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CERUM Working Paper 67:2003

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Font: Garamond (Adobe)

CERUM Working Paper 67:2003
ISBN 91-7305-564-6
ISSN 1404–5362

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Using Spatial Econometrics to Analyze Local Growth in Sweden - Revised and Extended

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October 31, 2003

Abstract

This paper investigates factors that determine the average income growth and net migration rates in Swedish municipalities during the period 1981 to 1999. The main issue is to test the hypothesis that, conditional on a set of other possible determinants of regional growth, the growth rate in one municipality is affected by the growth rates in its neighboring municipalities. We also test the hypothesis of conditional convergence, that is, the hypothesis that initially 'poorer' regions tend to grow faster than initially 'richer' regions conditional on the other explanatory variables in the model. We find a positive correlation between net migration rates in neighboring municipalities, which suggests that net migration tend to 'spill over' to neighboring municipalities. When it comes to average income growth, our results indicate spatial dependence in the error terms during the 1980's. Such dependence is important in the sense that it indicates that shocks into the system not only affect the municipality where the shock has its origin but spread across the country. In addition, and in contrast to previous empirical findings based on Swedish data, we do not find any clear evidence in favour of the hypothesis of conditional convergence. Instead, our results predict conditional divergence between municipalities located in the Stockholm region throughout the period and also for municipalities outside the Stockholm region during the 1990's.

Keywords: Spatial effects, conditional convergence, regional growth, net migration.

JEL classification: C31, R11, R58.

1. Introduction

The main part of the in many respects dramatic expansion of the public sector in Sweden during the last three decades has taken place at the regional and local parts of the public sector. For example, in 1970, 8 percent of the total labor force was employed within the local public sector and 12 percent within the national government. In 1995, these figures where 23 and 6 percent respectively. During the same period, the local public expenditures have doubled in real per capita terms. The services provided by the local public sector[1] in Sweden are mainly financed through a local personal income

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†Special thanks to Sofia Lundberg and Krister Sandberg for their very valuable comments on previous versions of this paper. This research has been financed by the research project Urban Design and STINT.

tax, which the local governments are free to independently adjust. This means that the local tax base, and also the local governments ability to uphold national standards in the provision of local public services, depends largely on the average income level within the municipality and the extent to which the municipality is attractive to high-income individuals. Considering that the average private income levels and net migration rates vary quite much between municipalities and that the expansion of the local public sector mainly has been driven by political decisions made at the national level of government, the national government has felt a need to compensate regions with relatively small tax bases. This has been accomplished either by subsidizing the local government or the local private sector. A typical example of the former policies is the grant-in-aid system and location subsidies to the industrial sector are an example of the latter. The national government has also tried to affect local 'conditions' via investments in the infrastructure and the location of new universities, university colleges and government authorities.

This paper concerns the dynamics of the local tax base in Sweden during the period 1981 to 1999. Following Aronsson *et al.* (2001) and Lundberg (2003), the growth rate of the local tax base is decomposed into two components, the average income growth and net migration rates. The main issue is to test the hypothesis that, conditional on the other explanatory variables, the average income growth and net migration rates in one municipality 'spillover' and affect the growth rates in neighboring municipalities. Such spatial externalities may exist for different reasons. For instance, if one municipality (i) is highly attractive to migrants, this could also have a positive effect on the net migration rate in neighboring municipalities if this causes housing prices to increase in municipality i. That is, some individuals who would like to live in municipality i settle for one of municipality i's neighbors due to high housing prices in municipality i. On the other hand, high net migration rates for municipality i may also be at its neighbors expense if neighboring municipalities are regarded as relatively 'unattractive' to migrants making residents within these municipalities to migrate to municipality i. When it comes to average income growth, one reason for spatial externalities relate to private consumption. As the average income level increase within one region, some of this money may be spent in neighboring regions, which might have a positive effect on the economic activity and the average income levels within these regions. Another reason relate to 'spin-offs' from existing companies. This could either be as new businesses started up by former employees, subcontractors to existing companies, or other types of service providers for company employees or companies. Such businesses may locate in neighboring municipalities, which could have effects on the average income level where they locate.

The introduction of spatial effects is important from a policy perspective because it can answer the question if the growth rates within one municipality occur at its neighbor's expense or if municipalities with high growth rates tend to have a positive effect on its neighbor's growth rates. If the average income growth and net migration rate in one municipality is affected by the growth rates in neighboring municipalities, this should, for example, have consequences for the design of national regional policy programs. The inclusion of spatial effects is also important from an econometric perspective. If the underlying data generating process includes a spatial dimension, and this is omitted, the estimates could become biased and inconsistent (see Anselin (1988), Anselin and Bera (1998) and Anselin (2001)). In addition to the hypothesis of potential spillover effects, we also test the hypothesis of conditional convergence, i.e. that, conditional on the other explanatory variables, initially 'poorer' regions grow faster than initially 'richer' ones.[2]

The empirical literature on regional income growth and also on net migration is quite extensive. Many studies on regional growth have focused on the hypothesis of conditional and/or unconditional convergence.[3] For example, Barro and Sala-i-Martin (1992, 1995) find support for the hypothesis of income convergence between U.S. states, Japanese prefectures and European countries. Using a data set covering Swedish counties during the period 1911 to 1993, also Persson (1997) find clear evidence of unconditional income convergence. However, some authors have taken the lack of convergence as evidence against the neoclassical growth model; see for instance Romer (1986) and Lucas (1988). Other studies have focused attention on a broader set of possible determinants of regional growth. For instance, Helms (1985) found local public revenues used to fund transfer payments tend to reduce economic growth, whereas local public revenues used to improve public services such as highways, education and public health tend to have a positive impact on economic growth. Glaeser *et al.* (1995) did not find support for the hypothesis of income convergence between U.S. cities, whereas they did find cities with low industrial exposure, highly educated inhabitants, and low unemployment rates to have a positive effect on population growth. The results presented by Aronsson *et al.* (2001) and Lundberg (2003) suggest conditional convergence between Swedish counties and municipalities respectively. They also report that the initial unemployment rate, the endowments of human capital, and regional public expenditures are important determinants of the regional growth pattern.

Analyses of regional income growth are closely related to population movements and changes in labor supply. The reason is that income growth may be due to changes in labor supply and/or the composition of the labor force, which makes the parameter estimates of empirical growth models difficult to interpret if the effects of population movements are ignored. Therefore, it is of importance to also include net migration or population movements in analysis of regional income growth. Previous studies of migration have found different economic 'opportunity' factors such as the expected wage and the probability of receiving that wage (Treyz *et al.* (1993) and Davies *et al.* (2001)) to be important determinants of migration patterns within the U.S.. In an analysis of the relationship between local public attributes and household migration in Sweden, Westerlund and Wyzan (1995) found the local income tax rate to be an important factor for short-distance migration.

