Spatial autocorrelation in employment-output relation

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ERSA 2003 Congress
University of Jyväskylä, Finland
27th-30th August, 2003

Abstract

This study reconsiders the employment-output relation in Finland from a spatial econometric perspective using NUTS4-level data from 1988 to 2000. Spatial econometric methods provide new insights into the employment-output relation making it possible to research whether there are spatial dependencies in the relation and whether the growth centres have any spread or backwash effects on their neighbouring regions. This paper shows that there are spatial dependencies in the relation but that these dependencies are not straightforward. Despite that the Finnish growth centres - the capital region Helsinki, Turku, Tampere, Oulu, and Jyväskylä - do not have any clear spread or backwash effects on their neighbours' employment and output, the spatial dependencies in the employment-output relation in their group are somewhat different from those in the country as a whole.

1 Introduction

In the early 1990s the Finnish economy fell into recession. From 1989 to 1993 over 20 per cent of jobs were lost and unemployment rose from about 3 per cent to more than 16 per cent. The collapse of the economy in 1991 resulted in a 6.3 per cent decline in GNP. In 1992 and 1993 GNP dropped further by over 3 and over 1 per cent, respectively. Between 1993 and 2000 economic growth was rapid by both historical and international standards, with a growth rate between 3.4 and 6.8 per cent. Despite these years of rapid output growth, employment has risen too slowly to approach the level of the late 1980s - the average unemployment rate in 1989 was only 3.1 per cent while in 2002 it was 9.1 per cent.

Thus, the relationship between employment and output, which is widely established in traditional economics, came into question in Finland as elsewhere in the 1990s (e.g. Peltola 1997). It was argued that economic growth was producing less employment than it did before the recession. The discussion reflected the concern about the weakened effect of economic growth on employment that was widespread among specialists and in the media across the western world during the previous decade. This concern arose from the fear that the current forms of technological change have lowered or even eliminated the traditional positive correlation between output and employment.

According to Vihriälä & Virén (1997), the recovery after the recession was not sufficient to bring unemployment back to the level of the late 1980s, and the shock seemed to have permanent effects. Blanchard & Katz (1992) in the USA, Bentolila & Jimeno (1995) in Spain, Decressin & Fatás (1995) in Europe, Fredriksson (1999) in Sweden, and Böckerman (1998) and Pekkala & Kangasharju (2002) in Finland have investigated the process of adjustment of the regional labour market to a sudden drop in a labour demand. From this demand perspective, Böckerman (1998) found that most of the change is absorbed by unemployment. According to Pekkala & Kangasharju (2002), the participation in the workforce also has an important role in the adjustment to region-specific shocks. In addition, they found that the shocks have permanent effects on employment in Finland.

Regional development became more divergent in Finland after the recession. New jobs emerged in a few areas while employment continued to fall in many regions. The whole economic environment changed during and after the recession - the Finnish economy is now more tightly connected with other economies in the European Union as well as globally, which has also had impacts at the regional level. According to Böckerman's & Maliranta's (2001) study on job creation and destruction, the churning rate (i.e. gross job and worker flows together) is an important factor in regional disparities in unemployment rates - the churning rate is low in regions with relatively high unemployment rates. Thus, the structural change does not revitalise the economic structure of the regions enough and unemployment remains high.

Sauramo (1999a and b) has investigated the jobless growth phenomenon in Finland from a productivity point of view. He argues that the growth of aggregate labour productivity was rapid during the period between 1992 and 1994, but did not, however, continue. The developments of aggregate productivity were dominated by positive technology shocks, which mainly reflected micro-structural changes, such as company restructuring and labour reallocation in manufacturing rather than within-plant improvements in technology. Sauramo's (1999a and b) results in Finland follows those of Gordon (1993) who is also sceptical of the belief widely held in the 1990s that a new era of faster productivity growth was at hand in America.

Despite the arguments about the lack of change in the employment intensity of output growth, the growth rate of output that keeps employment unchanged in Finland still appears to be somewhat higher than it was in the late 1980s (Pehkonen 2000). Romppanen & Valppu (1997) conclude that the output growth rate that is required to keep employment stable was about 2.5 per cent during 1975-1995 while in e.g. the USA it was only 0.5 per cent. From the industry perspective, Kangasharju & Pehkonen (2001) have found some signs of differences in the employment-output link between industries. These differences also lead to differences between regions because regions have divergent industrial structures. The massive structural change that has taken place in the Finnish economy has resulted in the highest exogenous decline in employment in regions oriented towards the public sector and agriculture. In contrast, the exogenous change in employment is lowest in the regions with a high proportion of private sector services.

Private sector services are also an important industry determining the correlation between changes in employment and output.

Böckerman (1998) also found regional differences in the relation between employment and output using data on labour districts in Finland during the period 1988-1995. In the southern part of Finland, where economic activity is largely concentrated, the link between employment and output is very strong while in some districts in the eastern, northern, and western part of the country the link disappears. According to Böckerman (1998), various exogenous factors play a more important role in employment fluctuations in the northern part of the country than elsewhere. Kangasharju's & Pehkonen's (2001) results on regions oriented towards the public and agricultural sector are in line with this.

