Does academic research affect the local growth pattern?

Empirical evidence based on Swedish data

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Abstract

The main issue in this paper is to analyze to what extend academic research at universities and university colleges have any effects on the regional growth pattern. In particular, we analyze the dynamic effects of research activities at universities and university colleges by including the number of dissertations at each university or university college in a Barro and Sala-i-Martin type (Barro and Sala-i-Martin (1992)) of empirical growth model. Moreover, we control for other potentially important determinants of local growth such as local income taxes, local labor market conditions and demographic factors. Based on a data set covering the Swedish municipalities during the period 1990-2007, our results suggests that academic research only have minor effects on the regional growth pattern. One potential explanation for this result is that even though academic research might have a positive effect on economic growth at the national level, the in many respects small municipalities in Sweden where the main part of the universities and university colleges are located do not have the resources in terms of infrastructure needed to fully benefit from academic research.

Keywords: Net migration, income, convergence, academic research, human capital, spatial effects

JEL: I-23, I-25, I-28, O-15, O-38, R-11

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1. Introduction

In Sweden as well as in many other countries, considerable amounts of public funds are each year spent on academic research and higher education. One of the main motivations for this is the belief that research and new knowledge stimulates economic growth and wealth which finds support in theoretical growth models. For instance, Mankiw et al. (1992) augmented human capital to the traditional Solow model (Solow (1956)) while and Romer (1986, 1990) and Lucas (1988) directly related human capital with technology adoption. In Sweden, the location of new universities and university colleges has partly been used as regional policy instrument in order to equalize economic development and opportunities across the country. The policy is also based on the belief that the presumed positive effects from a university or university college will "spillover" to neighboring municipalities. This paper focus on the effects of this policy. In particular, the main issue is to test the hypothesis that research activities that take place at universities and university colleges, here measured as the number of dissertations at each separate university or university college is an important determinant of average income growth and net migration rates at the municipal level. We also test the hypothesis that the location of a university or a university college will not only affect the growth pattern within the municipality where it is located but spread and effect the growth in neighboring municipalities. The focus on average income growth and net migration is motivated by the fact that the proportional income tax is the main source of income for local governments. Changes in the development of local taxbases will therefore depend on changes in the average income level and net migration making these two factors of importance for the local governments' ability to provide the public services they are obligated by the national government to provide. The analysis is based on a data set covering the Swedish municipalities for the period 1990-2007.

Before we proceed, let us give some basic facts regarding the local public sector, local in- come growth and net migration in Sweden during the last decades. The major part of the in many respects dramatic expansion of the public sector in Sweden has taken place at the local level of government. One reason is that the national government has delegated and imposed new obligations on local authorities and that municipalities are the main providers of services such as child care, elementary schools, secondary schools and care for the elderly. These activities are mainly financed through the local income tax, a proportional tax which the local government in formal terms is free to adjust, and through the intergovernmental grant program. The highest average income levels and net migration rates are found near the major city areas. The national government has tried to affect regional conditions by, among other things, the location of new universities, university colleges and national institutions. Municipalities containing a university or a university college have in general experienced larger net migration during the period 1990 to 2007 compared to other municipalities.² However, the average income growth rates are often lower within these regions.³ From this perspective, it is of interest to analyze the effects of these policy decisions on the local average income growth and net migration rates as changes in these variables affect the local tax base and, consequently, the municipalities' abilities to finance and provide the services they are obligated to provide. From a policy perspective it is also of interest to test for potential spillover effects from universities and university colleges on growth in neighboring municipalities. Moreover, the inclusion of spillover

² The average net in migration to municipalities with a university or a university college was 8-percent during the period 1993 to 2007. This should be compared to an average of 0.4-percent for municipalities without a university or a university college.

³ On average, 24-percent compared with 28-percent growth in average income levels.

effects is also important from an econometric perspective because if the data generating process include a spatial dimension, and if this dimension is omitted, the estimates could become biased and inconsistent (see Anselin (1988)).