Despite of its importance from both a policy and econometric perspective, only recently there has been an increasing interest in incorporating spatial effects in empirical analysis of regional growth. For instance, Rey and Montouri (1999) analyze regional growth in the U.S. using spatial econometric techniques. Their results suggest a strong spatial autocorrelation, which indicates that the underlying data generating process includes a spatial dimension. Armstrong (1995) argue that the support of the convergence hypothesis between European countries reported by Barro and Sala-i-Martin are due to the omission of spatial autocorrelation in the analysis and a biased selection of European regions. Spatial correlation is also found by Fingleton (2001), who introduce spillovers in an endogenous growth model estimated on data covering 178 regions within the European Union. However, in studies where spatial effects are incorporated or tested for, other possible determinants of regional growth, like population movements and different policy decision, are often ignored.

This paper complements earlier studies of regional growth using spatial econometric techniques (e.g. Rey and Montouri (1999)) in at least two ways. Firstly, we recognize the close relationship between average income growth and net migration by estimating two equations: one average income growth equation and one net migration equation. This makes it possible to (at least to some extent) relate the parameter estimates in the average income growth equation to changes in labor supply and/or the composition of the labor force. Secondly, we allow for a set of other potentially important factors for regional growth including local and national policy decisions, which, of course, is of interest from a policy perspective. This paper also complements previous studies of regional growth and migration using Swedish data (e.g. Westerlund and Wyzan (1995), Persson (1997), Aronsson *et al.* (2001) and Lundberg (2003)) by introducing spatial effects in the analysis. The different level of aggregation compared to Persson (1997) and Aronsson *et al.* (2001) is of importance as an analysis based on a more disaggregated level makes it possible to identify growth and mobility patterns that have not been captured in the previous studies.

Methodologically, this paper follow Glaeser *et al.* (1995), Aronsson *et al.* (2001) and Lundberg (2003) in that we use initial conditions for a set of variables to explain the successive average income growth and net migration rates. The explanatory variables can roughly be divided in four categories: (i) indicators of earning potential such as the average income level, endowments of human capital and unemployment rates; (ii) local and (iii) national policy decisions directed toward the local government sector; and (iv) demographic structure. In addition, we introduce spatial externalities in the model; i.e., the growth pattern within municipality i is affected by the growth rate of its neighbors. The analysis is based on a data set covering 271 Swedish municipalities from 1980 to 1999.

The rest of this paper is organized as follows. The theoretical outline, empirical specification and econometric issues are discussed in Section 2. The data set used is described in Section 3. The results, specification tests, parameter estimates and interpretations are presented in Section 4 and a summary is made in Section 5.

2. Theoretical outline, empirical specification and econometric issues

2.1. *Theoretical outline*

Let us start with a brief discussion of the theoretical outline and how we think about the local tax base. Following Aronsson *et al.* (2001) and Lundberg (2003) we define the local tax base in municipality i at time t as

$$B_{i,t} = Y_{i,t} \times P_{i,t}$$

where Y is the average income level and P is the population. Consequently, the growth rate of the local tax base may be decomposed in two components, the average income growth, y, and population growth, m. Define the average income growth between time $t-T$ and t as $y_{i,t} = \ln(Y_{i,t}/Y_{i,t-T})$ and the net migration rate as $m_{i,t} = \ln\left(\left(P_{i,t-T} + \sum_{k=t-T}^{t} mig_{i,k}\right)/P_{i,t-T}\right)$, where mig is net migration. Note that we, in contrast to Glaeser *et al.* (1995) analyze net migration rates (not population growth). Net migration differs from population growth in that it does not include fertility. This means that net migration may capture the extent to which municipalities are becoming more attractive to migrants. Hence, the growth rate of the local tax base between period $t-T$ and t, $b_{i,t}$, is given by

$$b_{i,t} = y_{i,t} + m_{i,t} \tag{1}$$

2.2. Empirical specification

From (1), we define and estimate two equations, one describing the development of the average income growth

$$y_{i,t} = g^{y} \left(y_{j,t-T}, EO_{i,t-T}, LP_{i,t-T}, NP_{i,t-T}, SE_{i,t-T} \right) \tag{2}$$

where $i \neq j$, and EO, LP, NP and SE are vectors containing economic opportunity variables, local policy variables, national policy variables and demographic variables respectively. The net migration function is defined in a similar way as

$$m_{i,t} = g^{m} \left(m_{j,t-T}, EO_{i,t-T}, LP_{i,t-T}, NP_{i,t-T}, SE_{i,t-T} \right) \tag{3}$$

We assume that the rate of return is equal between municipalities, which means that the attractiveness of a community for migrants mainly will depend on the earnings opportunities as well as on the characteristics that affect individual's well being. The net migration pattern will then mainly capture the extent to which municipalities are becoming more attractive habitats and labor markets. The selection of variables that will actually capture 'economic opportunities', the local policy, national policy and demographic characteristics is often a delicate issue in regional growth models. Let us here in brief discuss and, mostly based on previous studies, motivate our choice of indicators.

As mentioned in the Introduction, spatial externalities in equations (5) and (4) may exist for different reasons. For instance, if one municipality (i) is highly attractive to migrants, this could also have a positive effect on the net migration rate in neighboring municipalities if this causes housing prices to increase in municipality i. That is, some individuals who would like to live in municipality i settle for one of municipality i's neighbors due to high housing prices in municipality i. On the other hand, high net migration rates for municipality i may also be at its neighbors expense if neighboring municipalities are regarded as relatively 'unattractive' to migrants. When it comes to average income growth, one reason for spatial externalities relate to private consumption. That is, as the average income level increase within one region, some of this money may be spent in neighboring regions, which might have a positive effect on the economic activity and the average income levels within these regions. Another reason relate to 'spin-offs' from existing companies, either as new businesses started up by former employees, subcontractors to existing companies, or other types of service providers for company employees or companies. Such businesses may locate in neighboring municipalities, which could have effects on the average income level where they locate.

The set of indicators of earning possibilities to be used here consists of three variables: the level of average income, an indicator of human capital endowments in the municipality and the unemployment rate (see for instance Treyz *et al.* (1993), Westerlund and Wyzan (1995), Fagerberg *et al.* (1997), Aronsson *et al.* (2001) and Davies *et al.* (2001). The average income level is necessary in order to test the hypothesis of conditional convergence. In this case, a negative correlation between the average income growth and the initial average income level is taken as evidence in favor of conditional convergence. On the other hand, the endowment of human capital is often believed to have a positive impact on average income growth. When it comes to migration, a positive correlation between both the initial average income level and endowments of human capital and the subsequent net migration is often expected. One reason is that regions with high average income levels and endowments of human capital is often considered as 'socially stable' which makes these regions, all other things equal, attractive to migrants. A high average income level within a region may also 'spill over' and have a positive effect on the income level of new citizens. Measures of unemployment rates may reflect the probability of a potential migrant to receive the average income level within the region, which makes unemployment rates a potential indicator of 'economic opportunities'.

