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Estimating the Wage Curve with Spatial Effects and Spline Functions

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Abstract

In this paper, we provide new empirical evidence on the relationship between regional wages and unemployment using spatial econometric techniques and allowing for nonlinearities in the model. The estimates are based on Austrian administrative data for the year 2001. The wage elasticity with respect to the unemployment rate is about -0.03 and thus quite low in international comparison. This can be explained by institutional characteristics of the Austrian wage bargaining system. Allowing for a more flexible functional form by estimating a model with linear spline functions, we find that the wage curve is only present in areas with a medium level of unemployment. The often used quadratic specification is therefore inadequate in describing the shape of the earnings unemployment relationship. Finally, we show how OLS tends to overestimate the wage-curve elasticity in absolute terms.

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1. Introduction

The wage curve describes an inverse relationship between individual wages and the local unemployment rate. This means that workers living in regions with high unemployment earn a lower wage than workers with similar attributes in regions with low unemployment. Blanchflower and Oswald (1990, 1992, 1994, 2005) carried out a broad, in-depth empirical study of this issue, and concluded that the average elasticity of wages with respect to unemployment is about -0.1. [1] This elasticity, which implies that an increase in unemployment by 10 per cent leads to a drop in wages by 1 per cent, is often regarded as an "empirical law of economics". Recently, Nijkamp and Poot (2005) conclude that the wage-curve elasticity corrected for the publication bias is about -0.07 using a meta-analysis based on 208 wage/unemployment wage-curve elasticities from the literature.

Interestingly, the elasticity of wages to unemployment is quite stable across countries, time periods, levels of aggregation and empirical methodologies. Two points can be noted from the literature. Firstly, the majority of the studies cited in Nijkamp and Poot (2005) do not account for spatial correlation, which may bias the wage curve elasticity.[2] There are several motivations for a spatial lag specification of the wage curve. For example, if a region is close to other regions with large labor markets, firms may not be able to respond to a local negative demand shock by lowering wages, as the threat of unemployment is less when employment opportunities in surrounding regions are plentiful. Secondly, very few studies investigate the shape of the relationship between wages and unemployment besides the quadratic or inverse quadratic specification.

The main novelty of our article lies in the application of spatial econometric techniques to investigate the Austrian wage curve. Furthermore, we provide fine-grain empirical evidence using different specifications to account for non-linearities in the relationship between wages and unemployment. Our results confirm the presence of spatial effects in the wage curve. The elasticity of pay with respect to unemployment is about -0.03 using the spatial lag model when measured as the direct effect. Spline functions indicate that the wage-curve elasticity in absolute terms is considerably greater in regions with medium unemployment rates (e.g. unemployment rates within the middle third of the distribution).

2. Empirical model

The main hypothesis is that the wage curve's elasticity (in absolute terms) in Austria is low due to the presence of collective wage bargaining at the sectoral level. For the majority of industries in Austria, wages are negotiated nationally at the industry level between employer

[1] For other recent wage curve studies see Ammermueller *et al.* (2010) based on 19 administrative Italian regions and 16 German Länder; Baltagi *et al.* (2009) for German districts, Sanz-de-Galdeano and Turunen (2006) for NUTS 1 regions in the Euro area, Johnes (2007) and Park and Shin (2007) based on data for the UK and South Korea, respectively.

[2] A small but increasingly important strand of literature has focused on the role played by geographic proximity and the extent of economic integration for understanding regional variations in wage levels. Studies that account for spatial effects in the wage-curve equation include Büttner (1999), Elhorst *et al.* (2007) and Longhi *et al*. (2006).

representatives and unions. These negotiations lead to a set of collective agreements that apply not only to union members, but in practice to all employees working in the sector. According to Traxler and Behrens (2002) and Golden et al. (2007), the coverage ratio (i.e. ratio of workers covered by a collective wage agreement to the total dependent workforce) is about 70 per cent. Since the public sector is excluded from the right to bargain collectively, the adjusted coverage rate is 98 per cent (Traxler and Behrens, 2002).[3] This coverage rate, which is extremely high by international standards, is due to the legal framework governing industrial relations in Austria: On the employers' side, almost all agreements are concluded by the Economic Chambers (*Wirtschaftskammern*) for which membership is mandatory (Traxler, 2000).