The issue of local and regional growth has received quite much attention in the economics literature during the last decades. For instance, in the seminal work by Barro and Sala-i- Martin (1992, 1995) they find support for income convergence between U.S. states, Japanese prefectures and European countries. Income convergence is also found between Swedish counties (Persson (1997) and Aronsson et al. (2001)) and municipalities (Lundberg (2003, 2006)). Aronsson et al. and Lundberg also report initial unemployment rate, endowments of human capital and regional public expenditures and taxes to be important determinants of regional and local growth. There has also been an increasing interest in incorporating the influence of spatial externalities on regional growth and income inequalities.⁴ Among others, Rey and Montouri (1999), and Ramajo et al. (2008) and Mohl and Hagen (2010) find evidence in favor of spatial dependence across U.S. and European regions respectively, which indicate that the underlying data generating process includes a spatial dimension. Similar results are reported in an application using Swedish data by Lundberg (2006). However, there is only a limited number of papers on the effects of and potential spillovers from academic research on local growth, i.e. that the accumulation of human capital in one municipality affect the growth rate in neighboring municipalities. Early exceptions are Florax (1992) and Anselin et al. (1997). Another is a study by Lall and Yilmaz (2001) who, based on data on U.S. data, estimate a conditional convergence model with human capital spillovers. They find human capital spillovers to be important in explaining income differences and convergence across states. Positive spillover effects are presented by Rauch (1993), Fingleton and López-Bazo (2006), and Rosenthal and Strange (2008), while opposite results are reported by Adamson et al. (2004) and Olejnik (2008). In addition, results presented by Petrakis and Stamatakis (2002) suggest different schooling levels to have different effects on the regional growth pattern. They find primary and secondary education to have a stronger effect on growth in less developed countries while the opposite in more developed countries. These results are verified by Vandenbussche et al. (2006) and by Pereira and St. Aubyn (2009).

The empirical point of departure in this paper is an Barro and Sala-i-Martin type of growth equation (Barro and Sala-i-Martin (1992)) based on which it is straight forward to test the so-called conditional convergence hypothesis which predicts that initially "poorer" regions grow faster compared with initially "richer" ones. Methodologically, we follow Glaeser et al. (1995) and Aronsson et al. (2001) in that we use the initial conditions for a broad set of variables to explain the successive average income growth and net migration rates. The explanatory variables used in this paper are indicators of earning potential such as the average income level, endowments of human capital and research "production" at universities and university colleges, local income tax rates, and the local socioeconomic and demographic structure. We start by estimating what we refer to as the "benchmark" model where the data set is divided in five year intervals. Then we estimate what we refer to as the "panel data" model. Both models are estimated with fixed effects and with and without spillover effects.

⁴ For an overview of empirical papers, see Abreu et al. (2005).

This paper contributes to the empirical literature on regional growth in that we are analyzing the effects of academic research undertaken at universities and university colleges in Sweden by using information on the "production" of dissertations which, at least to our knowledge, has not been done before. We also test for spatial spillover effects from the "production" of academic research. These two tests serve as an evaluation of the national policy to use the location of and *R&D* resources to universities and university colleges as a regional policy instrument. Compared to many of the previous studies including spatial externalities such as Rey and Montouri (1999), Ramajo et al. (2008) and Mohl and Hagen (2010) we make use of a richer set of potential determinants of average income growth. In addition, we estimate two equations simultaneously, one explaining the average income growth and one net migration which makes it possible to, at least to some extent, relate the results from the average income growth equation to changes in labor supply. This approach provides a richer interpretation of the parameter estimates in the income growth equation.

The remainder of this paper is organized as follows. In Section 2, the basic methodology, data and econometric issues are discussed. The empirical results are presented and discussed in Section 3 and concluding remarks are formulated in Section 4.

2. Basic methodology, empirical specification and econometric issues

i. Basic methodology

The dynamics of the local tax base is characterized by changes in average income and net migration. Following Aronsson et al. (2001) and Lundberg (2003), the local tax base in municipality i at time t, here denoted $B_{i,t}$, is defined as

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

where $Y_{i,t}$ is the average income level and $Pop_{i,t}$ is the population. If the growth rate of average income in municipality *i* at time *t* is defined as

$$y_{i,t} = ln(Y_{i,t}/Y_{i,t-T})$$

and the net migration to municipality i during the period s as

$$m_{i,s} = ln\left(1 + \sum_{l=0}^{l=T} \left(\frac{mig_{i,t-l}}{Pop_{i,t-T}}\right)\right)$$

the growth rate of the local tax base between years t - T and t could then be expressed as

$$b_{i,t} = y_{i,t} + m_{i,t}$$

It is s assumed that the rate of return is equal across regions which imply that the net migration will primarily depend on differences in earnings possibilities and local socioeconomic characteristics (see Brown (1993)). Hence, the rate of net migration into a region is assumed to be a function of initial conditions relating to labor productivity and socioeconomic factors (Barro and Sala-i-Martin (1995, Chapter 11)). Labor productivity is assumed to be closely correlated with the local supply of human capital, in this case measured as the "production" of dissertations at universities and university colleges and the share of the population with higher education. In accordance with policy believes it is assumed that the effects of academic research do not only effect the net migration in the

municipality where the university or university college is located but spread to neighboring municipalities.⁵ That is, the "production" of academic research in municipality i is allowed to affect the net migration into municipality j if municipalities i and j are defined as neighbors. Here, neighbors are defined as municipalities sharing a common border. It is also assumed that the effects of a highly educated population is not limited to the municipality but instead tend to affect the net migration into neighboring municipalities. In other words, academic research as well as human capital is assumed to be a (local) public good.

