DISCUSSION PAPER

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Spatial Dependence of Regional Unemployment in the European Union

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HWWA DISCUSSION PAPER

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Abstract

The findings of recent studies on adjustment processes suggest that regional labour markets in the EU and the US differ significantly. Low wage flexibility and limited labour mobility in European countries involve persistent unemployment differentials across regions. However, the spatial dimension of regional labour market problems is largely neglected in the corresponding analyses. In contrast, the present paper focuses on the spatial structure of regional unemployment disparities. Regions are tightly linked by migration, commuting and interregional trade. These types of spatial interaction are exposed to frictional effects of distance, possibly causing spatial dependence of regional labour market conditions. Spatial association of regional unemployment is analysed for a sample of European countries between 1986 and 1998 by measures of spatial autocorrelation and spatial econometric methods. The results point to a significant spatial dependence among regional labour markets in Europe. Regions marked by high unemployment as well as areas characterised by low unemployment tend to cluster in space. The findings suggest that different forms of spatial interaction with varying scope affect the evolution of regional unemployment in Europe.

Zusammenfassung

Die Resultate aktueller Untersuchungen regionaler Anpassungsprozesse deuten darauf hin, dass sich die Funktionsweise regionaler Arbeitsmärkte in der EU und den USA wesentlich voneinander unterscheidet. Geringe Lohnflexibilität und eine begrenzte Mobilität der Arbeitskräfte führen zu anhaltenden Unterschieden zwischen den regionalen Arbeitslosenquoten in Europa. Bisherige Studien vernachlässigen jedoch weitgehend die räumliche Dimension regionaler Arbeitsmarktprobleme. Im Gegensatz dazu konzentriert sich die vorliegende Untersuchung auf die räumliche Struktur entsprechender Disparitäten. Regionen sind eng durch Migration, Pendlerverflechtungen und interregionalen Handel miteinander verbunden. Es ist davon auszugehen, dass regionale Arbeitsmarktbedingungen durch räumliche Abhängigkeiten geprägt sind, weil Interaktionen zwischen regionalen Arbeitsmärkten friktionellen Effekten der geographischen Distanz ausgesetzt sind. Im Rahmen der empirischen Analyse wird die räumliche Abhängigkeit regionaler Arbeitslosigkeit in einigen EU-Staaten zwischen 1986 und 1998 untersucht. Hierzu werden Maße der räumlichen Autokorrelation und Methoden der räumlichen Ökonometrie angewendet. Die Ergebnisse weisen auf erhebliche räumliche Abhängigkeiten zwischen regionalen Arbeitsmärkten in Europa hin. Regionen mit hoher Arbeitslosigkeit bilden ebenso wie Gebiete mit günstigen Arbeitsmarktbedingungen räumliche Cluster. Die empirische Analyse lässt vermuten, dass verschiedene Formen räumlicher Interaktion mit unterschiedlichen Reichweiten die Entwicklung der regionalen Arbeitslosigkeit in Europa beeinflussen.

Keywords: Regional unemployment, Spatial interaction, Spatial econometrics, Europe

JEL classification: C21, E24, R12

1 INTRODUCTION

The adjustment of labour markets after region-specific shocks has been a central issue of recent research on regional labour markets. Implications for regional labour markets in Europe caused by establishing the European Monetary Union (EMU) have been analysed by quite a few studies. Since the EMU implies a loss of policy options at the national level, the functioning of the remaining adjustment mechanisms has become a central topic. Corresponding empirical research paid much attention to one mechanism - interregional labour mobility. Evidence provided by *Eichengreen* (1993), *Obstfeld* and *Peri* (1998) or *Blanchard* and *Katz* (1992) indicates that the responsiveness of migration to regional wage and unemployment differentials is much greater in the US than in Europe. The results of *Möller* (1995) suggest that migration is important for the adjustment of regional labour markets in West Germany, but the speed of adjustment is rather low compared to the US.[1] *Bertola* (2000) concludes that the large and persistent unemployment differentials across European regions are caused by inflexible wages and low labour mobility in the European Union (EU).

The research on adjustment processes focuses on more or less isolated regions. Spatial aspects of labour market problems are largely neglected although interaction between regions is considered to some extent when analysing migration. But the methodology of most studies implies that migration takes place in a non-spatial world, since the location of origin and destination of migration flows is of minor importance. Frictional effects of distance are ignored. However, empirical evidence points to strong effects of distance as an obstacle to both migration and trade. The probability of migration varies inversely with the geographical distance between origin and destination since direct costs of moving rise and benefits from migration become increasingly unknown (*Helliwell* 1998, *Tassinopoulos* and *Werner* 1999). *Burda* and *Profit* (1996) discuss the significance of distance with respect to job matching across regions, i.e. job-search activities of workers and recruiting activities of firms across borders of local labour markets. An important element of the matching approach is the significance of trading frictions and, according to *Burgess* and *Profit* (2001), the frictional impact of distance in labour markets is a crucial one.

1 *Möller* (2001) provides a theoretical framework for analyzing regional adjustment processes after shocks.

The present paper focuses on the consequences of frictional effects of distance regarding regional unemployment in Europe. Regions are tightly linked by migration, commuting and interregional trade. Central issue of the empirical analysis is whether these different types of interaction result in a spatial dependence of regional labour market conditions. The significance of spatial dependence with respect to regional unemployment in Europe is investigated using measures of spatial autocorrelation and spatial econometrics.

Up to now, only a few studies have explicitly considered the spatial dimension of regional labour markets. Some studies investigate the wage curve taking spatial effects into account. *Manning* (1994) analyses the relationship between earnings and unemployment for British counties. The empirical evidence points to a negative effect of local unemployment on local earnings. Thus, the investigation supports the wage-curve hypothesis. However, the results also indicate that linkages between local labour markets have to be considered since there are significant effects across borders of labour market areas in the UK. The significance of spatial effects with respect to the wage curve is as well pointed out by an analysis of German regions by *Buettner* (1999). Both wages and unemployment are marked by a significant spatial autocorrelation. Neglecting spatial dependence results in an underestimation of the effect of local unemployment on local wages.

Burridge and *Gordon* (1981) analyse spatial effects between British labour market areas. Their study focuses on the relationship between migration and regional unemployment taking into account effects arising from the development in neighbouring areas. They provide evidence for an equilibrating effect of migration on regional unemployment rate differentials. This effect arises largely from migration induced by variations of employment growth. Moreover, their results suggest that in more accessible labour markets larger changes in employment growth are required to induce changes in unemployment. An analysis by *Molho* (1995) confirms that there is significant spatial interaction among regional labour markets in the UK. According to the results, local employment growth has significant effects on local unemployment. But this effect is not confined to the local labour market. Unemployment in neighbouring areas is affected as well. These spillovers are marked by a relatively low distance decay consistent with migration behaviour. Furthermore, the study also determines highly localised effects pointing to a spatial dependence caused by commuting.

The findings regarding spatial effects are affirmed by investigations that extend the common matching function approach in order to account for spillovers among neighbouring regions. *Burgess* and *Profit* (2001) explore the importance of spatial effects with respect to unemployment and vacancy flows of travel-to-work areas in Britain. Their results point to significant spatial interaction. High unemployment in adjacent regions increases the number of filled vacancies and decreases the outflow from unemployment in local labour markets. *Burda* and *Profit* (1996) and *López-Tamayo* et al. (2000) provide corresponding evidence for Czech and Spanish regions. Thus, the studies emphasise the importance of spatial spillovers for matching. Job-seekers and job opportunities in neighbouring regions matter for the matching process in local labour markets.