The theory is of little guidance regarding the functional form of the relationship between wages and unemployment. The standard formulation of the wage curve equation assumes a constant elasticity of wages along the unemployment distribution. However, some empirical findings contradict this mainstream view (e. g. Büttner, 1999; Longhi et al., 2006) and there are some arguments in favour of a non-linear relationship between wages and unemployment. For instance, one can argue that regions differ with respect to the share of workers with low bargaining power. In their comprehensive meta-analysis, Nijkamp and Poot (2005) find that less than 15 per cent of surveyed studies investigate this issue. We are interested in uncovering non-linearities in the wage curve by using spline functions.

As previously stated, we expect that earnings in the home region may depend on the level of earnings in the surrounding regions. In this case one can use a spatial lag model in which the spatial dependence is accounted for by including a spatially weighted lag term (WY) (Anselin and Bera, 1998):

$$Y = \rho WY + X\beta + \varepsilon , \tag{1}$$

where Y is the dependent variable, X is a matrix of explanatory variables and W denotes the spatial weight matrix. β denotes the corresponding coefficient vector, ρ is the spatial lag parameter and ε is the error term that is normally distributed with mean zero and variance σ. It is well known that OLS is inconsistent in the presence of significant spatial lag effects because it suffers from the omitted variable bias. An alternative way to incorporate spatial effects is to model the error term as an autoregressive random term. The resulting spatial error model can be written as follows (Anselin and Bera, 1998):

$$Y = X\beta + u \text{ and } u = \lambda Wu + v, \tag{2}$$

[3] "[…] The unadjusted rate is defined as the number of employees covered by a collective agreement as a proportion of the total number of employees (regardless of whether certain groups are excluded from bargaining); and the adjusted rate is defined as the number of employees covered by a collective agreement as a proportion of the number of employees equipped with the right to bargain (i.e. the total number of employees minus the number of employees excluded from the right to bargain)" (Traxler and Behrens, 2002).

where parameter λ is the coefficient on the spatially correlated errors indicating the extent of spatial correlation between the residuals. The disturbance term v is independent and identically distributed. The parameters of both spatial models can be estimated by maximum likelihood. Note that in the case of spatial autocorrelation, OLS is still unbiased but no longer efficient. The specification of the weight matrix is the sensitive point of the spatial econometric approach (Anselin and Bera, 1998). There are various ways to define the spatial weight matrix. In this study, we use the shortest road distance to calculate the weights in the spatial weight matrix, $w_{ij} = 1/d_{ij}$, where d_{ij} is defined as road distance between district capital *i* and district capital *j*. In the next step, the elements of the spatial weight matrix have been row-standardized, i.e. the elements of each row add to unity. Beyond some distance, wages of district *j* should no longer affect those in district *i*. For this reason, an upper distance is typically chosen beyond which all weights are equal to zero. We select 100 km as the upper distance threshold since the overall fit of the model is better than when based on other upper distance thresholds. This is done by replacing values above the upper distance by the maximum possible value.

The wage-curve equations with spatial effects (i.e. specified as the spatial lag (3) and spatial error (4) model respectively) can be written as follows:

$$\ln E_i = \alpha_0 + \rho W \ln E_i + \alpha_1 \ln U_i + \sum_{j=1}^{J} X_{ji} \beta_j + e_i, \tag{3}$$

$$\ln E_i = \tilde{\alpha}_0 + \tilde{\alpha}_1 \ln U_i + \sum_{j=1}^{J} X_{ji} \tilde{\beta}_j + \lambda W u_i + v_i \qquad (4),$$

where *E* denotes annual average earnings of full-time workers, *U* is the unemployment rate, and *X* includes control variables such as average years of education, average age, share of women in employment (excluding self-employed), share of employment in agriculture, employment share of large firms (200 and more employees), employment share of medium and high-technology industries and population density. α_1 and $\tilde{\alpha}_1$ measure the wage curve elasticity. Note that in the spatial lag model, the total effect of the unemployment rate on earnings consists of the direct effect and the indirect effect from the impact of wages in neighbouring districts. To calculate the total effect, one has to multiply α_1 by the spatial multiplier defined as $1/(1-\rho)$.