Formally, we assume that the systematic part of net migration into region i between years t - T and t can be approximated by a function such as

$$m_{i,t} = f^m (Y_{i,t-T}, Y_{j,t-T}, \boldsymbol{h}_{i,t-T}, \boldsymbol{h}_{j,t-T}, \boldsymbol{g}_{i,t-T}, \boldsymbol{p}_{i,t-T}) \forall i, j \text{ where } i \neq j$$
(1)

where the vector h contain information on human capital endowments and research efforts, which affect present and future marginal products of labor. Together with conditions on the local labor market (g), Y and h may be thought of as economic "opportunity" factors. Note also that we allow the initial average income level in municipality i to affect the net migration in neighboring municipalities. The basic intuition behind this is that the average income level may also reflect housing prices. Therefore, an individual who would like to move into municipality i might settle for a neighboring municipality j if the average income level (e.g. house prices) in municipality i is (too) high. Hence, a high income level in municipality i might have a negative effect on the net migration in municipality i while a positive effect on net migration into neighboring municipalities. Net migration into a region may also be affected by characteristics of the local part of the public sector. The vector p contains other characteristics of the regions such as the sum of the local- and regional income tax rate and demographic structure.

Migration is also related to the growth rate of average income. One of the difficulties of interpreting results from regressions of average income growth or average wage growth is that they may reflect changes in the population composition, changes in the technology or both. Barro and Sala-i-Martin (1995, Chapter 11) estimate an equation for the average income growth, where the systematic part depends on the initial level of average income and the rate of net migration were net migration is instrumented for to avoid endogeneity problems. The latter is important in the sense of recognizing that average income growth and net migration may be determined simultaneously. In what follows, we assume that the systematic part of the reduced form equation for the growth rate of the average income can be written on a general form as

$$y_{i,t} = f^{y}(Y_{i,t-T}, Y_{j,t-T}, \boldsymbol{h}_{i,t-T}, \boldsymbol{h}_{j,t-T}, \boldsymbol{g}_{i,t-T}, \boldsymbol{p}_{i,t-T}) \forall i, j \text{ where } i \neq j$$
(2)

Clearly, the variables on the right hand side of equation (1) may affect the growth rate of average income via the rate of net migration, meaning that population movements across municipalities and changes in the population composition are (potentially) important for average income growth. However, even if we were to hold the population constant, these variables may, nevertheless, affect the growth rate of average income (or wages) via their influence on the labor productivity and/or the trade-off between consumption and leisure at time t - T. This is also discussed by Glaeser et al. (1995) in the context of the growth pattern of U.S. cities.

⁵ See Lall and Yilmaz (2001).

ii. Data

The data set used in this study originates from official statistics provided by Statistics Sweden and refers to the Swedish municipalities during the period 1990-2007. During this period, the number of municipalities varied between 284 and 290 making the panel unbalanced.

The initial average income level, $Y_{i,t}$, and the growth rate of the average income level $y_{i,t}$ is calculated for the subpopulation aged 20 or above. This enables us to avoid at least part of the dependence of average income on changes in the age composition of the population. This is reasonable since we disregard natural population growth. The net migration rate $m_{i,t}$ is measured as migration into a municipality minus the migration out of that municipality. Individuals migrating into (out of) municipality *i* can either come from (go to) another municipality or abroad. Consequently, the sum of net migration levels over the municipalities is not necessarily equal to zero.

The number of dissertations are divided into two groups where the variable $R\&D^S$ contain the number of dissertations in the fields of mathematics, medicine and natural science, while $R\&D^O$ contain the number of dissertations in all other fields. The main reason behind this division is to capture potentially differences in the effects from different types of research.⁶ Note that R&D is measured in levels which mean that R&D is treated as a public good. $Hcap^H$ is defined as the share of the population aged 25 or above with at least 3 years of university studies and $Hcap^L$ is defined as the share of the population aged 25 or above with a university education less than 3 years. The unemployment rate, *Unemp*, is defined as the share of the working force that is unemployed.