Finally, *Overman* and *Puga* (2000) analyse unemployment clusters across European regions. The results of their nonparametric approach indicate that unemployment rates are much more homogenous across neighbouring areas than across regions in the same EU country. Common characteristics of adjacent regions, such as sectoral composition or skill structure, do not account for the spatial association of unemployment. This neighbour effect also marks the change in regional unemployment and transcends national borders. Moreover, their findings suggest that the intensity of effects among domestic and foreign neighbours does not significantly differ. Applying a similar empirical framework, *López-Bazo* et al. (2001) analyse regional unemployment in Spain. They determine a spatial dependence of unemployment differentials that might point to different types of interaction across regional labour markets.

To sum up, the results emphasise the importance of spatial effects. The analysis of regional labour markets has to pay attention to the fact that regions are not isolated entities. Regional labour markets are more or less integrated by factor mobility and interregional trade (*Buettner* 1999). The present paper is an attempt to provide additional information on the spatial dimension of unemployment and labour markets in Europe, focusing on the extent of spatial effects and different forms of spatial interaction. The analysis deals with the issue whether spatial dependence is a central feature of regional labour markets. Spatial dependence of regional labour market conditions is investigated for a sample of European countries between 1986 and 1998. The spatial association of regional unemployment, i.e. the significance of spatial clusters of high or low unemployment, is analysed using measures of spatial autocorrelation. The regression analysis concentrates on the relationship between the change in regional unemployment,

employment growth and spillovers between regional labour markets. Spatial econometric methods are applied in order to determine whether regional unemployment is affected by employment growth in neighbouring regions.

The rest of the paper is organised as follows. In section 2 the empirical methodology is presented. The data and empirical results are described in section 3. Section 4 concludes.

2 METHOD

The present analysis aims at investigating the significance of spatial interaction for regional unemployment disparities in Europe. However, a direct analysis of various forms of spatial interaction between regional labour markets is not possible due to a lack of data. Comparable data on commuting and interregional trade are not available. Data on interregional migration in Europe is restricted to rather large regions and intranational flows. The scarcity of data requires to apply a method that allows to analyse the effects of spatial interaction without quantitative information on different linkages between labour markets. In this paper the spatial dimension of European labour markets is investigated by measures of spatial autocorrelation and spatial regression models.

2.1 Testing for Spatial Dependence in Regional Unemployment

Significant spatial interaction between neighbouring labour markets implies that cross sectional data are marked by a positive spatial autocorrelation. In this case, similar values, either high or low, are more spatially clustered than could be caused by chance. In contrast to the clearly defined autocorrelation in time-series, the dependence is multidirectional in the spatial case. Measures of spatial autocorrelation take into account various directions of dependence by a spatial weights matrix **W**. For a set of R observations, the matrix **W** is a $R \times R$ matrix the diagonal elements of which are set to zero. The matrix specifies structure and intensity of spatial effects. Hence, the element w_{ij} represents the intensity of effects between two regions i and j (see *Anselin* and *Bera* 1998). A frequently applied weight specification is a binary spatial weight matrix such that $w_{ij} = 1$ if the regions i and j share a border and $w_{ij} = 0$ otherwise. Instead of using the concept of binary contiguity, in this study the elements of **W** are based on a distance decay function. To generate different structures of spatial interaction, a negative exponential function is employed:

$$w_{ij} = \exp(-\beta_E \cdot d_{ij}) \qquad (0 < \beta_E < \infty) \tag{1}$$

with d_{ij} as distance between the centres of the regions *i* and *j* and β_E as distance decay parameter. A transformed distance decay parameter γ_E $(0 \leq \gamma_E \leq 1)$ measures the percentage decrease of the spatial effects as distance expands by a given unit (see *Bröcker* 1989, *Stetzer* 1982).[2] To facilitate the interpretation and computation of spatial autocorrelation, spatial weights matrices are row-standardised, i.e. the weights w_{ij} are divided by the corresponding row sum.

It is assumed that spatial interaction such as commuting, migration or interregional trade is exposed to frictional effects of geographical distance. With increasing γ_E these geographical impediments gain in strength, so that the decline of spatial effects becomes more pronounced with increasing distance from region i. The results of tests for spatial dependence are influenced by both the choice of the regional unit of analysis and the choice of spatial weights (*Anselin* 1988). In order to check the sensitivity of results with respect to a variation of **W**, the whole range of γ_E is considered throughout the analysis. Concerning the effects across national borders, three assumptions are made. Firstly, it is assumed that national borders do not matter. In this case, the calculation of cross border and intranational weights does not differ. Thus, spatial interaction between neighbouring regions belonging to different countries is only affected by frictional effects of distance. There are no additional impediments resulting from crossing a national border. Secondly, it is assumed that national borders prevent linkages between neighbouring labour markets. Significant cross border effects are excluded. All corresponding weights are set to zero.

However, the correct cross border weights are probably somewhere between these extreme specifications. Studies on interregional trade flows point to significant trade impeding effects of national borders even for well integrated countries. The estimates of *Bröcker* (1998), *McCallum* (1995) and *Helliwell* (1998) imply a reduction of interna-

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2 The transformed parameter is given by: $\gamma_E = 1 - e^{-\beta_E \cdot D_{MIN}}$, where D_{MIN} denotes the average distance between the centres of immediately neighbouring regions over the whole cross-section, in the present case 40 kilometres.

tional trade, as compared to intranational trade, by a factor around 20 (for EU countries respectively the Canada-US border).[3] Therefore, the third weight specification allows for border-specific impediments, i.e. a particular border effect for every pair of countries. The corresponding weights are calculated by reducing the purely distance-based weights by a border-specific factor. These factors are based on trade impediments estimated by *Bröcker* (1998).[4]

The spatial association of regional unemployment is analysed by Moran's correlation coefficient:

$$I_t = \frac{R \cdot \sum_{i=1}^{R} \sum_{j=1}^{R} x_{i,t} x_{j,t} w_{ij}}{R_b \sum_{i=1}^{R} x_{i,t}^2} \tag{2}$$

where $x_{i,t}$ ($x_{j,t}$) is the considered variable in region i (j) in year t (in deviations from the mean), R is the number of regions and R_b the sum of all weights. So, in the present case, with standardised weights, R_b equals R. Values for Moran's I_t range between approximately –1 and +1. With no spatial autocorrelation present, Moran's I_t approaches its expected value, –1/(R–1). Thus, the mean will tend to zero as the sample size increases. A coefficient larger than the expected value indicates positive spatial autocorrelation, i.e. a clustering of similar values. A Moran coefficient less than its mean points to negative spatial dependence, the proximity of dissimilar values.

For measuring spatial autocorrelation in regression residuals, a number of tests has been developed. In order to derive robust inference, several tests are used in the following regression analysis: a Moran test and two robust Lagrange Multiplier tests (LM_{LAG}, LM_{ERR}). The Moran test provides reliable results for alternative forms of ignored spatial dependence, whereas the LM tests supply precise information about the kind of spatial dependence (see *Anselin* and *Rey* 1991, *Anselin* and *Florax* 1995). According to the re-

3 *Helliwell* (1998) also provides evidence of significant border effects on migration.

4 Only the study of *Bröcker* (1998) provides, to our knowledge, estimates of border-specific impediments. There are no estimates for Spain, Portugal and Ireland. For these countries the average border effect is assumed or the estimates for a neighbouring country are used (estimates for UK applied to Ireland).

sults of these tests, different spatial models can be estimated if necessary, i.e. in case of a misspecification.[5]

2.2 Estimation of Spatial Effects

Common approaches applied to investigate regional unemployment differentials and adjustment mechanisms of European labour markets largely neglect linkages between neighbouring regions. Studies that focus on the adjustment of regional labour markets to shocks usually estimate vector autoregression systems in order to analyse adjustment mechanisms such as changes in wages and labour force participation. Linkages between regions are considered to some extent since migration is taken into account. However, corresponding models do not explicitly incorporate a spatial dimension. It is ignored that migration and other forms of spatial interaction are exposed to frictional effects of distance.