We apply the linear spline techniques in order to account for non-linearities in the relationship between wages and unemployment (see Greene, 2003). The piecewise linear spline function approach is preferred to the quadratic approach because it is more flexible. The basic idea is that any continuous function can be approximated by a piecewise linear function. In the case of the spatial lag model (3), the specification of the wage-curve equation using a spline function with one knot can be written as:

$$\ln E_i = \widetilde{\alpha}_0 + \widetilde{\alpha}_1 \rho W + c_1 \log U_i + c_2 d(\log U_i - k) + \sum_{j=1}^{J} \ln X_{ji} \widetilde{\beta}_j + \widetilde{e}_i, \quad (5)$$

where k denotes the cut-off point, or knot and d is a dummy variable which equals 1 if $\log U_i > k$ and 0 if $\log U_i \leq k$.

The model allows for different slopes for the unemployment rate before and after the knot (c_1 and c_2). Here, the log unemployment rate is divided into two segments, and the knot is equal to the median of the logarithm of the unemployment rate. In addition, we use two knots determined by the 33^{th} and 66^{th} percentile of the unemployment rate.

3. Data and descriptive statistics

We use grouped data for all administrative districts (*politische Bezirke*) based on the 2001 Austrian population census provided by Statistics Austria.[4] We count the metropolitan area of Vienna and its 23 political districts as one district, resulting in a total of 99 districts. The unemployment rate is defined as the share of the labour force that was unemployed and actively seeking work in the week of the survey for the year 2001. Earnings data are drawn from the annual wage-tax statistics for 2002 since comparable data are not available for the year 2001. The data refers to the district level, and to average annual gross earnings (in Euros). The Austrian wage-tax statistics (*Lohnsteuerstatistik*) reports distinct tables covering full-time workers who have been in employment throughout the year (*mit ganzjährigen Bezügen*). The applied definition refers to full-time workers who were in employment for at least 334 days in the course of the year. Seasonally or sporadically employed workers, as well as those who have been unemployed for more than 30 days, are not included. It can be argued that annual earnings of full-time workers reflect the actual wage level very accurately. The advantage of the wage-tax data is that all wage components (such as bonuses), are included in the statistics and that there is no earnings threshold above which the exact value of earnings is unknown.[5]

Average years of education for the labour force aged 15 years and older are constructed from eight categories of completed education, following the methodology of De la Fuente and Doménech (2002) and is drawn from the 2001 population census. In addition, we use the 2001 population census to calculate the average age of the labour force aged between 15 and older, as well as the share of agriculture in the labour force. The employment share of large firms (200 and more employees) is drawn from the 2001 firm census, and is calculated at place of work rather than at place of residence. The employment share of medium and high-technology industries consists of the manufacturing industries NACE 29 to 35 and the

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[4] This data can be downloaded from: www.statistik.at/web_en/publications_services/isis_database/index.html.

[5] Quite conversely, numerous wage curve studies use wage information from social security statistics. These data often have the limitation that reported wages are censored for individuals whose income exceeds the threshold defined as the contribution assessment ceiling. In such cases, only the value of this threshold is reported (see for instance Baltagi *et al.*, 2000). On the other hand, hourly wages which are constructed using survey information, as in numerous other studies, are confronted with accuracy problems with respect to reported wages and working hours.

business services NACE 72 to 74. The data is drawn from the wage-tax statistics and refers to wage and salary workers. Population density is defined as total population per square kilometre for the year 2001. Road distance between district capitals is provided by the Austrian Federal Ministry of Transport, Innovation and Technology.[6] Note that the unemployment rate, age and years of schooling enter our model in the form of logarithms. Shares are expressed in percent. All variables are measured at the district level covering 99 political districts at the place of residence, except for the employment share of large firms. It is important to note that wages are measured at the place of residence rather than at place of work.

Table 1 presents descriptive statistics. The mean unemployment rate across the districts is 5.4 per cent in 2001 and average annual gross earnings are € 29,789. The number of years spent in education is 11 years on average and the average age of the workforce is 36 years. The share of women among full-time workers is 35 per cent. The unweighted mean of the employment share of agriculture, forestry and fishing is 5.4 per cent. The final variables are the employment share of large firms with 200 or more employees with about 21.5 per cent on average and the employment share of medium and high tech industries with about 12.4 per cent on average. Average population density is 239.