This study reconsiders the employment-output relation in Finland from a spatial econometric perspective. Spatial econometric methods make it possible to examine whether employment in a given region is affected by output or employment in neighbouring regions. In particular, the present interest is in the impacts of the Finnish growth centres' (the capital region Helsinki, Turku, Tampere, Oulu, and Jyväskylä)[1] on their neighbouring regions.

Section 2 of this paper introduces the spatial perspective into the employment-output relation. Section 3 presents the European Union's NUTS4-level output and employment data from 1988 to 2000 that is used in the analyses. The period investigated includes the era of rapid employment growth of the late 1980s, the dramatic decline in employment and output growth in the early 1990s, and the years of the recovery in the mid 1990s.

Section 4 introduces the models that are used in the analyses. The results are reported in Section 5. A basic cross-sectional model for the employment-output relation in different periods and three spatial dependence models - a spatial error, a spatial lag, and a spatial cross-regressive model - are formed and compared with each other (see Rey and Montouri 1999). The results obtained from the data on the growth centres and their neighbours are also compared with the results obtained from the whole data. It is investigated whether there are differences in the employment-output relation between the growth centres and the whole country and whether the spatial dependencies in the relation are different in the growth centres and their neighbouring regions from those elsewhere.

The results obtained on the local spatial dependencies are also reported in Section 5. The local Moran analysis for spatial autocorrelation is carried out for both the employment growth and the output growth variables. This measure provides insights into possible high growth or low growth clusters and into developments in these clusters on time. Section 6 concludes. Spatial dependencies are found in the Finnish employment-output relation but these dependencies are not straightforward. Despite the fact that the Finnish growth centres do not have any straightforward impact on their neighbours' employment or output, the spatial dependencies in the employment-output relation in their group are somewhat different from those for the whole country.

2 A spatial perspective in the employment-output relation

Economies of scale and externalities cause the concentration of production processes. Location requirements have strengthened in Finland because of expanding globalisation and greater integration with other economies. Technical development has also given location even more importance because new innovations tend to be created in the large centres of production, R&D-activities and markets. New activities also tend to locate in areas already characterised by large output and extensive networks. This has made the Finnish growth centres winners in the competition between the regions for labour and production. The reduction of employment in the public sector since the recession has had greater impacts in the rural areas than in the urban areas. The changes in agriculture caused by membership of the European Union have also heavily affected the rural areas.

Thus, the question of the effects of growth centres on their neighbouring regions is important from the Finnish perspective. Do employment and output growth concentrate only in few centres while other regions lose their final chances to survive or do the centres act as an engine of growth to their neighbouring regions? This is also interesting from a policy point of view. The recent regional policies emphasise that every region has its own opportunities for growth and is responsible for its own development. The policy of trying to bring opportunities to regions from outside has been abandoned.

Gaile (1980) proposes that a complex set of spatial processes operates when economic development in an urban core affects the surrounding region. These processes include intra-regional flows of information and technology, residents and commuters, private and public expenditures for goods and services, private capital, political influence, and public investments.

According to Gunnar Myrdal, *backwash effects* are the detrimental effects suffered by poor regions as a result of their interaction with rich regions and, conversely, *spread effects* are the beneficial effects enjoyed in poor regions as a result of that interaction. Spread effects include both the backward linkages between the sectors of the core economy and those industries that function as their input suppliers on the periphery and the diffusion of investments, innovation, and growth attitudes from core to periphery (Hughes & Holland 1994). Backwash effects include the migration of labour and capital from the periphery to the core. Core service sectors may also displace their counterparts on the periphery. Myrdal's main idea was that the play of market forces normally tends to increase rather than decrease the inequalities between regions (Vanhove & Klaassen 1987).

According to Richardson (1978), there are variations over time in the effects of the growth centres on their neighbouring regions. The negative effects are relatively strong at first because resources, such as labour, tend to gravitate toward the growth centre. These negative effects are the most powerful by a lag of a few years after which they gradually weaken. After the point of the maximal polarisation the net effects begin to grow, while continuing to remain negative. The net effects grow effectively and become positive because of the strengthening of the positive spread effects, while the negative effects diminish towards zero. Finally, the net effects even out when growth reaches its saturation point.

It is very difficult to define the point in time when the positive effects begin to dominate. In every case, however, it takes many years before the positive spread effects compensate for the backwash effects of the early stage. Krugman (1991) has argued that a core-periphery economic structure may exist for a number of years but under the right conditions even small changes in the economic structure can set off a rapid, cumulative process of import substitution and growth in the periphery.

3 Data

The empirical analyses are based on regional level data in which the municipalities of mainland Finland are divided in 83 groups that correspond to the NUTS4-level in the European Union.[2] These sub-regions also coincide with the Finnish labour districts. The period of investigation runs from 1988 to 2000 and is divided into four groups: 1990-1993, 1993-1996, 1996-1998 and 1998-2000. The period 1988 to 1990 is considered only as a preceding period for the first research period. The data for the last year is preliminary.[3] The first period is the period of deep recession in Finland and the second is the recovery period. The last two periods are positive in the Finnish economy at an aggregate level but there is regional variation.

Employment refers to the number of jobs at the end of the year and the output variable is the regional gross national product (RGNP) at 1995 prices. The data source is Statistics Finland. The growth centres and their neighbours which consist of 29 NUTS4-level regions, are included in the whole country analysis and also considered as a group on their own (Appendix 1). The capital region with its neighbouring sub-regions is unquestionably the most important centre in the Finnish economy.

