Impact of Structural Funds on Regional Growth: How to Reconsider a 7 Year-Old Black-Box?

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IMPACT OF STRUCTURAL FUNDS ON REGIONAL GROWTH: HOW TO RECONSIDER A 7 YEAR-OLD BLACK-BOX [*]

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Abstract:
Econometric estimations of the impact of structural funds on the growth process of the European regions started 7 years ago. However, it is striking to realize that all previous estimations in this field are based on some form of the neoclassical growth model (Solow's model). This model is still widely used despite the numerous critics it has raised (Quah, 1996) and its lack of consideration for increasing returns to scale, which are at the heart of agglomeration and growth processes according to endogenous growth theories and new economic geography models. In addition, few estimations have paid attention to the nature of the cohesion objectives under study. For example, the expected impact of objective 1 funds, devoted to public infrastructures, is indeed theoretically and empirically very different from the one of objective 3 funds devoted to long-term unemployed. As a result, the aim of this paper is to propose a careful assessment of the impact of structural funds on the manufacturing sector of 145 European regions in the context of a Verdoorn's law for the period 1989-2004. First, the results are presented with total structural funds and funds differentiated by objective. Second, interregional linkages are included by means of spatial econometric techniques. Third, potential endogeneity of the explanatory variables is taken into account.

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Introduction

The excitement of the 2007 enlargement of the European Union to include Romania and Bulgaria is associated with the traditional question on how the current members will be able to promote the economic development of these countries. While some successes have been experienced in the past (we see for instance that Spain, Portugal and Ireland did converge towards to the European average income after a decade of membership), the economic gap between the new member countries from Central and East Europe is tremendous.

Regional development policies have often been presented as a proposed solution to compensate regions facing any type of restructuring difficulties. They are assumed capable of erasing inequalities of income across EU regions (including both old and new members), compensating regions experiencing high unemployment, providing a sufficient level of restructuring in old-fashioned industries, promoting social cohesion…all of this for only one-third of the EU budget. By comparison, the Common Agricultural Policy receives nearly twice as much budget and is devoted to the agricultural sector only.

With so many expectations regarding the impact of regional policies on growth, it is not surprising that it has attracted the attention of many researchers. In a recent article, Dall'erba and de Groot (2006) find that more than one hundred studies (published and unpublished) deal with European regional policies[1]. However, only 11 articles performed a formal econometric estimation of the impact of structural funds on growth. Structural funds are still the most important tool of regional policies. Econometrics is by

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[1] At the time we write our work, this journal has two articles on EU regional policy in press: Kutan and Yigit (2007) and Ulltveit-Moe (2007).

far the most common technique employed for the estimation of the funds (as opposed to input-output models and general equilibrium models). These 11 studies have a great deal of heterogeneity in their estimation results: some conclude a positive and absolute impact of the funds on growth, some note that it is conditional upon several variables, while others find a non-significant or even negative impact of the funds. Among the studies that find a positive impact, Beugelsdijk and Eijffinger (2005) find the greatest average impact (5.17, see Dall'erba and de Groot, 2006). However, this may be a consequence of the *national* level of analysis. Cappelen *et al*. (2003) and Garcia-Solanes and María-Dolores (2001) who base their estimations on the *regional* level, also conclude a significant but very little impact of the funds (respectively 0.0057 and 0.0036). When looking at different expenditure axes, Rodriguez-Pose and Fratesi (2004) find that only investments in education and human capital have medium-term positive effects, whilst support to agriculture has short-term positive effects on growth. The approach by development objective is also adopted by Fayolle and Lecuyer (2000) who conclude that within an assisted country, the wealthiest regions are the ones that benefit the most from structural funds. The conditionality of the effectiveness of structural funds is developed by Ederveen *et al*. (2006) who conclude that the funds are efficient only in countries with good institutions while Ederveen et *al*. (2002) show that conclusions are sensitive to the type of convergence one is looking at (no dummy vs. regional or national dummies). Finally, Dall'erba and Le Gallo (2004, 2007) do not find a significant impact of the funds, even when their impact is measured on the recipient region and its neighbors. While their study focuses on the 1989-1999 decade, Puigcerver-Peñalver (2004) recommends that the period be split in two to stress how the funds may have positively affected the recipient regions over 1989-93 whereas their impact has been null or negative over 1994-99.

