THE DETERMINANTS OF REGIONAL GROWTH IN EUROPE: ASSESSING THE ROLES OF SPATIAL SPILLOVERS AND AGGLOMERATION

─ EXTENDED ABSTRACT ─

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1. INTRODUCTION

The determinants of European regional economic growth have been widely investigated by scholars. Generally, the focus has been put not only on classical variables coming from economic groeth theory, but also on further explanatory factors, which generally come from New Economic Geography (NEG) and institutional economics. These factors, among others, rely on soft and hard capital, institutional quality, agglomeration economies, etc.

The objective of this study is to come up with a simple yet robust explanatory model for regional growth in Europe over the period 2000-2011. In this context, we are particularly interested in improving the way the spatial dimension of regional economic growth is taken into account, to better assess (i) the strength of spatial spillovers and (ii) the role of spatial agglomerations. We employ a NUTS-3-based dataset that, compared to coarser regional aggregations, is more effective in capturing spatial heterogeneities and relationships.

With regards to the measuring of spatial spillovers, we will resort to spatial econometric techniques and use spatial weight matrices derived from a dataset with modelled travel time between NUTS-3, different decay functions and the most suitable cut-off distances. From a policy perspective, a good representation of the shape and extent of spatial spillovers, allows for more sound expectations regarding the actual geographical impact of policies with territorial dimension.
According to NEG, spatial agglomerations are associated with regional growth and inequality. Previous empirical estimations, however, show rather heterogeneous results. This could be due to insufficient data availability at detailed spatial scales, making it challenging to measure spatial agglomeration in an efficient manner. In this study we try to overcome this limitation by using an innovative measure of agglomeration at NUTS-3 level derived from the combination of high-resolution population and built-up areas. All the data and methods employed in this study are elements of the LUISA Territorial Modelling Platform, developed by the European Commission for ex-ante evaluation of regional and local impacts of policies and trends.

2. DATA AND METHODS

The empirical strategy is based on an augmented growth equation based on the framework of Barro and Sala-i-Martin (1991):

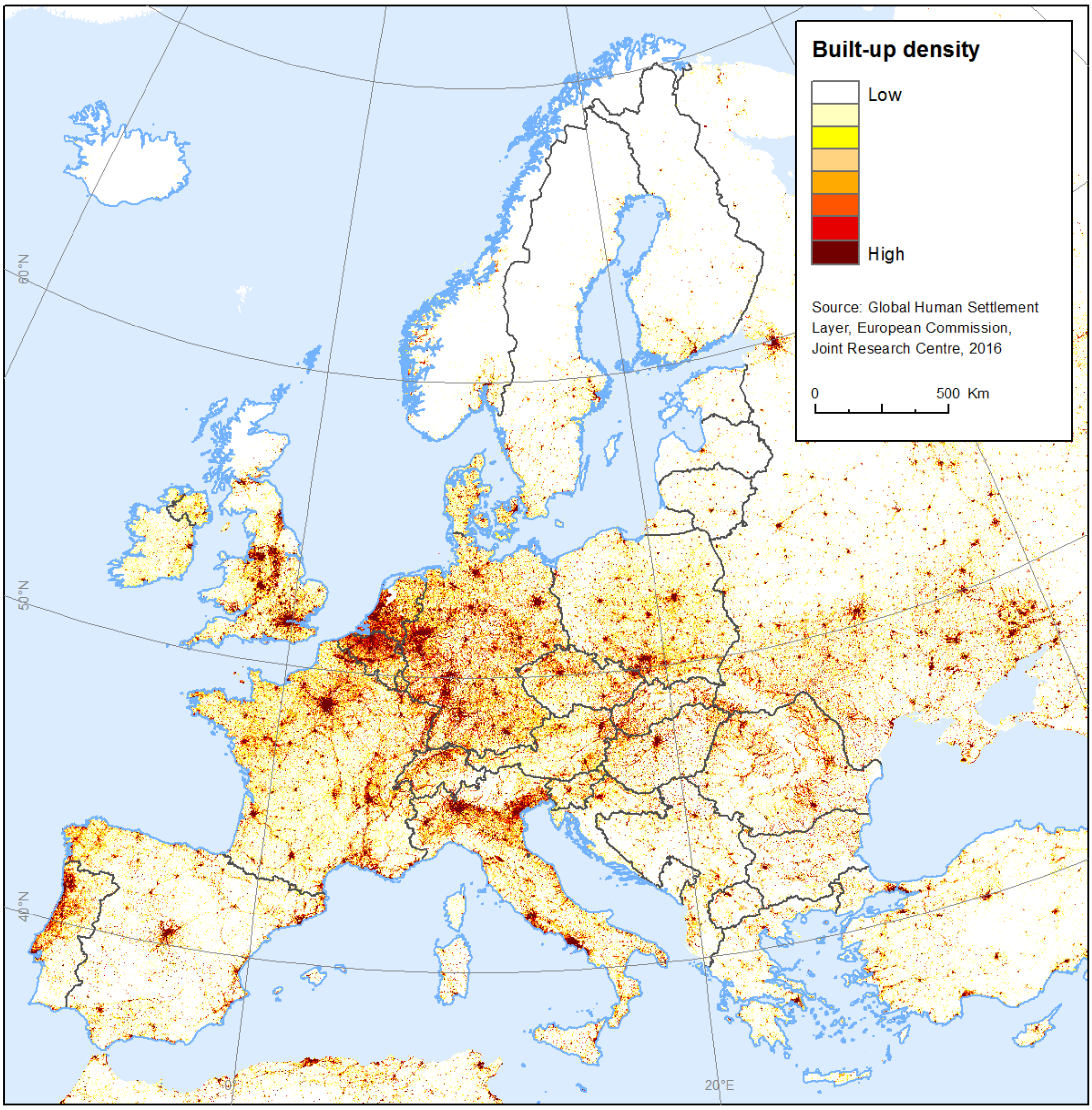
$$\frac{1}{T} ln\left(\frac{y_{i,T}}{yi,0}\right) = \alpha + \beta ln\left(y_{i,0}\right) + \theta ln\left(y_{i,0}\right)^2 + \delta\left(\text{secondary edu.}_0\right) + \vartheta\left(\text{tertiary edu.}_0\right) + \eta\left(\text{capital metro region}\right) + \phi ln(\text{agglomeration}_0) + \varepsilon_i \quad (1)$$

