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Abstract

Based on a sample of 1,084 European regions (EU15) over the period 1995-2004, we estimate the determinants of regional growth of GDP per capita, allowing for both spatial lag and spatial error dependence. We find that robust LM tests can not reject the null hypothesis of no spatial dependence when country dummy variables are included in the growth equation. OLS and robust regression methods show that population density and industry share are significantly and positively related to economic growth. Regions that received EU structural funds have a significantly higher growth of GDP per capita, but the effect is only marginally significant. Blinder-Oaxaca decompositions reveal that the growth differential between Objective 1 regions and the remaining regions is solely due to the difference in the characteristics and not to differences in the coefficients. Finally, we find that the added value gained in Objective 1 regions is much lower than the resources that have been alloacted to them.

Keywords: regional growth, EU's structural funds, Objective 1 funding, spatial dependence, urbanisation

JEL Classification: C14, O52, R11, R15

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1. Introduction

Average growth rates of GDP per capita are highly variable among European regions. Given the differences in economic growth at the EU regional level, studies on the determinants of regional economic growth have drawn increasing attention from academics and policy experts. It is widely accepted that initial GDP per capita, degree of urbanisation and spatial effects are important determinants of regional growth of GDP per capita and/or labour productivity (see, among others, Armstrong 1995; López-Bazo et al. 2004; Badinger et al. 2004; Carrington 2003; Ertur et al. 2006; Ciccone 2002; Fingleton 2001). Furthermore, a number of studies investigate the impact of the EU's structural funds on economic growth. Using data at the NUTS 2 level, previous studies find a positive but small impact of Objective 1 funding on growth of GDP per capita (see Beugelsdij/Eijffinger 2005; Puigcerver-Peñalver 2007; Cappelen et al. 2003; Rodriguez-Pose/Fratesi 2004; Ederveen et al. 2006). Other scholars find that country dummies reflecting aggregate country-specific factors also play an important role in explaining regional economic growth. For instance, using data on European regions, Attfield et al. (2000) find that spatially correlated growth is explained by regional dummies and initial incomes, but that geographical proximity per se does not matter. Other studies investigate the relationship between the industrial structure and growth of GDP per capita. It is often argued that a high share of agriculture hinders economic growth. Cappelen et al. (2003) confirm findings on the EU results for the US (Deller et al. 2003; Monchuk et al. 2006), namely that the employment share of agriculture is significantly and negatively related to regional growth.

In this paper we adopt a spatial econometric approach to analyse the growth effects of the EU structural funds for the Objective 1 regions. Spatial econometrics has been used extensively in studies on regional growth (see Abreu et al. 2005 for a recent literature review). This technique allows us to measure the extent to which the growth rate of one region depends upon that of its neighbours. The main novelty of the paper is that we use a level of aggregation much lower than the level used in other studies. In particular, we estimate the determinants of regional growth of GDP per capita as a function of initial level of GDP per capita (measured in purchasing power parity), share of primary and secondary sectors, whether or not the region in question received EU structural funds (Objective 1 area), population density (measured as regional population in working age per square kilometre). The empirical growth model is tested for robustness using different specifications and enhanced by a spatial econometrics approach (i.e. a spatial lag model and a spatial error model). Furthermore, our empirical analysis also addresses the problem of outliers that may significantly distort the results. It is well known that data quality at the NUTS 3 level is often lower than at the NUTS 2 level. We employ both robust estimation techniques and use outlier detection methods. Finally, in order to investigate the sources of the growth differential between Objective 1 and other regions, we apply Blinder-Oaxaca decomposition.

2. Empirical model

There are a number of socio-economic and regional characteristics that influence economic growth. The growth empirical model explaining regional growth can be described as follows:

$$\overline{\Delta}Y_i = \beta_0 + \beta_1 \log(Y_{i,95}) + \beta_2 shagr_i + \beta_3 shind_i + \beta_4 \log(density)_i + \beta_5 sfob1_i + \sum_{j=1}^{N} \theta_j co_{ij} + e_i,$$

where $\overline{\Delta}Y_i$ denotes the average annual growth rate of GDP per capita in pps in the period 1995-2004, $\log(Y_{i,95})$ denotes the initial level of per capita GDP in pps for the year 1995, *shagr* denotes the share of value added in the primary sector (NACE A and B) as a percentage of total value added, *shind* is the industry share of value added (NACE C to E), and *density* is the population density measured as population per square kilometre. *sfob1* is dummy variable indicating whether the region in question received priority funding as an Objective 1 region. e_i is the error term – that is, $N(0,\sigma^2)$ – and co_{ij} is a set of dummy variables taking the value 1 if the region is part of country j and zero otherwise.