This article raises a couple of criticisms on previous econometric studies. First, we challenge the theoretical model upon which they rely. With the exception of Fayolle and Lecuyer (2000) who use a catching-up model, and some estimates in Rodriguez-Pose and Fratesi (2004), all studies rely on some version of the neoclassical growth model described in Barro and Sala-i-Martin (1991). Even after the recent advances in economic growth theory that highlight the substantive role of increasing returns to scale, these authors comply with the drawbacks of the β-convergence model. Its underlying assumption of diminishing returns to scale and the eventual presence of Galton's fallacy have recently raised some doubts on its theoretical and empirical relevance (Quah, 1993, 1996). Because our theoretical approach is singularly different from the traditional neoclassical model, our estimation results of the impact of the funds on growth may also differ. Indeed, while investing in poorer regions can (only temporarily) increase the growth rate along the transition to the new steady state in a neoclassical framework, endogenous growth theory clearly grants public policies an important role in the determination of growth rates in the long run. For instance, Aschauer (1989) and Barro (1990) predict that if public infrastructures are an input to the production function, then policies financing new public infrastructures increase the marginal product of private capital, hence fostering capital accumulation and growth.

Second, a couple of points have been overlooked when estimating the impact of the funds on growth. Those points are:

- previous estimations have not paid attention to the particularities of the funds implemented. With the exception of Rodriguez-Pose and Fratesi (2004) and Puigcerver-Peñalver (2004), previous articles simply pool all structural funds together. We believe that pooling, say, objective 1 structural funds devoted to low-income regions with objective 5 structural funds devoted to agricultural restructuring may be misleading because their impact on regional growth is clearly different.

- a particular project is never fully financed by the European budget. Part of it has to be co-financed by the recipient region and / or country. This rule, called the principle of additionality, impedes regions from presenting unviable projects. However, it introduces a bias stemming from the fact that peripheral regions are just able to double the Community support, whereas the wealthiest northern Spanish regions, for instance, and numerous core regions succeed in providing between 2.5 and 6.4 times the amount committed by structural funds (Dall'erba, 2005). Among the previous estimations, only Dall'erba and Le Gallo (2004) and Fayolle and Lecuyer (2000) have considered this issue.

- we want to explore the question of whether public investments may take some time before fully impacting growth. This is because their effect on supply is not as immediate as that on demand. To our knowledge, only Rodriguez-Pose and Fratesi (2004) have focused on this issue by including a temporal lag of up to 7 years. However, even with such a lag, they do not find any significant impact of the whole funds.

Third, we follow previous work by Dall'erba and Le Gallo (2004, 2007) who adopt a spatial econometric approach. The purpose of such an approach is to determine whether any spatial relationship among the variables is merely random or respond to a pattern of spatial dependence. Spatial econometrics has been used extensively in studies of regional growth (see Abreu et al., 2005, for a recent literature review). Applied to regional development issues, this technique allows us to measure the extent to which the growth rate of one region depends upon that of its neighbors, or whether the allocation of regional funds has a significant impact on the growth rate of the targeted regions and on the one of their neighbors. While spatial econometrics tends to be more widely used, the problem of endogeneity of explanatory variables in a spatial econometric model has usually been overlooked. In our case, the potential risk of endogeneity comes from the fact that 68% of structural funds are devoted to regions of which per capita GDP (as an average of the three years prior the beginning of the programming period) is below 75% of the EU average. This is the criteria necessary for a region to apply for objective 1 funds. None of the previous studies quoted earlier had addressed this problem whether they adopted a spatial approach or not. The only exception is the one of Dall'erba and Le Gallo (2007) where the Hausman test results reveal that structural funds are indeed endogenous in their study.

