *manufacturing* and *construction* sectors, the employment development of a region in *financing, leasing and business services* sector is hindered by productivity growth and enhanced in the *hotel, trade and traffic industryies* and *private and public services* sectors.

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

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

5 Discussion

These results however, become especially interesting when viewed in light of theory, the existing body of literature on the topic, and previous empirical research. First of all, it is apparent from this work 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 proceeds by analyzing the individual determinants.

Adjusted wage growth

Theoretically both a positive and a negative influence of (adjusted) wages on employment is conceivable, 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 has accordingly observed the 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: 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), this work finds that the wages in nearby regions have no significant influence on employment development in the observed regions. Suedekum and Blien (2007) find a positive relationship between the wages in nearby regions and employment development in the observed region, pointing to the dominance of firms' migration. However, the authors only included western Germany while in this paper all German regions are included. This paper additionally includes migration flows of employees from eastern to western Germany, potentially compensating for the positive influence of the nearby regions' wages on the observed region's employment development due to migration of firms. Thus the insignificant influence of the adjusted wage growth rate's spatial lag 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 chances for qualified people in the labor market are better; Secondly, due to an interdependence between the under-qualified and the highly qualified, the poorly qualified benefit from the qualifications of the highly qualified. Previous empirical studies confirm the positive influence of the share of qualified employees on the development of employment in 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 its indirect influence through productivity. However, it has to be kept in mind that in the present paper the share of average and highly 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 the share of qualified employees in neighboring regions having a negative influence on employment development in 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, the sectorally varying influence of productivity on employment growth appears plausible. Elastic demand in the branches of the tertiary sector, it is assumed, leads 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 that a sectoral decomposition is necessary. However, there is no study for German regions, which directly measures 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 influence of productivity increases (which vary according to sector) on regional employment growth. Significant sectoral differences in influence become apparent. However, this 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 is strongly by the sector effects. However, the underlying influences for sector effects remain subject to research.

Productivity Spillover

The endogenous growth theory literature discusses knowledge spillovers at length. Given their relation to distance, a product of 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 for 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.

Nearby regions' productivity growth has no significant influence on the subject region in the *agriculture, forestry and fisheries* sector, nor does it in the *manufacturing* and *construction* sector. However, employment development in the *financing, leasing and business services* sector is positively influenced by the productivity growth of nearby regions, while the latter has a negative influence in the *hotel, trade and traffic industries* sector and the *private and public services* sector. There are indications of positive knowledge spillovers between regional labor markets only in the *hotel, trade and traffic industries* sector and the *private and public services* sector. However, as productivity growth has a negative influence on employment growth the *hotel, trade and traffic industries* sector, the result cannot be interpreted as confirmation of positive knowledge spillovers. Finally, the underlying theory does not deliver a satisfactory explanation for the observed effects in the *financing, leasing and business services* sector.

6 Conclusions

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

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

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

The results indicate that the adjusted wage has a negative influence on regional employment growth: 'excessive' increases in wages negatively affect regional employment development. Additionally, the share of qualified employees in nearby regions appears to have a negative influence on the employment development of the subject region, which indicates a competitive relationship between nearby regional labor markets.

Structural change is explained by the Appelbaum and Schettkat (1993) model through the 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 does not provide evidence for the structural change hypothesis for all sectors. Instead structural change is captured by sectoral fixed effects. What these fixed effects are based on, however, remains subject to research.

Regional interdependencies are visible in 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 the *hotel, trade and traffic industries* sector and the *financing, leasing and business services* sector the reasons for observed relationships remain subject to research and for the remaining sectors no influences occur.

The main finding of this paper, ultimately, is that regional interdependencies are important to regional employment growth and that they can be 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:

$$y = \beta_0 + \beta_1 X_{ex} + \beta_2 X_{end} + \epsilon \tag{11}$$

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:

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

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

$$X_{end} = \gamma_0 + \gamma_1 X_{ex} + \gamma_2 Z + \varepsilon \tag{13}$$

The estimated values $\hat{X_{end}}$ are included in the primary regression:

$$y = \beta_0 + \beta_1 X_{ex} + \beta_2 X_{end} + \beta_3 \hat{X_{end}} + \epsilon \tag{14}$$

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

$$\frac{\hat{\beta_3}^2}{var(\hat{\beta_3})} \sim \chi^2(l) \tag{15}$$

The tests for endogeneity are applied to those cross sectional analyses, where productivity exerts a significant influence. In those 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 $\left(\hat{\frac{W}{P}}\right)$, 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 $\left(\hat{\frac{W}{P}}\right)$, 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 $\hat{\beta}_3$ form 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: Author's own calculations.