In contrast, the present analysis emphasises spatial aspects of labour markets using small units of observation. Data availability for the corresponding regional system entails restrictions with respect to the methodology. Panel specifications or vector autoregressions are not applicable since time series for the analysed regions are rather short. Therefore, the point of departure is a traditional cross-sectional regression. Using matrix notation, the non-spatial model applied to analyse the evolution of regional unemployment in Europe is given by:

$$\mathbf{\Delta u} = \alpha_0 \boldsymbol{\iota} + \alpha_1 \mathbf{\Delta e} + \sum_{k=2}^{N} \alpha_k \mathbf{C_k} + \boldsymbol{\varepsilon} \qquad (3)$$

where $\mathbf{\Delta u}$ is the change in the regional unemployment rate, $\boldsymbol{\iota}$ is a column vector of R ones, $\mathbf{\Delta e}$ is regional employment growth and $\boldsymbol{\varepsilon}$ is a vector of residuals. The analysis focuses on effects of employment growth and corresponding spillovers on regional unemployment. Apart from regional employment growth, a number of control variables $\mathbf{C_k}$ are considered to avoid misspecifications due to omitted systematic variables. These comprise population density, indicators for sectoral composition and country dummies. Since employment growth is included in order to capture labour demand effects on re-

5 See *Anselin* (1988) for a detailed description of test statistics and spatial regression models.

gional unemployment, the control variables and country dummies should reflect labour supply effects, country-specific labour market regulations or differences regarding the efficiency of matching workers to jobs.[6]

Population density can be applied as an indicator for large and dense urban labour markets. These regions could be marked by a higher efficiency of the matching process because more job-seekers and job offers might lead to faster matching and lower unemployment (*Elhorst* 2000). However, population density can also reflect amenities of large European agglomerations which might cause strong immigration and higher unemployment. Indicators for the industrial composition can be used as approximations of the skill structure of the regional labour force. Structural change is characterised by an expanding service sector and declining employment in manufacturing and agriculture. Thus, matching jobs and job-seekers is possibly more difficult in regions marked by a labour supply specialised in agriculture or manufacturing (*Elhorst* 2000, *Taylor* and *Bradley* 1997). Finally, country-specific labour market regulations and policies, allowed for by the inclusion of country dummies, can affect matching process or labour supply.

The OLS estimation of equation (3) provides the Best Linear Unbiased Estimator (BLUE) in case the error terms are independently and identically distributed with zero mean. Standard inference procedures assume that the joint probability distribution is a normal distribution:

$$\boldsymbol{\varepsilon} \sim N(0, \sigma^2 \mathbf{I}) \tag{4}$$

Spatial dependence resulting from factor mobility or interregional trade is not explicitly considered in this standard model. Nevertheless, the approach might include spillover effects, operating through interregional trade. Corresponding effects imply that employment growth in region *i* generates employment growth in region *j*, which again affects unemployment in region *j*. This mechanism of transmission causes a spatial autocorrelation of employment growth (see *Molho* 1995). If interregional trade is the only or by far the most important source of spillovers affecting the spatial structure of unemployment, the model given by (3) might already capture the entire spatial dependence. However, other forms of interaction or measurement problems can also result in a spatial autocorrelation of unemployment. Ignoring any significant spatial effects leads to

6 A comprehensive consideration of all corresponding effects, e.g. regarding regional differences in participation, qualification of the work force or occupational structure of the working population, is not possible due to severe data restrictions.

serious econometric problems. In case regional unemployment is marked by a spatial autocorrelation not captured by the explanatory variables, the model given by equation (3) is misspecified. Depending on the form of spatial autocorrelation, different spatial regression models can be applied to solve the problem.

The spatial error model is an appropriate approach in case the autocorrelation pertains to the error term. This form of spatial autocorrelation can be caused by measurement problems as for example a poor match between regional labour market areas and the units of observation. The spatial process pertaining to the error term can be expressed as:

$$\boldsymbol{\varepsilon} = \lambda \mathbf{W}\boldsymbol{\varepsilon} + \boldsymbol{\mu} \qquad \boldsymbol{\mu} \sim N(0, \sigma^2 \mathbf{I}) \tag{5}$$

where $\boldsymbol{\mu}$ is a vector of independently and identically distributed disturbances, λ is a spatial autoregressive parameter and $\mathbf{W}\boldsymbol{\varepsilon}$ is the weighted average of the errors in adjacent regions. Taking into account the spatial autocorrelation of the error term, the regression model becomes:

$$\Delta\mathbf{u} = \alpha_0 \boldsymbol{\iota} + \alpha_1 \Delta\mathbf{e} + \sum_{k=2}^{N} \alpha_k \mathbf{C_k} + \lambda \mathbf{W}\boldsymbol{\varepsilon} + \boldsymbol{\mu} = \alpha_0 \boldsymbol{\iota} + \alpha_1 \Delta\mathbf{e} + \sum_{k=2}^{N} \alpha_k \mathbf{C_k} + (\mathbf{I} - \lambda \mathbf{W})^{-1} \boldsymbol{\mu} \tag{6}$$

If, in contrast, the ignored spatial effects are of the substantive form, the OLS regression of equation (3) will result in biased estimates and incorrect inference. To achieve proper estimates, the dependence can be incorporated through a spatial lag of the dependent variable:

$$\Delta\mathbf{u} = \rho \mathbf{W} \Delta\mathbf{u} + \alpha_0 \boldsymbol{\iota} + \alpha_1 \Delta\mathbf{e} + \sum_{k=2}^{N} \alpha_k \mathbf{C_k} + \boldsymbol{\varepsilon} \tag{7}$$

where ρ is the spatial autoregressive parameter of the spatially lagged dependent variable. *Molho* (1995) offers an interpretation of the spatial lag model for an application focusing on the regional unemployment rate. According to *Molho*, the spatial lag specification implies that, starting from a steady state pattern of regional unemployment, a region-specific shock will not only affect the respective labour market, but instead spill over to neighbouring regions. The induced changes of unemployment in neighbouring areas again spill over to adjacent labour markets, including the location where the shock originated. This process of spatial adjustments continues until a new steady-state pattern of regional unemployment is reached. However, the spatial lag model does not allow to draw precise conclusions regarding different mechanisms that might cause a spatial association of regional unemployment. The spatially lagged dependent variable probably captures various spillover effects leading to spatial dependence.

A substantive dependence characterising regional unemployment can as well be incorporated by spatial lags of explanatory variables. As in the case of the spatially lagged dependent variable, the consequences of a corresponding specification error are serious: biased coefficient estimates and invalid inference procedures. The corresponding spatial cross-regressive model is given by:

$$\mathbf{\Delta u} = \alpha_0 \boldsymbol{\iota} + \alpha_1 \mathbf{\Delta e} + \sum_{k=2}^{N} \alpha_k \mathbf{C_k} + \tau \mathbf{W \Delta e} + \boldsymbol{\varepsilon} \tag{8}$$

In the following regression analysis, a spatial lag of employment growth $\mathbf{W\Delta e}$ is included to capture spillovers between regional labour markets. Whereas the spatially lagged dependent variable might cover all forms of spillovers, the spatial lag of employment growth is restricted to those spatial effects that function via regional employment. *Florax* and *Folmer* (1992) emphasise the specific meaning of cross-regressive spatial dependence by considering the example of a regional production function. In this case, spatial dependence in general implies that the production in region *i* is also influenced by production in adjacent areas. In contrast, cross-correlation represented by spatially lagged explanatory variables indicates that production in region *i* is also affected by the availability of inputs in adjacent areas. In the present context, the former implies that change in regional unemployment is influenced by the evolution of unemployment in neighbouring areas. The latter implies that a change in unemployment in region *i* is influenced by employment growth in adjacent regions. Thus, the cross-regressive model is restricted to certain mechanisms of transmission but, thereby, is allowing more precise conclusions. Different types of spatial causation can also be considered simultaneously by including a spatial lag of employment growth in the spatial lag model.