This paper is organized as follows. In section 1 we present Verdoorn's law upon which we will rely on to test for the impact of structural funds and several other variables on economic growth while paying attention to increasing returns. Section 2 describes the model we use, the data and the spatial weights matrix that allows us to connect regions with each other. Section 3 presents the results of our empirical estimations, while section 4 concludes and provides policy recommendations.

Section 1 – Verdoorn's law and economic growth

The theoretical background underlying most empirical estimations of the impact of structural funds on the convergence process is the neoclassical growth model initiated by Solow (1956) and Swan (1956). This model is based on constant returns to scale (or diminishing returns to capital) and an exogenously-determined spatially uniform technical progress. Due to diminishing returns to capital, regions with a small capital to labor ratio will experience faster productivity growth while regions with high capital-labor ratio grow relatively slowly. As a consequence, at equilibrium, productivity of all the regions grows at the same rate, which equals the exogenous rate of technical progress.

Empirical evidence for convergence to single steady-state position is rather mixed especially when large sample of countries or regions are considered. In response to the gap between theoretical predictions and empirical evidence, basic neoclassical theory has been extended to include the concept of conditional convergence wherein each region (or country) grows to its specific steady state rather than to a single steady state. However, both convergence concepts (absolute or conditional) have been heavily criticized on theoretical and methodological grounds. Friedman (1992) and Quah (1993) show that convergence tests may be plagued by Galton's fallacy of regression toward the mean. Furthermore, these tests face several methodological problems such as heterogeneity, endogeneity, and measurement problems, and several estimation methods have been suggested to overcome them (Durlauf and Quah, 1999; Temple, 1999; Islam, 2003).

Our main reason for favoring a different approach than the neoclassical model is the presence of both theoretical and empirical arguments to consider increasing returns to scale. The theoretical arguments are embodied in endogenous growth theory and the new economic geography. Endogenous growth theory insists that technical progress is not exogenous and that externalities are a source of increasing returns (Romer, 1986; Lucas, 1988; Aghion and Howitt, 1998). Increasing returns also have a prominent place in the new economic geography literature (Krugman, 1991; Krugman and Venables, 1995; Ottaviano and Puga, 1998). Constant returns to scale and perfect competition do not allow explanation for the emergence of agglomeration and increasing returns that are a central concept at the origin of the current geographic distribution of economic activities (Scotchmer and Thisse, 1992). In the European case, increasing returns and cumulative processes act as agglomeration forces leading to the emergence of the well-known core-periphery structure of economic activities highlighted in Krugman's model (1991). As pointed out by Krugman (1991), "we live in an economy closer to Kaldor's vision of a dynamic world driven by cumulative processes than to the standard constant returns model."

At the heart of Kaldor's vision is the Verdoorn's law (Verdoorn, 1949), which constitutes an alternative to the neoclassical approach for regional growth analysis. The Verdoorn's law links the growth rate of labor productivity (*p*) and output (*q*) in a linear relationship. The basic single equation specification is given by equation (1).

$$p = b_0 + b_1 q + \varepsilon \qquad (1)$$

where p is the growth rate of labor productivity, q is the growth rate of output and ε is an error term with the usual properties. b_1 is the Verdoorn coefficient, for which values of around 0.5 have been found in empirical estimations[2] (Fingleton and McCombie, 1998).

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[2] For a review of the different approaches to the estimation of the Verdoorn's law see Leon-Ledesma (2000).

This is interpreted as evidence for increasing returns, as the ratio of productivity to output growth can be thought of as a measure of increasing returns.