Table 1: Descriptive statistics

	mean	median	standard deviation	minimum	maximum
average annual earnings in 2002 in EUR	29,789	29,381	2,804	25,526	42,656
unemployment rate in 2001 in per cent	5.4	5.2	1.6	2.3	10.8
average years of education in 2001 in years	10.9	10.9	0.3	10.5	11.8
average age of workers in 2001 in years	35.8	35.7	1.0	33.7	38.5
share of women in 2001 in per cent	35.4	35.2	3.2	29.7	45.1
population density in 2001 in population per square metres	239	74	528	21	3,736
share of employment in agriculture in 2001 in per cent	5.4	5.1	3.3	0.4	15.4
employment share of large firms (200 & more employees) in 2001 in per cent	21.5	20.8	13.6	0.0	59.4
employment share of medium and high-technology industries (NACE 29 to 35 and 72-74) in 2002 in per cent	12.4	12.1	3.7	4.7	29.2

Note: The number of observations is 99. Source: Census of population, Census of firms and Austrian wage-tax statistics.

Figure 1 in the Appendix presents a map of Austria's political districts including information on the wage level. We can see that districts with a high level of earnings are situated in the capital region, Vienna, in the surrounding districts as well as in the capitals of the Federal States (especially Linz, Graz and Klagenfurt). In order to get an initial idea on the pattern of the spatial correlation, we employ Moran's I scatterplot with log annual earnings on the x–axis and the spatially weighted log annual earnings on the y-axis, where both variables are standardized (see Figure 2 in Appendix). One can see that the magnitude of the spatial correlation is more pronounced in the greater Vienna area (see quadrant HH). This clearly shows that the districts in the metropolitan area of Vienna, which share a number of common characteristics (e.g. concentration of services, dense road and public transport networks), also show great similarities in the level of earnings. Furthermore, a number of districts with a low

[6] The complete data set including the distance matrix is available from the authors upon request.

level of earnings are surrounded by districts which are also characterised by a low wage level (see the LL quadrant). Alternatively, one can also use local indicators of spatial association (LISA) cluster maps based on the local Morans' I statistic to identify spatial patterns in wages (Figure 3 in Appendix). Dark areas indicate regions where the spatial correlation coefficients are significantly positive with values of 0.50 and higher, whereas white and light coloured areas represent districts where these are close to zero or even negative. The map clearly shows high positive spatial associations in the Vienna area, as well as in a few isolated areas in Lower Austria and East Tyrol.

4. Empirical results

Table 2 displays the estimation results of the wage curve equation with spatial lag effects. We experimented with several alternative weight matrices. We report only results based on a cut-off point at 100 km (where the model has the best fit).[7] We report separate estimates for the specification including a dummy variable for bordering districts of Vienna (see specifications (ii) and (iv) in Table 2).