With respect to the interpretation of different spatial effects a second issue has to beconsidered. The cross-regressive model including employment growth and the spatially lagged employment change can provide evidence on the significance of different forms of spatial interaction. Whereas employment growth, marked by a positive spatial autocorrelation, may be interpreted as capturing the effects of interregional trade, the spatially lagged employment change can point to spillovers caused by commuting and migration. As mentioned above, spatial effects associated with regional employment growth imply that growth in region *i* induces growth in region *j* which affects unemployment in region *j*. In contrast, the spatially lagged employment growth can indicate spatial interaction based on labour mobility since the variable implies that employment changes in region *i* influence unemployment in region *j* even in case employment in region *j* remains constant. Thus, rising regional labour demand is associated with increasing job opportunities in neighbouring areas as well.

3 EMPIRICAL RESULTS

3.1 Data

The analysed cross-section includes 359 European regions (Belgium (9), Denmark (12), Germany (71), Spain (46), France (88), Ireland (7), Italy (65), Luxembourg (1), Netherlands (12), Portugal (5), United Kingdom (43)). The sample contains NUTS2 and NUTS3 regions as well as functional regions that comprise several NUTS units. The selection of regions aimed at a spatial system with areas of comparable size and, as far as possible, application of functional regions. Due to data restrictions the sample covers only those countries that have been EU members since 1986. Greece is not considered because of lacking regional data. A detailed description of the sample is given in the Appendix. Regional data on unemployment, working population, employment, population and area were collected from the Eurostat Regio database. For some regions missing observations were taken from Cambridge Econometrics' European regional databank.

The spatial dependence of regional unemployment in Europe was analysed over the 1986-1998 period. Thus, the change in the regional unemployment rate between 1986 and 1998 is the dependent variable in the regression analysis. Since data on regional employment is available only until 1995, the explanatory variable employment growth refers to the 1986-1995 period. The spatially lagged employment change was calculated for weight matrices that cover the whole range of distance decay parameters. To avoid misspecifications, a number of control variables were considered, including sectoral specialisation and population density in 1987. All variables were expressed in logarithms. The indicators for the sectoral composition of the regions base on employment data by NACE-CLIO R3 classification (B01: Agricultural, forestry and fishery products, B02: Manufactured products, B03: Market services). Corresponding employment shares, i.e. percentages of regional employment in manufacturing respectively market services, were used as control variables. Moreover, country dummies were included. As outlined in section 2, these variables were considered in order to capture labour supply effects, country-specific labour market conditions or differences regarding the efficiency of the matching process.

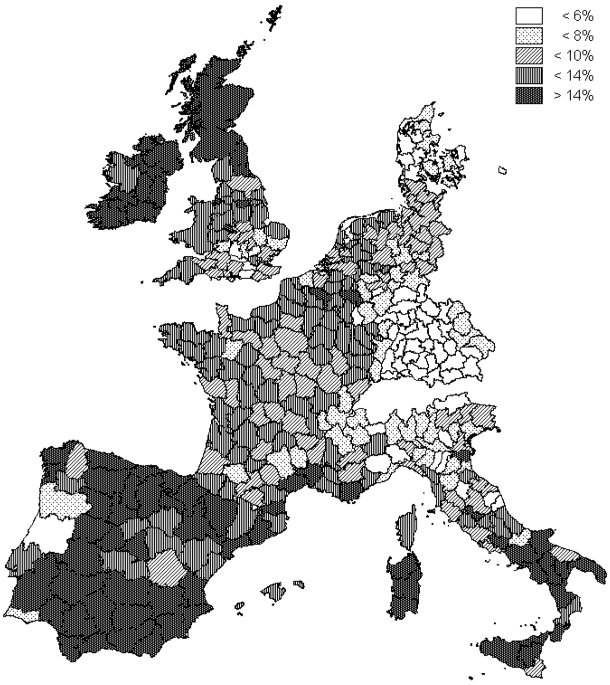
3.2 Unemployment Clusters across European Regions

Between 1986 and 1998 the average unemployment rate in the EU (EU12) slightly decreased from 10.7% to 10.2%.[7] However, this average change masks significant national and regional differences. While some countries realised a distinct reduction of unemployment since the mid of the 1980s, others experienced deteriorating labour market conditions. For instance, the unemployment rate of the Netherlands fell from 10% to 4% and the decline in Ireland was even more pronounced (18.1% in 1986, 7.9% in 1998). In contrast, unemployment in Germany increased from 6.6% to 9.8%, in Italy from 10.5% to more than 12%.

As the Figures 1 and 2 illustrate for the sample of European regions, some features of regional unemployment in the EU remained more or less unchanged since the mid of the 1980s, whereas others changed dramatically. Since quite a few studies have analysed the European unemployment problem, the large and persistent unemployment differentials are well known by now (e.g. *Mauro* et al. 1999, *Bertola* 2000, *Overman* and *Puga* 2000). In 1986 as well as in 1998 Spain and the southern part of Italy suffered from severe labour market problems, with unemployment rates of more than 30% in some areas. In contrast, Denmark and the northern part of Italy achieved modest unemployment rates of around 5% in the mid of the 1980s and at the end of the 1990s. However, simultaneously significant changes in the spatial structure of unemployment are obvious. Most regions in Ireland, the UK and the Netherlands realised a distinct reduction of unemployment. At the same time, the disparities between the northern and southern part of Italy became even more pronounced and a cross border cluster of high unemployment evolved in the French-Belgian border area.

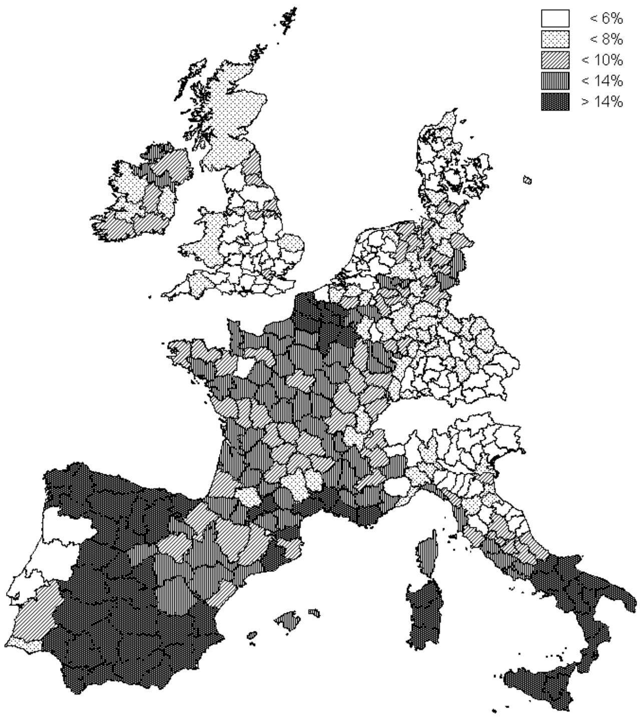
7 The unemployment rate of the EU12 declined until the beginning of the 1990s (1990: 8%) and rose again until the mid of the 1990s (1994: 11.3%).

