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Spatial Policy for Growth and Equity

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Abstract: In spite of the on-going efforts that several countries made into promoting a more balanced economic development within their territory, economic growth theory and even empirical evidence do not come to a unanimous conclusion on the efficiency of public intervention. As such, this chapter reviews the various strands of the theoretical literature, analyzes the results of empirical estimations in Europe and in the US where regional development policies are already well established, and provides recommendations for future research in this field.
1- Introduction

Why would a country finance public programs aiming at minimizing regional inequalities within its territory? The first reason is because it is not obvious that regional disparities will disappear by themselves. Globalization and decreasing transportation costs have led to a fragmentation of the production process and increasing agglomeration in a few places. This process is often reinforced by internal migration and foreign investments. The second argument which results naturally from the previous one is that persistent regional inequalities have raised concerns of national solidarity. It is based on the idea that citizens should be given the same opportunities in terms of access to public services, such as health and education, and to jobs no matter where they live in the country. Furthermore, because problems in accessing jobs are sometimes exacerbated by problems of social exclusions and discontent that may take a violent form, regional cohesion may act as a form of social cohesion. Policy intervention also has an efficiency goal by enhancing competition, boosting productivity and international competitiveness. Programs aiming at removing barriers to internal trade, fostering the movement of the factors of production and enhancing fair competition belong to this category.

In addition, while changes in the exchange rate have often been used to support the economy of a country, their impact on regional cohesion at the sub-national level is not necessarily straightforward. Because of differences in their specialization, economic structure and trade linkages with foreign partners, regions are not all equally sensitive to changes in the exchange rate, so that devaluation can actually increase regional inequalities. Finally, in absence of systematic adjustments through devaluation, local decision-makers may want to concentrate their efforts on a tax policy that attracts the mobile factors of production. Empirical evidence indicates that it can lead to a tax competition across regions, thus taking the form of a “race-to-the-bottom” where mobile factors are offered lesser tax levels and the decrease in tax revenues is compensated by higher taxes on the immobile factors. As a result, regional development policies can be seen as an efficient tool to avoid a regional tax competition as well.

Yet, and despite the phenomena highlighted above, implementation and support for regional policies are not straightforward because of the important controversy about their efficiency. From a theoretical viewpoint, regional policies lead to different conclusions in terms of convergence according to the economic growth school of thought one focuses on (Dall’erba and Le Gallo, 2008). From a practical perspective, several countries experience a lot of difficulties in assessing which regional development strategies work as empirical evidence shows conflicting results.

Therefore, section 2 of this chapter is devoted to the theoretical impact of regional development policies under the lens of the neoclassical growth, endogenous growth and new economic geography theories. The lack of consensus in their predictions is corroborated by empirical evidence, as indicated in section 3 which highlights the results of the key econometric studies that have measured the impact of public spending on regional growth. While many countries have on-going regional development policies, we focus on the cases of the European Union and the US. No other country or group of countries has a regional policy as developed and studied as the European Union. Starting with the first enlargement from 6 to 9 countries in 1973, it has since then been an intrinsic part of the EU integration process and up to one-third of the European budget is devoted to it. Regarding the US, the presence of a highly mobile labor force and of a federal tax adjustment mechanism have guaranteed that regional inequalities are much less pronounced than in Europe. However, the country is not immune of regional imbalances either. In addition, the implementation of the American Recovery and Reinvestment Act (ARRA) by the Obama administration in 2009 represents an example of why it is important to assess what regional development programs have been successful in the past in order to draw the right strategies for the future. As a consequence, the fourth section will provide a list, although not exhaustive, of elements that recent academic
contributions have highlighted as necessary to consider for future developments in this field. Finally, the last section will provide a summary and concluding remarks.

2- Growth theory and regional development policy
From a theoretical viewpoint, the expected impact of regional policies is not straightforward. It varies from one strand of growth theory to the next. In a neoclassical framework based on Solow (1956), investments in physical capital per worker lead to a higher steady state income. However, due to the decreasing marginal product of capital, the rate of investment must decline towards the steady state income where the stock of capital per person is constant and of which growth is completely determined by technology. Therefore, regional policies in poor regions may stimulate their growth above their usual steady state level, but it is only transitional and does not raise the steady state income in the long run. On the other hand, public policies are granted a more central role in influencing long-run growth in the endogenous growth theory. Rejecting the neoclassical assumption of decreasing returns to scale, the endogenous approach sees public infrastructure as an input in the production function, hence its presence increases the marginal product of private capital which fosters capital accumulation and growth. However, the addition of public capital in the production function does not allow one to look explicitly at the impact of regional policies on industry location. Indeed, firms choose to locate/relocate not only according to the transfers of purchasing power to the poor areas that accompany a regional policy, but also based on the effect of the latter on capital returns and trade costs between and within regions. Hence, the theoretical approach that is the most appropriate when analyzing the impact of regional policies on growth is the new economic geography literature such as Fujita et al. (1999) as a large share of regional programs is often devoted to transportation infrastructure. Its appeal lies in returns which appear in the short-run, a convenient feature for political purposes, and in its capacity to promote accessibility to/from any area which is commonly seen as beneficial to its economic development. The reality is more complicated. Supporting investments in interregional transportation infrastructure yields a decrease in transportation costs, which affects the process of industry location and often reinforces the agglomeration process which is already taking place in the rich regions. Agglomeration is due to the local labor/consumer market, knowledge externalities, local input-output linkages and local infrastructures which are more developed in rich areas than poor ones.