OLS estimation of the parameters can be biased or inefficient in the presence of spatial dependence. In particular, spatial dependence occurs when the dependent variable or error term in each region is correlated with the dependent variable or error term in a neighbouring region. In order to account for spatial effects, we first use the spatial error model in which spatial dependence affects the error term. The growth equation including spatial error dependence can be written as:

$$\overline{\Delta} Y_i = \beta_0 + \beta_1 \log(Y_{i,95}) + \beta_2 shagr_i + \beta_4 shind_i + \beta_5 \log(density)_i + \beta_6 sfob1_i + \sum_{j=1}^{N} \theta_j co_{ij} + u_i \text{, and}$$

$$u = \lambda W \varepsilon + \varepsilon^* \text{,}$$

where parameter λ is a coefficient of the spatially correlated errors indicating the extent of spatial correlation between the residuals. A negative parameter implies that the errors of the opposite sign are clustered together geographically. An alternative way to incorporate spatial effects is to use the spatial lag model, which accounts for spatial dependence by including the serially autoregresssive term of the dependent variable (Anselin/Bera 1998):

$$\overline{\Delta} Y_i = \beta_0 + \rho W \overline{\Delta} Y_i + \beta_1 \log(Y_{i,95}) + \beta_2 \sigma_i + \beta_3 shagr_i + \beta_4 shind_i + \beta_5 \log(density)_i + \beta_6 sfob1_i + \sum_{j=1}^{N} \theta_j co_{ij} + \varepsilon_i \text{,}$$

where *W* denotes a distance-based weight matrix and ρ is the spatial lag parameter. Each element of the matrix is proportional to the inverse of the Euclidean distance in kilometres between the centres of the regions. The distance matrix is row-standardised such that each row adds to unity. The spatial lag parameter ρ can be positive or negative. Positive spatial dependence indicates that the growth in neighbouring regions affects a region's growth rate positively. Negative spatial dependence occurs if regions with high growth rates are located alongside those with low growth rates, or vice versa. This is commonly referred to as the existence of a "checkerboard pattern" (Anselin/Bera 1998). The parameters of both spatial models can be estimated by maximum likelihood. In the case of spatial autocorrelation, OLS is still unbiased but no longer efficient. However, OLS is biased in the presence of spatial lag effects resulting from misspecification in omitting a significant explanatory variable in the regression model. The specification of the weights matrix is the sensitive point of the spatial econometric modelling. We follow the spatial literature by using weights on geographical distance, as its exogeneity is unambiguous (Anselin/Bera, 1998).

We advance a number of hypotheses concerning the determinants of regional economic growth. First, we expect the impact of Objective 1 funding to be positive. The second hypothesis concerns the presence of ß convergence, which exists if the coefficient of initial GDP per capita is negative and significant. This means that regions with a low GDP per capita grow faster than those with higher GDP per capital. The literature on ß convergence for EU regions agrees that while the impact of initial GDP per capita is significantly negative, the rate of convergence is very slow (see, among others, Le Gallo and Dall'erba 2006; López-Bazo et al. 2004). Third, we expect a high share of value added in agricultural sector to have a negative impact on growth of GDP per capita (see, for example, Deller et al. 2003; Monchuk et al. 2007; and Esposti 2007). This is justified by the fact that in industrialised countries, the income elasticity of demand is lower for primary goods than for manufacturing goods or services. A small share of agriculture is also a proxy for the level of GDP per capita, as the relative size of the agriculture sector decreases as a region develops. Fourth, we expect population density to have a positive impact on economic growth, reflecting the impact of agglomeration and urbanisation.