The net migration rate and the average income growth are also likely to depend on local and national policy decisions (see Helms (1985), Glaeser *et al.* (1995), Aronsson *et al.* (2001) and Lundberg (2003)). For instance, the local income tax rate is one factor that might influence migration between municipalities located in densely populated areas near major cities, where the decision to move does not necessarily mean that the individual changes his/her place of work (see Westerlund and Wyzan (1995)). Similarly, the local government consumption per capita and local government investments per capita probably provide indicators of the present and expected future service levels, which makes them potential determinants of net migration and income growth. In addition, in order to maintain national standards in local public services, national decision-makers have felt a need to equalize opportunities between locations. For example, the location of public universities and university colleges in particular areas together with intergovernmental subsidies are, in many respects, designed to affect migration patterns and average income growth. Migration and average income growth may also depend on demographic factors such as population density and the age structure of the population.

To sum up and to be more specific. Besides potential spatial externalities, the growth rate of the average income level and net migration rates between years T and t, where $t > T$, are assumed to depend on the following explanatory variables measured at time T:[4] (i) economic 'opportunity' factors [the average income level (Y), the endowment of human capital (h) and the unemployment rate ($unemp$)]; (ii) local policy decisions [the local income tax rate (tax), local government expenditures (exp), and local government investments ($invest$)]; (iii) national policy decisions [a dummy variable indicating the presence of a university (u), a dummy variable indicating the presence of a university college (uc), and intergovernmental grants ($grants$)]; (iv) demographic structure [the percentage of the population aged 0-15 years ($age\ 0-15$), above 65 years ($age\ 65-$) and population density ($dens$)].

2.3. Econometric issues

To empirically test the hypothesis that the average income growth and net migration rates in one municipality 'spillover' and affect the growth rates in neighboring municipalities we make use of spatial econometric techniques. Within the field of spatial econometrics, one often distinguishes between two types of regression models, the spatial lag and the spatial error model. In our case, the spatial lag model is relevant when focus is on how the growth rate within one region relate to the growth rates within its neighbors, conditional on the other explanatory variables. On the other hand, the spatial error model is relevant when the error terms from different regions may display spatial covariance. Through econometric tests and a proper specification strategy it is often possible to discriminate between the spatial lag and error models and arrive at the model which best describe the data generating process (see Florax *et al.* (2003)). However, let us come back to the estimation strategy and testing in the results section, and now focus on the differences between the spatial lag and error models, and the specification of our model.

The spatial lag model: Let n be the number of municipalities and $\mathbf{W}$ a spatial weighting matrix of dimension $(n \times n)$ whose elements assign the neighbors to each municipality. The weights matrix to be used here can be characterized as $\mathbf{W} = \{w_{ij}\}$ such that $0 < w_{ij} \leq 1\ \forall\ i \neq j$ if i and j are neighbors, otherwise $w_{ij} = 0$. Note that $w_{ii} = 0$. Here, neighbors are defined as those municipalities who share a common border. Moreover, using row-standardized weights, which is advisable,[5] $\sum W_i = 1$. Using the notation introduced above, for the spatial lag model it is assumed that the net migration rate (m_i) and average income growth (y_i) develop according to the two equations:

$$
\begin{aligned}
m_i \quad = \quad & \alpha^m + \rho^m \cdot \mathbf{W} \cdot m_i + \beta^m \cdot \ln(y_{i,t-T}) + \delta_h^m \cdot \ln(h_{i,t-T}) + \delta_{unemp}^m \cdot \ln(unemp_{i,t-T}) + \\
& \delta_{tax}^m \cdot \ln(tax_{i,t-T}) + \delta_{exp}^m \cdot \ln(exp_{i,t-T}) + \delta_{invest}^m \cdot \ln(invest_{i,t-T}) + \\
& \delta_{grant}^m \cdot \ln(grant_{i,t-T}) + \delta_u^m \cdot u_{i,t-T} + \delta_{uc}^m \cdot uc_{i,t-T} +
\end{aligned}
$$

$$\delta^m_{age\ 0-15} \cdot \ln (age\ 0-15_{i,t-T}) + \delta^m_{age\ 65-} \cdot \ln (age\ 65-_{i,t-T}) +$$
$$\delta^m_{dens} \cdot \ln (dens_{i,t-T}) + \varepsilon^m_i \qquad (4)$$

and

$$\begin{aligned} y_i = {} & \alpha^y + \rho^y \cdot \mathbf{W} \cdot y_i + \beta^y \cdot \ln (y_{i,t-T}) + \delta^y_h \cdot \ln (h_{i,t-T}) + \delta^y_{unemp} \cdot \ln (unemp_{i,t-T}) + \\ & \delta^y_{tax} \cdot \ln (tax_{i,t-T}) + \delta^y_{exp} \cdot \ln (exp_{i,t-T}) + \delta^y_{invest} \cdot \ln (invest_{i,t-T}) + \\ & \delta^y_{grant} \cdot \ln (grant_{i,t-T}) + \delta^y_u \cdot u_{i,t-T} + \delta^y_{uc} \cdot uc_{i,t-T} + \\ & \delta^y_{age\ 0-15} \cdot \ln (age\ 0-15_{i,t-T}) + \delta^y_{age\ 65-} \cdot \ln (age\ 65-_{i,t-T}) + \\ & \delta^y_{dens} \cdot \ln (dens_{i,t-T}) + \varepsilon^y_i \end{aligned} \qquad (5)$$

where the α:s, β:s, ρ:s, and δ:s are parameters to be estimated and ε is the error term. In the spatial lag model, the hypothesis of spatial correlation relate to the parameter ρ, where $H_0 : \rho = 0$ is tested against the alternative $H_1 : \rho \neq 0$. If H_0 is rejected, two possibilities arise. A positive and significant parameter estimate of ρ indicates a positive correlation between the growth rates in neighboring municipalities. That is, high growth rates tend to 'spillover' and have a positive effect on growth rates in neighboring municipalities. However, this effect could also be negative which indicates that, conditional on the other explanatory variables, the growth within one municipality tends to be at its neighbor's expense.

The spatial error model: In the spatial error model, the dependence between municipalities works through the error process as the errors from different regions may display spatial covariance. In technical terms, the difference between the spatial lag model as specified in the two equations (4) and (5), and the spatial error model relate to the parameter ρ and the error term ε. In the spatial error model, $\rho \equiv 0$ and $\varepsilon = \lambda W \varepsilon + u$, or rearranging, $\varepsilon = (I - \lambda W)^{-1} u$ where λ is a scalar spatial error coefficient, $u \sim N(0, \sigma^2 I)$ and the original error term has the non-spherical covariance matrix $E[\varepsilon\varepsilon'] = (I - \lambda W)^{-1} \sigma^2 I (I - \lambda W)^{-1}$. If the spatial error model is the right specification, the interpretation of the model is that a random shock will not only affect the region where it is introduced. Instead, it will spread not only to neighboring municipalities but also throughout the system.