While it is not possible to make this interpretation on the basis of the equation system developed by Verdoorn, it is possible to relate the Verdoorn's law coefficient to the degree of returns to scale in a Cobb-Douglas production function (Fingleton and McCombie, 1998; Fingleton, 2001). Assume a Cobb-Douglas production function of the form:

$$Q = A_0 \exp(\lambda t) K^{\alpha} E^{\beta} \tag{2}$$

where A_0 is the initial level of technological development, λ is the growth rate of total factor productivity, Q, K and E are the level of output, capital and employment at time t, and α and β are their respective elasticities. Taking natural logs and differentiating with respect to time and allowing for the presence of other effects, after rearranging (2) can be expressed:

$$p = \frac{\lambda}{\beta} + \frac{\beta - 1}{\beta} q + \frac{\alpha}{\beta} k + \varepsilon \tag{3}$$

We assume that $k = q$ on the basis of the stylized fact that the growth of capital stock equals the output of growth (or the capital-output ratio is constant) in developed countries (McCombie and Thirlwall, 1994; Fingleton, 2000) so that equation (3) reduces to:

$$p = \frac{\lambda}{\beta} + \frac{\alpha + \beta - 1}{\beta} q + \varepsilon \tag{4}$$

If $b_1 = \frac{\alpha + \beta - 1}{\beta} > 0$ then $\alpha + \beta > 1$, which means that the economy displays increasing returns to scale.

Earlier empirical studies are consistent with the existence of increasing returns to scale as embodied in Verdoorn’s law in a regional context [3] (Bernat, 1996; Casetti and Tanaka, 1992; Fingleton and McCombie, 1998; Harris and Lau, 1998; Leon-Ledesma, 2000; McCombie and Ridder, 1983; Pons-Novell and Viladecans-Marsal, 1999). Therefore, incorporating potential returns to scale in an empirical analysis of growth seems to be relevant for our purpose.

Verdoorn’s law per se is too simplistic to capture the fundamental reasoning of endogenous theory, except for increasing returns. Typically, in the basic specification of Verdoorn’s law, variation in the growth rate of labor productivity is only linked to the growth rate of output, while other factors could be relevant to influence the nuances of growth, especially at the regional level. Therefore, we follow Fingleton (2000; 2001) who adds endogenous technical progress to the traditional Verdoorn’s law.

More precisely, the rate of growth of technical progress, represented by λ is assumed to depend on spillovers, on the diffusion of technology and on the level of human capital within regions. By assuming that technical change is proportionate to capital accumulation (in the form of the growth of capital per worker) and that the growth of capital per worker is equal to the growth of productivity, it follows that:

$$\lambda = \lambda^* + \Phi p + \varpi W p \tag{5}$$

where Φ and ϖ are coefficients and W is a spatial weights matrix which captures spillover effects between regions, i.e. the extent to which the productivity growth rate in

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[3] See Bernat (1996), McCombie et al. (2002) and Pons-Novel and Viladecans-Marsal (1999) for references of empirical studies supporting the relationship in international comparisons or countries individually.

one region is affected by that in neighboring regions. λ is proportional to intraregional productivity growth but also to the extraregional productivity growth through the term on the right-hand side of the equation. Productivity growth in a region will be increased by faster productivity growth in surrounding regions through spillover effects via technical progress. The term λ^* depends on socioeconomic conditions within each region, namely the initial level of technology and the level of human capital.

The initial level of technology is introduced as a technology gap between each region and the leading technology region to capture the possible effect of innovation diffusion from high technology regions to low technology regions. This is based on the two following assumptions. First, differences in technology imply differences in productivity (Barro and Sala-i-Martin, 2004). Second, technology-advanced regions grow by innovation while technology-laggard regions may imitate and adapt the technologies of the leader regions (Baumol, 1986, Leon-Ledesma, 2002; Targetti and Foti, 1997). As a consequence, technological diffusion to laggard regions could imply faster growth in these regions and the impact of the leading technology region is all the higher as the technological gap is high with a laggard region (Abramovitz, 1986; Leon-Ledesma, 2002).