Empirical evidence indicates that at the sub-national level transportation networks are firstly developed within and between rich regions because this is where the demand for transportation is the highest. In addition, in some cases, the transportation network is based on hub-and-spoke connections, like in Spain, where transportation costs from the hub (Madrid) to any spoke are lower than between spokes. As a result, connecting a poor area to the existing network may increase its accessibility, but the literature indicates that gains in accessibility will always be relatively higher in the central location than in the peripheral and poor one (Vickerman et al., 1999).

Even supporting transportation infrastructure projects within poor areas does not necessarily guarantees their sudden attractiveness as the spillovers they generate may be too small to counterbalance the agglomeration process already at work in the rich areas. In other words, accessibility is not the only challenge that poor areas have to deal with. It is often accompanied by a lack of infrastructure of any type, a less educated and smaller labor force and less efficient or inexistent local input-output linkages. While it may not be a problem to sectors interested in access to natural resources or cheaper labor, assuming that interregional wage differences exist, the poorest areas often offer very few factors to promote location/relocation within their territory. As a result, several authors in the field of regional development have come to qualify regional policy as a trade-off between efficiency, which can be achieved by fostering agglomeration in the rich areas, and equity; meaning that public
spending is used to maintain some level of economic activity and wellbeing in the poor places.

3- Empirical evidence and lessons learned in the EU and the US

3.1. European regional policy

Three main groups of results appear in the literature that estimates econometrically the effectiveness of the European cohesion policy on regional growth. Most of them focus on the so-called structural funds, the main tool of the EU regional policy. The first group, which concludes that structural funds have a significant and positive impact, is composed of the studies of Fayolle and Le Cuyer (2000), Cappelen et al. (2003), Beugelsdijk and Eijffinger (2005), and more recently Becker et al. (2010). The contribution by Fayolle and Le Cuyer (2000) concludes that the regions that benefited the most from structural assistance are the wealthiest regions in the poorest countries. They explain that the reason for this is twofold: first, the new demand generated by structural funds support in the poor regions is supplied by the rich regions of the same country and, second, new transportation infrastructure helps the rich regions sell their products to the poor ones. Fayolle and Le Cuyer (2000) are also the first ones to tackle the issue of co-funding which obliges the recipient regions to provide a share (between 15% and 85%, depending on the project) of the investment cost, a practice that softens the redistributive effects of the funds (Dall’erba and Le Gallo, 2008). This level of detail allows Fayolle and Le Cuyer to account for the actual amount of public spending in each regional economy, as structural funds per se are just a fraction of it.

The conclusions of Cappelen et al. (2003) are somewhat similar to the ones of Fayolle and Le Cuyer (2000) as it also indicates that support is the most efficient when it is allocated to regions with a good economic environment, such as low unemployment and high R&D capabilities, which often are experienced in the most developed recipient regions. Hence support is least efficient where it is most needed, which supports the idea that there is indeed an efficiency-equity trade-off. Finally, to our knowledge, the most recent contribution of the estimation of the impact of the funds is Becker et al. (2010). They focus explicitly on the group of regions recipient of objective 1 structural funds (allocated to regions of which per capita GDP is below 75% of the EU average) and regions which qualify for these funds but did not receive them. They do not to consider the amount of funding allocated to each region, but instead whether a region is recipient or not. Their approach differs from previous works since they focus on European regions of similar economic development level.

The second group of studies concludes that the impact of the funds is either non-significant or significant but negative impact. This group consists of the two studies by Dall’erba and Le Gallo (2008) and by Fagerberg and Verspagen (1996) respectively. Dall’erba and Le Gallo (2008) include a spatial econometric approach to convergence which allows them to account for the non-random distribution of structural funds and regional income, to proxy various variables at the origin of spillover effects, such as interregional trade, migration, technology externalities, and to measure coefficient estimates which are efficient. While their 2008 contribution pools all forms of structural funding together, the Dall’erba and Le Gallo (2007) work proposes an approach disaggregated by cohesion objective.