Variable	Mean	St. dev.	Min.	Max.			
$\mathcal{Y}_{i,t}$	1.09	0.08	0.83	1.37			
$m_{i,t}$	1.00	0.03	0.89	1.19			
$Y_{i,t-T}$	65.39	10.85	45.89	151.33			
$Hcap_{i,t-T}^{H}$	0.12	0.06	0.04	0.54			
$Hcap_{i,t-T}^{L}$	0.14	0.04	0.06	0.35			
$R\&D_{i,t-T}^{S}$	113.60	103.51	0.50	366			
$R\&D_{i,t-T}^{O}$	28.27	33.97	0	153			
$LT_{i,t-T}$	31.29	1.33	25.70	34.41			
$Unemp_{i,t-T}$	0.06	0.03	0.01	0.17			
Children _{i,t-T}	0.08	0.01	0.05	0.13			
$Young_{i,t-T}$	0.12	0.01	0.06	0.16			
$Old_{i,t-T}$	0.19	0.04	0.06	0.30			
$Dens_{i,t-T}$	124.45	410.99	0.21	4228.24			

Table 1.	Descriptive	statistics.	Т	= 5.
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The average income growth and net migration rate may also depend on other variables such as local income tax rates and demographic factors. Here, the local income tax rate (LT) is defined as the sum of the local and regional income tax rate and the demographic factors included are population

⁶ The different econometric estimations presented in the paper has also been estimated with $R \& D = R \& D^S + R \& D^O$. However, the results are in practice the same as those presented here.

density (*Dens*), the percentage of the population below 6 years of age (*Children*), between 7 and 15 years of age (*Young*) and the percentage aged 65 or above (*Old*). Descriptive statistics of the variables in the data set are found in Table 1.

iii. Empirical specification and econometric issues

To test for potential spillover effects from academic research on net migration and average income growth in neighboring municipalities, we make use of spatial econometric techniques.⁷ There are typically two types of spatial models. One is the spatial error model where the spatial effect is captured in the error term. The interpretation of a significant spatial effect in these models is that an external chock to the system will spread across all locations. The other, which is used here, is the spatial lag model which is commonly used to, for instance, estimate reaction functions when it comes to testing for potential spillover effects in the provision of local public services.⁸ As we are interested in direct effects of conditions in one municipality on the growth rates in neighboring municipalities, a spatial lag model is used. The lag model is also used in many previous studies on regional growth, see among others Ramajo et al. (2008), Dall'erba and Le Gallo (2008) and Mohl and Hagen (2010).

One issue in spatial econometric models is the definition of neighbors which has to be done prior to estimation of the parameters in the model. One of the most commonly used definitions of neighbors is based on the criteria that jurisdictions share a common border, a definition which is also used in this paper. The motivation is that we are interested in if the academic research that takes place at a specific university or university college has any effects on the growth pattern in just neighboring municipalities. The use of a geographical measure of closeness is also in line with many previous studies on economic growth using spatial econometrics, see among others Ertur and Koch (2006) and Mohl and Hagen (2010) who uses the 10 nearest neighbors. However, other definitions are also possible such as the geographical distance between the center of the jurisdictions, distance in population densities, political representation in the local government etc.

To be more specific regarding the empirical set up. Let n be the number of observations in the data set and consider a matrix \mathbf{W} of dimension $(n \times n)$ where $\mathbf{W} = \{w_{ij}\}$ such that $w_{ij} = 1 \forall i \neq j$ if i and j are neighbors, otherwise $w_{ij} = 0$.⁹ Especially, note that $w_{ii} = 0$. Here, $w_{ij} = 1$ if i and j share a common border, otherwise $w_{ij} = 0$. Using row-standardized weights, which is preferably, $\sum W_i = 1$. Based on this and the discussion above, the average income growth and net migration rate are assumed to develop according to

$$\begin{aligned} y_{i,t} &= \alpha_{i,t}^{y} + \beta_{1}^{y} \times \ln(Y_{i,t-T}) + \rho_{1}^{y} \times \mathbf{W} \times \ln(Y_{i,t-T}) + \beta_{2}^{y} \times \left(R \& D_{i,t-T}^{S}\right) + \rho_{2}^{y} \times \mathbf{W} \times \left(R \& D_{i,t-T}^{S}\right) + \\ \beta_{3}^{y} \times \left(R \& D_{i,t-T}^{0}\right) + \rho_{3}^{y} \times \mathbf{W} \times \left(R \& D_{i,t-T}^{0}\right) + \beta_{4}^{y} \times \ln(Hcap_{i,t-T}^{H}) + \rho_{4}^{y} \times \mathbf{W} \times \ln(Hcap_{i,t-T}^{H}) + \\ \beta_{5}^{y} \times \ln(Hcap_{i,t-T}^{L}) + \rho_{5}^{y} \times \mathbf{W} \times \ln(Hcap_{i,t-T}^{L}) + \beta_{6}^{y} \times \ln(Unemp_{i,t-T}) + \beta_{7}^{y} \times \ln(LT_{i,t-T}) + \\ \beta_{8}^{y} \times \ln(Children_{i,t-T}) + \beta_{9}^{y} \times \ln(Young_{i,t-T}) + \beta_{10}^{y} \times \ln(Old_{i,t-T}) + \beta_{11}^{y} \times \ln(Dens_{i,t-T}) + \\ \varepsilon_{i,t}^{y} &= 0. \end{aligned}$$

⁷ For an introduction to spatial econometrics, see the seminal work by Anselin (1988).