Table 2: ML estimates of the spatial lag model for the wage curve equation

	Spatial Lag Model		Spatial Error Model	
	Baseline (i)	**Extended (ii)**	**Baseline (iii)**	**Extended (iv)**
	coeff.	coeff.	coeff.	coeff.
log unemployment rate	-0.036 ***	-0.030 ***	-0.037 ***	-0.038 **
log average years of education	1.587 ***	1.574 ***	1.608 ***	1.568 ***
log average age	1.210 ***	1.039 ***	1.457 ***	1.392 ***
share of women	-0.003 ***	-0.004 ***	-0.005 ***	-0.006 ***
share of employment in agriculture	-0.006 ***	-0.006 ***	-0.005 ***	-0.006 **
empl. share of med. & high-tech. industries	0.002 ***	0.001	0.001	0.000
employment share of large firms	0.001 **	0.001 **	0.001 **	0.001
ln population density	0.003	0.008 *	0.002	0.009
dummy var. Border districts of Vienna		0.051 ***		0.058 *
dummy var. Burgenland (ref.: Lower Austria)	-0.055 ***	-0.039 ***	-0.069 ***	-0.051 ***
dummy var. Carinthia	-0.048 ***	-0.037 ***	-0.042	-0.050 *
dummy var. Upper Austria	-0.001	0.006	0.009	0.002
dummy var. Salzburg	0.006	0.013	0.015	0.005
dummy var. Styria	-0.018 **	-0.012 *	-0.029 *	-0.031 *
dummy var. Tyrol	0.000	0.003	-0.018	-0.015
dummy var. Vorarlberg	0.051 ***	0.056 ***	0.033	0.056 **
dummy var. Vienna	-0.013	-0.048 ***	-0.003	-0.025
Constant	-2.611 ***	-1.227	1.474 *	1.820
λ lambda (spatial error parameter)			0.780 ***	0.369
ρ (spatial lag parameter)	0.483 ***	0.409 ***		
LM test, chi^2 stat. (p-value)	33.27 ***	27.68	2.75	0.07
robust LM test, chi^2 stat (p-value)	31.45 ***	31.19	0.93	3.58
McFadden's pseudo R^2	0.946	0.957	0.891	0.940

Notes: The dependent variable is the average annual earnings of full-time workers, excluding temporary or seasonal employees, for the year 2002. The number of observations is 99. ***,(**),(*) denote significance at the 1%, (5%) and (10%) level. The pseudo R^2 of the spatial lag model is calculated as the squared value of the correlation between the observed and predicted ln annual earnings. The cut-off point in the distance matrix is 100 km.

[7] We carried out robustness checks with cut-off points of the road distance at 75, 125 and 150 km. In general, the results are not sensitive to the choice of the cut-off point.

For comparison, we also provide results for the spatial error model (see specifications (iii) and (iv)). *McFadden*'s pseudo R^2 shows that the spatial lag model has a better fit as compared to the spatial error model. Therefore, the interpretation focuses on the results based on the spatial lag model. The spatial parameter ρ is highly significant and equal to 0.41 in our preferred specification, indicating that districts with a similar level of earnings are clustered together. Using the spatial lag model, the coefficient of annual earnings with respect to the unemployment rate is -0.03, with a z-value of -3.47, based on our preferred specification in column (ii) in Table 2. A one-tailed t-test shows that this coefficient is significantly lower at the one percent significance level than -0.1 which is regarded as the "empirical law" of the wage curve (Blanchflower and Oswald, 1994). It is also lower than the average wage-curve elasticity corrected for the publication bias reported by Nijkamp and Poot (2005).

Note that the coefficient on the explanatory variable in the spatial lag model measures only the direct effect of the unemployment rate on the wages. The total effect is the product of the coefficient of -0.03, and the spatial multiplier $1/(1-\rho)$ (equal to 1.69), which gives an elasticity of -0.051. It is interesting to compare the wage-curve elasticities of the spatial lag model with those obtained using OLS. Based on the latter, we find an elasticity of annual earnings of -0.04, with respect to the unemployment rate, implying that OLS overestimates the direct magnitude of the wage curve elasticity by roughly one third.[8] This is consistent with Longhi *et al.* (2006) and Büttner (1999), who also find that OLS leads to biased results for the unemployment elasticity of pay. The results for wage-curve elasticity should be compared with previous studies based on Austrian data. For male workers, Winter-Ebmer (1996) reports a similar elasticity of -0.03 using individual data for 1983, although the author uses a different empirical methodology.

Turning to the control variables, we find that all district level characteristics included in our model are significant and show the expected signs except for the employment share of medium & high-technology industries. First, districts with a better educated workforce and with an older workforce have a higher level of earnings. Second, the variables measuring industry structure and firm size distribution are also significant, including the employment share of the primary sector (negative) and employment share of large firms (positive).[9] The coefficient on the dummy variable for the border districts of Vienna is equal to 0.051, indicating that the level of earnings is 5 per cent higher than in the non-border districts. The dummy variable for the eight Federal states are jointly significantly different from zero. Earnings are highest in Vorarlberg and lowest in Burgenland. It is worth mentioning that the pseudo R^2 is about 0.95.[10]

In order to allow for a more flexible functional form, we provide estimates of the spatial lag model that include spline functions for the unemployment rate. Table 3 shows the estimation

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[8] OLS estimates with spatial correlated robust standard erros are available upon request. This robustness check was done using the Conley correction for spatial autocorrelation.