On the one hand, the level of human capital is assumed to be an increasing function of the level of urbanization since larger human capital stocks are supposed to boost innovation and hence productivity growth. On the other hand, the level of human capital should be a negative function of peripherality since peripheral regions are sparsely populated, have a lower level of human capital and are less technologically advanced than the core regions. (Baldwin, 1999; Baldwin and Martin, 2004).

Section 2 –Augmented Verdoorn's law, data and spatial weights matrix

After arithmetic manipulations, Fingleton (2000; 2001) proposes to estimate the following specification:

$$p = \varpi Wp + b_0 + b_1 q + b_2 G + b_3 u + b_4 l + \varepsilon \tag{6}$$

where *p* is the growth rate of labour productivity (in log) in the manufacturing sector and *q* is the growth rate of output (in log) in the same sector and ε is an error term, that is identically and independently distributed. *G* is the technological gap (proxied by the labour productivity differential) at the initial period between each region of the sample and the leading region. Note that, in the spatial econometrics literature, specification (6) corresponds to a spatial lag model, where the coefficient ϖ is meant to reflect the presence of interregional spillovers, i.e. that productivity growth occurring in surrounding regions (defined by the *W* spatial weights matrix) affects the growth of productivity (via technological progress) in region *i*. The spatial lag specification described in model (6) is not the only way to include spatial dependence across regions. For this purpose, we will investigate whether the appropriate form of spatial autocorrelation for our sample is the spatial error version of the Verdoorn's law (Bernat, 1996; Pons-Novell and Viladecans-Marsal, 1999):

$$\begin{cases} p = b_0 + b_1 q + b_2 G + b_3 u + b_4 l + \varepsilon \\ \varepsilon = \lambda W \varepsilon + u \end{cases} \qquad u \approx iid(0, \sigma^2) \tag{7}$$

In this specification a region's growth is affected by growth in neighboring regions only to the extent that neighbouring regions have above or below normal growth (Bernat, 1996). Regional transmission of random shocks is at the heart of this specification.

In (6) and (7), the explanatory variables are the following: a measure of urbanization (*u*) and a measure of peripherality (*l*). Urbanization is measured in terms of population density and aims to proxy for the density of economic activity. While in Fingleton (2001) the variable *l* measures the geographical distance of a given region from a central point (Luxembourg), reflecting the core-periphery structure of the economic system under analysis, we decide to measure peripherality as an index of accessibility of a region (noted *acc* from now on). These data, which come from Fürst *et al*. (2000), are an indicator of accessibility by road, rail and air for each region. These data have been used in a couple of studies (see, for instance, Spiekermann and Wegener, 1996; Vickerman et al., 1999). We believe that a measure of accessibility is richer than pure geographical distance to a central location because it reflects the characteristics of the transportation network and sector. As highlighted in Dall'erba and Le Gallo (2007), the relationship between gains in accessibility and economic development still requires considerable empirical investigation, especially given the variations in transportation demands by sector and differences in the productive structure of each region. However, the literature clearly indicates that gains in accessibility due to interregional transport infrastructures will always be relatively higher in the central location than in the peripheral one (Vickerman et al. 1999; Puga 2002; Venables and Gasiorek 1999).

The data on manufacturing productivity, manufacturing output, initial productivity level gap (which is used as a proxy for the initial technology gap) and density (noted *d* from now on) come from the most recent version of the Cambridge Econometrics database. They cover the 1989-2004 period. In 1989, Ile-de-France was the region with the highest level of productivity in the manufacturing sector.

We extend models (6) and (7) above to consider the impact of structural funds. We specifically focus on objective 1 and objective 2 structural funds since they are the only ones to enter the production function and they represent, with respectively 68% and 11% of the total of the funds, the two most important cohesion objectives. Indeed, while objective 1 funds have mostly been financing public infrastructures in the least favored regions, objective 2 funds have been devoted to the restructuring of areas in industrial crisis. This is where our approach differs from most of previous contributions on the impact of the funds, because we believe that simply including the sum of all the funds may be misleading: objectives 3 to 6 were clearly devoted to other objectives, which, by definition, have nothing to do with the production function (respectively high-unemployment regions, agricultural restructuring or low density regions).