The third and final group of studies advocates for more mitigated conclusions on the impact of the funds. This group is composed of Rodriguez-Pose and Fratesi (2004), Ederven et al. (2002), Ederven et al. (2006), Dall’erba and Le Gallo (2007), Esposti and Bussoletti (2008), Bähr (2008), Mohl and Hagen (2010). Focusing on objective 1 regions only, Rodriguez-Pose and Fratesi (2004) are the first ones to measure if the type of project financed, such as support for human capital or for agriculture, and the time it takes for funding to support growth (up to 7 years) matter. They conclude that support to infrastructure and to businesses does not have a significant effect, even in the long-run. On the other hand, investment in education and human capital has medium-term positive effects whilst support to
agriculture has short-term positive effects on growth. Dall’erba and Le Gallo (2007) are also driven by the desire to differentiate the impact of funding by the type of project this funding finances. In the absence of data for every project, they focus on all the categories of structural funds instead and pay attention to the amounts of additional funds, as in Fayolle and Lecuyer (2000). They find that peripheral regions are significantly but very little affected by some structural funds (objectives 1 and 3&4 funds, Community Initiatives), whether additional funds are accounted for or not. Based on a spatial econometric approach, they also highlight that peripheral regions seem more affected by the funds allocated to their neighbors than to themselves, more especially when they are objectives 2, 3&4 funds or Community Initiatives. In the frame of a spatial panel setting, Mohl and Hagen (2010) concur that the conclusions are sensitive to the cohesion objective that is being analyzed.

Ederven et al. (2002) claim that the results depend on whether convergence is measured without fixed effects (convergence across all the European regions), or with a national or regional fixed effect. They conclude that the more optimistic one is about convergence (no fixed effect), the less efficient structural funds spending appears to be, and vice versa. They are the first ones to highlight three detrimental mechanisms in the allocation of the funding across regions: rent seeking which takes place when regional governments design projects that meet the criteria of the EU but are not necessarily effective in stimulating growth; moral hazard which happens when local/regional authorities use EU funds for low-productive projects, so as to keep their region within the eligibility criterion for cohesion support; and crowding-out which represents the fact that EU support creates a disincentive for local/regional/national governments to support their poor regional economies themselves. This substitution effect also takes place when EU funding reduces the incentive of the private sector to invest locally and/or workers to migrate to more productive areas, which would promote greater cohesion. Both Esposti and Bussoletti (2008) and Bähr (2008) find that structural funds per se have a negative impact on regional growth, but their impact becomes positive and significant when they interact with another variable such as R&D investments or human capital (in the case of Esposti and Bussoletti, 2008) or decentralization, measured by the level of regional autonomy, in the case of Bähr (2008).

3.2. Regional policy in the US
In the US, the earliest contribution focusing on the role of public capital on output is Aschauer (1989). His findings rely on national level data and put the elasticity of public capital at 0.39. This result is somewhat similar to the one of Munnell (1990a) who obtains an elasticity of public capital (net of military spending) of which magnitude is between 0.31 and 0.37. However, both studies adopt a national level approach. Since then, an increasing number, though still not very large, of studies has focused its attention on the sub-national level. For instance, Munnell (1990b) measures the participation of public capital among 48 states, assuming a Cobb-Douglas production function in levels. At the regional level, it is necessary to have an estimate of private and public capital stocks for each state, since the elasticity of the factors is measured by a Cobb-Douglas production function. As such, Munnell (1990b) develops a methodology that distributes the national stock of capital to each state. It allows her to find an elasticity of public capital on output of around 0.15 in the unconstrained equation and of magnitude in between 0.06 and 0.08 when the Cobb-Douglas coefficients are constrained by constant returns to scale (the sum of their elasticity equals one). Based on a panel data set for the 48 contiguous states over 1969 to 1986 and capital stock data from Munnell (1990b), Holtz-Eakin (1994) finds an elasticity of 0.203, which is in line with previous works. However, once he uses more complex estimation techniques, such as a fixed effect approach, IV and GLS, he does not find any significant effects.

More recently, Shioji (2001) measures the impact of public capital on economic growth based on a beta-convergence model and a set of panel data for the US States over 1973-1993. While he uses different econometric techniques to refine his results (GMM, LSDV), his
approach does not include the role of private capital. His findings are ambiguous since he finds a range of impacts that goes from 0.572 (pooled regression) to 0.407 or even non-significant impact (based on LSDV and GMM). Once he disaggregates public capital into education spending and infrastructure spending, his results indicate a negative impact of the former and a positive one of the latter. The negative impact of public spending for education on growth is a result that several other US-focused studies have highlighted also. It indicates the counter-cyclical nature of this type of policy and it reflects the high degree of mobility of US workers (Garcia-Mila et al., 1996). Paying attention to local effects, Nizalov and Loveridge (2005) measure the impact of economic development policies and highway infrastructure on growth and jobs across Michigan counties. They define three types of public expenditures: the Michigan Economic Growth Authority (MEGA), a program that grants businesses with tax credits for 8 to 20 years and targets investments and job creation, the Renaissance Zone (RZ) which provides local tax waivers to firms and individual residents of economically distressed areas, and the Brownfield Development Authority (BDA) which targets the re-development of blighted, functionally obsolete and contaminated sites on Brownfield sites and highway infrastructure. Their approach is a linear estimation of the impact on growth of the above programs in addition to education, manufacturing, government, farming and business concentration. They find ambiguous results, from a positive and significant effect of highways on job growth to a negative and significant effect of MEGA on income.