Table 1. Employment and output growth: basic statistics

83 NUTS4-level regions									
Year	**Average employment change, per cent**					**Average RGNP change, per cent**			
	Mean	Min	Max	St.dev.		Mean	Min	Max	St.dev.
1988-1990	-1.3	-4.3	1.4	1.1	1988-1990	2.8	-8.6	12.7	3.4
1990-1993	-7.2	-12	-4.2	1.2	1990-1993	-4.6	-12.1	3.6	2.9
1993-1996	0.1	-5.4	4.9	1.7	1993-1996	3.2	-1.8	8.5	2.4
1996-1998	2.7	-0.5	6.2	1.5	1996-1998	3.9	-4.8	21.4	3.3
1998-2000	2.7	-0.9	7.8	2.2	1998-2000	1.6	-6.2	14.9	3.6

Table 2. Employment and output growth in the growth centres and their neighbouring regions: basic statistics

29 NUTS4-level regions									
Year	**Average employment change, per cent**					**Average RGNP change, per cent**			
	Mean	Min	Max	St.dev.		Mean	Min	Max	St.dev.
1988-1990	-1.4	-4.3	1.4	1.4	1988-1990	2.8	-3.8	7.7	3.1
1990-1993	-7.1	-11.5	-4.2	1.4	1990-1993	-4.5	-10.7	3.3	3.0
1993-1996	1.0	-2.6	4.9	1.7	1993-1996	3.9	-1.8	8.5	2.7
1996-1998	3.3	-0.01	6.2	1.7	1996-1998	4.8	-4.8	21.4	4.5
1998-2000	2.6	-0.2	7.8	2.2	1998-2000	1.8	-3.4	14.9	3.6

The number of jobs was already on the decline in 1990 while RGNP was still growing on average. Despite the dramatic decline in average employment and output from 1990 to 1993, there were regions in which RGNP continued to grow (Tables 1 and 2). Figure 1 shows clearly the increased variation of both employment and output after the recession. In spite of the years of growth at the aggregate level, there were twelve regions in which employment was lower in 2000 than in 1993 and three regions in which this holds for output (see Appendix 2).

The maximum values for employment growth in the whole country in every period come from the growth centre group. In output, the same holds in the three later periods. Mean employment growth in 1993-1996 was 1.0 per cent in the growth centre group while for the whole country it was only 0.1 per cent. From 1996 to 2000 RGNP in the sub-region of Salo grew by an enormous amount because of growth in the information technology sector, particularly Nokia.

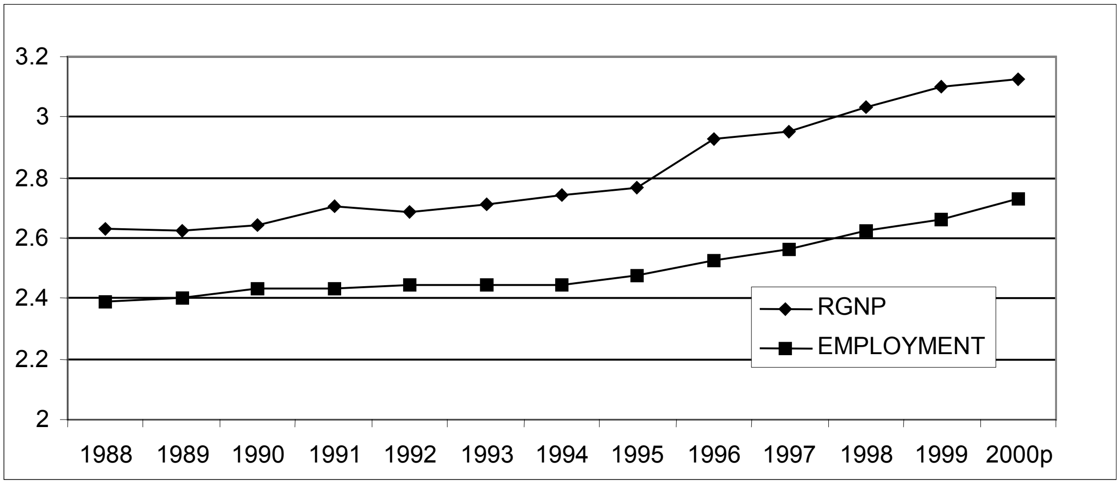

Figure 1. Coefficient of Variation for RGNP and employment in 83 NUTS4-level regions

4 Models for employment-output relation

In the previous studies on the employment-output relation at the regional level the unit of analysis has been an individual region. Each region has been viewed as an independent entity and the potential for observational interactions across space has been ignored, whereas in this study the employment-output relation is studied from the spatial perspective. Four different models for the employment-output relation are formulated: a basic model without spatial variables and three spatial dependence models that contain the variables for spatial interaction (see Rey and Montouri 1999).