As a result, the starting model we test is the following:

$$p = b_0 + b_1 q + b_2 G + b_3 d + b_4 acc + b_5 SF + \varepsilon \tag{8}$$

where the data are the same as above and *SF* is a matrix of explanatory variables that can be filled in four different ways as described below. All of these variables cover the sum of the funds over the 1989-1999 period.

(i) Total amount of funds allocated to a region

(ii) Structural funds differentiated by objectives, objectives 1 and 2 only

(iii) Total cost of the projects financed (i.e. the sum of the structural funds and the additional funds provided by the region/country itself)

(iv) Total costs differentiated by objectives, objectives 1 and 2 only.

The period under study covers the first two programming periods and the data on structural funds come from the publications of the Commission: the data over 1989-1993 are from "*Community structural interventions*", *Statistical report n°3 and 4,* (European Commission, 1992a, b) and for 1994-1999, from *The 11th annual report on the structural funds* (European Commission, 1999). These data represent the total payments over each period plus the commitments taken during the second period (but that have not been paid yet). The lack of more recent data leads us to assume that structural funds commitments and expenditures are strongly correlated. All data are in 1995 euro prices. Data in euro (as opposed to data in purchasing power parity) allow us to consider differences in the capacity to produce goods.

Our sample is composed of 145 regions at NUTS II level over the EU12. NUTS (Nomenclature of Territorial Units for Statistics) is the spatial classification established by Eurostat on the basis of national administrative units. It is used by the Commission as a regional statistical concept.

Section 3 - Econometric estimations of the impact of the funds

In order to evaluate consistently the impact of structural funds on regional growth, several technical aspects must be taken into account: the possible endogeneity of the growth rate of manufacturing output and the presence of spatial autocorrelation and spatial heterogeneity in the coefficients and/or the variance. While we start with a basic OLS estimation, we will investigate all these issues in this section.

3.1 OLS results

We first start with the OLS results of model (8) for the 1989-1999 period. Estimation results displayed in table 1 differ by the type of structural funds considered, as described in the previous section: (i) total amount of the funds (first column) (ii) objectives 1 and 2 funds only (second column) (iii) total cost of the projects financed (third column) (iv) objectives 1 and 2 costs only (fourth column).

The results indicate that the coefficients associated with the technological gap and density are significantly positive for every specification. However, the coefficient associated with accessibility is not significant. The Verdoorn coefficient ranges from 0.675 to 0.699 and is always significant, which clearly indicates the presence of increasing returns. Total structural funds and total costs appear to significantly but negatively affect growth. This result is in tune with Ederveen et al. (2006), and some estimates in Ederveen et al. (2002) which are significantly negative. However, when these variables are split by objective, the coefficient associated with objective 1 funds/costs is significant and negative while that associated with objective 2 is not. The non-significance of the funds split by objective is also found in Dall'erba and Le Gallo (2004) and Rodriguez-Pose and Fratesi (2004).

[Table 1 around here]

We also checked whether extending the period up to 2004 changes these results. Indeed, structural funds are public investments which may take some time before impacting regional productivity (Rodriguez-Pose and Fratesi, 2004). The results are displayed in table 2. The only difference with the previous findings is a decrease of the value of the Verdoorn coefficient, which is still significant but now ranges from 0.582 to

0.599. This is consistent with previous studies carried out on European regions (Fingleton and McCombie, 1998; Pons-Novell and Viladecans-Marsal, 1999). As a result, this specification confirms the findings of Rodriguez-Pose and Fratesi (2004) who also conclude that adding a temporal lag does not change their conclusions on the impact of the funds.