As is well known within the spatial econometric literature, ordinary least square (OLS) is not an appropriate estimator for the spatial lag or the spatial error model. For the spatial lag model, OLS will provide biased as well as inconsistent parameter estimates. For the spatial error model, OLS will generate unbiased while no longer efficient parameter estimates. The parameters variance will also become biased. Instead of OLS, inference is often based either on maximum likelihood (ML), instrumental variable (IV) or general methods of moments (GMM) estimators.[6] Here, we apply two stage least square (2SLS) where $y_{i,t-T-1}$, $\mathbf{W} \cdot y_{i,-1}$ and $\mathbf{W} \cdot m_{i,-1}$ are used as instruments for the endogenous $y_{i,t-T}$, $\mathbf{W} \cdot y_i$ and $\mathbf{W} \cdot m_i$ respectively. Preferably, the average income growth and net migration equations should be estimated simultaneously. However, as the two equations are specified with the same explanatory variables except for the spatial interaction variable, we argue that the efficiency gain from a simultaneous estimation procedure will not be that significant. Therefore, and due to the fact that the estimation procedure will become less complicated, each equation will be estimated separately for each time period.

As pointed out earlier, the elements of $\mathbf{W}$ assign to each municipality its neighbors. From equations (4) and (5) it is evident that the definition of the elements in the weights matrix (i.e. the definition of neighbors) is crucial for the results, especially so for the parameter estimates of ρ and λ. In the best of worlds, the elements in $\mathbf{W}$ should be estimated along with the other parameters in the two equations. This is, however, not possible since there are not enough degrees of freedom, which means that $\mathbf{W}$ has to be (carefully) specified a priori. In our case, as we deal with municipalities, maybe the most intuitive definition of neighbors are two municipalities who share a border. Neighbors may also be defined based on traveling distance between municipal centers (the nearest, the two nearest, those within a traveling distance of less than 30 minutes etc.) or based on distances in population, population density, local public expenditures or taxes (see for instance Case *et al* (1993)). Here neighbors are defined as municipalities who share a common border. We argue that this definition is theoretically reasonable, and it is also the definition used by Rey and Montouri (1999). However, it should always be kept in mind that the results are conditional on the definition of the elements in the weights matrix.

3. Data

The data set used originate from the official statistics on municipalities provided by Statistics Sweden. It contains information on the average income level for the five years 1980, 1981, 1989, 1990 and 1999, and the net migration rate for the period 1980 to 1999. In addition, the explanatory variables are collected for two years, 1981 and 1990.

During the period 1980 to 1999, the number of municipalities varied between 279 in 1981 and 289 in 1999. Responsibilities and structures differ somewhat between municipalities. In contrast to the other municipalities, Gotland, Göteborg, and Malmö are responsible for the provision of health care, which is normally provided at the county level. This makes it difficult to obtain comparable data for these municipalities and they are, therefore, excluded from the empirical analysis. Municipalities whose borders were changed during the estimation period are also excluded. This leaves us with a data set containing 271 Swedish municipalities. The exclusion of some municipalities from the analysis is unfortunate because it will automatically induce spatial 'holes' in the data set. Particularly, the exclusion of two out of three major municipalities, Göteborg and Malmö are unfortunate. We are aware of this problem. Yet, instead of manipulating the data and trying to construct comparable figures for these municipalities we choose to exclude them from the analysis. However, the municipalities surrounding Göteborg and Malmö are still in the data set.

Table 1 and 2 presents descriptive statistics of the variables in the data set. Unfortunately, we lack measures of differences in price levels between municipalities.[7] Therefore, all monetary variables are deflated by the national index for consumer prices. Note that the average income growth (y) and the average income level (Y) are only measured for the population aged 20 or above. By measuring income in this way, we avoid some of the dependence between the age composition of the population and the average income level. This is reasonable as we disregard natural population growth.

Table 1 and 2 about here.

Human capital (h) is measured as the percentage of inhabitants aged 25 and above with at least 3 years of post high school studies. This information has only been collected by Statistics Sweden since 1985. In order to obtain data on the variable h for the period 1981-1984, $h_{i,t}$ is regressed on a constant, $h_{i,t-1}$, $h_{i,t-2}$, $h_{i,t-3}$, $h_{i,t-4}$, $h_{i,t-5}$ and $h_{i,t-6}$. Using ordinary least squares (OLS), this model explain 99.9 percent of the variation in h. Based on this equation, h is calculated for the period 1981-1984. The highest endowments of human capital are found in the Stockholm area and in municipalities with a university. The unemployment rate ($unemp$) is measured in percentage points of the unemployed labor force.

Primary and secondary education, childcare, care for the elderly and social care account for a large proportion of local government expenditure (exp) (approximately 75 percent in 1990). These services are mainly financed by the local income tax, where each municipality (at least in formal terms) is free to independently adjust the tax rate (tax). The other main source of revenues for the municipalities is the intergovernmental grants ($grant$). Local government investments ($invest$) may also be financed by income taxes or intergovernmental grants. Alternatively, they may be funded by loans or funds built up through budget surpluses. The number of universities (u) has been constant during the period 1981 to 1990, while the number of municipalities with a university college (uc) has increased from 20 in 1981 to 23 in 1990.[8]

4. Results

Previous empirical work on regional growth has divided the data set into different time intervals. For instance, Davies *et al.* (2001) uses one year, Aronsson *et al.* (2001) five while Persson (1997) and Rey and Montouri (1999) uses ten or longer intervals. It may be argued that it takes time, often more than a single year, for different policy decisions like investments to affect the local growth pattern. For instance, it may take many years for a new university or a university college to have an impact on local growth. Here, we have chosen to use time intervals of nine years which means that the two equations (4) and (5) are estimated using $t = 1990$ and 1999, and $T = 9$. This seems to be a reasonable time interval in order to evaluate the total effects of the different policy variables on regional growth. Given the data set, the use of $y_{i,t-T-1}$, $\mathbf{W} \cdot y_{i,-1}$ and $\mathbf{W} \cdot m_{i,-1}$ as instrument for $y_{i,t-T}$, $\mathbf{W} \cdot y_i$ and $\mathbf{W} \cdot m_i$ respectively, the two equations (4) and (5) are to be estimated for two periods, 1981-1990 and 1990-1999.

4.1. Specification tests

One potential source of misspecification in spatial econometric models comes from spatial heterogeneity. There are typically two aspects to spatial heterogeneity, structural instability and heteroskedasticity. Structural instability means that one or both of the in many respects strong assumptions of constant parameter estimates and functional form across regions has to be relaxed. Heteroskedasticity follows from any kind of misspecification that leads to non-constant variance in the error term. In order to avoid this type of misspecification and to discriminate between the spatial lag and spatial error components model, estimation of the final model will be preceded by specification tests, the results being reported in Table 3 below.