The analyses are carried out using SpaceStat 1.90, which is designed for spatial econometric analysis (Anselin 1992). Positive spatial autocorrelation indicates variable values more similar to those of the neighbouring regions than would occur in the random case and negative autocorrelation indicates more different values than in the random case. A spatial lag operator is a weighted average of the values of a random variable in the neighbouring regions (Anselin 1999). Neighbouring regional relationships are included in the models by using a binary contiguity [4]matrix where a matrix element gets value one if the regions share a border and zero otherwise. The elements of the weights matrix are row-standardised such that for each i, $\sum_j w_{ij} = 1$. The spatial lag can therefore be interpreted as a weighted average of the neighbouring regions.

The basic model for the employment-output relation is

$$\frac{\ln(L_{t+k}/L_t)}{k} = \alpha + \beta_1 \frac{\ln(Q_{t+k}/Q_t)}{k} + \beta_2 \frac{\ln(Q_t/Q_{t-l})}{l} + \varepsilon \qquad (1)$$

The average logarithmic difference in employment, which approximates the average growth rate in each period in each region, is regressed by the average logarithmic difference in output in the same period and in the previous period. Because of the institutional inflexibilities and lags in firms' adjustment processes, output growth is transmitted to employment by a lag (e.g. Romppanen & Valppu 1997). Thus, it is justified to include the output lag into the model.

The spatial error specification is relevant when the dependence works through the error process, which means that there is covariance between the errors of the regions' employment-output relations. Using a vector notation, the error term can be expressed as

$$\begin{aligned} \varepsilon &= \lambda W \varepsilon + \mu \\ \varepsilon &= (\mathrm{I} - \lambda W)^{-1} \mu \end{aligned} \qquad (2)$$

$W\varepsilon$ is a spatial lag for error terms, λ is a scalar spatial error coefficient and $\mu \sim \mathrm{N}(0, \sigma^2 I)$.

The spatial error model for the employment-output relation is

$$\frac{\ln(L_{t+k}/L_t)}{k} = \alpha + \beta_1 \frac{\ln(Q_{t+k}/Q_t)}{k} + \beta_2 \frac{\ln(Q_t/Q_{t-l})}{l} + (I - \lambda W)^{-1}\mu \qquad (3)$$

A random shock that appears in a single region affects employment growth not only in that particular region but also, through the spatial transformation $(\mathrm{I} - \lambda W)^{-1}$, in other regions as well. As the sparseness of the spatial weight matrix suggests, any region has a limited number of neighbours (Rey and Montouri 1999). Thus, the inverse operator in the transformation defines an error covariance structure that diffuses region-specific shocks not only to the region's neighbours but also throughout the system. Ignoring this kind of spatial dependence leads to the unbiased estimators of the parameters but the biased estimators of the parameters' variances (Anselin 1992). The inferences based on the estimators of the basic model can be misleading, but the consequences are not as severe as those that follow from ignoring the spatial lag dependence.

The spatial lag model includes spatially lagged employment growth as an explanatory variable and is expressed as

$$\frac{\ln(L_{t+k}/L_t)}{k} = \alpha + \beta_1 \frac{\ln(Q_{t+k}/Q_t)}{k} + \beta_2 \frac{\ln(Q_t/Q_{t-l})}{l} + \rho W \frac{\ln(L_{t+k}/L_t)}{k} + \varepsilon \qquad (4)$$

$\varepsilon \sim \mathrm{N}(0, \sigma^2 I)$,

where ρ is a scalar autoregressive parameter. If it is statistically significant, the region's employment growth is related to employment growth in the neighbouring regions. Because the spatial lag of the endogenous variable is dependent on the error term, OLS can not be used. Thus, the estimation method that is used is ML. If this form of spatial autocorrelation is ignored, the estimates will be biased and all inference based on the standard regression models will be incorrect (Anselin 1992).

The spatial cross-regressive model for the employment-output relation is

$$\frac{\ln(L_{t+k}/L_t)}{k} = \alpha + \beta_1 \frac{\ln(Q_{t+k}/Q_t)}{k} + \beta_2 \frac{\ln(Q_t/Q_{t-l})}{l} + \tau W \frac{\ln(Q_{t+k}/Q_t)}{k} + \varepsilon, \qquad (5)$$

$\varepsilon \sim \mathrm{N}(0, \sigma^2 I)$

In this model, the effect of output growth in the neighbouring regions on employment growth in a particular region is included in the model. OLS is a feasible estimation method because the spatially lagged output growth variable is exogenous.

The local Moran for a region i takes the following form (Anselin 1992):

$$I_i = \left(\frac{x_i}{m_0}\right) \sum_{j=1}^{n} w_{ij} x_j \text{ with: } m_0 = \sum_i^n x_i^2 \qquad (6)$$

The local Moran measures whether a region is surrounded by regions with variables of similar or dissimilar values caused by the location, i.e. the values are more similar or dissimilar caused by the location than they would be in the random case.

It is possible that: 1) employment growth or output growth has been high and has also been high in the neighbouring regions (*high growth, positive spatial dependence*); 2) growth has been low and it has been similar in the neighbourhood (*low growth, positive spatial dependence*); 3) employment growth or output growth has been high in the particular region but low in the surrounding regions (*high growth, negative spatial dependence*); and 4) growth has been low in the particular region but high in the surrounding regions (*low growth, negative spatial dependence*)

5 Results

The whole country

The output elasticity of employment growth varies between the periods (Table 3). The elasticity with respect to output during the same period is clearly higher in 1993-1996 than in the period of the recession or in the periods of the late 1990s. The coefficient of lagged output growth is statistically significant in every period except 1998-2000. Employment reacts to changes in output by a lag because of the many regulations in the labour market and the costs of hiring and shedding labour. In 1996-1998 the elasticity of employment is even higher with respect to lagged output growth than output growth during the same period.