3. Descriptive statistics

We employ data on the EU-15 NUTS 3 regions (except Luxembourg) from the Eurostat database REGIO, which contains information on GDP per capita in purchasing power standards (PPS), total population, square kilometres, and share of primary and secondary sector in GDP. The regions are classified by whether they receive funding (Objective 1 regions) or not. Note that purchasing power standards are based on national price differences but do not account for differences in the GDP deflator within countries. The growth rate is calculated as the average annual change in GDP per capita in PPS. Eurostat suggests that GDP in PPS should not be used to calculate national growth rates. However, preliminary estimates show that the estimation results are not sensitive with respect to whether GDP is measured in EUR or in PPS.

Table 1 shows the descriptive statistics for the total sample and the two subsamples. The average annual growth rate (in current PPS) between 1995 and 2004 is 4%, with higher growth rates in the Objective 1 regions than in the others. As expected, Objective 1 regions have a low level of GDP per capita (75% of the sample average). This is not surprising, given that it is the necessary criteria for regions applying for Objective 1 funds. Furthermore, Objective 1 regions have a much higher share of agriculture in value added (6% as compared to 3.4%) and a lower population density (234 vs. 588 inhabitants per square kilometre).

Table 1: Descriptive statistics

	means	median	std. dev	min	max
	total sample (# of obs 1084)				
average annual growth of GDP in per capita in current ppp, 1995-2004	4.1	3.9	1.4	0.8	11.6
GDP per capita in current ppp, 1995	15978	14856	7956	5718	68604
population density (persons per km^2)	494	160	1079	2	20529
share of agricultural sector in total GDP	3.4	2.3	3.9	0.0	28.4
share of secondary sector in total GDP	28.2	27.7	9.4	4.0	75.2
	non Objective 1 region (# of obs 796)				
average annual growth of GDP per capita in current ppp, 1995-2004	3.9	3.7	1.2	0.8	10.6
GDP per capita in current ppp, 1995	17415	16221	5667	8235	68604
population density (persons per km^2)	588	199	1220	7	20529
share of agricultural sector in total GDP	2.4	1.8	2.4	0.0	17.9
share of secondary sector in total GDP	29.1	28.5	9.1	5.4	75.2
	Objective 1 region (# of obs 288)				
average annual growth of GDP per capita in current ppp, 1995-2004	4.6	4.7	1.6	1.2	11.6
GDP per capita in current ppp, 1995	12008	10794	11330	5718	31276
population density (persons per km^2)	234	90	429	2	3916
share of agricultural sector in total GDP	6.0	4.4	5.6	0.0	28.4
share of secondary sector in total GDP	25.6	25.5	9.8	4.0	62.7

Note: Figures have been multiplied by 100 (except for population density and GDP per capita). Source: New Cronos, own calculations.

Table 2: Distribution of country dummy variables

	total	non-Objective 1	Objective 1
Austria	3.2	4.0	1.0
Belgium	4.0	5.4	0.0
Denmark	1.4	1.9	0.0
Spain	4.6	1.9	12.2
Finland	1.8	1.5	2.8
France	8.9	12.1	0.0
Germany (east)	10.4	0.1	38.9
Germany (west)	30.1	41.0	0.0
Greece	4.7	0.0	17.7
Ireland	0.7	0.6	1.0
Italy	9.5	9.2	10.4
Netherlands	3.7	5.0	0.0
Portugal	2.8	0.6	8.7
Sweden	1.9	1.9	2.1
United Kingdom	12.3	14.8	5.2

Note: Figures have been multiplied by 10.

4. Empirical results

Table 5 in the appendix displays the estimation results of the spatial lag and spatial error models of the determinants of regional economic growth, excluding country-specific effects. We provide two different specifications for each type of spatial model, one including and the other excluding country dummy variables. In order to detect the appropriate form of spatial autocorrelation, we use the specific-to-general search approach described in Anselin et al. (1996). We use Lagrange Multiplier (LM) tests and their robust versions. The robust LM error test and the robust LM lag test indicate the presence of spatial dependence in the data when country dummy variables are excluded. However, the LM tests show that the hypothesis of no spatial dependence cannot be rejected when country dummy variables are included.