[9] We also tested the inclusion of the employment share of manufacturing in our model. However, the variable is not significant at any conventional significance level and therefore not included in the final specification.

[10] The pseudo R^2 is measured as the squared correlation of predicted earnings and actual earnings.

results for two different specifications of the spline function (i.e. two and three segments of the unemployment rate distribution) for all workers. In addition, we provide estimation results for the semi-elasticity of earnings with respect to unemployment. We find that the null hypothesis of a log-linear functional form is significantly rejected for the specifications with two knots. For the spline functions with one knot, the null hypothesis that the wage elasticity is similar in districts below and above the median value of the logarithm of the unemployment rate cannot be rejected. This result does not change when we set the knot equal to the national unemployment rate (6.4 per cent in 2001). The main finding is that wage elasticity is only significantly different from zero in the middle third of the unemployment rate distribution. In contrast, for districts with low and high unemployment rates (i.e. greater or lower than the middle third), we find a wage elasticity close to zero, and not significantly different from zero.

Table 3: ML estimates of the spatial lag model for the wage equation with spline functions

	Spline functions results with one knot					
	Log functional form			**Semi-log**		
	coeff.		z	coeff.		z
(log) unemployment rate aa [2.3 <=U<= 5.15]	-0.031	*	-1.80	-0.009	**	-2.02
(log)unemployment rate ab [5.15 <U <=10.76]	-0.028		-1.53	-0.004		-1.25
control variables	yes			yes		
Constant	-1.24		-1.46	-1.26		-1.49
ρ (spatial lag parameter)	0.41	***	5.38	0.41	***	5.41
robust LM test	28.18	***	0.00	31.06		0.00
F-test: (log) unemployment rate aa= (log)unemployment rate ab	0.01		0.92	0.70		0.44
	Spline functions results with two knots					
	coeff.		z	coeff.		z
(log)unemployment rate ba [2.3 <= U <= 4.58]	-0.007		-0.33	-0.001		-0.23
(log)unemployment rate bb [4.58 < U <= 5.88]	-0.076	**	-2.38	-0.015	**	-2.41
(log)unemployment rate bc [5.88 < U <= 10.76]	-0.007		-0.27	-0.001		-0.15
control variables	yes			yes		
Constant	-1.10		-1.29	-1.11		-1.29
ρ (spatial lag parameter)	0.39	***	5.17	0.39		5.13
robust LM test	28.37	***	0.00	28.14	***	0.00
F-test ba=bb	2.76	*	0.10	1.79		0.18
F-test ba=bc	2.23		0.14	2.79	*	0.09

Notes: See Table 2. The coefficients are the slope parameters of the spline function. The knots are equal to a level of unemployment of about 5.15 per cent in the upper panel, 4.6 and 5.9 in the lower panel. The pseudo R^2 is about 0.96 in all specifications.

The finding that the wage-curve elasticity (in absolute terms) is only present in areas with medium levels of unemployment stands partly in contrast with previous studies. For instance, Longhi *et al.* (2006) find that in Germany the wage-curve elasticity becomes less negative at higher unemployment rates. A similar conclusion is reached by Büttner (1999), who bases his analysis on district data for the period 1987-1994. The results of these studies are difficult to compare to our findings. In particular, it has to be pointed out that the Austrian labour market in 2001 was characterised by comparatively low unemployment. The highest unemployment rate that we observe in our data, at 10.6 per cent, lies well below the values for Germany included in the studies by Büttner (1999) and Longhi *et al.* (2006). Using quantile regressions, Sanz-de Galdeano and Turunen (2006) come to the conclusion that in the Euro area the wage-curve elasticity decreases along the wage distribution, indicating that wages of workers at the bottom of the distribution are more responsive to the local unemployment rate.