Figure 1: Regional unemployment rates 1986



Source: Eurostat; own presentation

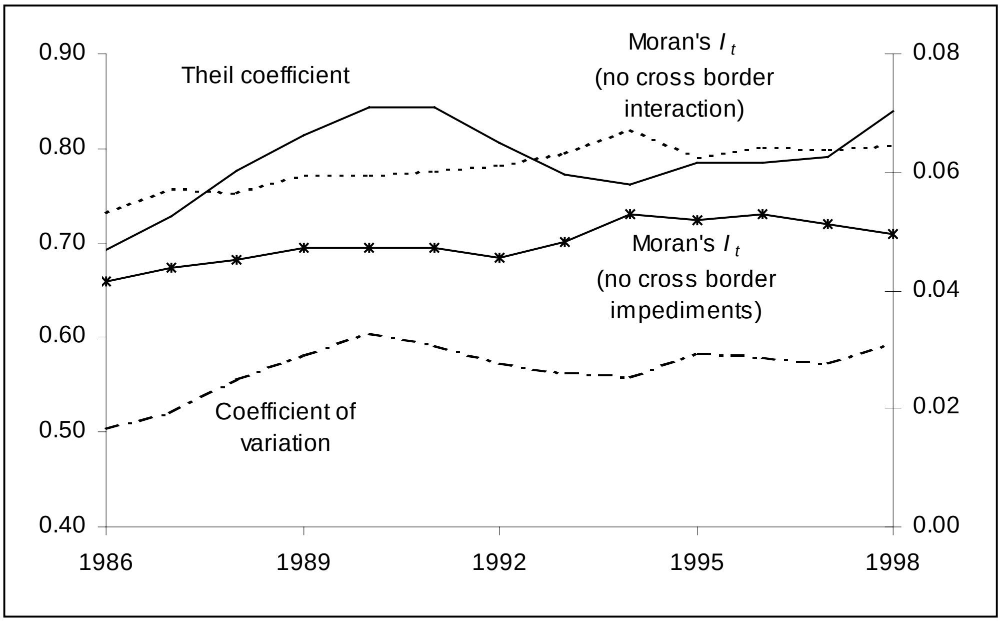
Figure 2: Regional unemployment rates 1998



Source: Eurostat; own presentation

These changes were accompanied by an increase in regional unemployment disparities. The dispersion of regional unemployment rates, measured by the coefficient of variation, rose from 0.5 in 1986 to 0.6 in 1998 (see Figure 3). This increase is based on both a rising dispersion between member states and a higher regional variation within most of the analysed countries[8] (see also *Mauro* et al. 1999). A similar trend characterises the concentration of regional unemployment in Europe. During the period under consideration, the concentration of unemployment, measured by the Theil coefficient[9] rose from 0.05 (1986) to 0.07 (1998). And again, this change is based on concentration processes effective between and within the countries.

Figure 3: Concentration, dispersion and spatial autocorrelation of regional unemployment in Europe



Source: Eurostat; own calculations

Altogether, the geographical distribution of unemployment suggests that the spatial dimension, i.e. spatial dependence is an important aspect of regional labour markets in Europe. Moreover, regional unemployment disparities as for example in Italy or Ger-

8 Only in Denmark and West Germany the dispersion of regional unemployment rates declined between 1986 and 1998.

9 The Theil coefficient is given by: $TC_t = \sum_i U_{it} \cdot \log\left(U_{it} / WP_{it} \right)$, where U_{it} and WP_{it} are regional shares of unemployment and working population in year t respectively.

many and cross border unemployment clusters like the area at the French-Belgian border indicate that unemployment clusters are not exclusively based on national differences.

Table 1: Spatial autocorrelation of regional unemployment in Europe

Variable	Moran's I_t (standardised z-value) Distance decay parameter γ_E				
	0.1	0.3	0.5	0.7	0.9
$u_{i,1986}$					
no cross border interaction	0.54	0.65	0.73	0.78	0.81
	(42.8)**	(41.3)**	(34.1)**	(26.5)**	(19.3)**
no border impediments	0.21	0.53	0.66	0.73	0.78
	(68.7)**	(49.9)**	(36.4)**	(27.4)**	(19.5)**
border–specific impediments	0.50	0.64	0.73	0.77	0.80
	(50.6)**	(43.6)**	(34.8)**	(26.9)**	(19.5)**
$u_{i,1998}$					
no cross border interaction	0.52	0.70	0.80	0.85	0.84
	(41.3)**	(44.5)**	(37.3)**	(28.9)**	(21.1)**
no border impediments	0.22	0.57	0.71	0.79	0.88
	(71.1)**	(53.7)**	(39.2)**	(29.3)**	(21.0)**
border–specific impediments	0.48	0.69	0.79	0.84	0.87
	(48.9)**	(46.7)**	(37.9)**	(29.2)**	(21.1)**
$u_{i,1986} / u_{n,1986}$					
no cross border interaction	0.12	0.34	0.48	0.55	0.60
	(9.4)**	(21.4)**	(22.3)**	(18.7)**	(14.4)**
no border impediments	0.05	0.29	0.45	0.53	0.59
	(17.7)**	(27.4)**	(25.0)**	(19.9)**	(14.7)**
border–specific impediments	0.11	0.33	0.48	0.55	0.60
	(11.5)**	(22.7)**	(22.8)**	(19.0)**	(14.5)**
$u_{i,1998} / u_{n,1998}$					
no cross border interaction	0.16	0.44	0.59	0.66	0.70
	(13.1)**	(28.2)**	(27.4)**	(22.4)**	(16.8)**
no border impediments	0.08	0.39	0.56	0.64	0.69
	(25.5)**	(37.2)**	(30.9)**	(23.8)**	(17.2)**
border–specific impediments	0.16	0.44	0.59	0.65	0.70
	(16.1)**	(30.0)**	(28.1)**	(22.7)**	(16.9)**
$\Delta u_{i,1986-1998}$					
no cross border interaction	0.35	0.48	0.57	0.61	0.65
	(27.7)**	(30.8)**	(26.3)**	(21.0)**	(15.6)**
no border impediments	0.05	0.27	0.45	0.55	0.62
	(15.5)**	(26.1)**	(25.0)**	(20.7)**	(15.4)**
border–specific impediments	0.27	0.46	0.55	0.61	0.65
	(27.5)**	(31.3)**	(26.5)**	(21.1)**	(15.7)**

Notes: ** significant at the 0.01 level

These presumptions derived from visual examination are confirmed by the results of Moran's I_t (see Table 1). The correlation analysis points to a strong positive autocorrelation of both regional unemployment ($u_{i,t}$) and the change in regional unemployment during the period under consideration ($\Delta u_{i,1986-1998}$). This result is rather robust since a significant spatial autocorrelation is detected for all applied spatial weights, in other words for the whole range of distance decay parameters. Adjacent regions that form clusters of high and low unemployment seem to be a central feature of disparities in Europe. Furthermore, spatial dependence is not solely the consequence of national differences since a significant autocorrelation also characterises relative unemployment rates, i.e. the ratio of the regional unemployment rate to the nation-wide unemployment rate ($u_{i,t} / u_{n,t}$). Unemployment clusters are not exclusively national clusters, covering all regions that belong to the same EU member state. Disparities below the national level, as for example in Spain, Italy or Germany, are as well marked by clusters that add to the overall spatial dependence of unemployment. These intranational clusters and national differences seemingly account for most of the spatial autocorrelation because Moran's I_t tends to be higher for the national weight specifications (no cross border interaction) than for weight matrices including unrestricted or restricted cross border interaction (no border impediments respectively border-specific impediments). Thus, cross border clusters, as the area on both sides of the French-Belgian border, are more likely to be the exception than the rule.[10]

Comparing the results for unemployment rates in 1986 and 1998 suggests that the intensity of spatial dependence has increased during the period under consideration. Figure 3 displays the evolution of spatial autocorrelation for regional unemployment rates over the 1986-1998 period. Apart from Moran's I_t (for $\gamma_E = 0.5$), the coefficient of variation and the Theil coefficient are mapped in order to examine the relationship between dispersion, concentration and spatial dependence of regional unemployment. As shown in Figure 3, all measures are characterised by a more or less pronounced increase, though, the statistics do not develop in a perfectly synchronized manner. The results for Moran's I_t indicate that the increase of spatial association was a relatively continuous process, whereas the evolution of dispersion and concentration is marked by fluctuations. Both the Theil coefficient and the coefficient of variation have rapidly increased between 1986 and 1990, have declined until the mid of the 1990s and have risen again thereafter. This suggests that the evolution of dispersion and concentration of regional unemploy-

10 See *Overman* and *Puga* (2000) for an interesting analysis of this cross border cluster. They discuss in detail the circumstances that led to the emergence of the unemployment cluster.

ment is affected by the overall change in unemployment. The decline of unemployment in the EU12 between 1986 and 1990 was associated with increasing dispersion and concentration. Moreover, both measures were decreasing when the average unemployment rate in the EU12 was rising again until 1994. However, the fairly continuous increase of Moran's I_t implies that the change in spatial dependence is rather unaffected by the overall development of unemployment in Europe.