where on the left hand side (LFS) of Eq. (1) we have the average growth of Gross Domestic Product (GDP) per capita between period *0* and *T*, where *0* is year 2000 and *T* is year 2011. On the right hand side (RHS), in addition to the constant α and the GDP per capita at time 2000, y_{i0}, there is a set of additional explanatory variables for the 1290 NUTS-3 regions, including educational levels (percentage of people with secondary and tertiary education), the capital metro region and agglomeration.
While the effect of human capital has been deeply analysed in literature (Kalaitzidakis et al. 2001), our focus is in on the effects of agglomeration and spatial spillovers.
According with the 2009 World Development Report, large cities or highly urbanized areas contribute to regional economic growth economies due to higher investment returns. Capital metro region are among the largest cities in Europe. As highlighted by Dijkstra (2013), this is the product of accumulation of centuries of investment. This is coherent with Myrdal’s theory of cumulative causation (1957) and often it is still valid. In Europe, there are cases of much higher public investments in capital cities than in the rest of country (European Commission, 2010) and this is due to both to national policymakers that favour the national capital for reasons of personal advance and beliefs about its intrinsic productivity advantage (Henderson, 2003).
Following endogenous growth theory, spatial concentration of economic activities produces spillovers with a beneficial effect on innovation which raises average productivity in the agglomeration, and hence the growth of real output (Gardiner et al., 2010). At the same time, the increase of competition within a region can lead to a decline of profits of companies, and the raise of congestion effects with the related negative externalities. These phenomena can reduce regional income inequalities and growth. In this study agglomeration is defined as:

$$\text{agglomeration}_0 = \left(\frac{\text{population}_0}{\text{Residential Built−up Areas}_0}\right) \times \text{population}_0 \quad (2)$$

The first element of the formula, total population over residential built-up areas (see Figure 1) captures the level of geographical concentration of population within each region, while the second element the demographic size of the region. Both density and size are *sine qua non* elements agglomeration.

Figure 1: residential built-up density



Source: own elaboration based on Global Human Settlement Layer.