Since spatial effects seem to be unimportant, the interpretation of the results focuses on the OLS and robust regression estimates. Columns i and ii of Table 3 show the results of median regression and OLS estimates with heteroscedasticity-robust standard errors. Column iii shows the results of the robust regression technique, which is an iterative, weighted-least-squares procedure that controls for outliers. In addition, we employ Cook's distance technique in order to detect possible outliers. About

64 regions exhibit a Cook's distance above the conventional cut-off point. These outliers are located in Greece (about 40%) and to a lesser extent in Germany. Column iv shows the OLS results excluding observations with a residual exceeding the cut off point of 0.0038.

Table 3: OLS and median regression estimates of the regional growth equation

	OLS			median regression			robust regression			OLS exluding outliers		
		(i)			(ii)			(iii)			(iv)	
	coef.		t	coef.		t	coef.		t	coef.		t
log GDP per capita in current ppp, 1995	-0.003		-1.28	-0.005	**	-2.45	-0.005	***	-4.35	-0.005	***	-3.75
log population density	0.001		1.61	0.001	**	2.31	0.001	***	4.09	0.001	***	3.38
share of agriculture in total GDP	-0.032	*	-1.66	0.011		0.58	0.002		0.17	-0.017		-1.36
share of industry in total GDP	0.009	*	1.70	0.017	***	3.08	0.012	***	3.38	0.012	***	3.08
Objective 1 region	0.002	*	1.75	0.002		1.38	0.001		1.14	0.002	*	1.84
Austria	0.004	***	3.10	0.003	*	1.74	0.005		2.5	0.004	**	3.33
Belgium	0.003	***	1.77	0.003		1.26	0.002		1.33	0.002		1.54
Denmark	0.001	***	0.88	0.002		1.27	0.002		0.78	0.003	**	2.53
Spain	0.016	***	11.29	0.015	***	8.76	0.016	***	8.36	0.016	***	13.61
Finland	0.010	***	5.40	0.010	***	3.69	0.011	***	4.56	0.011	***	6.87
Germany (east)	0.005	**	2.40	0.006	***	2.66	0.005	***	2.56	0.004	**	2.29
Germany (west)	-0.005	***	-5.23	-0.005	***	-5.01	-0.005	***	-4.45	-0.006	***	-6.39
Greece	0.012	***	2.96	0.008		1.58	0.000		0.16	0.011	***	4.93
Ireland	0.040	***	8.33	0.039	***	8.51	0.040	***	11.33	0.040	***	24.42
Italy	-0.010	***	-9.91	-0.011	***	-9.07	-0.010	***	-7.14	-0.010	***	-10.49
Netherlands	0.009	***	6.07	0.009	***	6.36	0.009	***	4.97	0.009	***	7.46
Portugal	0.002		0.68	0.001		0.22	-0.001		-0.22	0.000		-0.02
Sweden	0.000		0.08	0.002		0.74	0.002		0.8	0.001		0.35
United Kingdom	0.010	***	6.59	0.009	***	4.86	0.008	***	6.03	0.009	***	6.82
constant	0.061	***	2.85	0.074	***	3.99	0.079	***	6.89	0.080	***	6.10
# of obs		1084			1084			1084			1020	
Adj- R2		0.37									0.48	
Adj- R2 due to country effects		0.35									0.46	

Notes: t-values are based on heteroscedasticity-consistent standard errors.

The comparison of OLS and both the median regression (50% quantile) and the robust regression indicates that there are substantial differences between both estimates. This suggests that OLS is driven by some extreme observations. The results of the robust regression technique and the median regressions show that the convergence coefficient exhibits the expected negative sign and that it is significant at the 5% level. The speed of convergence is about 0.5% per year, which is in line with earlier studies.[1] Furthermore, Objective 1 regions grow faster than other regions, but the effect is only significant at the 10% level based on OLS and OLS-excluding outliers. As expected, we find that the population ratio has a positive and significant effect on growth of GDP per capita. Furthermore, the

[1] The speed of convergence is calculated as $\ln(1-T\beta_1)/T$, where T is the length of the time period.

share of agricultural GDP is negative but not significantly different from zero. This stands in contrast to previous findings based on NUTS 2 data (see, for instance, Cappelen et al., 2003 and Fagerberg/Verspagen, 1996) and results from 2,240 non-metropolitan counties in the US (Deller, Gould and Jones, 2003).