First, as some of the tests to follow are based on the assumption of normality, the Jarque-Bera test for normality is calculated.[9] Using the conventional 95-percent level of significance and normality being the null hypothesis, the hypothesis of normality will be rejected as the probability exceeds 0.05. Either the Breuch-Pagan (BP)[10] or the Koenker-Bassett (KB) test[11] for heteroskedasticity follows the Jargue-Bera test. As the BP-test has been shown to have low power in small samples when the errors are non-normal, the Koenker-Bassett test is calculated when normality is rejected by the Jarque-Bera test. Like the Jarque-Bera test, as the probability of the BP and KB tests exceed 0.05, the null hypothesis of homoskedastic errors will be rejected. In addition, the Moran's I test for spatial correlation based on OLS-residuals is calculated for each equations (4) and (5).[12]

Our specification strategy is primarily based on two robust Lagrange Multiplier (LM) tests (LM_λ for spatially autoregressive errors and LM_ρ for a spatial lag) and highly influenced by Florax *et al.* (2003). In short, the LM_λ (LM_ρ) tests the null hypothesis of no spatial correlation against the alternative of the spatial error (lag) model being the right specification. As the test statistic increases and the probability decreases, the probability of the spatial error (lag) model being the most proper specification increases. We follow the recommendations in Florax *et al.* and use the so called 'classical specification strategy', which is a 6 step procedure: 1) Estimate the initial model using OLS; 2) Test the hypothesis of no spatial dependence due to an omitted lag or spatially autoregressive errors, using robust Lagrange Multiplier tests (LM_λ and LM_ρ); 3) If non of these tests are significant, stay with the OLS estimates from step 1, otherwise proceed to; 4) If both tests are significant, chose the estimates from the model with the more significant of the two tests, otherwise proceed to step 5; 5) If LM_ρ is significant while LM_λ is not, use the lag specification, otherwise proceed to step 6; 6) If LM_λ is significant while LM_ρ is not, use the spatial error specification.

Table 3 about here.

Test statistics are reported in Table 3, where the two equations are estimated separately for each period. Based on the Jarque-Bera test for normality, the hypothesis of normality of the error terms are rejected for all equations. As normality is rejected, the Koenker-Bassett test for heteroskedasticity is calculated. Based on this test, the hypothesis of homoskedastic errors is rejected for the migration equation for the period 1981-1990, and also for the average income growth equation for both periods. Moreover, the Moran's I is positive and significant for both equations and periods, which indicate spatial dependence in the residuals in the sense that municipalities with similar growth rates are more spatially clustered than could be expected from pure chance. Even though not totally reliable as normality is rejected, the two LM tests suggests the net migration equation to be estimated using the spatial lag specification, while average income growth equation to be estimated using the spatial error specification for the period 1981-1990 and without spatial dependence for the period 1990-1999.

One way to deal with the problems of non-normality and heteroskedasticity is to relax the hypothesis of constant parameter estimates across regions. Instead, it is quite likely that parameter estimates differ between regions, something that is supported by previous empirical work on regional growth and migration based on Swedish data (see Westerlund and Wyzan (1995), Aronsson *et al.* (2001) and Lundberg (2003)). We have elaborated with many different subgroups of the data (or spatial regimes); municipalities located in the northern part of the country, near one of the major city areas Stockholm, Göteborg and Malmö, and combinations of these subgroups. However, to save space, we only report test results from the specification when using the Stockholm region as one regime and the rest of the country as the other, which turned out to be the one who performed best. The test results for this specification are reported in the lower half of Table 3.

As can be seen in the lower part of Table 3, the Jarque-Bera test for normality suggest that we still have some problems with normality for the later period, while this problem seems to be solved for the earlier period. However, the Breuch-Pagan and Koenker-Bassett tests for heteroskedasticity suggest that we no longer have problems with non-homoskedastic errors. Having taken care of this problem, the Moran's I indicate that we still have positive spatial dependence in the residuals. For the first period, the two LM-tests suggests the net migration equation (4) to be estimated using the spatial lag specification for both periods, and the average income growth equation (5) by using the spatial error specification for the earlier period. However, even though the Moran's I indicate spatial correlation, the two LM-tests are insignificant and give no guidance of the form of this correlation in the average income equation for the period 1990-1999. Based on the LM-tests in Table 3, the net migration equation (4) will be estimated using the spatial lag specification for the two sub-periods, while the average income equation (5) will be estimated using the spatial error specification for the period 1981-1990, and without spatial correlation for the later period, 1990-1999.

4.2. Parameter estimates

The parameter estimates of equations (4) and (5) for the period 1981-1990 and 1990-1999 are presented in Table 4 and 5 respectively. The column 'Major city' refers to parameter estimates for the Stockholm area, while the column 'Basic' refers to parameter estimates for the rest of the country. Let us first discuss the results presented in Table 4 where the net migration equation (4) is estimated using the spatial lag specification and the average income growth equation (5) using the spatial error specification.

Table 4 about here.

The results presented in Table 4 suggest a positive and significant parameter estimate of ρ that indicate that net migration rates (m) tend to 'spillover' to neighboring municipalities and have a positive effect on their net migration rates. This is important from a policy perspective as it indicates that the net migration rate to one municipality is not at its neighbor's expense. Instead, highly attractive municipalities tend to have a positive impact on net migration rates within its neighbors. Consequently, if, for any reason, net migration rates into one municipality increases, our model predict this to have a positive effect on the net migration rate of its neighbors. This result is also interesting from an econometric perspective as it indicates that net migration does not only depend on characteristics within the municipality. Instead, is suggests that net migration rates are associated with spatial correlation and, consequently, that spatial effect should at least be tested for in empirical work on net migration and population movements using Swedish data. Our results also suggest positive parameter estimates for λ in the average income growth equation. This result is important in the sense that random shocks into the system do not only affect the municipality where the shock has its origin and its neighbors, it will spread across the country.

Turning to the hypothesis of conditional convergence. Outside of the Stockholm region, our model predicts a negative and significant correlation between the initial average income level (Y) and the subsequent average income growth (y) during the period 1981-1990. This implies convergence in the sense that municipalities with low initial income levels tend to grow faster than municipalities with high initial income levels conditional on the other explanatory variables in the model. This is in line with previous studies using data on U.S. states (Barro and Sala-i-Martin (1992, 1995)), Rey and Montouri (1999), Swedish municipalities (Lundberg (2003)) and counties (Persson (1997) and Aronsson *et al.* (2001)). As pointed out in Aronsson *et al.* (2001), one explanation for this result could be that capital mobility tends to make municipalities (in their case counties) more homogeneous over time. Another explanation put forward by Aronsson *et al.* is the centralized system of wage formation during this period, which may have compressed the wage distribution. However, the results presented in Table 4 suggest a positive correlation between y and Y in the Stockholm region, which implies conditional divergence. This contradicts to previous results based on Swedish data (Lundberg (2003) find no significant correlation between y and Y in the major city areas Stockholm, Göteborg and Malmö).

To make further interpretations of the correlation between y and Y, it is important to analyze how the initial average income level (Y) affects the subsequent net migration (m). This relationship is estimated to be negative for both regions, which is in contrast to the results presented by Aronsson *et al.* (2001) while in line with Lundberg (2003). At first glance, this result suggests that high-income levels do not attract migrants. However, the average income level (Y) is not the only indicator of future earnings opportunities within a municipality. They may also depend on the initial endowments of human capital (h) and labor market conditions such as the initial unemployment rate ($unemp$). Our model predicts a strong positive correlation between the initial endowments of human capital (h) and both the subsequent net migration rate (m) and average income growth (Y), the latter outside of the Stockholm region. The initial average income level (Y) and the endowments of human capital (h) are highly correlated (correlation coefficient of 0.86). If we impose the restriction $h = 0$, the correlation between Y and m is estimated to be positive and significant outside of the Stockholm region. Consequently, the negative correlation between Y and m should be interpreted with caution.