Two key studies on the 48 contiguous US states are Garcia-Mila and McGuire (1992) and Garcia-Mila et al. (1996) who focus on the impact of publicly provided inputs on income. In the former article the authors use a Cobb-Douglas production function and a panel data set over 1969 to 1983. Public capital is split between highway capital (expenditures on highways by state and local governments) and support to education (state and local expenditures for K-12 and postsecondary education). They find a positive and significant impact of highways on output (0.045) and a positive and significant impact of publicly provided education with a magnitude in between 0.165 (without a variable of median years of schooling) and 0.072 (with a variable of median years of schooling). When it comes to private capital, the estimated elasticity is in between 0.373 and 0.449 when it is measured as capital in equipment and it is in between 0.027 and 0.104 when it is measured as capital structures. In the latter study (1996), they extend previous results by considering highways as well as water and sewers as publicly provided inputs over almost the same time period (1970-1983). They also use various fixed and random state effects to address the issue of heterogeneity in the data. Without controlling for state effects, they find similar results as Munell (1990b) where highways as well as water and sewers have a positive and significant impact on output (0.37 and 0.069 respectively). However, once they controlled for state effects, the coefficients diminish to 0.120 for highways and 0.043 for water and sewers. Because they assume a potential serial correlation in their results, they run their model once more but on the variables measured into first differences. In this specification, all the publicly provided services appear to have a negative and significant impact, which is in tune with the conclusions of Holtz-Eakin (1994). Private capital has an impact in between 0.289 and 0.348, as usually found in the literature.

Using an extended version of Munnell (1990b) data, Lall and Yilmaz (2001) construct private and public capital stocks in order to estimate a beta-convergence model across the 48 contiguous states over 1969-1994 while controlling for business cycles by time-period dummies. Their results indicate a non-significant impact of lagged public capital in two specifications (without state or time dummies and with state dummies) and a significant but negative impact with state and time dummies, when the human capital variable is excluded from the equation.

Finally, the two most recent contributions on this topic have taken note of the theoretical advances advocated by the new economic geography literature as well as of the developments of the spatial econometric techniques to detect, model and measure the presence of
interregional externalities. As such, the work of Garrett et al. (2007) provides a spatial econometric estimation of beta-convergence across states over 1977-2002. Among the explanatory variables, government expenditures are measured as a proportion of state gross product while local government revenues are captured by the share of state and local revenues. They find a negative and significant impact of government share of which magnitude (between -0.3097 and -0.3270) varies with the absence or presence of spillover effects. When it comes to the role of local revenues, their impact on growth is significant and negative with a range in between -0.0207 and -0.0218. Overall, they conclude that state-level fiscal policies can significantly influence income growth in neighboring states. The presence of interregional spillover effects is also at the core of the contribution of Dall’erba and Llamosas-Rosas (2012) who, in addition, measure the actual federal, state and local public investments in education and other public capital from two databases: the Consolidated Federal Fund Reports (for federal spending) and the State and Local Government Finances (for local and state spending). It allows them to avoid using proxies for public investments. Their results are in line with Holtz-Eakin (1994) since they find that public capital investments do not have a statistically significant impact while public support for human capital has a negative and significant impact on per capita income. This corroborates the work of Kilkenny (2010) who shows that governments often neglect the negative feedback effects such as the rural “brain drain” of rural education to urban areas when rural development policies are implemented.

Looking at the previous results, we may wonder what reasons would explain such a diversity of outcomes both among European or US studies. We stipulate that there is a great deal of heterogeneity in the way they approach the same problem. The choice of the sample (only objective 1 regions vs. all the EU regions), time period (because of business cycles), estimation process (cross-section vs. panel, presence or absence of fixed-effects), the variables chosen (actual spending vs. some proxy) and the treatment of spatial dependence necessarily affect the estimation results. In addition, Edervene et al. (2002) note that the conclusions are dependent upon the type of convergence estimated. In an absolute convergence framework, it is assumed that all the regions are converging to the same steady-state, while adding spatial regimes (convergence clubs) or country dummies in the case of Europe allows for differences in regional steady-states. The difference is not trivial since in the latter case the underlying assumption is that inequalities persist, even in the long-run.

Differences in regional steady-states are also controlled by the explanatory variables included in the model. The range and quality of explanatory variables that have been used in the studies above varies greatly. For instance, private investments statistics are available across EU regions but do not exist for the US states. As a result, they have to be constructed based on national data and following various methodologies such as the one of Munnell (1990b) or Garofalo and Yamarik (2002). There is no doubt that this affects the quality of the estimations.