The relation between output and employment is evident, excluding 1998-2000. During this period, it seems that the link between output and employment growth disappears and that employment would have increased regardless of growth in output. In 1999 there was a drop in output growth that possibly affected employment only by the lag. Otherwise, exogenous changes in employment are negative in 1990-1993 and 1993-1996 and positive in 1996-1998. The recovery of employment after the mid 1990s seems to have been so powerful that employment would have increased even without growth in output.

During the periods 1990-1993 and 1993-1996, the diagnostics for the OLS estimations show spatial dependencies that should become modelled (Table 4). Robust LM tests indicate spatial lag autocorrelation during these periods. In 1993-1996, the Breuch-Pagan test for heteroskedasticity is statistically significant, which implies that spatial heterogeneity models are needed during this period. Spatial autocorrelation and spatial heteroskedasticity cannot, however, always be separated and the tests can give unreliable results (Anselin 1992). In particular, the heteroskedasticity tests react on autocorrelation. Thus, the result that rejects homoskedasticity assumption can be due to autocorrelation and not heteroskedasticity.

Table 3. The results for the basic model

Basic model, OLS	83 NUTS4-level regions					
	R^2	LIK	AIC	α	β_1	β_2
1990-1993	0.194	259.2	-512.4	-0.067***	0.194***	0.130**
1993-1996	0.513	249.3	-492.5	-0.007*	0.474***	0.149**
1996-1998	0.307	248.0	-489.9	0.014***	0.151***	0.252***
1998-2000	0.013	199.8	-393.5	0.024***	0.032	0.061

*** significance level 0.001, ** significance level 0.01, * significance level 0.05

Table 4. The diagnostics for the basic model

Diagnostics	83 NUTS4-level regions		
Spatial dependence, p-value			
	Moran's I (error)	Robust LM(error)	Robust LM(lag)
1990-1993	0.081	0.075	0.018
1993-1996	0.157	0.172	0.005
1996-1998	0.201	0.826	0.417
1998-2000	0.396	0.531	0.494
	Heteroskedasticity Breusch-Pagan, p-value	Normality of errors Jarque-Bera, p-value	
1990-1993	0.221	0.562	
1993-1996	0.005	0.670	
1996-1998	0.139	0.518	
1998-2000	0.531	0.044	

When comparing the basic OLS model and the spatial dependence models, the maximised log likelihood (LIK) and the Akaike Information Criterion (AIC), which are based on a likelihood function, are used as measures. The model with the lowest AIC or the highest LIK achieves the best fit. It should be noted that a spatial autoregressive coefficient in the error model is not included in the AIC computation while in other models these coefficients are counted (Anselin 1992). This tends to favour the error model over the lag model.

The spatial lag model achieves the best fit in 1990-1993 and 1996-1998, and the spatial cross-regressive model in 1993-1996 (Tables 3 and 5). The spatial autoregressive coefficient is not, however, significant in 1996-1998, and the LR-test for the autoregressive coefficients does not support this model (Table 6). In 1993-1996, the LM and LR test performed on the cross-regressive model for employment lag dependence or error dependence are not significant, which implies that there is no need to take these lags into consideration. During this period, heteroskedasticity is a serious problem both in the basic model and in the spatial dependence models.

The are differences in the β-coefficients between the basic OLS model and the spatial dependence models, the β-estimates in the dependence models are somewhat lower than those in the basic model. In 1998-2000, the connection between employment and output growth seems to disappear and all of the models are poor.

Table 5. The results for the spatial dependence models

Spatial dependence models	83 NUTS4-level regions					
	LIK	AIC	α	β_1	β_2	λ,ρ,τ
1990-1993						
Spatial error (ML)	260.5	-514.9	-0.068***	0.172***	0.117**	0.266
Spatial lag (ML)	261.4	-514.8	-0.045***	0.184***	0.124**	0.315*
Cross-regressive(OLS)	260.2	-512.5	-0.061***	0.201***	0.131**	0.128
1993-1996						
Spatial error (ML)	250.0	-494.1	-0.001	0.429***	0.157***	0.222
Spatial lag (ML)	252.4	-496.8	-0.005	0.429***	0.164***	0.287*
Cross-regressive(OLS)	254.4	-500.9	-0.016***	0.429***	0.163***	0.320**
1996-1998						
Spatial error (ML)	248.4	-490.9	0.014***	0.150***	0.243***	0.158
Spatial lag (ML)	248.7	-489.3	0.009*	0.150***	0.242***	0.164
Cross-regressive(OLS)	248.0	-487.9	0.014**	0.150***	0.252***	-0.008
1998-2000						
Spatial error (ML)	199.9	-393.9	0.024***	0.028	0.059	0.097
Spatial lag (ML)	200.0	-391.9	0.021***	0.029	0.061	0.106
Cross-regressive(OLS)	200.0	-392.0	0.023***	0.023	0.064	0.099