All the socio-economic data per NUTS-3 were collected from Eurostat online database. The accounting of residential built-up areas per NUTS-3 was done by aggregating fine-scale built-up areas from the combination of Global Human Settlement Layer and CORINE Land Cover. Travel times between NUTS-3 population-weighted centroids are used to construct the **W** matrices necessary for the spatial econometric specifications (see section 3). The construction of population-weighted centroids relied on a high-resolution population grid map (Batista e Silva et al. 2013), whereas travel times are based on the road network used in the TRANS-TOOLS European transport model (Richt et al., 2009) and computed using shortest-path routines in the GeoDMS software (ObjectVision, 2014).
In the case in which the parameter β is statistically significant and negative, the convergence hypothesis holds: poorer economies tend to grow faster than richer ones. In the case in which parameters δ, ϑ, η, ϕ are not statistically significant we can assume absolute convergence, i.e. all regions converge to the same steady state. Otherwise we have conditional convergence, i.e. equilibrium differs across regions, and each one approaches its own steady state equilibrium, dependent on the regions characteristics/conditions.

The parameter θ measures the curvature of the coefficient related to convergence. If β is negative and θ is positive the parabola opens upward; vice versa the parabola opens downward. The estimation of different signs for β and θ suggests the presence of two clubs of regions. In the former case regions converge up to the estimated threshold of GDP per capita level, while divergence trends dominate afterwards. In the second scenario, we would have divergence of regions with initial GDP per capita levels below the estimated threshold, followed by slowdown of the wealthiest economies (Petrakos et al., 2011). The turning point is defined as $-\beta/2\theta$.
The estimation of the equation is performed using standard Ordinary Least Squares (OLS) and spatial econometric techniques (Anselin, 1988). The latter, in fact, allow us not only to deal with spatial dependence in the data, but also to account formally for the spatial spillover effects (Anselin, 2003). If spatial structure is in the residuals of an OLS regression model, this will lead to inefficient estimates of the parameters, meaning that the standard errors of the parameters will be too large. This leads to incorrect inference on significant parameter estimates. When spatial structure is in the data, the value of the dependent variable in one spatial unit is affected by the independent variables in nearby units. In this case the assumption of uncorrelated error terms as well as of independent observations is also violated. As a result, parameter estimates are both biased and inefficient. In the first case a spatial error model will be adopted, and in the second a spatial lag model. The main difference between the two models is that in the estimation of the marginal effect of the variables, spatial lag model needs to account for the coefficient of spatial autoregressive dependent variable, which captures the strength and direction of the spatial spillovers. In this framework, the partial derivative is defined as: $(\mathbf{I}-\rho\mathbf{W})^{-1}\beta = (\mathbf{I}+\rho\mathbf{W}+\rho^{2}\mathbf{W}^{2}\ldots)\mathbf{I}\beta_r$ where $\mathbf{I}$ is the identity matrix, $\mathbf{W}$ the spatial weight matrix, ρ the spatial autoregressive parameter bounded between -1 and 1 and β_r a vector of parameters (Anselin, 2003).

3. PRELIMINARY RESULTS

When using spatial econometric tools, a first, fundamental step is the choice of the spatial weight matrix **W**, as it determines the shape, strength and direction of the spatial spillovers. According to Arbia and Fingleton (2008), the spatial weight is a non-stochastic matrix capturing the hypothesis regarding the nature of the spatial interactions, and its arbitrary creation is often subject to criticism. Hence the scholars suggest forms of sensitivity analysis and theoretical justification to support the choice of weight matrix structures.
In this study we run *spatial lag* and *spatial error* models using different decay functions to determine **W** and different distance cut-off. The distance is defined in minutes of travel time between NUTS-3 population-weighted centroids. The optimal cut-off for each decay function was determined upon the analysis of the improvement to the Akaike Information Criterion (AIC). The decay functions used are as follows:

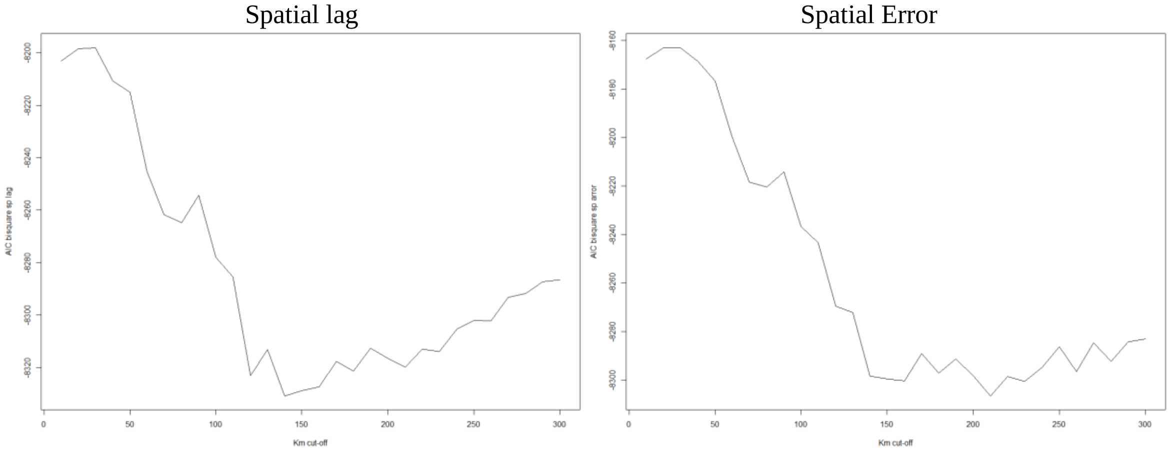
- Gaussian: $exp(-\,dist/cutoff)$
- Gravity: $1/dist^2$

Our preliminary results shown in Figure 2, which shows the relation between the travel time in minutes, on the x-axis, and the AIC, on the y-axis. That ideal cut-off value is where the AIC stops to decrease and is situated around 150 minutes.

Figure 2: decay functions and AIC as a function of distance cut-off values in minutes

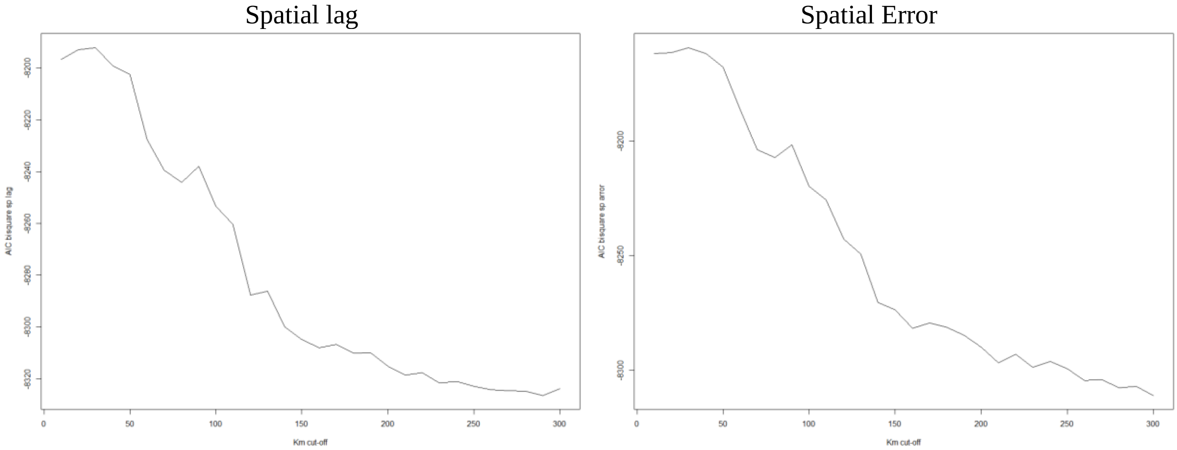
Gauss decay function

Spatial lag | Spatial Error



Gravity decay function

Spatial lag | Spatial Error



Source: own elaboration.

In function of these outcomes we estimate our models, whose results are reported in table 1. Coherently with growth theory, the coefficient of GDP per capita at the base year is negative and significant. In addition, a concave curvature is clearly statistically significantly different from zero. Secondary education has a slighly concave shape too, while tertiary education has a strong positive and significant sign. The result related to the capital metro regions shows a positive and significant coefficient.

Agglomeration economies, have a strong positive effect on growth, confirming the NEG theory (see Baldwin and Martin, 2004 and Petrakos et al., 2011).

Moran's I and Lagrange Multiplier (LM) tests are very significant pointing that the spatial dependence in residuals is present in the OLS specification, and clearly justifying the use of spatial econometric models.