4- Looking ahead
4.1. Including spatial dependence and reporting the right measurements
The last two decades have seen an increasing recognition of the role of spatial externalities in economic growth theory and empirical evidence. Because this movement has taken place in conjunction with a formalization of the spatial econometrics framework necessary for the estimation of various phenomena, the literature now displays a rather large number of studies estimating growth at the sub-national level while accounting for spatial autocorrelation. As mentioned in Dall’erba and Le Gallo (2008), spatial autocorrelation refers to the fact that the spatial distribution of the variables used in the econometric model is not random. Rich areas tend to be close to other rich areas and poor areas tend to be close to other poor areas. This phenomenon may come from factors such as trade, labour and capital mobility, technology and knowledge diffusion that affect simultaneously nearby regions. It may also arise from
model misspecifications (omitted variables, measurement errors) or from a variety of measurement problems such as a mismatch between the administrative boundaries used to organize the data and the actual boundaries of the economic processes believed to generate growth.

If spatial autocorrelation proves to be present in an econometric model, the traditional assumption of independence of the error terms needs to be rejected, otherwise it leads to unreliable estimates and inferences. Second, spatial autocorrelation allows the user to capture the presence of geographic spillover effects between observations, indicating that public funding in one location is not going to impact growth in the recipient location only. Third, spatial lags of the dependent variable can act as a proxy for omitted variables that are spatially dependent.

Among the studies listed in section 3, only three have used these techniques in the European case and 3 in the US case. Details about the form of the spatial model they use, the definition of the variable of interest and the estimated mean, minimum and maximum impact appear in table 1 below.

Table 1- Summary of the impact of public spending on growth across spatial econometric studies.

<table>
<thead>
<tr>
<th>Primary Study</th>
<th>Spatial Model</th>
<th>Variable definition</th>
<th>Mean Impact</th>
<th>Minimum Impact</th>
<th>Maximum Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>European regions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mohl and Hagen (2010)</td>
<td>Spatial Panel Lag Model</td>
<td>Structural funds per capita (objectives 1,2,3 − in log)</td>
<td>0.0003</td>
<td>-0.0092</td>
<td>0.0114</td>
</tr>
<tr>
<td>Dall'erba and Le Gallo (2008)</td>
<td>Spatial 2SLS Lag Model</td>
<td>Sum of structural funds per capita (in log)</td>
<td>-0.01 (not significant)</td>
<td>-0.01 (not significant)</td>
<td>0.002 (not significant)</td>
</tr>
<tr>
<td>Dall'erba and Le Gallo (2007)</td>
<td>Spatial Error Model</td>
<td>Sum of structural funds per capita (in log)</td>
<td>0.0005</td>
<td>-0.002</td>
<td>0.007</td>
</tr>
<tr>
<td><strong>US states or counties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garrett, Wagner and Wheelock (2007)</td>
<td>Spatial lag and/or spatial error</td>
<td>Government share (first diff of log)</td>
<td>-0.3154</td>
<td>-0.3207 (spatial lag model)</td>
<td>-0.3097 (spatial lag and error model)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Local revenue tax share (first diff of log)</td>
<td>-0.0211</td>
<td>-0.0218 (spatial error model)</td>
<td>-0.0207 (spatial lag and error model)</td>
</tr>
<tr>
<td></td>
<td>Spatial lag model only</td>
<td>Government share (first diff of log)</td>
<td>-0.3169</td>
<td>-0.3214 (Census divisions)</td>
<td>-0.3149 (Census divisions)</td>
</tr>
</tbody>
</table>
## Table 1: Different Spatial Models and Their Results

<table>
<thead>
<tr>
<th>Model</th>
<th>Dependent Variable</th>
<th>Coefficient (Census Regions)</th>
<th>Coefficient (Census Divisions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lall and Yılmaz (2001)</td>
<td>Local revenue tax share (first diff of log)</td>
<td>-0.0206</td>
<td>-0.0214</td>
</tr>
<tr>
<td></td>
<td>Lag on Human Capital only SLX</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Public capital (Constructed following Munnell (1990))</td>
<td>0.002</td>
<td>-0.017</td>
</tr>
<tr>
<td></td>
<td>(Census regions)</td>
<td></td>
<td>(Public capital only)</td>
</tr>
<tr>
<td></td>
<td>(Census divisions)</td>
<td></td>
<td>(Public and human capital)</td>
</tr>
<tr>
<td></td>
<td>Not significant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dall’erba and Llamosas (2012)</td>
<td>Spatial Durbin Model</td>
<td>-0.077</td>
<td>-0.154 (not significant)</td>
</tr>
<tr>
<td></td>
<td>Public investment in infrastructure</td>
<td></td>
<td>-0.067 (not significant)</td>
</tr>
<tr>
<td></td>
<td>Unrestricted model</td>
<td></td>
<td>Restricted model</td>
</tr>
<tr>
<td></td>
<td>Restricted model</td>
<td></td>
<td></td>
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</tbody>
</table>

As can be seen in Table 1, different spatial models have been used in the literature to account for spatial dependence in a regression framework. More precisely, all these contributions have rejected the traditional (OLS) way of formulating an econometric growth model given by:

\[
y = \alpha_{t_n} + X\beta + \epsilon \quad \text{with} \quad \epsilon \sim N(0, \sigma^2 I_n)
\]

where \(y\) is the growth rate of a period, \(X\) is a set of explanatory variables including public spending and beta is a set of coefficients to be estimated. As such, the spatial econometric models they have been measured in the contributions above are described below:

- The spatial lag model (SAR):
  \[
y = \alpha_{t_n} + \rho Wy + X\beta + \epsilon \quad \text{with} \quad \epsilon \sim N(0, \sigma^2 I_n)
  \]
  \[
y = (I_n - \rho W)^{-1}(\alpha_{t_n} + X\beta + \epsilon)
  \]

- The spatial error model (SEM):
  \[
y = \alpha_{t_n} + X\beta + u \quad \text{with} \quad u = \rho Wu + \epsilon \quad \text{and} \quad \epsilon \sim N(0, \sigma^2 I_n)
  \]
  \[
u = (I_n - \rho W)^{-1}\epsilon
  \]
  \[
y = \alpha_{t_n} + X\beta + (I_n - \rho W)^{-1}\epsilon
  \]

- The spatial error and spatial lag model (SAC model):
  \[
y = \alpha_{t_n} + \rho W_1 y + X\beta + u \quad \text{with} \quad u = \theta W_2 u + \epsilon \quad \text{and} \quad \epsilon \sim N(0, \sigma^2 I_n)
  \]
  \[
y = (I_n - \rho W_1)^{-1}(X\beta + \alpha_{t_n}) + (I_n - \rho W_1)^{-1}(I_n - \theta W_2)^{-1}\epsilon
  \]

- The spatial cross-regressive model (SLX):
  \[
y = \alpha_{t_n} + X\beta + WX\beta + \epsilon \quad \text{with} \quad \epsilon \sim N(0, \sigma^2 I_n)
  \]

- The spatial Durbin model (SDM):
  \[
y = \rho W_1 y + \alpha_{t_n} + X\beta + W_2 X\beta + \epsilon \quad \text{with} \quad \epsilon \sim N(0, \sigma^2 I_n)
  \]
  \[
y = (I_n - \rho W_1)^{-1}(\alpha_{t_n} + X\beta + W_2 X\beta + \epsilon)
  \]

where \(W\) is the spatial weight matrix and alpha is the constant term. Note that in the case of the SAC and SDM models, \(W_1\) and \(W_2\) can be equal or different. The reader can refer to LeSage and Pace (2009) for other forms of spatial models. It is important to understand that the interpretation of the parameters is not as simple as in a traditional linear regression model and may vary across spatial models. In the linear case, it is easy to interpret the impact on the...
dependent variable of a change in any explanatory variable. Indeed, the value of this impact is
the magnitude of the coefficient. In addition, since the model assumes independence across
observations, the effect of a change in any exogenous variable affects the dependent variable
of that specific region only. Formally, \( \frac{\partial y}{\partial x^r} = \beta_r \) (for any exogenous variable ‘r’). In a
spatial econometric model, the presence of spillover effects often, but not always, makes the
interpretation of the beta coefficients more complicated but richer. For instance, in a spatial
error model as used in Dall’erba and Le Gallo (2007) or Garrett et al. (2007), the coefficient
beta has the same meaning as in an OLS model. On the other hand, in a SLX model as used in
Lall and Yilmaz (2001), a change in an explanatory variable is measured by:

\[
\frac{\partial y}{\partial x^r} = (I_n \beta_r + W \theta_r)
\]

In this formulation, since the weight matrix is standardized and contains zeros on the main
diagonal, the coefficient \( \beta_r \) reflects direct effects while \( \theta_r \) captures local spatial spillovers.
Finally, global spatial spillovers are measured in the frame of a spatial lag, as used in
Dall’erba and Le Gallo (2008), Mohl and Hagen (2010), Garrett et al. (2007), or when
estimating a spatial Durbin model as in Dall’erba and Llamosas (2012). Indeed, in these
studies the marginal effect is written as follows:

SAR: \[ \frac{\partial y}{\partial x^r} = (I_n - \rho W)^{-1}I_n \beta_r \]

SDM: \[ \frac{\partial y}{\partial x^r} = (I_n - \rho W)^{-1}(I_n \beta_r + W \theta_r) \]

Because the term \( (I_n - \rho W)^{-1} \) can be expressed as the following infinite sequence: \( (I_n + \rho W + \rho^2 W^2 + \rho^3 W^3 + \ldots) \), it involves that a change in any region will affect not only the
region itself, but its neighbors, the neighbors of its neighbors (which includes feedbacks to the
original region) and so on.

It is important to stress that this non-linear relationship implies that we cannot interpret
the coefficients of a SAR or SDM model as in any of the other types of models, as the former
measure both direct effects and spillover effects at the same time. This point has been
overlooked in previous spatial econometric estimations of the role of public spending on
growth where \( \beta \) is interpreted as in a non-spatial model while the spatial lag coefficient is left
capturing all kinds of spillover effects. Following the suggestion of Le Sage and Pace (2009),
the correct interpretation of a spatially lagged endogenous variable require us to disaggregate
the total effect of a change in an exogenous variable into direct effects which capture the sum
of the impacts in the region that experiences a change and indirect effects which capture the
impact due to changes in other regions. In order to do so, direct effects are calculated as the
mean of the main diagonal elements of the \( n \times n \) matrices while indirect effects correspond to
the mean of the sum of the off-diagonal elements from each row of the \( n \times n \) matrices. Details
about the method to draw statistical inference on each effect can be found in Le Sage and
Pace (2009).