Thus, the evolution of the measures suggests that unemployment has become more concentrated and that this process of concentration was accompanied by an increasing spatial dependence. Consequently, the rising concentration of labour market problems probably corresponds with a concentration of unemployment in spatial clusters. Such a process of spatial concentration is consistent with the polarisation of unemployment detected by *Overman* and *Puga* (2000) for EU regions and by *López-Bazo* et al. (2001) for Spanish regions.

To sum up, the results point to a significant spatial dependence, i.e. both regions marked by high unemployment rates and areas characterised by rather favourable labour market conditions tend to cluster in space. These clusters are not exclusively caused by national differences. Intranational disparities are characterised by a spatial clustering as well. Moreover, the empirical evidence suggests that the change in regional unemployment is also marked by significant spatial effects. The following regression analysis focuses on the latter.

3.3 Estimation Results

Table 2 shows the regression results for different specifications applied to analyse spatial effects that characterise the change in regional unemployment rates between 1986 and 1998. OLS estimates of the non-spatial model, given by equation (3), are presented in column (1). All explanatory variables are significant at the 5% level. The coefficient of the share of market services in total employment ($\mathbf{serv}_{t_0}$) indicates that a relatively high fraction of service employment in 1987 is associated with a decrease (or a relatively small increase) in regional unemployment. In other words, regions characterised by a specialisation in services tended to realise a rather favourable development of unemployment since the mid of the 1980s. The negative coefficient of the share of manu-

Table 2: Regression results for the change in regional unemployment 1986-1998

Explanatory variables	OLS (1)	OLS (2)	Maximum Likelihood (ML) (3)
$\mathbf{manu}_{t_0}$	-0.36** (4.78)	-0.30** (4.37)	-0.17** (3.02)
$\mathbf{serv}_{t_0}$	-0.40* (2.17)	-0.30 (1.82)	-0.15 (1.33)
$\mathbf{dens}_{t_0}$	0.06** (3.24)	0.06** (3.12)	0.04** (2.65)
$\mathbf{\Delta e}$	-0.50* (2.51)	-0.49** (2.59)	-0.40* (2.42)
$\mathbf{W\Delta e}$ ($\gamma_E = 0.1$) no border impediments		-11.52** (4.16)	-3.9* (2.12)
$\mathbf{W\Delta u}$ ($\gamma_E = 0.6$) border-specific impediments			0.63** (10.92)
Country Dummies			
Belgium	0.26	0.17	-0.01
Denmark	0.46*	0.34	0.09
Germany	0.73**	0.59**	0.17
Spain	0.45*	0.38*	0.10
France	0.62*	0.41*	0.11
Ireland	-0.22	-0.16	-0.09
Italy	0.40	-0.02	-0.06
Netherlands	-0.35	-0.39*	-0.25*
United Kingdom	-0.12	-0.13	-0.10
R^2_{adj}	0.64	0.67	
AIC	-15.3	-45.2	-120.6
Moran´s I_t	24.4** (0.1)[1)] [0.1-0.9][2)]	17.4** (0.1) [0.1-0.9]	
Robust LM_{ERR}	17.9** (0.3) [0.2-0.6]	6.3* (0.3) [0.3-0.5]	2.2 (0.2) [-]
Robust LM_{LAG}	29.7** (0.4) [0.1-0.9]	13.3** (0.5) [0.1-0.9]	
Breusch-Pagan		63.7**	89.2**
Koenker-Bassett	52.4**		

1) corresponding distance decay γ_E;
2) range of γ_E with significant spatial autocorrelation of the error term at the 0.05 level
The OLS *t*-statistics are based upon White's heteroscedasticity-adjusted standard errors.
Notes: ** significant at the 0.01 level; * significant at the 0.05 level

facturing in total employment ($\mathbf{manu}_{t_0}$) implies that regions specialised in manufacturing achieved on average a decline (or again relatively small increases) in unemployment as well.[11] In contrast, the evolution of unemployment tended to be rather unfavourable in highly agglomerated European regions, as indicated by the positive coefficient of the population density ($\mathbf{dens}_{t_0}$).

The latter result is not in line with a highly efficient matching process in large and dense urban labour markets, as discussed in section 2. The estimate rather points to the opposite, i.e. a slower matching process because it takes more time to gather all relevant information in such large labour markets. Another explanation might be an above average increase of labour supply in these areas. If the highly agglomerated regions in Europe are preferred destinations of migration flows, the corresponding increase in labour supply might result in a smaller reduction of unemployment for every given expansion of employment. Furthermore, the coefficients of the employment shares of manufacturing and services indicate that a corresponding specialisation of regions is probably not reducing the efficiency of the matching process. At the same time, this finding suggests that the skill structure in regions specialised in agriculture tends to exacerbate the regional matching process.

The effect of regional employment growth ($\mathbf{\Delta e}$) on unemployment is negative, as one would expect. Beyond that, the variable incorporates another interesting effect. Since regional employment growth is marked by a significant spatial autocorrelation, this explanatory variable also includes spillover effects. According to the discussion of different regression models in section 2, this result might be interpreted as spatial interaction caused by interregional trade. Thus, the inclusion of the spatially autocorrelated employment growth entails already the consideration of interregional spillovers although spatial effects are not explicitly modelled in this approach. However, spatial interaction that bases on interregional trade is obviously not the only source of spatial dependence characterising the evolution of regional unemployment. All three tests for spatial autocorrelation provide strong evidence of a misspecification due to omitted spatial effects.[12]

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11 This result confirms evidence provided by *Overman* and *Puga* (2000). They argue that this negative effect on unemployment is caused by the development of Northern and Central European regions specialised in heavy industry. Since the worst part of their adjustment process was over by the mid of the 1980s, many of these areas attained a reduction in unemployment.

12 The tests for spatial autocorrelation apply the unrestricted cross border weight specification (for the whole range of distance decay parameters) because these weights might offer a more stringent method of testing.

Furthermore, results concerning the included country dummies suggest that there are more country-specific effects beyond national differences in employment growth. Negative coefficients, though not significant, point to a favourable development of unemployment in countries, such as Ireland, the Netherlands or the UK which pursued wide-ranging structural reforms since the second half of the 1980s. In contrast, positive and significant coefficients emerged for countries marked by less comprehensive reforms, as e.g. Germany or France.[13]

Regression results for models that explicitly include spatial effects are given in columns (2) and (3). The selection of spatial models is based on a variation of the distance decay parameter, respectively weight matrix, of the integrated spatial effects. All assumptions concerning cross border effects (no cross border interaction, restricted and unrestricted cross border interaction) are taken into account regarding the calculation of spatial variables. Information criteria and tests for spatial autocorrelation are used to identify appropriate spatial weights. Thus, the chosen model, i.e. distance decay, provides the best fit simultaneously capturing, if possible, the overall spatial interaction that characterises the change in regional unemployment.