The initial endowments of human capital (h) are estimated to have a positive effect on net migration (m) in both the Stockholm region and the rest of the country. Our model also predicts a positive correlation between h and the average income growth rate (y) outside the Stockholm region. One possible interpretation of these results is that municipalities with high initial endowments of human capital tend to attract highly skilled individuals, which has a positive effect on the proportion of productive individuals within the municipality. A higher proportion of productive individuals (or highly educated if one believe there is a correlation between these two) have a positive effect on the average income growth rate. The model does predict any significant relationship between the initial unemployment rate ($unemp$) and the subsequent net migration rate (m) or average income growth (y).

Turning to the local policy variables, our model suggest a negative relationship between initial local public expenditures (exp) and the subsequent net migration rate (m) outside the Stockholm region. For the same region, the results also suggest initial investments ($invest$) to have a positive impact on net migration (m). However, our model predicts no significant correlation between any of the local policy variables and the subsequent average income growth rate (y). One interpretation of these results is that even though initial local public expenditures (exp) and investments ($invest$) cause out and in migration respectively, these two variables do not affect the proportion of skilled and unskilled labor leaving the average income growth unaffected. However, as pointed out by Aronsson *et al.* (2001), as the local governments where not obligated to balance their budget each year, the local government income tax rates (tax), expenditures (exp) and investments ($invest$) may not only reflect the current service level and cost for tax payers, they may also signal future policy changes.[13] This makes it difficult to interpret these parameter estimates. Therefore, with no further interpretations, we only note that local public expenditures and investments seem to have a negative and positive impact respectively on net migration outside the Stockholm region, a result also reported in Lundberg (2003).

As the main part of the services provided by local governments are financed through the local income tax, national decisions makers have felt a need to equalize financing opportunities between municipalities in order to maintain national standards in local public services. One example of this policy is the location of universities or university colleges in particular areas together with intergovernmental subsidies. These policy instruments are in many respects designed to affect the regional migration pattern and average income growth. Our results indicate that national grants ($grant$) directed toward the local public sector within the Stockholm region tend to have a positive impact on the subsequent average income growth (y), while a negative impact on net migration (m). One interpretation of this result is that as national grants cause out migration, labor supply decreases which has a positive effect on the average income growth. This means that intergovernmental grants during this period actually have had a positive effect on the local tax base expressed in per capita terms for municipalities located in the Stockholm region, even though it causes out migration.

The other main political tool to compensate regions with relatively 'small' tax bases has been the location of universities (u) and university colleges (uc). However, the results presented in Table 4 suggest that universities (u) located in the Stockholm region have a negative impact on net migration (m) while leaving the average income growth (y) unaffected. In addition, the results suggest that university colleges (uc) located outside the Stockholm region to have a negative impact on net migration (m), while university colleges (uc) in the Stockholm region have a positive impact on net migration. These results indicate that even though u and uc affect net migration, the proportion of skilled and unskilled remain approximately constant, leaving the average income growth rate (y) unaffected. This seem to be a reasonable explanation given that after the first few years of starting up a new university or university college, the number of new students will approximately equal the number of student who graduate and, in many cases, leave the region where the seat of learning is located. Hence, the dummy variable introduced in our model to capture the effects of a university or university college may reflect to what extent the municipality is able to attract students after they have graduated. The absence of a clear effect on the average income level could also be due to the fact that, even if more productive, the relatively large amount of students may have a moderate effect on wages, especially if the university or university college is the main working site in the region. Newly graduated students are, before they leave, part of the potential labor force, which could have a moderate effect on wages within the region.

Table 5 about here.

Let us now compare the parameter estimates for the period 1981-1990 reported in Table 4 with the results from the period 1990-1999 reported in Table 5. Like the results presented in Table 4, the results in Table 5 suggest a positive and significant parameter estimate of ρ in the net migration equation. Based on these results, we conclude that through the period 1981 to 1999, high (or low) net migration rates (m) tend to 'spillover' to neighboring municipalities and have a positive effect on their net migration rates. Moreover, from Table 5 it is evident that we no longer find any support for the hypothesis of conditional convergence. Instead, our model predicts conditional divergence among all municipalities. In addition, the former negative correlation between Y and m is no longer significant. Furthermore, the initial amount of human capital (h) does no longer show a significant impact on net migration (m) in the Stockholm region, and the positive correlation between h and y outside the Stockholm region is no longer significant (it is even estimated to be negative, while not significant). The initial unemployment rate ($unemp$) is now estimated to be negatively correlated with m in the Stockholm region and negatively correlated with y outside the Stockholm region. This result implies that, during this period, high initial unemployment rates have a different effect on net migration and average income growth rates in and outside of the Stockholm region. Assuming that the income level of those employed are strictly higher that of those unemployed, one interpretation of this result is that, in the Stockholm region, high initial unemployment rates cause out-migration of both employed and unemployed leaving the average income level unaffected. On the other hand, outside the Stockholm region, high initial unemployment rates do not generate the same amount of out migration and, therefore, has a negative effect on the average income growth rate.

As discussed previously, it is difficult to interpret the parameter estimates that relate to the local public policy variables. Therefore, we (again) settle with the observation that initial local public investments ($invest$) is still estimated to have a positive effect on net migration (m) outside the Stockholm region, while the correlation between local public expenditures (exp) and m is now estimated to be negative for regions outside of the Stockholm region.

Finally, for the period 1990-1999, our model predicts a positive correlation between universities (u) located in the Stockholm region and the subsequent net migration rate (m). This contradicts the results for the period 1981-1990, for which the model predicted a negative correlation. Moreover, the effects from a university college (uc) on net migration (m) has disappeared as well as the positive correlation between initial intergovernmental grants ($grant$) and the subsequent average income growth rate (y) in the Stockholm region. In addition, the negative correlation between $grant$ and m in the Stockholm region is no longer significant.

The results above indicate that the parameter estimates differ between the two time periods. For instance, the support of the conditional convergence hypothesis outside the Stockholm region for the 1980's is no longer valid for the later period. Instead, our results suggest conditional divergence. Based on our model and the data set used it is, however, difficult to give explanations and interpretations for these differences. We just settle with the observation that the parameter estimates tend to change over time.

5. Summary and concluding remarks

The main issue in this paper has been to test the hypothesis that the average income growth and net migration rates at the municipal level in Sweden are affected by the growth rates in neighboring municipalities. Using a data set covering 271 municipalities during the period 1980-1999, we find evidence in favor of this hypothesis. In particular, we find that the net migration rates in one municipality are affected positively by the net migration rates within its neighbors, which suggests that net migration rates tend to 'spillover' on neighboring municipalities. This result is of importance from a policy perspective as it suggests that if a municipality, for any reason, is attractive to migrants, it will also affect the net migration rates into its neighboring municipalities. Moreover, this result is also of importance from an econometric perspective as it suggests that spatial effects should be incorporated, or at least tested for, in analysis of net migration rates and population movements using Swedish data. Our results also indicate the presence of spatial correlation in the error term for the average income growth rates during the 1980's. This result implies, at least for the 1980's, that a shock into the system do not only affect the municipality where the shock has its origin but will spread across the country and affect the average income growth rates in other municipalities. Based on this result, we make the recommendation that spatial effects should also at least be tested for when analyzing average income growth.