LM and Robust LM tests were carried to check whether lag or error spatial dependence could be at work. In this case, 'lag' refers to the spatially lagged dependent variable, whereas 'error' refers to the spatial autoregressive process for the error term. If only one is significant, lag or error, we choose the correspondent model. If both are significant, than we have to check the Robust LM tests. As before, if only one is significant, we choose the correspondent model, otherwise, if they are both significant, we choose the test with the biggest value. In this case we prefer the spatial lag model. The spatial multiplier associated to this model is equal to $(1-0.5810)^{-1}=2.38$. Thus almost 3/2 of the impact of growth is reflected in neighborhood growth, through indirect reaction effects from neighbors.

Failure to account for the redundancy in shocks through muting the indirect effects (OLS model) would lead to rise of the estimated marginal impacts, which are biased upwards in magnitude, because the model is misspecified by omission of spatial spillover effects Mobley et al. (2009). Taking the example of agglomeration, we have that the parameter of OLS is equal to 0.0010, while in spatial lag model to 0.0007. This means that the OLS overestimates by 43% the direst effect on growth. Accounting for spatial multiplier effect, we have 0.0007×2.38=0.0017, which is higher than the OLS estimate because it accounts for the feedback effects coming from the surrounding regions.

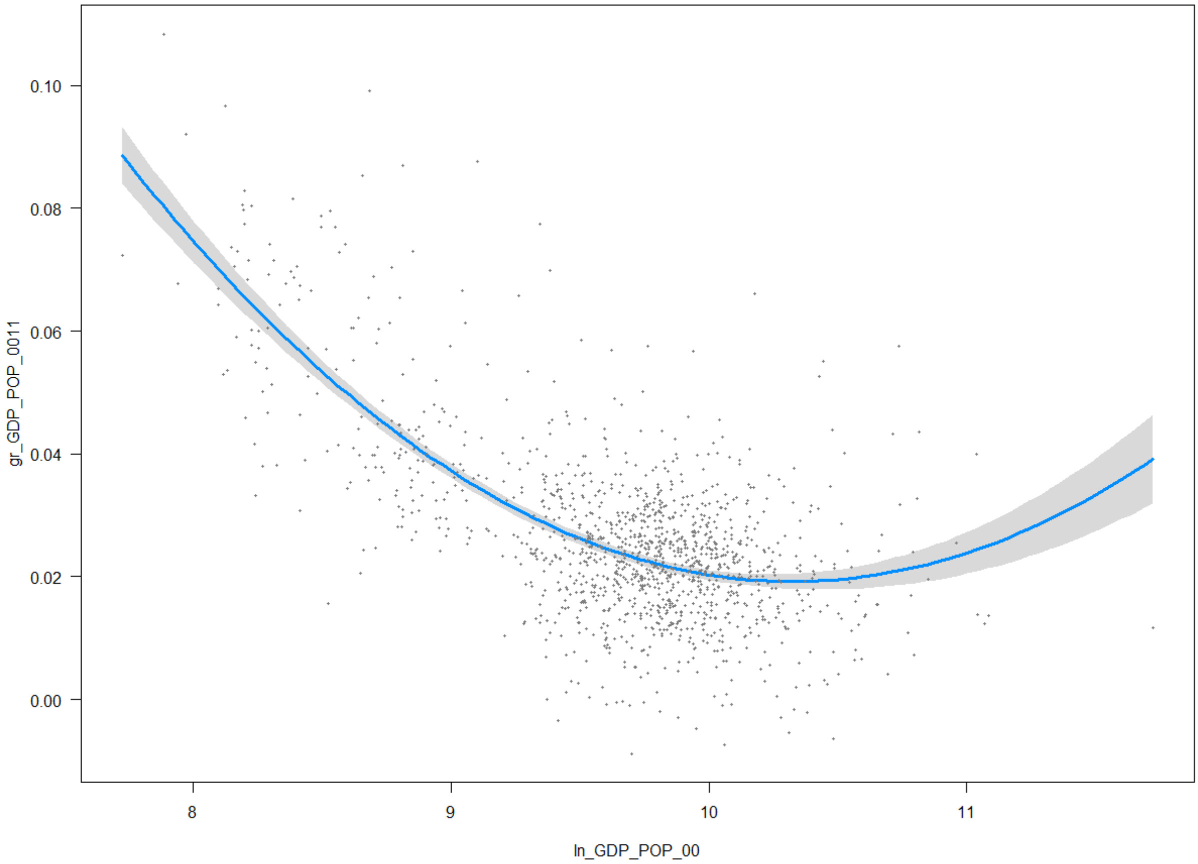
Table 1: estimation results

Sp. Weight matrix		**Gravity, cut-off = 150 min**		**Gauss, cut-off = 150 min**	
Model	**OLS**	**Spatial lag**	**Spatial error**	**Spatial lag**	**Spatial error**
Intercept	1.0904***	0.4878***	0.7158***	0.4069***	0.5453***
	(0.0671)	(0.0628)	(0.0705)	(0.0631)	(0.0752)
ln(GDP/pop 2000)	-0.2115***	-0.0944***	-0.1398***	-0.0786***	-0.1042***
	(0.0137)	(0.0128)	(0.0143)	(0.0128)	(0.0152)
ln(GDP/pop 2000)^2	0.0102***	0.0045***	0.0067***	0.0037***	0.0049***
	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0008)
Secondary edu. 2000	-0.0783***	-0.0416***	-0.0567**	-0.0372***	-0.0501**