To our knowledge, there is no study so far that has used this approach to estimate the
impact of regional development policies on growth in Europe or in the US. The only study
that comes close to it is Fischer (2011) who reports the magnitude of direct and indirect
effects of (public and private) investments in physical and human capital across EU regions

4.2. Measuring the actual investments, not proxies

Earlier analyses, whether they focused on the European Union or on the US, often used a
(poor) proxy of the true amounts of public spending allocated across areas. Some popular
proxies could be as simplistic as a dummy variable of which the value, 1 or 0, would reflect if
a region is a recipient or not. The problem with this approach lies in its complete disregard for
the actual amount of investment. Other contributions use the *stock* of human capital, such as the education level, in a Cobb-Douglas production function which is supposed to measure the role of human capital *investments*. Some authors recognize that the consistency and the reliability of their estimates, hence the quality of their conclusions, suffer from these proxies but not all.

While some scholars are to be blamed for their lack of rigor in collecting / constructing the appropriate data when they are available, the list of challenges they meet includes, but is not limited to: availability of the data at all, availability in electronic format vs. hardcopy, updated vs. outdated data, data covering all types of projects vs. some only, detailed description of the project financed (for instance, “transportation” is too vague), description of the region where the projects have been allocated (the finer spatial scale the better), data that correspond to the actual payments vs. investment commitments.

However, the prospects are much better. For instance, after years of relying on hardcopy reports displaying data that would present many of the challenges listed above, the European Commission has moved on to creating a “Computerized monitoring systems and electronic data exchange” site that serves as a unique reference for documenting the ways in which the funds are being used. The site is accessible here: [http://ec.europa.eu/regional_policy/sources/exchange/exch_en.htm](http://ec.europa.eu/regional_policy/sources/exchange/exch_en.htm). It represents a significant step in the right direction, even though it is still very far from the level of transparency and detail that one experiences when working with the data of the US Census Bureau’s Consolidated Federal Fund Reports. They report electronically all types of federal spending, whether for regional policy purposes or not, for every county or smaller spatial units on a yearly basis since 1993. These data are available here: [http://www.census.gov/govs/cffr/](http://www.census.gov/govs/cffr/). Recently, Dall’erba and Llamosas-Rosas (2012) have relied on this database to estimate the role of public spending on the regional economies of the US in the frame of a Cobb-Douglas production function.

### 4.3. Combining different strands of theory and techniques

Many of the studies described in section 3 rely on the famous neoclassical growth model initiated by Solow (1956) even though its underlying assumption of diminishing returns to capital and the eventual presence of Galton’s fallacy have raised some doubts on its theoretical and empirical relevance. As a result, future works should consider theoretical models that mix different strands of the literature. In that sense, the contributions of Garrett *et al.* (2007) and Dall’erba and Le Gallo (2007, 2008) are innovative because they add the presence of interregional spillovers to a traditional neoclassical framework. Based on spatial econometric techniques, their results allow them to measure the extent to which structural funds impact not only the region where they are allocated but on neighboring regions as well. Another contribution that blends the various schools of economic growth theory even further is Ertur and Koch (2007). Based on a Cobb-Douglas framework, they propose to distinguish and model three factors that explain growth in technological progress: the first part is the stock of knowledge that is shared by all the firms and grows at an exogenous and constant rate as is usually assumed in the neoclassical approach. A second part of it is generated by the presence of knowledge externalities between nearby firms as described in the endogenous growth theory. Neither the first nor the second elements account for the role of dependence over space which has been brought to the forth by the new economic geography literature, which is why they attribute the third and final part of technological progress to localized interregional knowledge externalities.

Beyond a better integration of theoretical approaches, future contributions will also emphasize the need to integrate modeling techniques further. Spatial econometrics has become a popular and straightforward way to model and measure spatial dependence, but it does not rely on the “true” factors at the origin of interregional spillovers. It relies on a matrix of geographical proximity across regions which has the advantage of being determined
exogenously. However, when it comes to economic growth and regional policy, it is mostly trade and migration that explains spatial dependence, hence techniques capturing these interregional flows need to be adopted. It is the essence of interregional input-output (IO) analysis that has experienced increasing popularity since the early contributions of Wassily Leontief. However, interregional IO data are long and costly to gather; hence some authors such as Rey (2000) have suggested complementing the traditional input-out techniques with spatial econometrics to generate multiregional linkages that are both industrially and spatially disaggregated.