Finally, we investigate the sources of the growth differential between Objective 1 and other regions. Using a variant of the Blinder-Oaxaca decomposition introduced by Oaxaca and Ransom (1994), the growth differential between non-Objective 1 and Objective 1 regions, $\overline{\Delta} Y_{nsf} - \overline{\Delta} Y_{sf}$, can be decomposed into two components:

$$\overline{\Delta} Y_{nsf} - \overline{\Delta} Y_{sf} = \hat{\beta}\left(\overline{X_{nsf}} - \overline{X_{sf}}\right)' + \left[\overline{X_{nsf}}'\left(\hat{\beta}_{nsf} - \hat{\beta}\right) + \overline{X_{sf}}'\left(\hat{\beta} - \hat{\beta}_{sf}\right)\right] = \text{explained part + unexplained part.}$$

The first part of the gap is the characteristics component (i.e. contributions from group differences in the variables) and the second part is the "unexplained" component resulting from differences in the coefficients. $\overline{X_{sf}}$ and $\overline{X_{snf}}$ represent vectors of the mean values of the explanatory variable in the two subsamples, namely Objective 1 and non-Objective 1 regions. $\hat{\beta}_{nsf}$, $\hat{\beta}_{sf}$ and $\hat{\beta}$ denote the vectors of the OLS coefficients of the regressions for the two subsamples and of the coefficients from the pooled sample. We are interested in determining how much of the growth differential can be explained by observable differences between Objective 1 and non-Objective 1 regions in characteristics such as initial GDP per capita, economic structure, and population density. The results in Table 4 indicate that the growth difference between Objective 1 and other regions (about 0.76 percentage points) is almost solely due to the difference in these characteristics (about 0.69 percentage points). The remaining coefficients' effect accounts for 0.06 percentage points and is not significantly different from zero.

Table 4: Blinder-Oaxaca decomposition for the growth difference between Objective 1 and non-Objective 1 regions

average annual growth rate, non-Objective 1 region	0.0386		
average annual growth rate, Objective 1 region	0.0462		
	effect		t-value
difference in growth rate of GDP per capita	-0.0076		
unexplained	-0.0006		-1.33
explained	-0.0069		-7.34
log GDP per capita in current ppp, 1995	-0.0015	**	-1.33
log population density	0.0007	**	2.01
share of agriculture, hunting, forestry and fishing in total GDP	0.0011	*	1.75
share of industry in total GDP	0.0003	**	2.04
country dummies	-0.0076		
Austria	0.0001	*	1.87
Belgium	0.0001		1.45
Denmark	0.0000		0.49
Spain	-0.0018	***	-4.37
Finland	-0.0001		-1.11
Germany (east)	-0.0027	***	-3.78
Germany (west)	-0.0020	***	-4.05
Greece	-0.0024	***	-4.29
Ireland	-0.0002		-0.62
Italy	0.0001		0.59
Netherlands	0.0005	***	3.97
Portugal	-0.0003		-1.12
Sweden	0.0000		-0.07
United Kingdom	0.0010	***	4.24

Note: This table reports the results of the Blinder-Oaxaca decomposition of the growth differential using Oaxaca and Ransom's (1994) methodology.

5. Conclusions

Based on a sample of 1,084 European regions (EU15) over the period 1995-2004, we estimate the determinants of regional growth of GDP per capita as a function of the initial level of GDP per capita measured in (current) purchasing power parity, share of primary and secondary sectors, whether or not each region received EU structural funds (Objective 1 area), and population density. The empirical growth model is tested for robustness using quantile regressions and also accounts for spatial dependence. We also address the problem of outliers.