	(0.0109)	(0.0095)	(0.0176)	(0.0095)	(0.0198)
Secondary edu. 2000^2	0.1403***	0.0739***	0.1150***	0.0660***	0.1085***
	(0.0123)	(0.0111)	(0.0195)	(0.0111)	(0.0217)
Tertiary edu. 2000	0.0354***	0.0193***	0.0276***	0.0172***	0.0248***
	(0.0044)	(0.0039)	(0.0066)	(0.0039)	(0.0069)
ln(agglomeration)	0.0010***	0.0007**	0.0017**	0.0007**	0.0014**
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Capital regions	0.0034***	0.0023***	0.0043***	0.0028***	0.0049***
	(0.0013)	(0.0011)	(0.0015)	(0.0011)	(0.0013)
Rho (spatial lag)		0.51401***		0.5810***	
Lambda (spatial error)			0.5735***		0.6783***
AIC	-8004.625	-8304.8	-8276.3	-8327.5	-8300.2
R^2	0.6253	0.7209	0.7195	0.7238	0.7246
Moran’s I	0.3254***	-0.0242	-0.0438	-0.0083	-0.0254
LM error	318.918***				
LM lag	342.879***				
Robust LM error	16.442***				
Robust LM lag	40.403***				
Breusch-Pagan test	109.41***	80.689***	39.506***	83.207***	39.958***
	(df = 7)	(df = 7)	(df = 7)	(df = 7)	(df = 7)

*Significant at 1%, ** significant at 5%, *** significant at 10%. Standard error in brackets.

The nonlinear effect of initial levels of GDP per capita, on the x-axis, on growth, on the y-axis, is shown in Figure 3. However, only about 21 NUTS-3 regions with GDP per capita higher than exp(0.0786×2.38)/(2×0.0037×2.38) = ~ 41k € are diverging upwards. This is coherent with J-shaped pattern of regional per capita GDP growth found by Petrakos et al. (2011), indicating that, above some threshold level of development, regional convergence trends vanish and regional divergence starts to emerge.

Figure 3: nonlinear convergence effect on growth



Source: own elaboration.

Education also shows a nonlinear effect on growth (figure 4). It has a flex point at (0.0372×2.38)/(2×0.0660×2.38) = ~ 28%. It means that there are decreasing marginal returns until the share of people with secondary education over total population is equal to 28%, and then the marginal returns start to rise exponentially. As an example, if the secondary educational attainment in a region raise from 15% to 16%, the marginal returns are:

(-0.0372×2.38)+2×(0.0660×2.38)×0.16 - (-0.0372×2.38)+2×(0.0660×2.38)×0.15 = -0.0414 – (-0.0383) = 0.0031