⁸ See Revelli (2005) for an overview.

⁹ Hence, as **W** is of dimension $(n \times n)$ it is not possible to estimate the elements in **W** together with the other parameters in the model.

and

$$\begin{split} m_{i,t} &= \alpha_{i,t}^{m} + \beta_{1}^{m} \times \ln(Y_{i,t-T}) + \rho_{1}^{m} \times \mathbf{W} \times \ln(Y_{i,t-T}) + \beta_{2}^{m} \times \left(R \& D_{i,t-T}^{S}\right) + \rho_{2}^{m} \times \mathbf{W} \times \\ \left(R \& D_{i,t-T}^{S}\right) + \beta_{3}^{m} \times \left(R \& D_{i,t-T}^{O}\right) + \rho_{3}^{m} \times \mathbf{W} \times \left(R \& D_{i,t-T}^{O}\right) + \beta_{4}^{m} \times \ln(Hcap_{i,t-T}^{H}) + \rho_{4}^{m} \times \mathbf{W} \times \\ \ln(Hcap_{i,t-T}^{H}) + \beta_{5}^{m} \times \ln(Hcap_{i,t-T}^{L}) + \rho_{5}^{m} \times \mathbf{W} \times \ln(Hcap_{i,t-T}^{L}) + \beta_{6}^{m} \times \ln(Unemp_{i,t-T}) + \beta_{7}^{m} \times \\ \ln(LT_{i,t-T}) + \beta_{8}^{m} \times \ln(Children_{i,t-T}) + \beta_{9}^{m} \times \ln(Young_{i,t-T}) + \beta_{10}^{m} \times \ln(Old_{i,t-T}) + \beta_{11}^{m} \times \\ \ln(Dens_{i,t-T}) + \varepsilon_{i,t}^{m} \end{split}$$

$$\end{split}$$

where α , β , and ρ are parameters to be estimated and $\varepsilon_{i,t}$ is white noise.

The main hypothesis to be tested boils down to significance tests of the parameters β_1 to β_5 and ρ in equations (3) and (4). A significant β -estimate is referred to as a direct effect, e.g. a specific initial condition in municipality *i* affect the subsequent growth pattern in municipality *i*. A significant ρ -estimate is referred to as a spillover effect, e.g. a specific initially condition in municipality *i* affect the subsequent growth pattern in municipality *j* if *i* and *j* are defined as neighbors.

The concept of conditional convergence, that $\partial y_{i,t}/\partial Y_{i,t-T} < 0$, is tested by the sign and significance of β_1^y . If $\beta_1^y < 0$ we shall interpret this result as being consistent with the concept of conditional convergence. That is, municipalities with initially lower average income levels tend to "catch" up in terms of average income levels with municipalities with initially high average income levels. If ρ_1^y and/or ρ_1^m are negative, this means that the initial average income level in one municipality has a negative effect on the average income growth and net migration rates in neighboring municipalities respectively. The effect of academic research relates to the parameters β_2 , β_3 , ρ_2 , and ρ_3 . The hypothesis is that academic research has not only a positive direct effect on the local growth rates (e.g. that $\beta_2, \beta_3 > 0$) but also a positive effect (a spillover effect) on neighboring municipalities (e.g. that $\rho_2, \rho_3 > 0$. In a similar way, the parameters β_4, β_5, ρ_4 , and ρ_5 relates to the endowments of human capital.

Using an annual panel data set covering all Swedish municipalities over a period of 17 years gives a wide range of possible specifications of equations (3) and (4). What has become "standard" procedure within the growth literature is to, in our case, choose either T = 17, or divide the sample in a number of intervals, for instance, five year intervals with t = 2007, 2002, 1997 and T = 5. The first example will leave us with $1 \times n$ observations, the second with $3 \times n$ observations. As an alternative, equations (3) and (4) could be estimated as a "panel data" model with T = 5. There are at least two advantages with the panel data set up. First, the estimates will be less sensitive for the choice of time period and intervals (e.g. the choice of t and T). Second, the number of observations increase to $(11 \times n)$ if T = 5 and values at time t - 6 and t - 7 could be used as instruments for potentially endogenous variables. We estimate both the "benchmark" model with T = 5 and t = 2007,2002 and 1997 and the "panel data" model, without spatial effects (Model 1) and with spatial effects (Model 2). As is well known from the literature on spatial econometrics, estimating equations like (3) and (4) using ordinary least squares (OLS) yield biased and inconsistent estimates.¹⁰ Therefore, inferences based on OLS estimates may be misleading. Instead, maximum likelihood (ML), instrumental variable (IV) or Generalized Methods of Moments (GMM) techniques are often used. Here, and in accordance with among many others, Dall'erba and Le Gallo (2008), IV-estimation is

¹⁰ For more details, see Anselin (1988).

used. Note also that all models are estimated with municipal fixed effects. Instruments used for Y and, when included in the model, $\mathbf{W} \times Y$, are the number of widows in the municipality at time t - 7 together with $Y_{i,t-7}$ and $\mathbf{W} \times Y_{i,t-7}$. The Hansen J statistics presented together with the parameter estimates suggest that the instruments are valid. Moreover, the Kleibergen-Paap underidentification LM and Wald tests reject the null hypotheses at the 95 percent level of significance suggesting that the instruments are adequate to identify the equation.