*** significance level 0.001, ** significance level 0.01, * significance level 0.05

Table 6. The diagnostics for the spatial dependence models

Diagnostics	83 NUTS4-level regions		
	Error dependence LR/LM-test, p-value	Lag dependence LR/LM-test, p-value	Heteroskedasticity Breusch-Pagan-test, p-value
1990-1993			
Spatial error (ML)	0.115	0.047	0.269
Spatial lag (ML)	0.165	0.036	0.322
Cross-regressive (OLS)	0.312	0.139	0.029
1993-1996			
Spatial error (ML)	0.210	0.026	0.003
Spatial lag (ML)	0.092	0.012	0.002
Cross-regressive (OLS)	0.766	0.906	0.007
1996-1998			
Spatial error (ML)	0.326	0.455	0.130
Spatial lag (ML)	0.879	0.231	0.094
Cross-regressive (OLS)	0.498	0.248	0.098
1998-2000			
Spatial error (ML)	0.544	0.761	0.504
Spatial lag (ML)	0.424	0.511	0.510
Cross-regressive (OLS)	0.367	0.344	0.289

Growth centres and their neighbouring regions

The variation over time in the employment-output relation in the Finnish growth centres and their neighbouring regions follows the same pattern that found for the whole country. In the period 1993-1996, the elasticity of employment with respect to output of the same period is clearly higher than the same relation in the other periods (Tables 3 and 7). Compared to the model for the whole country, the elasticity is higher in 1990-1993 and lower in 1993-1996.

Table 7. The results for the basic model: the growth centres and their neighbouring regions

Basic model, OLS	29 NUTS4-level regions					
	R^2	LIK	AIC	α	β_1	β_2
1990-1993	0.30	87.7	-169.4	-0.066***	0.266**	0.245**
1993-1996	0.42	85.0	-164.1	-0.008	0.421***	-0.036
1996-1998	0.31	82.9	-159.7	0.018**	0.082	0.287*
1998-2000	0.10	71.4	-136.8	0.026***	0.267	-0.103

*** significance level 0.001, ** significance level 0.01, * significance level 0.05

In 1993-1996 and 1998-2000 employment growth is independent of lagged output growth and in 1998-2000 also of output growth in the same period. Contrary to the model for the whole country, the employment growth in the recovery period is independent of changes in output during the recession period. In 1996-1998, only lagged output growth matters. In 1998-2000 the link between output and employment seems to disappear as such in the whole country model. With regard to the diagnostics, robust LM tests imply spatial lag dependence in 1993-1996 and no problems with heteroskedasticity (Table 8).

Table 8. The diagnostics for the basic model: the growth centres and their neighbouring regions

Diagnostics		29 NUTS4-level regions	
Spatial dependence, p-value			
	Moran's I (error)	Robust LM(error)	Robust LM(lag)
1990-1993	0.976	0.487	0.486
1993-1996	0.771	0.079	0.027
1996-1998	0.100	0.354	0.776
1998-2000	0.719	0.213	0.238
	Heteroskedasticity Breusch-Pagan, p-value	Normality of errors Jarque-Bera, p-value	
1990-1993	0.195	0.937	
1993-1996	0.246	0.544	
1996-1998	0.457	0.408	
1998-2000	0.760	0.069	

The diagnostics for the basic model imply lag dependence in 1993-1996. During this period, a spatial autoregressive coefficient is significant in both the lag and the cross-regressive model (Table 9). According to LIK and AIK, the cross-regressive model, however, achieves the best fit. The cross-regressive model also achieves the best fit in 1990-1993 and the error model the best fit in the last two periods. In 1990-1993 and 1998-2000 autoregressive coefficients are not, however, significant. They are negative, which indicates negative spatial dependencies. Unfortunately, the results have to be interpreted very carefully because of the small number of observations and the asymptotic properties of the tests (Anselin and Florax 1995).

Table 9. The results for the spatial dependence models: the growth centres and their neighbouring regions

Spatial dependence models	29 NUTS4-level regions					
	LIK	AIC	α	β_1	β_2	λ,ρ,τ
1990-1993						
Spatial error (ML)	87.7	-169.4	-0.066***	0.269**	0.248**	-0.044
Spatial lag (ML)	87.7	-167.4	-0.063***	0.267**	0.244**	0.049
Cross-regressive(OLS)	87.9	-167.8	-0.061***	0.286**	0.233*	0.100
1993-1996						
Spatial error (ML)	85.2	-164.4	-0.006	0.377***	-0.042	-0.166
Spatial lag (ML)	87.0	-165.9	0.004	0.333***	-0.031	-0.374**
Cross-regressive(OLS)	87.8	-167.6	0.011	0.327**	-0.016	-0.273*
1996-1998						
Spatial error (ML)	85.3	-164.6	0.021***	0.083	0.290**	-0.446***
Spatial lag (ML)	84.4	-160.8	0.036***	0.062	0.253**	-0.320*
Cross-regressive(OLS)	83.0	-158.0	0.012	0.091	0.314*	0.072
1998-2000						
Spatial error (ML)	71.6	-137.3	0.027***	0.334*	-0.154	-0.150
Spatial lag (ML)	71.5	-134.9	0.028***	0.283	-0.117	-0.056
Cross-regressive(OLS)	71.6	-135.3	0.020	0.020	-0.091	0.122