In addition to the hypothesis of spillover effects and spatial correlation between municipalities, we have also tested the hypothesis of conditional income convergence across municipalities. In contrast to previous research based on Swedish data (i.e. Aronsson *et al.* (2001) and Lundberg (2003)) we do not find any clear evidence in favor of this hypothesis. Instead, our results indicate conditional divergence across municipalities in the Stockholm region throughout the period and also for municipalities outside the Stockholm region during the 1990's. This result implies that average income levels do not tend to equalize across municipalities. Consequently, all other things equal, local tax bases and financial opportunities of local public services tend to diverge across municipalities. Further more, our results indicate that the initial endowments of human capital, here measured as the percentage of the population aged 25 or above with at least three years of higher education, has a positive effect on net migration, at least outside the Stockholm region. This result seems to be robust in the sense that it tend to be stable over time and that it is also in line with previous research based on Swedish data. From this, we conclude that the level of human capital is an important factor for net migration outside the Stockholm region, where, compared to the Stockholm region, municipalities are relatively large and the decision to move between municipalities often are associated with a change of working place.

Due to the fact that Swedish municipalities where not obligated to balance their budgets, it is difficult to interpret the parameter estimates that correspond to local policy decisions. However, our results indicate that local policy decisions are important determinants of net migration and average income growth rates. When it comes to the effects of national policy decisions, here represented by intergovernmental grants and the location of universities and university colleges, the parameter estimates differ between the two periods. For instance, intergovernmental grants are estimated to have a negative effect on net migration and a positive effect on the average income growth rate in the Stockholm region during the 1980's, while we find no significant effect on net migration or average income growth during the 1990's. Our model predict a negative correlation between the location of a university and net migration in the Stockholm region during the 1980's, while the effect of a university in this region is estimated to be positive during the 1990's. These results should be interpreted with caution as we use dummy variables to capture the effects of a university or a university college. This is, of course, a crude measure, and other measures like the number of students in relation to the total population, money spent on research at different faculties, the number of professors might be more accurate. However, we leave it for future research to develop and use more sophisticated measures for the presence of universities and/or university colleges.

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Notes

[1]The local public sector in Sweden is the main provider of primary- and secondary schooling, childcare, care for the elderly and social care.

[2]The hypothesis of income convergence is predicted by neoclassical growth models such as presented by Solow (1956), Cass (1965) and Koopmans (1965).

[3]Among others, see DeLong (1988), Barro (1991), Blanchard and Katz (1992), Borjas *et al.* (1992), Mankiw *et al.* (1992), Glaeser *et al.* (1992), Sala-i-Martin (1996) and Terassi (1999).

[4]Explicit definitions of all the variables are given in Appendix 1.

[5]See for instance Anselin (1988).

[6]See for instance Anselin (1988).

[7]Even if this is a potential source of misspecification of the model, it should be noted that Aronsson *et al.* (2001) tried to explore regional variation in the cost of living using a regional housing price index instead of the national index for consumer prices. However, their parameter estimates for the model using the regional housing price index were very close to those estimated using the national index of consumer prices.

[8]The large increase in the number of university colleges took place in 1976.

[9]This test is χ^2 distributed, has 2 degrees of freedom and a chritical value of 5.99 at the 95-percent level of significance. See Jarque and Bera (1980) for further details regarding this test.

[10]This test is χ^2 distributed with K degrees of freedom where K is the number of z variables in the heteroscedastic specification. See Breuch and Pagan (1979) for further details regarding this test.

[11]See Koenker and Bassett (1982) for further details regarding this test.

[12]Based on the OLS residuals, Moran's I is calculated as $I = n/S_0 \sum_i \sum_j w_{ij}\varepsilon_i\varepsilon_j / \sum_i \varepsilon_i^2$ where $S_0 = \sum_i \sum_j w_{ij}$ and n is the number of observations. Inference is often based on $z = (I - E[I])/SD[I]$. See Cliff and Ord (1972, 1981) for further details regarding this test.

[13]Lundberg (2003) tries to distinguish between different interpretations of the effects of previous decisions made by local government by introducing local budget surpluses in the model (see also Fischer (1993)). However, this experiment did not provide any additional insights.

Appendix 1: Variable definitions

Endogenous variables:

- Net migration, m: Net migration rate. Defined as $\ln\left(1+\frac{\sum m_{i,s}}{p_{i,t-T}}\right)$, where m is net migration and p population.
- Average income growth, y: Defined as $\ln\left(\frac{y_{i,t}}{y_{i,t-T}}\right)$, where y is the average income level.

Explanatory variables:

Economic 'opportunity' factors (i):

- Average income level, Y: Measured in thousand SEK per year for the population twenty years old or above.
- Human capital, h: Measured as share of the population aged 25 or above with post senior high school studies.
- Unemployment rate, *unemp*: The unemployment rate in percentage points.

Local government policy variables (ii):

- Local income tax rate, *tax*: Local plus regional income tax rate measured in percentage points.
- Local government expenditures, *exp*: Local government operating costs per capita. Measured in thousand SEK per capita.
- Local government investments, *invest*: Local government investments measured in thousand SEK per capita.

National policy variables (iii):

- Intergovernmental grants, *grant*: Total intergovernmental grants. Measured in thousand SEK per capita.
- University, u: Dummy variable indicating the presence of a university.
- University college, *uc*: Dummy variable indicating the presence of a university college.

Demographic structure (v):

- Population density, $dens$: Inhabitants per square kilometers.
- Population aged 0-15 years, $age\ 0-15$: Share of population aged 15 years or below.
- Population aged 65 years or above, $age\ 65-$: Share of population aged 65 years or above.

Table 1. Descriptive statistics for year 1981.

Variable	Mean	Std dev	Min	Max
Net migration rate 1981-1990	0.02	0.05	-0.18	0.17
Average income growth 1981-1990	0.19	0.02	0.12	0.26
Average income level (y)	50.09	5.99	39.96	87.60
Human capital (h)	0.19	0.11	0.08	0.75
Unemployment rate (unemp)	0.02	0.01	0.00	0.09
Local income tax rate in percent (tax)	28.78	1.18	24.10	32.25
Local government expenditures (exp)	10.86	1.85	7.68	19.53
Local government investments (invest)	1.57	0.71	0.56	6.57
Intergovernmental grants (grant)	3.28	0.74	1.01	6.93
University (u)	0.02	0.15	0.00	1.00
University college (uc)	0.07	0.26	0.00	1.00
Population density (dens)	10.35	34.60	0.03	345.59
Population aged 0-15 years (age 0-15)	0.22	0.03	0.13	0.34
Population aged 65- years (age 65-)	0.17	0.04	0.05	0.26
North (north)	0.24	0.43	0.00	1.00

Table 2. Descriptive statistics for year 1990.