[Table 2 around here]

3.2 Spatial autocorrelation tests

Several papers have shown that estimation results could be affected by the presence of spatial autocorrelation (Pons-Novell and Viladecans-Marsal, 1999; Fingleton, 2000). In order to detect the appropriate form of spatial autocorrelation, we use the classical "specific to general" specification search approach outlined in Anselin and Florax (1995) using tests described in Anselin *et al.* (1996). More specifically, they suggest Lagrange Multiplier (LM) tests (resp. LMERR and LMLAG) and their robust versions (resp. R-LMERR and R-LMLAG). The decision rule used to choose the most appropriate specification is as follows: if LMLAG (resp. LMERR) is more significant than LMERR (resp. LMLAG) and R-LMLAG (resp. R-LMERR) is significant whereas R-LMERR (resp. R-LMLAG) is not, then the most appropriate model is the spatial autoregressive model (resp. the spatial error model).

In order to carry out those tests, spatial weights matrices must be constructed. We use a distance-based weights matrix with the following form:

$$\begin{cases} w_{ij}^{*}(k) = 0 & \text{if} \quad i = j, \forall k \\ w_{ij}^{*}(k) = 1/d_{ij}^{2} & \text{if} \quad d_{ij} \leq Q_1 \\ w_{ij}^{*}(k) = 0 & \text{if} \quad d_{ij} > Q_1 \end{cases} \qquad \text{and} \qquad w_{ij} = w_{ij}^{*} / \sum\nolimits_{j} w_{ij}^{*} \tag{9}$$

where w_{ij}^{*} is an element of the unstandardized weights matrix; w_{ij} is an element of the standardized weights matrix W; d_{ij} is the great circle distance between centroids of region i and j; $Q1$ is the lower quartile of the great circle distance distribution. It is a cutoff parameter for $k = 1,...3$ above which interactions are assumed negligible[4]. We use the inverse of the squared distance, in order to reflect a gravity function. Each matrix is row standardized so that it is relative and not absolute distance which matters.

We have therefore estimated model (8) with all four specifications for *SF*, using OLS, and computed Moran's *I* and the LM test with this weights matrix, which we label D(1). The results are displayed in table 3 for the period 1989-2004[5]. The significant coefficient of the Moran's *I* indicates the presence of spatial autocorrelation in our sample. In other words, the distribution of regional labor productivity is clearly not random. The results indicate the correct form of spatial autocorrelation is a spatial error specification. Indeed, LMERR is significant whereas LMLAG is not, and R-LMERR is significant at 15% (except in one case) whereas R-LMLAG is not. We will therefore focus on a spatial error model in the rest of the paper (equation 7).

[Table 3 around here]

3.3 Endogeneity

Before estimating spatial models, we first need to take care of the endogeneity issue for the growth of manufacturing output variable. This problem has been raised by Fingleton

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[4] We acknowledge that the choice of the cut-off is quite arbitrary, but all the results are confirmed when using different cut-offs and other specifications of the weights matrix.

[5] All the following results will concern the 1989-2004 period. The results obtained for the 1989-1999 are qualitatively similar and are available upon request from the authors.

and McCombie (1998) and Fingleton (2000, 2004). Testing and accounting for endogeneity is a difficult problem in applied econometrics in general. An appropriate instrument should be independent of the error but should also correlate sufficiently highly with the endogenous variable. In this paper, we have investigated several possible instruments for the growth of manufacturing output variable:

- The growth rate of manufacturing output for the previous period (1980-1988) as in Fingleton and McCombie (1998).
- a "quasi-instrument", defined by the 3-group method, advocated by Kennedy (2003) in the context of measurement errors and used in a spatial context by Fingleton (2003). More precisely, we construct a variable that takes values of 1, 0 and -1 according to whether the values are in the top, middle or bottom third of their ranking, ranging from 1 to 145. By construction, this instrument is correlated with the endogenous variable. We have also constructed the spatial lag of this -1, 0, 1 variable. In the context of Verdoorn's law, these instruments have been used by Fingleton (2004).