*** significance level 0.001, ** significance level 0.01, * significance level 0.05

Table 10. The diagnostics for the spatial dependence models: the growth centres and their neighbouring regions

Diagnostics	29 NUTS4-level regions		
	Error dependence LR/LM-test, p-value	Lag dependence LR/LM-test, p-value	Heteroskedasticity Breusch-Pagan-test, p-value
1990-1993			
Spatial error (ML)	0.877	0.659	0.184
Spatial lag (ML)	0.662	0.864	0.189
Cross-regressive (OLS)	0.841	0.835	0.114
1993-1996			
Spatial error (ML)	0.568	0.019	0.175
Spatial lag (ML)	0.440	0.050	0.413
Cross-regressive (OLS)	0.539	0.450	0.945
1996-1998			
Spatial error (ML)	0.026	0.653	0.569
Spatial lag (ML)	0.340	0.078	0.421
Cross-regressive (OLS)	0.993	0.748	0.460
1998-2000			
Spatial error (ML)	0.513	0.407	0.079
Spatial lag (ML)	0.124	0.774	0.753
Cross-regressive (OLS)	0.138	0.160	0.953

In the local Moran analysis, the same variables as used earlier in the regression models are deployed. The analysis has been carried out using the whole data. The results for the growth centres with their neighbouring regions are reported in Table 11. The results show some significant spatial dependencies among the growth centres and their neighbouring regions but they do not show that the growth centres either form clusters of high employment or output growth (high growth, positive spatial dependence) or are hot spots among their neighbours (high growth, negative spatial dependence). The spatial dependencies vary between the periods even in the same region.

An interesting observation regarding Helsinki's neighbours remains: Lohja, Tammisaari, Riihimäki and Lahti seem to form an area of high output growth with positive spatial dependence around Helsinki during the recovery period 1993-1996. This area breaks up, however, later during the 1990s. In relation to employment growth, the dependencies in Lohja, Tammisaari and Riihimäki remain stable during 1993-1996 and

1996-1998. Otherwise, there are no signs of permanent spatial dependencies during the time.

Table 11. The results of the local Moran analysis for local spatial autocorrelation

Local Moran Significant values (p<0.05) with the type of the dependence	**Employment**				**Output**			
Region	90-93	93-96	96-98	98-00	90-93	93-96	96-98	98-00
Helsinki	-	-	-	-	-	-	-	-
Lohja	-	Group 1	Group 1	-	-	Group 1	-	-
Tammisaari	-	Group 2	Group 2	-	-	Group 1	Group 2	Group 1
Riihimäki	-	Group 1	Group 1	-	-	Group 1	-	-
Lahti	-	-	-	-	Group 2	Group 1	Group 3	-
Porvoo	-	-	Group 2	-	-	Group 2	-	-
Loviisa	-	-	-	-	-	-	-	Group 2
Turku	-	Group 1	-	-	-	-	Group 2	-
Åboland-Turunmaa	-	Group 2	-	-	-	-	Group 1	Group 2
Salo	-	-	-	-	-	-	-	-
Vakka-Suomi	-	-	-	-	-	-	-	-
Loimaa	Group 3	Group 2	Group 1	-	-	-	-	-
Tampere	-	-	-	-	Group 1	-	-	-
Luoteis-Pirkanmaa	-	-	-	-	-	-	-	-
Kaakkois-Pirkanmaa	-	Group 1	-	-	-	Group 2	-	-
Etelä-Pirkanmaa	-	-	Group 1	Group 2	-	-	-	-
Itä-Pirkanmaa	-	-	-	-	-	-	-	-
Pohjois-Pirkanmaa	-	-	-	Group 2	-	-	-	-
Lounais-Pirkanmaa	-	-	-	Group 2	-	-	-	-
Oulu	Group 1	-	-	-	-	-	-	-
Lakeus	-	-	-	-	-	-	-	-
Ii	-	-	-	-	-	-	-	Group 2
Siikalatva	Group 1	-	-	-	-	-	-	-
Kehys-Kainuu	-	-	-	-	-	-	-	-
Jyväskylä	-	-	-	-	Group 2	-	-	-
Kaakkoinen Keski-Suomi	-	-	-	Group 3	-	-	-	-
Keuruu	-	-	-	-	-	Group 2	-	-
Jämsä	-	-	-	-	-	-	-	-
Äänekoski	-	-	-	-	-	-	-	-

Group 1: high growth, positive dependence
Group 2: low growth, negative dependence
Group 3: low growth, positive dependence
Group 4: high growth, negative dependence

6 Conclusions

This study shows that spatial dependencies are present in the employment-output relation in Finland but that these dependencies are not straightforward. In addition, the spatial dependencies are somewhat different in the group composing the growth centres and their neighbouring regions compared to the situation in the whole country. In the whole country, employment growth spreads over boundaries affecting employment growth in the neighbouring regions in the period 1990-1993, whereas output growth affects employment over regional boundaries in 1993-1996. In the growth centres and their neighbours, output growth has negative effects on employment growth over regional boundaries in 1993-1996, and in 1996-1998 the dependencies work through the error process. There are also signs of the employment lag dependence in both groups in 1993-1996.