A.2 Tables and figures

Table 5: AIC and BIC for the cross sectional models

AIC

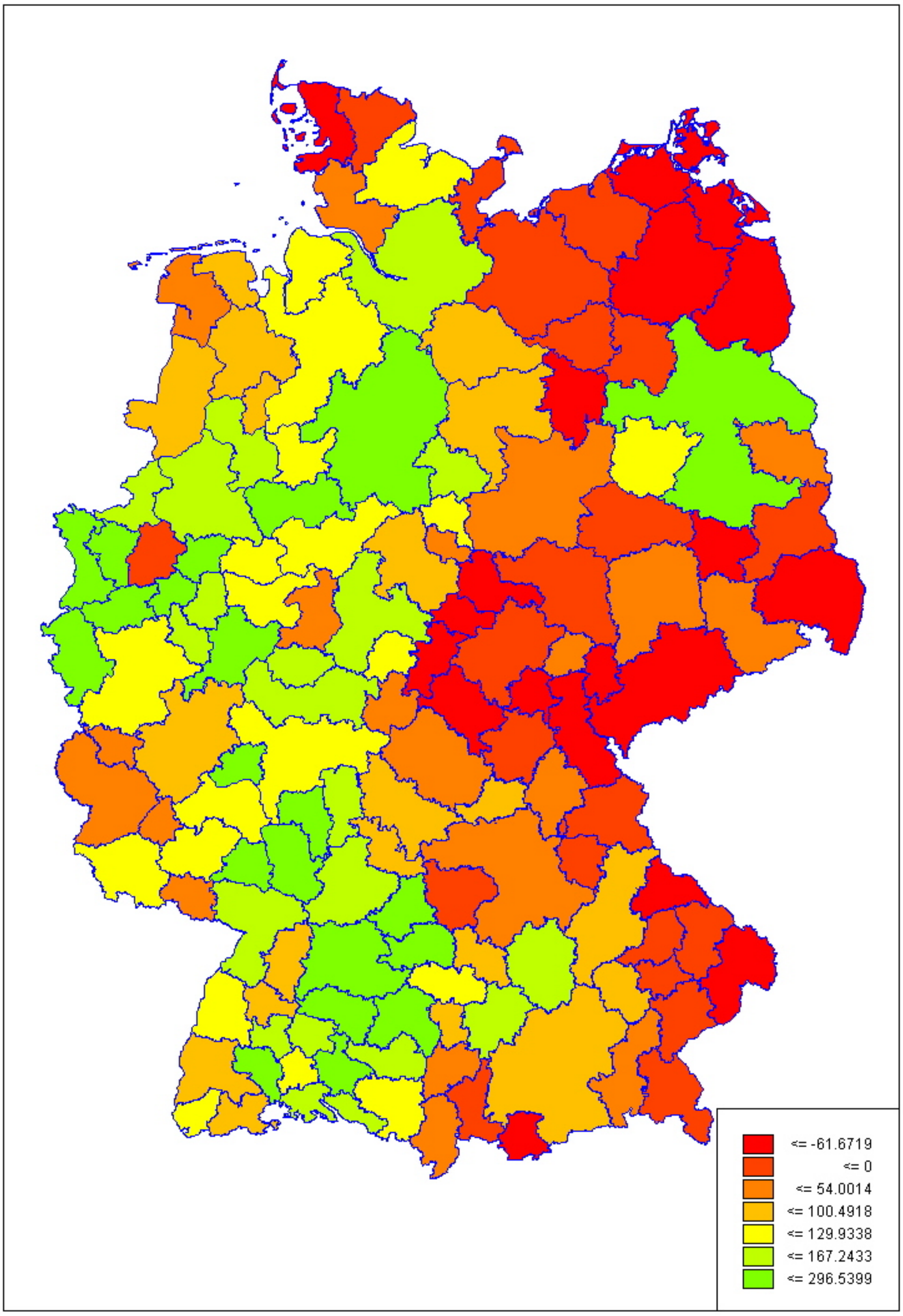
growth rate	sector	basic	spatial lag	spatial error	cross regressive
1999-2003	AB	-299.5297	-295.6033	-298.7497	-299.5297
1999-2003	CE	-426.5078	-424.2861	-422.9316	-443.8496
1999-2003	F	-447.3313	-477.8496	-456.4904	-459.7341
1999-2003	GI	-460.4102	-462.2685	-458.7365	-465.8334
1999-2003	JK	-342.7373	-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