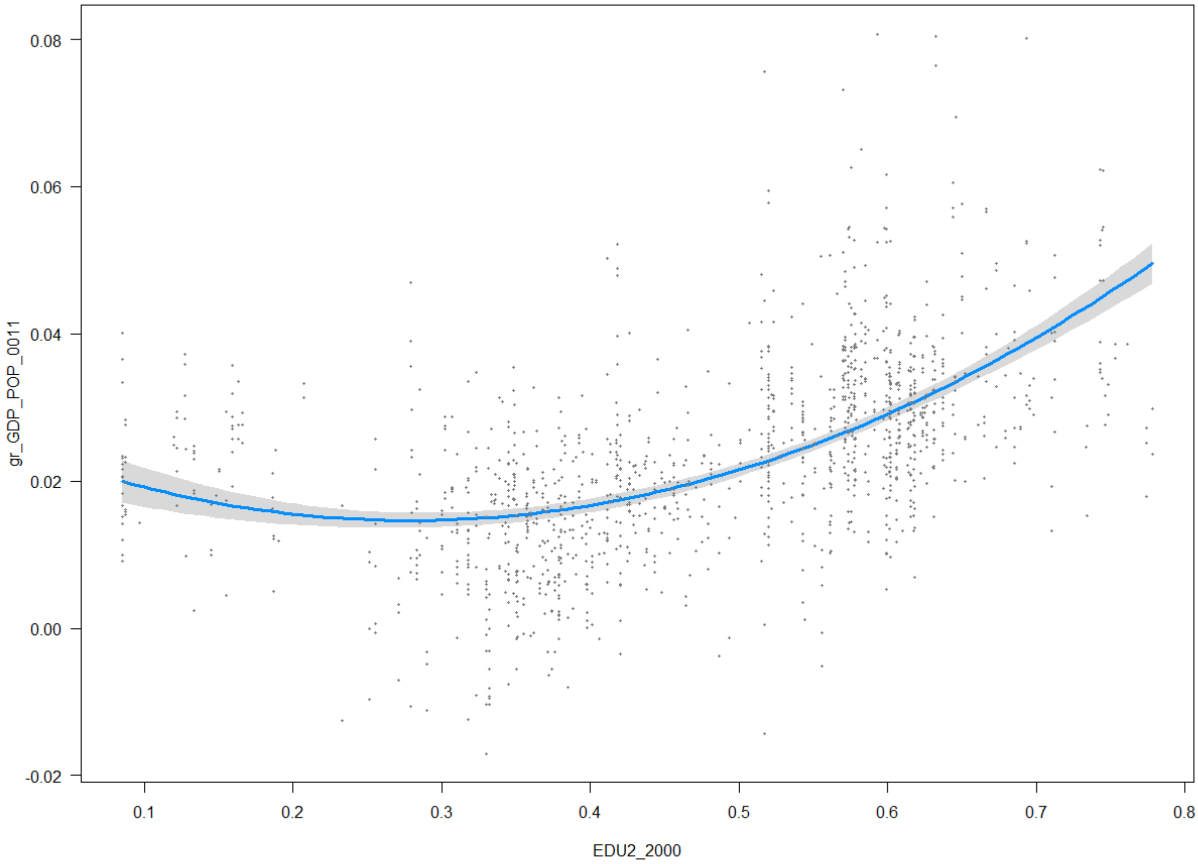
They are still negative, but "less" negative: from -0.041 to -0.038. Otherwise, if the secondary educational attainment in a region raise from 40% to 41% (still 1% difference), the marginal returns are:

(-0.0372×2.38)+2×(0.0660×2.38)×0.51 - (-0.0372×2.38)+2×(0.0660×2.38)×0.50 = 0.0717 – 0.0685 = 0.0031

The difference is still the same, but the marginal effect increases from 0.0685 to 0.0717.

Finally, we must underline that, contrary to the OLS specification, the spatial models do not present autocorrelation in the residuals (randomized Moran's I are not significant). However, despite the much higher variance explained by the spatial models in respect to the OLS (about 10% more), problems of heteroskedasticity still persist (see Breusch-Pagan test) possibly due to misspecification.

Figure 4: nonlinear effect of secondary education on growth



Source: own elaboration.

3. PRELIMINARY CONCLUSIONS AND WAY FORWARD

The aim of this study was to verify the role of spatial agglomerations and spillovers on regional growth. We used spatial econometric techniques and new geo-data sources to construct a dataset of socio-economic and transport data at NUTS-3 level. Our first results, in line with NEG, confirm that both these factors have a strong role, but leave some open questions that will be addressed in forthcoming research. These are mainly related to the necessity of testing alternative measures of agglomeration (Gardiner et al. 2010) as well as their 'life cycle' (Potter and Watts, 2010), i.e. how the incentives to agglomerate and disperse evolve over time, and the relationship between Marshall's agglomeration economies, which predicts that increased concentration of firms of the same industry within a region facilitates knowledge spillovers, and firms' capacity to remain innovate and performant.

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