The results do not indicate that output growth has a higher effect on employment in the growth centres and their neighbours than it does in the whole country. The relation between employment and output is evident in both groups, except in the period 1998-2000. It seems that the effect of output growth on employment was stronger during the period 1993-1996 than in the later periods but further analysis is needed to interpret this as a weakened effect of economic growth on employment. An analysis that takes both spatial and temporal dependencies into consideration is needed.

The local Moran analysis for local spatial autocorrelation does not indicate either that the growth centres form high growth clusters with positive spatial autocorrelation with their neighbours or that they are hot spots with negative spatial autocorrelation among their neighbours. According to the theoretical model on spread and backwash effects, it seems that the Finnish growth centres are near the point in time where the net effects are about zero, which means that the growth centres’ effects on their neighbouring regions will become positive in the future. Empirically, however, there are no signs of any such development.

Acknowledgements

This research has been funded by the Academy of Finland (project number 53374). I would like to thank Professor Hannu Tervo, Professor Jaakko Pehkonen and Senior Researcher Petri Böckerman for their helpful comments and suggestions. I also thank Research Director Aki Kangasharju for suggesting the research topic.

Endnotes

[1] The growth centres have been selected using the structures of colony, economy and population, migration, and educational level as criteria (see Kangasharju & Vihriälä (2000) and Moisio, Kangasharju & Ahtonen (2001)).

[2] The division is based on the classification that was prevalent in 2000.

[3] Employment in 2000 refers to the number of employees in the region, not the number of jobs, which can have a disturbing effect on the analyses.

[4] The neighbourhood could also be expressed in many different ways such as distance contiguity (having centroids within a critical distance band) or as a function of inverse distance or squared inverse distance.

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Appendix 1. Growth centres with their neighbouring regions

	Employment in 2000	RGDP/million Euros, in 2000, at 2000 prices
Helsinki with its neighbours	**830262**	**45624**
11 Helsinki	666296	38305
12 Lohja	27737	1354
13 Tammisaari	18515	722
52 Riihimäki	15085	616
71 Lahti	69256	2978
201 Porvoo	24873	1258
202 Loviisa	8500	391
Turku with its neighbours	**196541**	**9777**
23 Turku	126468	5757
21 Åboland-Turunmaa	8858	393
22 Salo	29701	2435
24 Vakka-Suomi	17037	678
25 Loimaa	14477	514
Tampere with its neighbours	**183875**	**8804**
64 Tampere	132805	6669
61 Luoteis-Pirkanmaa	11804	485
62 Kaakkois-Pirkanmaa	3965	142
63 Etelä-Pirkanmaa	15952	754
65 Itä-Pirkanmaa	4177	181
67 Pohjois-Pirkanmaa	5741	230
68 Lounais-Pirkanmaa	9431	343
Oulu with its neighbours	**100737**	**5375**
171 Oulu	79329	4555
172 Lakeus	3959	131
173 Ii	4724	186
175 Siikalatva	2797	103
181 Kehys-Kainuu	9928	400
Jyväskylä with its neighbours	**86576**	**4244**
131 Jyväskylä	54746	2518
132 Kaakkoinen Keski-Suomi	4442	164
133 Keuruu	7604	272
134 Jämsä	10019	667
135 Äänekoski	9765	623

Appendix 2. Changes in employment and output 1993-2000

Changes in employment 1993-2000 15 regions with highest growth	%	Changes in employment 1993-2000 15 regions with lowest growth	%
Oulu	36.9	Kärkikunnat	-6.4
Helsinki	36.3	Torniolaakso	-5.8
Salo	34.6	Kehys-Kainuu	-5.3
Tampere	29.8	Länsi-Saimaa	-5.3
Vakka-Suomi	27.9	Pielisen-Karjala	-5.0
Härmänmaa	27.1	Koillis-Lappi	-4.6
Lohja	25.3	Kaakkoinen Keski-Suomi	-2.4
Jakobstadsregionen	25.2	Juva	-2.4
Hämeenlinna	24.0	Pieksämäki	-1.8
Kaakkois-Satakunta	22.6	Ilomantsi	-1.0
Keuruu	22.1	Sisä-Savo	-0.9
Ylivieska	21.5	Keski-Karjala	-0.4
Mikkeli	21.4	Outokumpu	0.2
Kaakkois-Pirkanmaa	21.0	Savonlinna	0.6
Turku	20.8	Koillis-Savo	1.1

Changes in output 1993-2000 15 regions with highest growth	%	Changes in output 1993-2000 15 regions with lowest growth	%
Salo	165.8	Outokumpu	-3.6
Oulu	78.1	Kaakkoinen Keski-Suomi	-2.0
Helsinki	63.7	Koillis-Pirkanmaa	-0.8
Lohja	59.5	Pohjois-Lappi	0.0
Äänekoski	56.4	Torniolaakso	0.3
Tampere	56.2	Kehys-Kainuu	3.6
Jakobstadsregionen	49.0	Pieksämäki	5.2
Joensuu	47.0	Kärkikunnat	6.0
Kouvola	39.6	Lakeus	6.3
Lappeenranta	38.7	Itä-Häme	6.5
Varkaus	37.5	Raahe	6.9
Kokkola	36.2	Savonlinna	7.0
Joroinen	35.5	Loviisa	7.1
Pori	34.5	Tunturi-Lappi	7.6
Kotka-Hamina	34.3	Keski-Karjala	8.4