5. Conclusions

Our analysis provides further evidence on the importance of accounting for spatial factors when observing regional wages and unemployment based on 99 political districts in Austria. We find an estimated elasticity of pay with respect to unemployment of about -0.03 as measured by the direct effect, and -0.05 as measured by the total effect using the spatial lag model estimated by maximum likelihood. OLS estimates tend to overestimate the size of the wage curve elasticity in absolute terms. Allowing for a more flexible functional form by estimating a spline function reveals that the hypothesis of a uniform wage curve across regions can be rejected. In particular, the wage elasticity is only significantly different from zero in the middle third of the unemployment rate distribution. Future work should be directed to determining the correct functional form of the wage curve.

The estimated wage curve effect is quite small in international comparison. This low unemployment elasticity of wages is in line with our starting hypothesis for the Austrian labour market. In particular, it supports the view that the dominant role of collective bargaining at the sectoral level, and the high coverage rate of collective agreements reduce the monopsonistic power exerted by firms at the local level. Although we cannot provide rigorous empirics in this respect, a cross-country overview of wage curves suggests that countries with high collective agreement coverage rates have comparatively small wage curve effects. Next to Austria, Sweden, Belgium, and Germany can be seen as examples in this respect.

Further research is required. One limitation of our study is that spatial heterogeneity and possible endogeneity of some right hand variables are not addressed. Given the small number of observations it is difficult to account for both spatial heterogeneity and slope heterogeneity. Accounting for endogeneity requires panel data. The deficit can be addressed in future work based on new data sets combing a number of cross-sectional data.

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Appendix

Figure 1: Spatial distribution of annual earnings of full-time workers (in EUR)