3. Results

Parameter estimates of the benchmark and panel models are presented in Table 2 and 3 below. In all models, the initial average income level is estimated to have a negative impact on the subsequent average income growth. This suggests that initially "poorer" regions tend to "catch up" with initially "richer" regions which are in line with the concept of conditional convergence. This result is of interest from a policy perspective as it suggests a "natural" equalization of average income levels over time and hence an equalization of taxbases per capita. Income convergence is also found in studies including spatial effects such as Dall'erba and Le Gallo (2008), Ramajo et al. (2008), and Mohl and Hagen (2010). It also confirms the findings based on Swedish data (Persson (1997), Aronsson et al. (2001), and Lundberg (2003, 2006)). However, this process is very slow as the parameter estimates indicate an annual rate of convergence between of less than 0.38 and 0.10 percent (the estimate divided by the time period). The results also suggest the net migration rate to be negatively correlated with the initial average income level. One potential explanation for this is that high average income levels tend to have a positive impact on housing prices which, in turn, has a negative effect on net migration. However, this effect is only significant in one out of 4 equations. Moreover, the results presented in Table 2 and 3 give no clear support for the hypothesis that the initial average income level has any effect on the subsequent average income growth or the net migration rate in neighboring municipalities. Based on these estimates, we conclude that our results give support to the hypothesis of conditional convergence while no clear evidence in favor of the hypothesis of spillover effects from high average income levels on the growth pattern in neighboring municipalities.

Turning to human capital, the share of the population with higher education is estimated to have a positive impact on the average income growth. The effects from the share of the population with a less than 3 years of university studies $(Hcap^L)$ is stronger than the effect from the share of the population with at least 3 years of university education $(Hcap^H)$. This partly contradicts the results presented in Petrakis and Stamatakis (2002) who find primary and secondary education to have a stronger effect on growth in less developed countries while the opposite in more developed countries. However, they divide the educational level in primary and secondary education while here the educational level is divided into different levels of higher education. However, when spillover effects are introduced (Model 2), the effect from $Hcap_{i,t-T}^H$ on $y_{i,t}$ is no longer significant and even change sign. In addition, both $Hcap^L$ and $Hcap^H$ are estimated to have a positive effect on $y_{j,t}$. One potential explanation for this result relates to commuting. In order to exploit their full earning potential,

Table 2. Parameter estimates of the "benchmark" model by 2SLS.

	Model 1		Model 2	
Dependent variable	$y_{i,t}$	$m_{i,t}$	$y_{i,t}$	$m_{i,t}$
$Y_{i,t-T}$	-0.009 (-5.76)	-0.002 (-3.09)	-0.008 (-3.78)	-0.001 (-0.65)
$\mathbf{W} \times Y_{i,t-T}$	-	-	-0.002 (-0.69)	-0.002 (-2.10)
$Hcap_{i,t-T}^{H}$	0.115 (4.34)	0.040 (2.90)	-0.026 (-1.11)	0.006 (0.36)
$\mathbf{W} \times Hcap_{i,t-T}^{H}$	-	-	0.194 (4.90)	0.074 (2.65)
$Hcap_{i,t-T}^{L}$	0.184 (8.77)	0.012 (0.98)	0.090 (4.38)	-0.008 (-0.59)
$\mathbf{W} \times Hcap_{i,t-T}^L$	-	-	0.202 (5.93)	0.040 (1.93)
$R\&D^S_{i,t-T}$	0.001 (0.25)	-0.001 (-2.73)	0.001 (0.42)	-0.001 (-1.88)
$\mathbf{W} \times R \& D_{i,t-T}^S$	-	-	0.001 (0.92)	0.001 (068)
$R\&D^{O}_{i,t-T}$	-0.001 (-0.13)	-0.001 (-1.08)	-0.001 (-0.66)	-0.001 (-1.12)
$\mathbf{W} \times R \& D_{i,t-T}^{O}$	-	-	-0.001 (-1.36)	-0.001 (-2.13)
$LT_{i,t-T}$	0.823 (13.10)	-0.092 (-2.22)	0.587 (8.48)	-0.141 (-2.83)
$Unemp_{i,t-T}$	-0.008 (-0.81)	-0.030 (-5.57)	-0.002 (-0.21)	-0.029 (-5.65)
$Children_{i,t-T}$	-0.045 (-1.72)	0.025 (1.72)	-0.018 (-0.67)	0.028 (1.93)
$Young_{i,t-T}$	0.098 (3.69)	0.022 (1.23)	0.069 (2.70)	0.021 (1.18)
$Old_{i,t-T}$	0.104 (3.66)	0.073 (3.84)	0.058 (2.31)	0.061 (3.21)
$Dens_{i,t-T}$	0.236 (5.37)	-0.084 (-3.37)	0.282 (6.32)	-0.046 (-1.66)
Kleibergen-Paap LM statistic	21.16 (0.000)	21.16 (0.000)	42.46 (0.000)	42.46 (0.000)
Hansen J statistic	0.999 (0.318)	2.483 (0.115)	1.306 (0.253)	3.742 (0.053)