In column (2) the estimates of the spatial cross-regressive model (equation (8)) are presented. The regression yields a negative and significant coefficient for the spatial lag of regional employment growth. Coefficients of the other explanatory variables are more or less unaffected by inclusion of the spatial lag. Only the effect of a specialisation in services is reduced to insignificance. The result for the spatial lag of employment growth suggests that the generation of jobs not only reduces the unemployment rate of the corresponding region but also unemployment in neighbouring areas, thus, presumably spatial dependence caused by labour mobility. Weight specifications including unrestricted cross border effects achieve a slightly better fit than matrices with no or restricted cross border interaction. The coefficient of $\mathbf{W\Delta e}$ is rather high and the distance decay of the spatial lag rather low ($\gamma_E = 0.1$). According to the distance decay, the intensity of spatial effects based on labour mobility declines very slowly, by 50% over a range of 360 kilometres. This estimate is clearly not consistent with conventional commuting behaviour. Moreover, compared with the empirical evidence provided by *Molho* (1995), the distance decay also appears to be quite low with respect to migration. The corresponding estimates for regional labour markets in the UK point to a reduction of spatial effects by more than 90% over a range of 100 miles. However, some unusual

13 For a detailed description of structural reforms in the OECD countries, see OECD (1997).

forms of labour mobility might be relevant in this context. Temporary migration or long distance commuting (weekly or monthly) gain in importance and might contribute to the low distance decay.[14] Although labour mobility in Europe is too low in order to offset regional unemployment disparities, it is apparently one of the factors that generates the significant spatial dependence of regional labour market conditions.[15] However, tests for spatial autocorrelation still indicate a misspecification, even though the degree of residual autocorrelation is considerably reduced by inclusion of the spatially lagged explanatory variable.

The remaining problems are apparently not due to an inadequate regional system, i.e. administrative NUTS regions not matching functional labour market areas. The higher significance of the spatial lag test points to ignored spatial effects of the substantive form, and suggests that a spatial lag model should be estimated in order to capture the still unconsidered spillovers. Results of the spatial lag model are presented in column (3). Concerning the spatially lagged dependent variable, the weight specification reflecting border-specific impediments yields a better fit than specifications with no or unrestricted cross border interaction. This applies to the whole range of distance decay parameters. Thus, assuming no effects across national borders at all is apparently not adequate regarding spatial interaction between regional labour markets in Europe.

The Akaike Information Criterion (AIC) is minimised for a rather high distance decay ($\gamma_E = 0.6$). The significant coefficient of the spatially lagged dependent variable points to strong spillover effects that decline rather quickly with increasing distance.[16] The distance decay implies that the intensity of spatial interaction decreases by 50% over a range of roughly 40 kilometres. These spatial weights are more in line with highly localised interaction, such as daily commuting. But the declining coefficients of $\mathbf{\Delta e}$ and

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14 I am grateful to a referee for pointing to the potential effects of these unusual types of labour mobility. See also *Straubhaar* (2000). The conspicuously low distance decay might also partly be caused by national effects that are captured by the spatial lag as well. The inclusion of the spatially lagged employment growth reduces the coefficients of some country dummies.

15 In the last two decades labour mobility in Europe has declined markedly. The low mobility is frequently ascribed to cultural and linguistic differences. However, these factors should have been effective in periods of larger migration flows as well. Moreover, they cannot explain the low mobility within European countries. Recent studies emphasise inefficiencies in the regional matching process and high mobility costs, especially high house prices, as possible causes of low intranational mobility (see *Faini* et al. 1997, *McCormick* 1997).

16 The result that significant spatial effects mark the evolution of unemployment is rather robust with respect to a variation of the spatial weight matrix. The regressions yield significant coefficients for the spatial lags of employment growth and unemployment change for a number of different weight specifications.

$\mathbf{W\Delta e}$ suggest that the spatially lagged change in unemployment also picks up other forms of spatial interaction with a rather limited scope. Moreover, spatial variables seem to absorb some country-specific effects since their inclusion results in clearly reduced coefficients of all country dummies.

According to the regression results, the neighbourhood of regions marked by an unfavourable development of unemployment tended to worsen regional labour market conditions (and vice versa for the neighbourhood of regions characterised by a decrease of unemployment). Moreover, as indicated by the LM_{ERR} test, the inclusion of $\mathbf{W\Delta u}$ reduced the residual autocorrelation to insignificance. However, taking into account spatial interaction obviously does not eliminate heteroscedasticity, as indicated by the Breusch-Pagan test. The heteroscedastic error terms suggest that assuming the same intensity and distance decay of spatial effects for all European regions might not be adequate. Thus, the results also raise a number of issues left for future research.

4 CONCLUSIONS

The results of the present paper emphasise the importance of spatial interaction with respect to regional labour markets in Europe. The findings confirm the empirical evidence provided by several studies, pointing to significant spillovers among regional labour markets. In particular this applies to the analysis of *Overman* and *Puga* (2000). They conclude that unemployment rates of European regions are much closer to the rates of adjacent regions than to the average rate of other regions within the same EU country. Spatial concentrations of areas with similar skill composition or sectoral specialisation are not the primary cause of this spatial association. The present analysis as well points to a significant spatial dependence, i.e. both regions marked by high unemployment rates and areas characterised by rather favourable labour market conditions tend to cluster in space. Spatial dependence is a central feature of the large and persistent unemployment differentials that characterise EU regions. Moreover, the evolution of regional unemployment is also marked by spatial effects. The results suggest that the change in regional unemployment between 1986 and 1998 was associated with an increasing concentration of labour market problems in spatial clusters. This geographical concentration probably corresponds with polarisation processes detected by *Overman* and *Puga* (2000) or *López-Bazo* et al. (2001).

Furthermore, the findings point to different forms of spatial interaction that affect the change in regional unemployment. However, it turned out to be rather difficult to distinguish between effects resulting from commuting, migration or interregional trade. Taking into account the low cross border commuting and migration in the EU, the detected interaction including unrestricted effects is more likely due to interregional trade. In contrast, spillovers associated with a high distance decay and significant cross border impediments might point to spatial dependence caused by commuting and migration. To achieve more precise conclusions in this respect will necessitate a method based on consistent data on labour mobility and trade among European regions. Finally, the empirical evidence suggests that assuming different spatial regimes, e.g. country-specific intensities and distance decays of spatial effects, might be an appropriate approach. Thus, a number of issues remain to be investigated concerning spatial interaction of regional labour markets in Europe.

The findings concerning spatial effects among European labour markets have implications for regional policy. The existence of unemployment clusters, i.e. similar labour market conditions in neighbouring regions, suggests that especially policies that promote labour mobility across *longer* distances and national borders might be appropriate to reduce differences in regional unemployment. Regional disparities marked unemployment clusters cannot be reduced by short distance mobility within the borders of these clusters. As far as these clusters coincide with national clusters, in other words with international disparities, measures leading to more consistent labour market regulations in Europe constitute adequate policies as well. However, the clustering of unemployment in Europe also consists of intranational disparities. The harmonisation of national regulations and policies is no appropriate instrument to dissolve corresponding spatial structures within Germany, Italy or Spain.

Furthermore, as *Burgess* and *Profit* (2001) note, significant spillover effects between neighbouring regions imply wider consequences of local unemployment shocks. Massive layoffs in a certain region will tend to depress adjacent labour markets as well. Likewise, every measure that reduces local unemployment will also have positive effects in neighbouring labour markets. This calls for a close cooperation and common measures of regions in order to diminish severe labour market problems.