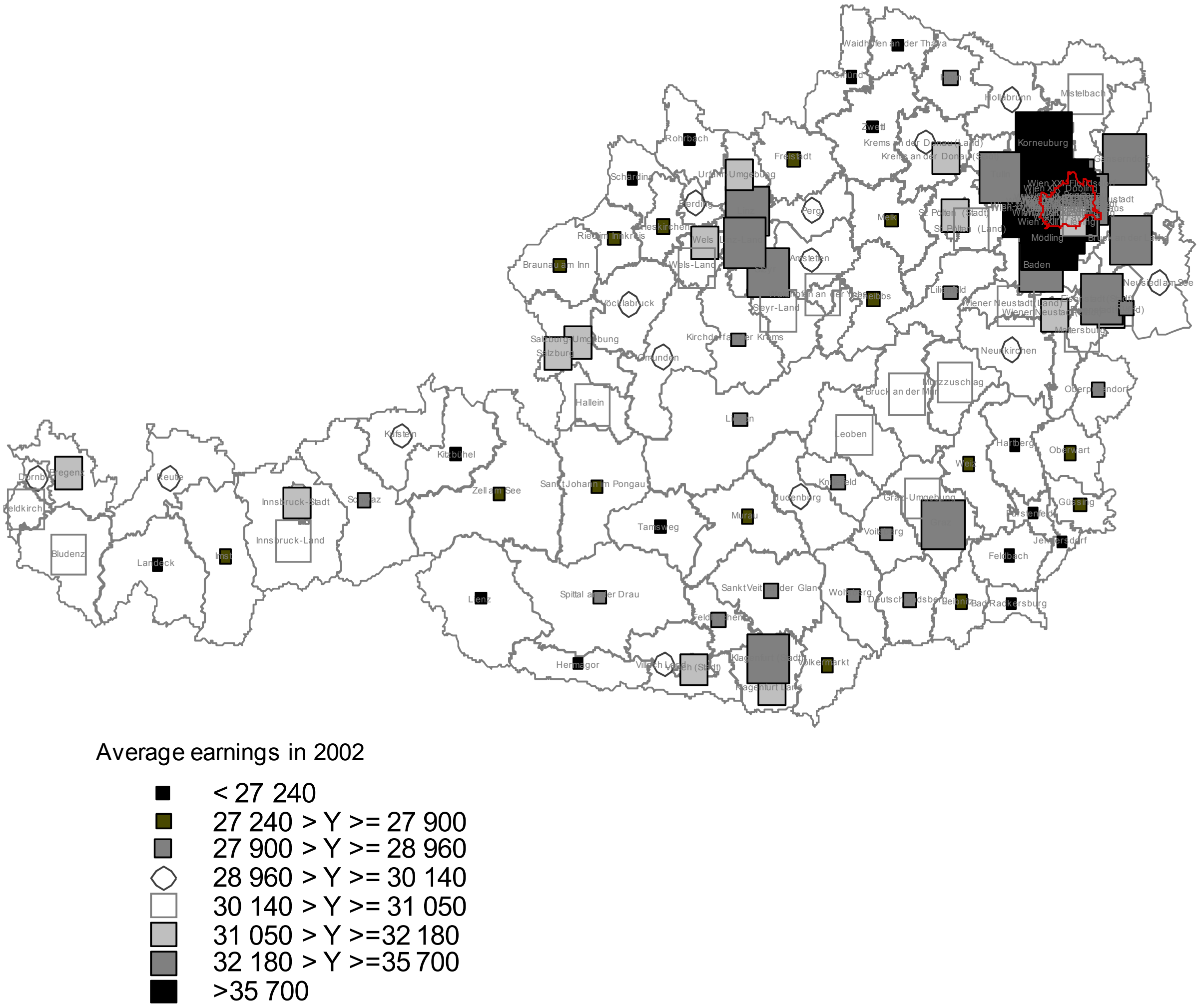
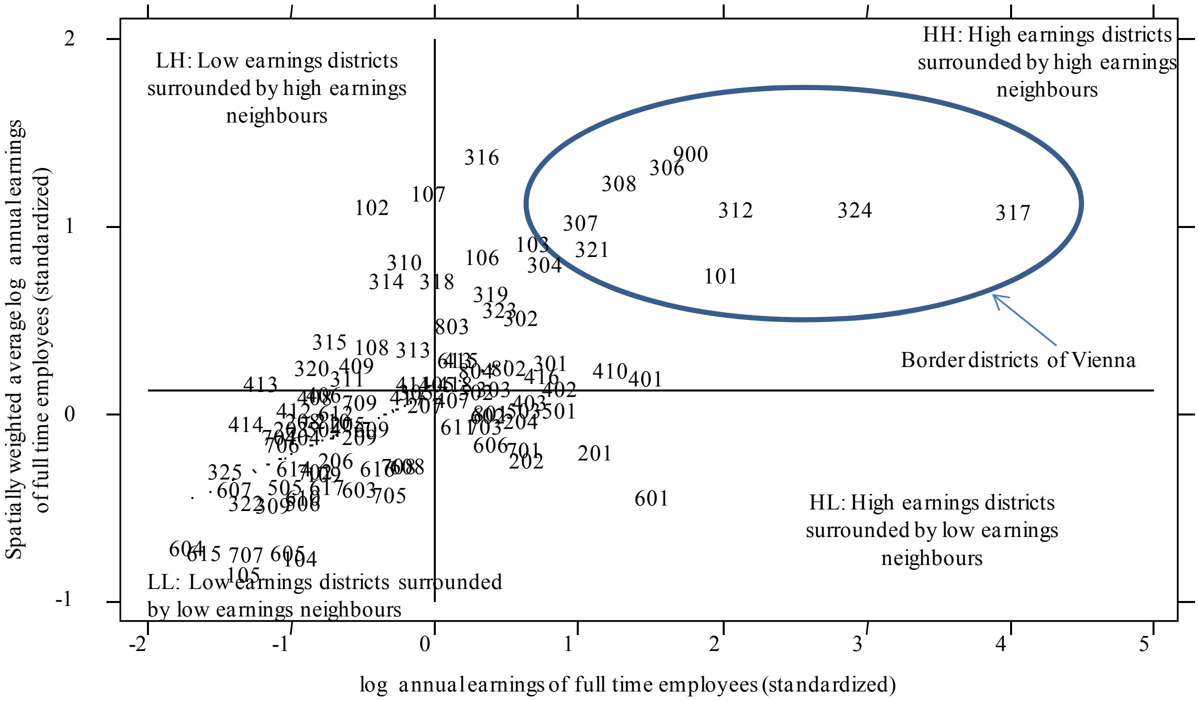


Figure 2: Morans' scatter plot



Note: Districts are represented by the district's identifying number. The underlying weight matrix is based on road distance with a cut-off value of 100 km.

Figure 3: Spatial distribution of local Moran's I statistic