Note: *t*-statistics are reported within parenthesis.

Table 3.	Parameter	estimates	of the	panel	mod	dels l	by 2	SLS.

	Model 1		Model 2		
Dependent variable	$y_{i,t}$	$m_{i,t}$	$y_{i,t}$	$m_{i,t}$	
$Y_{i.t-T}$	-0.0055 (-7.44)	-0.0004 (-0.68)	-0.0193 (-6.20)	-0.0006 (-0.39)	
$\mathbf{W} \times Y_{i.t-T}$	-	-	0.0059 (1.97)	0.0005 (0.40)	
$Hcap_{i,t-T}^{H}$	0.084 (9.85)	0.004 (-0.55)	-0.028 (-1.93)	-0.015 (-1.47)	
$\mathbf{W} \times Hcap_{i,t-T}^H$	-	-	0.244 (8.94)	0.011 (0.74)	
$Hcap_{i,t-T}^{L}$	0.194 (21.59)	-0.036 (-6.08)	0.039 (2.25)	-0.042 (-4.12)	
$\mathbf{W} \times Hcap_{i,t-T}^L$	-	-	0.208 (12.15)	0.011 (1.02)	
$R\&D_{i,t-T}^S$	-0.047 (-0.46)	-0.115 (-3.53)	0.147 (1.68)	-0.129 (-3.21)	
$\mathbf{W} \times R\&D_{i,t-T}^S$	-	-	0.512 (2.40)	-0.161 (-1.55)	
$R\&D_{i,t-T}^O$	0.200 (0.79)	-0.223 (-2.67)	-0.079 (-0.41)	-0.238 (-2.66)	
$\mathbf{W} \times R\&D_{i,t-T}^{O}$	-	-	-0.056 (-0.17)	0.246 (1.13)	
$LT_{i.t-T}$	0.071 (3.75)	-0.034 (-2.25)	0.179 (4.42)	-0.037 (-1.88)	
$Unemp_{i.t-T}$	0.021 (4.46)	-0.015 (-3.91)	-0.013 (-2.08)	-0.013 (-3.11)	
$Children_{i.t-T}$	0.052 (4.76)	-0.045 (-5.01)	0.050 (2.29)	-0.040 (-3.78)	
$Young_{i,t-T}$	0.007 (0.38)	-0.009 (-0.55)	0.137 (4.65)	-0.014 (-0.79)	
$Old_{i.t-T}$	0.060 (3.62)	0.057 (4.45)	0.088 (4.18)	-0.056 (3.73)	
Dens _{i.t-T}	0.021 (1.17)	-0.125 (-6.50)	0.173 (5.71)	-0.125 (-5.36)	
Kleibergen-Paap LM statistic	99.90 (0.000)	99.90 (0.000)	58.23 (0.000)	32.66 (0.000)	
Hansen J statistic	1.68 (0.641)	6.73 (0.081)	1.76 (0.415)	6.51 (0.089)	

Note: *t*-statistics are reported within parenthesis.

individuals with higher education (ability) tend to look for work over a larger area compared to individuals with less education and therefor tend to commute to a higher extend. As they commute

to work in a neighboring municipality, they contribute to the productivity in these municipalities leading to higher average income growth.

From our estimates, the effect of higher educational level on the subsequent and net migration rate is not clear. The parameter estimates presented in Table 2 and 3 are in some cases insignificant, and do also alter in sign between models. Therefore, we settle with the observation that our estimates give no clear evidence regarding the effect from Hcap on net migration.