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APPENDIX

The regional system was based on different administrative units: Belgium - NUTS2 (Brussels and adjacent regions merged), Denmark – NUTS3 (København and adjacent regions merged), Germany – Raumordnungsregionen (functional regions comprising several NUTS3 units), Spain – NUTS2 and NUTS3, France – NUTS2 and NUTS3, Ireland – NUTS3 (Dublin and the surrounding area merged), Italy – NUTS3 and units comprising several NUTS3 regions, Luxembourg, Netherlands – NUTS2, Portugal – NUTS2, United Kingdom – NUTS2, NUTS3 and units comprising several NUTS3 regions (data for Wales, Scotland and Northern Ireland are only available on the NUTS1 level). The following regions are not considered because of data restrictions: Berlin and all regions that were part of East Germany before 1990, Islas Baleares, Ceuta y Melilla (Spain), Départements d'outre-Mer (France), Açores, Madeira (Portugal). The 359 European regions used in the sample are:

Belgium (9): Brussels, Antwerpen, Limburg, Oost-Vlaanderen, West-Vlaanderen, Hainaut, Liège, Luxembourg, Namur

Denmark (12): København, Vestsjællands amt, Storstrøms amt, Bornholms amt, Fyns amt, Sønderjyllands amt, Ribe amt, Vejle amt, Ringkøbing amt, Århus amt, Viborg amt, Nordjyllands amt

Germany (71): Schleswig-Holstein Nord, Schleswig-Holstein Süd-West, Schleswig-Holstein Mitte, Schleswig-Holstein Ost, Hamburg, Bremen, Ostfriesland, Bremerhaven, Oldenburg, Emsland, Osnabrück, Hannover, Südheide, Lüneburg, Braunschweig, Hildesheim, Göttingen, Münster, Bielefeld, Paderborn, Arnsberg, Dortmund, Emscher-Lippe, Duisburg/Essen, Düsseldorf, Bochum/Hagen, Köln, Aachen, Bonn, Siegen, Nordhessen, Mittelhessen, Osthessen, Rhein Main, Starkenburg, Mittelrhein-Westerwald, Trier, Rheinhessen-Nahe, Westpfalz, Rheinpfalz, Saar, Unterer Neckar, Franken, Mittlerer Oberrhein, Nordschwarzwald, Stuttgart, Ostwürttemberg, Donau Iller (BW), Neckar Alb, Schwarzwald-Baar, Südlicher Oberrhein, Hochrhein-Bodensee, Bodensee-Oberschwaben, Bayrischer Untermain, Würzburg, Main-Rhön, Oberfranken West, Oberfranken Ost, Oberpfalz Nord, Mittelfranken, Westmittelfranken, Augsburg, Ingolstadt, Regensburg, Donau Wald, Landshut, München, Donau Iller (BY), Allgäu, Oberland, Südostoberbayern

Spain (46): La Coruña, Lugo, Orense, Pontevedra, Principado de Asturias, Cantabria, Pais Vasco, Comunidad Foral de Navarra, La Rioja, Huesca, Teruel, Zaragoza, Comunidad de Madrid, Avila, Burgos, León, Palencia, Salamanca, Segovia, Soria, Valladolid, Zamora, Albacete, Ciudad Real, Cuenca, Guadalajara, Toledo, Badajoz, Cáceres, Barcelona, Gerona, Lérida, Tarragona, Alicante, Castellón de la Plana, Valencia, Islas Baleares, Almería, Cadiz, Córdoba, Granada, Huelva, Jaén, Málaga, Sevilla, Murcia

France (88): Île de France, Ardennes, Aube, Marne, Haute Marne, Aisne, Oise, Somme, Eure, Seine Maritime, Cher, Eure et Loir, Indre, Indre et Loire, Loir et Cher, Loiret, Calvados, Manche, Orne, Côte d'Or, Nièvre, Saône et Loire, Yonne, Nord, Pas de Calais, Meurthe et Moselle, Meuse, Moselle, Vosges, Bas Rhin, Haut Rhin, Doubs, Jura, Haute Saône, Territoire de Belfort, Loire Atlantique, Maine et Loire, Mayenne, Sarthe, Vendée, Côte du Nord, Finistère, Ille et Vilaine, Morbihan, Charente, Charente Maritime, Deux Sèvres, Vienne, Dordogne, Gironde, Landes, Lot et Garonne, Pyrénées Atlantiques, Ariège, Aveyron, Haute Garonne, Gers, Lot, Hautes Pyrénées, Tarn, Tarn et Garonne, Corrèze, Creuse, Haute Vienne, Ain, Ardèche, Drôme, Isère, Loire, Rhône, Savoie, Haute Savoie, Allier, Cantal, Haute Loire, Puy de Dôme, Aude, Gard, Hérault, Lozère, Pyrénées Orientales, Alpes de Haute Provence, Hautes Alpes, Alpes Maritimes, Bouches du Rhône, Var, Vaucluse, Corse

Ireland (7): Border, Dublin, Midland, Mid-West, South-East, South-West, West

Italy (65): Torino, Novara, Alessandria, Cuneo, Valle d'Aosta, Imperia/Savona, Genova, Milano, Bergamo, Cremona/Mantova, Brescia, Pavia, Bolzano-Bozen, Trento, Verona, Vicenza, Belluno, Venezia, Padova, Friuli-Venezia Giulia, Piacenza, Parma, Reggio nell'Emilia, Modena, Bologna, Ferrara, Ravenna, Forli, Massa-Carrara/Lucca, Florenz, Livorno/Pisa, Arezzo, Siena, Grosseto, Perugia, Terni, Pesaro e Urbino, Ancona, Macerata, Ascoli Piceno, Viterbo, Rieti, Roma, Latina, Frosinone, L'Aquila, Pescara, Molise, Napoli, Salerno, Foggia, Bari, Taranto, Potenza, Matera, Cosenza, Catanzaro, Reggio di Calabria, Palermo, Messina, Catania, Siracusa, Sassari, Nuoro/Oristano, Cagliari

Luxembourg (1)

Netherlands (12): Groningen, Friesland, Drenthe, Overijssel, Gelderland, Flevoland, Utrecht, Noord-Holland, Zuid-Holland, Zeeland, Noord-Brabant, Limburg (NL)

Portugal (5): Norte, Centro, Lisboa e Vale do Tejo, Alentejo, Algarve

United Kingdom (43): Tees Valley and Durham, Northumberland/Tyne and Wear, Cumbria, Cheshire, Greater Manchester, Lancashire, Merseyside, East Riding and North Lincolnshire, North Yorkshire, South Yorkshire, West Yorkshire, Derbyshire and Nottinghamshire, Leicester/Rutland, Northamptonshire, Lincolnshire, Herefordshire/Worcestershire, Warwickshire, Shropshire and Staffordshire, West Midlands, Peterborough/Cambridgeshire, Norfolk, Suffolk, Luton/Bedfordshire, Hertfordshire, Essex, London, Berkshire, Milton Keynes/Buckinghamshire, Oxfordshire, Brighton, Hove/East Sussex, Surrey, West Sussex, Hampshire and Isle of Wight, Kent, Bristol/North and North East Somerset/Swindon/Wiltshire, Gloucestershire, Bournemouth, Poole/Dorset, Somerset, Cornwall and Isles of Scilly, Devon, Wales, Scotland, Northern Ireland

Regional unemployment rates and data on working population are taken from the Eurostat Regio database and base on the results of the Community Labour Force Survey.
Data on regional employment were taken from the Eurostat Regio database and Cambridge Econometrics' European regional databank. The indicators for the sectoral composition base on employment data by NACE-CLIO R3 sector (B01: Agricultural, forestry and fishery products, B02: Manufactured products, B03: Market services).
Data on population and area were collected from the Eurostat Regio database.