We find that LM tests cannot reject the null hypothesis of no spatial dependence when country dummy variables are included in the growth equation. Regions that received EU structural funds have a significantly higher growth rate of GDP per capita (0.2 percentage points per year). However, Blinder-Oaxaca decompositions reveal that the growth differential between Objective 1 regions and other regions is solely due to differences in the characteristics and not to differences in the coefficients. Furthermore, we find some evidence that population density has a positive and significant effect on growth of GDP per capita. This indicates that economically larger regions (i.e. regions with a higher density of production factors) exhibit, ceteris paribus, higher labour growth. The share of the primary sector is negative but insignificant. This indicates that a high share of agricultural production is not a burden on future economic growth, as results from other studies suggest. Finally, EU regions show clear evidence of convergence, with poorer regions demonstrating a tendency to grow faster. However, the convergence speed for the regions is quite low (about 0.5 percentage points per year).

During the programme (1994-1999), the EU's contribution of structural funds to Objective 1 regions amounted to €113 billion (at 1999 prices); the member-states spent an additional €493 billion on projects in these regions. The respective amounts for the 2000-2006 period were €129 billion and €628 billion (European Commission, 2006, Tables A.36 and A. 45). Total public expenditures on Objective 1 regions over the two programme periods thus amounted to €1.365 trillion. Using the estimates of growth differentials between Objective 1 regions and non-Objective 1 regions that are explained by regional characteristics (0.2 percentage points per year), we can estimate the growth effect in absolute terms, which amounts to €36 million over the period 1994-2006. Given the low effectiveness of the EU's structural funds in Objective 1 regions, further research clearly needs to be conducted on the impact of Objective 1 funding on economic growth. Currently, only a small number of papers apply regional data to examine this topic and there is still limited evidence concerning the question of which regions actually benefit from Objective 1 contributions. Given the huge discrepancy between the volume of structural funds spent and the resulting growth effects in Objective 1 regions, it seems that most of the benefits are seen in regions not directly addressed.

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Appendix

Table 5: Estimates of the regional growth equation with spatial effects

	spatial error model						spatial lag model					
	country dummies			no country dummies			country dummies			no country dummies		
	coef.		z	coef.		z	coef.		z	coef.		z
log GDP per capita in current ppp, 1995	-0.003		-1.54	-0.007	***	-3.17	-0.003		-1.39	-0.007	***	-3.20
log population density	0.001	**	2.01	0.001	***	3.39	0.001		1.64	0.001	***	3.44
share of agriculture in GDP	-0.029		-1.48	-0.024		-1.46	-0.033		-1.72	-0.018		-1.11
share of industry in total GDP	0.009		1.55	0.014	**	2.49	0.009		1.57	0.014	**	2.45
Objective 1 region	0.003	**	2.02	0.007	***	5.05	0.002		1.79	0.006	***	4.93
<u>country dummy variables:</u>												
Austria	0.006	***	3.53				0.005	***	3.37			
Belgium	0.002		1.24				0.004	**	2.29			
Denmark	-0.003		-1.40				0.001		0.67			
Spain	0.014	***	8.35				0.015	***	10.19			
Finland	0.010	***	4.81				0.010	***	4.92			
Germany (east)	0.003		1.28				0.006	***	2.77			
Germany (west)	-0.006	***	-3.91				-0.004	**	-2.47			
Greece	0.009	**	2.16				0.012	***	3.06			
Ireland	0.038	***	7.61				0.040	***	8.43			
Italy	-0.012	***	-9.18				-0.010	***	-9.11			
Netherlands	0.008	***	4.64				0.009	***	6.06			
Portugal	-0.001		-0.31				0.001		0.50			
Sweden	-0.001		-0.56				0.000		0.25			
United Kingdom	0.011	***	6.08				0.009	***	6.35			
Constant	0.066	***	3.15	0.097	***	4.59	0.103	***	3.08	0.245	***	11.10
spatial error coefficient, λ	-3.101	***	-5.81	-3.547	***	-19.57						
spatial lag coefficient, ρ							-0.974		-1.48	-3.556	***	-19.75
	chi2(1)			chi2(1)			chi2(1)			chi2(1)		
Lagrange multiplier test of lambda=0	2.81		0.09	208.6		0.00	1.44		0.23	222.2		0.00
Robust Lagrange multiplier	1.38		0.24	2.94		0.09	0.01		0.91	16.52		0.00

Notes: The dependent variable is the annual average growth rate of GDP per capital in current ppp. The number of observations is 1,084.

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