Based on the results presented in Table 2 and 3, research activities at universities and university colleges, here measured as the number of dissertations produced annually, does not have a clear cut effect on the regional growth pattern. In Model 1, the effect from $R\&D^S$ on migration is negative and significant, but this effect disappears when spatial effects are introduced in the benchmark model. In the panel data estimations the negative effect on net migration is clearer. However, we find no evidence in favor of a positive effect from R&D on y. Still, these results are of interest from a policy perspective as it suggests that if academic research has any effect at all on the regional growth pattern, the effect is a negative impact on net migration. One potential explanation is that academic research is not easily transferred into "productive" use in the jurisdiction where the university is located. That is, the local economy in the in many respects small municipalities hosting a university or university colleges in Sweden are not able to take the full benefits from academic research. So even if the country as a whole benefit from academic research, this effect is not measurable at the local level. Another explanation for the insignificant effects on average income growth presented here is that a longer time period may be needed in order to capture the local effects of a university or university college. One explanation for the negative effect on net migration in neighboring municipalities could be that as a majority of the universities and university colleges are located in the main municipality in areas otherwise scarcely populated, the university or university college tend to "drain" these municipalities on inhabitants.

The combination of the results from R&D and Hcap on the subsequent growth pattern is interesting. Assume R&D to reflect very high and specific knowledge not easily transferred to the public and at the same time needed to "produce" and to get high quality Hcap. Moreover, assume Hcap to be a "light" version of R&D which is easily transformed into higher productivity. Then our results suggests human capital to be of importance for average income growth while the location of the "production site" (e.g. the university) is not. It should also be noted that Hcap is higher in municipalities where the universities and university colleges are located, which is also one potential explanation for our results.

According to, among others, Helms (1985), public investments in infrastructure tends to have a positive effect while public consumption tends to have a negative impact on the regional growth pattern. As the estimates presented in Table 2 and 3 suggests the local income tax rate, *LT*, to have a positive effect on income growth this indicate that local public governments use a relatively large share of tax incomes on investments. Moreover, the local income tax rate also tend to have a negative impact on migration, which could mean that lower educated or individuals with lower incomes (low productivity) tend to move away from municipalities with high income taxes. It may also be that a high quality in public services is an important factor to produce other goods. That is, a good quality in child care and elder care may facilitate the productivity of the workforce. On the other hand, high income taxes usually tend to cause out migration of high income individuals. As it is

not possible from our data to determine whether it is high or low income individuals who migrate due to high income taxes or to what extend municipalities spend tax revenues on investments, it is difficult to discriminate between these explanations.

Unemployment, *Unemp*, is estimated to have a negative effect on migration while no unambiguous effect on income growth. These results indicate that even if high unemployment rates tend to cause out migration, the proportion of high skilled and low skilled is unaffected leaving the average productivity unaffected and so also the average income growth. The unemployment rate is also an indicator of economic opportunities, which is confirmed by our results.

So, why do we not find any clear evidence in favor of the hypothesis that academic research, or at least that the amount of human capital $(Hcap^H)$ has a strong and unambiguous positive effect on the local growth pattern? And it's not a failing mark for the general political trust in that greater human capital and increased resources on research leads to increased growth and attractiveness in terms of positive net migration? There might be several explanations for this. First, the number of dissertations may be a blunt measure of academic research and that academic research contain so many other aspects not captured by this measure. Second. individuals tend to move to a university town *i* to get their academic education and then move to the (neighboring) municipality *j* after they have finished their education leaving the net migration rate unaffected in municipality *i*. This is one potential explanation why we get the positive correlation between $W \times Hcap$ and *Y*. From a policy perspective it is interesting to note the positive effect of Hcap in combination with the unclear effects of R&D on the subsequent average growth. This suggests that human capital is of importance for regional growth while the location of the production of human capital is not.

4. Conclusions

The main purpose in this paper has been to empirically analyze to what extend academic research, here measured as the number of dissertations at the separate universities and university colleges, have had any effect on the regional growth pattern. We have also tested the hypothesis that academic research does not only affect the regional growth pattern in the municipality where the university or university college is located but spread to neighboring municipalities. These issues are of importance from a policy perspective as the location of new universities and university colleges in Sweden have partly been based on the presumed belief among decision makers that the positive effects from a university or university college will "spillover" to neighboring municipalities. The analysis has been based on a data set covering Swedish municipalities during the period 1990-2007.

The main findings are that academic research only has limited impact on the regional growth pattern. One potential explanation for this result is that even though academic research might have a positive effect on economic growth at the national level, the in many respects small municipalities in Sweden where many of the universities and university colleges are located do not have the resources and/or infrastructure needed in order to fully benefit from academic research in terms of higher average income levels and a positive net migration rate. However, our results suggest a positive correlation between the initial educational level and the subsequent average income growth which suggests that the availability of human capital is of importance for regional growth. In combination with the unclear effect of academic research on the regional growth pattern, our results suggests that human capital is of importance for regional growth while the location of the production of human capital is not.

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