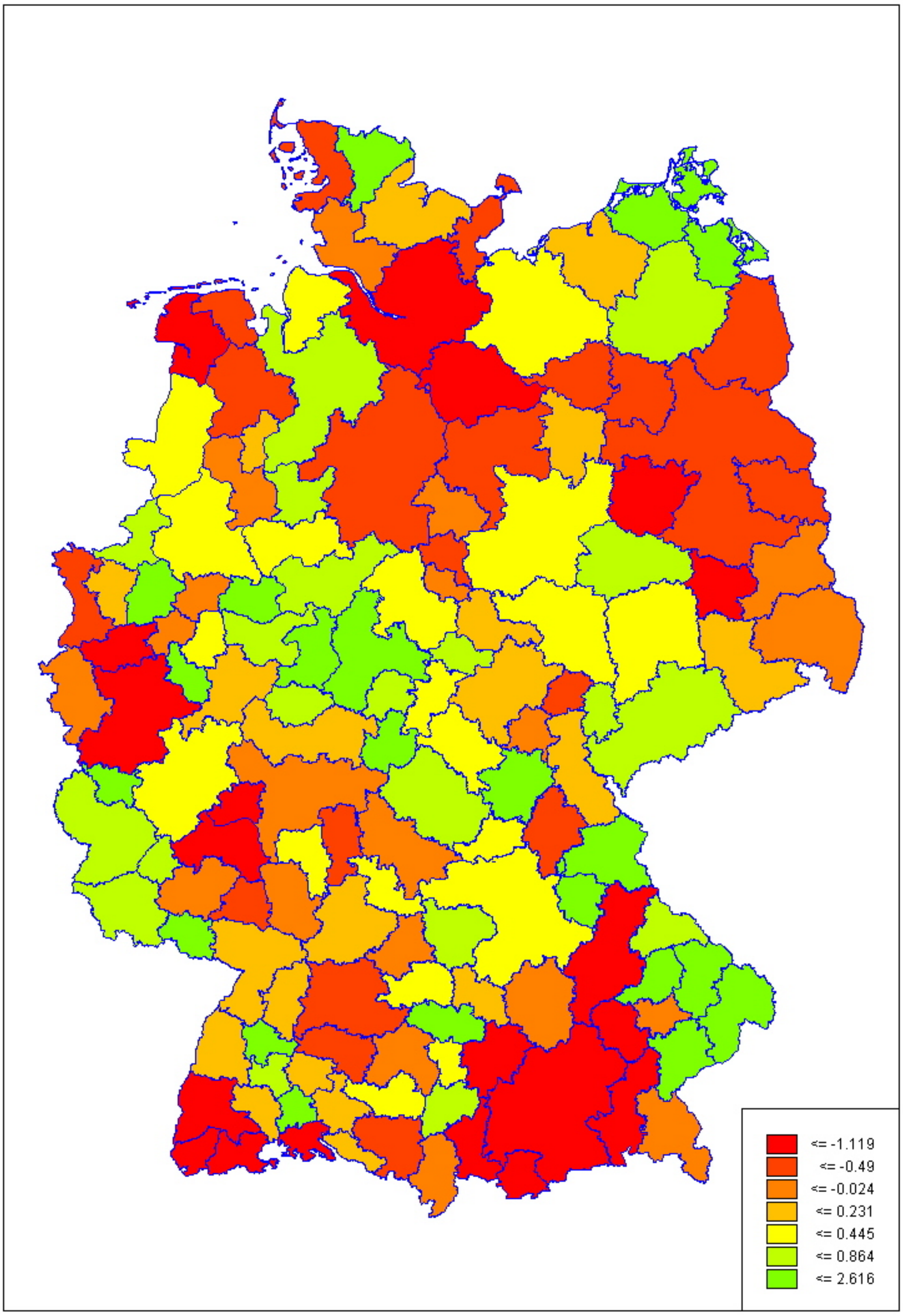
Source: Author's own calculations.

Figure 2: Regional effects of the adjusted wage regression



Source: Author's own calculations.

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



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