Variable	Mean	Std dev	Min	Max
Net migration rate 1990-1999	-0.01	0.05	-0.17	0.27
Average income growth 1990-1999	0.19	0.02	0.12	0.26
Average income level (y)	60.64	7.15	50.05	113.54
Human capital (h)	0.25	0.12	0.12	0.81
Unemployment rate (unemp)	0.01	0.01	0.00	0.06
Local income tax rate in percent (tax)	30.38	1.11	25.90	32.30
Local government expenditures (exp)	12.88	1.84	8.98	19.48
Local government investments (invest)	0.93	0.54	-0.59	3.63
Intergovernmental grants (grant)	3.58	1.08	1.14	7.98
University (u)	0.02	0.15	0.00	1.00
University college (uc)	0.08	0.28	0.00	1.00
Population density (dens)	11.03	37.71	0.03	358.92
Population aged 0-15 years (age 0-15)	0.20	0.02	0.14	0.28
Population aged 65- years (age 65-)	0.19	0.04	0.06	0.27

Table 3. Specification tests based on Ordinary Least Squares (OLS).

Time period	1981-1990				1990-1999			
	m		y		m		y	
	Value	Prob	Value	Prob	Value	Prob	Value	Prob
No structural change								
Jarque-Bera test for normality	12.565	0.000	10.328	0.006	607.374	0.000	11.551	0.003
KB test for heteroskedasticity	45.081	0.000	56.714	0.000	18.280	0.107	24.027	0.020
Moran's I	4.272	0.000	5.638	0.000	4.945	0.000	4.446	0.000
Robust Lagrange Multiplier (error)	0.798	0.372	25.214	0.000	1.393	0.238	0.056	0.814
Robust Lagrange Multiplier (lag)	3.522	0.061	3.377	0.066	11.453	0.001	7.628	0.006
Structural change								
Jargue-Bera test for normality	3.782	0.151	4.178	0.124	14.190	0.001	12.183	0.002
BP or KB test for heteroskedasticity	0.081	0.776	4.277	0.039	1.092	0.296	0.056	0.813
Moran's I	4.209	0.000	5.751	0.000	4.844	0.000	3.918	0.000
Robust Lagrange Multiplier (error)	0.176	0.675	25.565	0.000	0.438	0.508	1.750	0.186
Robust Lagrange Multiplier (lag)	13.063	0.000	2.490	0.115	9.655	0.002	0.547	0.460

Table 4. Parameter estimates of equations (4) - (5) for the period 1981-1990 via 2sls.

	m				y			
Dependent variable	Basic		Major city		Basic		Major city	
Constant (α)	1.669	(5.56)	3.409	(1.36)	1.532	(8.02)	-4.211	(-2.74)
ς	-	-	-	-	0.961	-	-	-
ρ	0.443	(5.53)	-	-	-	-	-	-
Economic 'opportunity' factors								
Average income level (β)	-0.268	(-3.53)	-0.979	(-3.13)	-0.227	(-4.85)	0.518	(2.98)
Human capital (δ_h)	0.120	(10.43)	0.258	(2.69)	0.018	(2.55)	-0.168	(-0.03)
Unemployment rate (δ_{unemp})	-0.002	(-0.24)	-0.016	(-0.32)	0.005	(0.97)	-0.037	(-0.95)
Local gov. policy variables								
Income tax rate (δ_{tax})	-0.003	(-0.06)	-0.149	(-0.40)	-0.058	(-1.39)	0.142	(0.59)
Expenditures (δ_{exp})	-0.057	(-2.88)	-0.080	(-0.85)	-0.022	(-1.86)	-0.082	(-1.40)
Investments (δ_{invest})	0.014	(2.70)	-0.008	(-0.30)	0.004	(1.49)	-0.017	(-1.09)
National policy variables								
Intergov. grants (δ_{grant})	-0.008	(-0.55)	-0.397	(-2.37)	-0.007	(-0.70)	0.270	(2.58)
University (δ_u)	-0.029	(-1.59)	-0.134	(-2.78)	-0.010	(-1.06)	-0.031	(-1.33)
University college (δ_{uc})	-0.016	(-1.96)	0.116	(2.00)	-0.005	(-1.04)	0.040	(1.37)
Demographic structure								
Pop. density (δ_{dens})	0.002	(0.81)	-0.015	(-0.47)	-0.002	(-0.78)	0.003	(0.21)
Pop. aged 0-15 ($\delta_{age\ 0-15}$)	0.053	(1.24)	-0.179	(-0.79)	0.086	(3.38)	0.025	(0.21)
Pop. aged 65- ($\delta_{age\ 65-}$)	0.102	(4.12)	-0.062	(-0.84)	-0.008	(-0.49)	0.074	(2.06)

Table 5. Parameter estimates of equations (4) - (5) for the period 1990-1999 via 2sls.

	m				y			
Dependent variable	Basic		Major city		Basic		Major city	
Constant (α)	0.982	(2.44)	0.007	(0.00)	-0.193	(-0.59)	-0.243	(-0.18)
ρ	0.574	(6.29)	-	-	-	-	-	-
Economic 'opportunity' factors								
Average income level (β)	-0.060	(-0.65)	-0.343	(-1.66)	0.203	(2.65)	0.466	(2.73)
Human capital (δ_h)	0.076	(5.74)	-0.002	(-0.02)	-0.004	(-0.40)	-0.021	(-0.22)
Unemployment rate (δ_{unemp})	0.009	(1.39)	-0.100	(-2.37)	-0.011	(-2.10)	-0.017	(-0.49)
Local gov. policy variables								
Income tax rate (δ_{tax})	-0.093	(-1.20)	0.655	(1.43)	-0.033	(-0.53)	-0.141	(-0.37)
Expenditures (δ_{exp})	-0.028	(-1.26)	-0.256	(-2.18)	-0.032	(-1.72)	-0.030	(-0.31)
Investments (δ_{invest})	0.009	(2.27)	-0.015	(-0.92)	0.004	(1.32)	-0.006	(-0.49)
National policy variables								
Intergov. grants (δ_{grant})	-0.009	(-0.75)	-0.016	(-0.30)	0.003	(0.31)	-0.061	(-1.37)
University (δ_u)	0.022	(1.18)	0.214	(2.44)	-0.007	(-0.46)	0.068	(0.93)
University college (δ_{uc})	0.013	(1.43)	-0.043	(-0.66)	-0.013	(-1.79)	-0.009	(-0.17)
Demographic structure								
Pop. density (δ_{dens})	0.003	(1.00)	0.020	(1.05)	-0.001	(-0.32)	0.000	(0.02)
Pop. aged 0-15 ($\delta_{age\ 0-15}$)	0.041	(0.89)	0.718	(2.35)	0.105	(2.77)	0.311	(1.24)
Pop. aged 65- ($\delta_{age\ 65-}$)	0.076	(2.58)	0.257	(3.61)	0.105	(4.29)	0.185	(3.15)

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ISBN 91-7305-564-6
ISSN 1404–5362