From a regional policy point of view, the advantage of combining techniques is twofold. First, it would allow scholars to avoid the “one-size-fits-all” approach that has prevailed in the field of regional development. Indeed, in a global (econometric) approach which is the setting most empirical studies rely on, the coefficient associated to each variable corresponds to the average impact of the latter on the dependent variable across the entire sample. As a result, global econometric estimates could, for instance, reveal a significant impact of regional spending (from a statistical point of view) on the average regional growth rate, while in reality it is a non-significant impact that should be found in some localities and a positive or negative one elsewhere. The advantage of an approach that would be more disaggregated lies in its capacity to expose significant local and sectoral variations, which are masked by a global and aggregated approach. Secondly, most empirical estimations of the impact of regional policies have overlooked the potential endogeneity of regional spending. This problem comes from the fact that regional spending is mostly devoted to regions with a low per capita GDP, a measurement that is intrinsically part of the dependent variable, growth. Dall’erba and Le Gallo (2008) address this problem and use a set of instrumental variables since their Hausman test results reveal that structural funds are indeed endogenous. As a result, an integrated IO-spatial econometric approach as suggested by Rey (2000) could alleviate this problem since, by definition, the IO approach models and measures shocks that are either endogenous or exogenous to the system at hand.

4.4. Need to develop tools that foster communication between stakeholders and academia
Preparation of material for dissemination in the public policy arena is not necessarily the main objective of many scholars in the field of regional development. However, the latter component is extremely important and undervalued as stakeholders are much more project-driven and interested in the policy arena than academic scholars. In addition, the former often take decisions based on reports that are not produced by the latter. As a result, the first author of this chapter has recently concentrated his efforts on developing an internet-based, free-of-charge, tool called the Regional Economic Impact Simulator. It transmits complicated theory and estimation techniques commonly used among regional scientists to an audience of specialists and non-specialists. In addition, it can be used as a decision-support tool for localities willing to compare the returns of various kinds of investments.

Based on a webGIS platform, the Regional Economic Impact Simulator allows anyone to build a regional policy scenario of his/her choice and to visualize on a map, in a matter of seconds, how regional economic growth is modified as a result of it. Because of interregional interactions captured by spatial econometric means, it is not only the locality where the scenario is implemented that will experience a change in growth, but the entire system.

An example of regional policy scenario is depicted in figure 1 below. It reflects how economic growth over 2000-2008 in each of the counties of the sample has been modified as a result of a 50% increase in federal support for private businesses in Boulder, Colorado, over the same period. While this county is the one which has experienced the greatest change in growth, growth has also spread to its neighbors and the neighbors of its neighbors, etc… but with a decreasing magnitude as distance from Boulder increases. Note also how a pop-up window allows users to get details about the magnitude of the change experienced in each county. Many more simulations can be performed on the Regional Economic Impact
Simulator as users are given the freedom of implementing shocks of any magnitude, on any of the 16 explanatory variables used in the model and any of the 3,076 counties of the database. The Regional Economic Impact Simulator is accessible here: http://webgis.arizona.edu/reis/. While it is, to our knowledge, the only tool of this nature available at the moment, we anticipate that the increasing desire for transparency and accountability in the use of public funding will lead to many more free, internet-based, decision-support tools.

**Figure 1 – Changes in county-level economic growth resulting from a simulated 50% increase in federal support for private businesses in Boulder, Colorado.**

![Figure 1](image)

**Conclusion**

Increasing interest for regional development policies has led to new theoretical advances and a growing number of empirical works, but it has not succeeded in providing a standard model for economic development intervention. Past empirical evidence indicates that the conclusions are very sensitive to a set of parameters, such as sample size, estimation method, time period and quality of the variables used, which confuses academic scholars, stakeholders and policy-makers. An example would be the 2009 American Recovery and Reinvestment Act which led 200 economists to predict that it would benefit the US economy and 200 others to forecast the exact opposite. As a result, uncertainty calls for “place-tailored” policies where intervention is designed to meet the specific economic and geographic characteristics of the recipient locality targeted for development. For instance, it is now well accepted that transportation infrastructures are not necessarily an efficient tool to promote equality as their impact does not always benefit the recipient area. Indeed, they may lead to depopulation of the latter and increase agglomeration in rich regions.

The most recent contributions in the field of regional development are focusing their efforts on avoiding some of the shortfalls of the past such as the correct interpretation of spatial models and the overwhelming reliance on proxies as opposed to the actual amounts of public spending. In addition, there is an increasing desire to combine the different strands of economic growth theory with each other while integrating further the set of regional science techniques already available. Ultimately, it should provide a more complete picture of the regional dynamics at stake and of the actual role of policy intervention. Last but not least,
Regional development practitioners need to rely more often on current technology, such as webGIS, to bridge the gap between the interests of stakeholder and the expertise of academic scholars as well as demonstrate to the general public the level of transparency and accountability they operate in. Only an increasing awareness of today’s regional development challenges will oblige us all to make future interventions more effective and efficient than past ones.

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References:
Bähr C. (2008), How Does Sub-National Autonomy Affect the Effectiveness of Structural Funds?, Kyklos, 61, 1, 3-18.