The two stage least squares (2SLS) estimation results are displayed in table 4 and the Hausman test of exogeneity of the growth of manufacturing output variable is shown in the second to last line of the same table. It has been computed with the -1, 0, 1 variable and its spatial lag as instruments and implies that the null hypothesis of exogeneity should be rejected at the 2% level. Note that these tests were not significant at conventional significance levels when the first instrument is chosen. However, as pointed out by Temple (1999), using the time lag of a variable as instrument is not without problems. We therefore choose to correct for possible simultaneity bias and perform the appropriate estimation method.

[Table 4 around here]

As in Dall'erba and Le Gallo (2007), we have also analyzed the possible endogeneity of the different structural funds variables, since structural funds are not allocated randomly but are conditional on GDP. Several instruments have been constructed for structural funds and total costs, in general or differentiated by objective:

- The distance by road to Brussels (in km), as the spatial distribution of structural funds follows a center-periphery distribution
- The travel time from the most populated town of each region to Brussels
- The 3-group instrument (defined similarly as for the growth rate of manufacturing output) and its spatial lag.

The full results are not shown here due to space constraints, but regardless of the specification considered and instrument chosen, the Hausman test never rejects the null hypothesis of exogeneity. Therefore, in the following estimations, the growth of manufacturing output is the only variable for which endogeneity has been taken care of. The 2SLS estimation results displayed in table 4 do not change the previous findings concerning the impacts of the different variables, apart from the fact that the Verdoorn coefficient is now close to 0.5 (implying increasing returns), a value found in Kaldor's (1966) original study and in many subsequent studies. Finally, we computed the Lagrange multiplier test of spatial error autocorrelation in a 2SLS framework. The null hypothesis of absence of spatial autocorrelation is always rejected at 5%, therefore spatial error autocorrelation should be taken into account together with the endogeneity of the output growth rate.

3.4 Spatial autocorrelation and spatial endogeneity

In the case of a spatial error model, dealing with a spatial error process together with an additional endogenous variable is a tricky issue that has been investigated recently by Fingleton and Le Gallo (2006). More precisely, they extend Kelejian and Prucha's (1998) feasible generalized spatial two-stage least squares (FGS2SLS) estimator to account for endogenous variables due to system feedback, given an autoregressive or a moving average error process. The estimation method applies instrumental variables in the first stage. The 2SLS residuals are then used to estimate the spatial error coefficient and the error variance using the GMM conditions derived by Kelejian and Prucha (1999). Finally, a Cochrane-Orcutt type transformation is applied to obtain the remaining estimates of the model.

The estimation results for the spatial error model, using FGS2SLS, with an endogenous variable are displayed in table 5. As for the OLS estimation results, the coefficients associated with density and the technological gap are significantly positive for every specification. The Verdoorn coefficient ranges from 0.528 to 0.541. The results concerning the impact of structural funds are not modified: the coefficients on the total funds (costs) and objective 1 funds (costs) are significant, negative and very little, whereas objective 2 funds (costs) are still not significant. Finally, the spatial autocorrelation coefficients are significant and positive in every specification.

[Table 5 around here]

3.5 Spatial heterogeneity

Our final check of robustness of the results concerns the possibility of spatial heterogeneity. It can be modeled in three ways: spatial instability of the coefficients and/or groupwise heteroskedasticity.

Several methods have been used in the literature to determine spatial regimes across a sample of regions. As in Le Gallo and Dall'erba (2006), we choose here to use the G-I* statistics developed by Ord and Getis (1995) on the regional labor productivity gap compared to Groningen (the leading region) in 1989[6]. These statistics imply a 2-way split of the sample, with 78 regions in the "core" and 67 regions in the "periphery". As can be seen from figure 1 below, the regions with a huge gap of productivity in 1989 compared to Groningen were the peripheral regions (in Greece, Italy, Spain, Portugal, Ireland and some in France and the UK).

[Figure 1 around here]

We re-estimated all the previous models (four specifications of the spatial error model with an endogenous variable) allowing for structural instability of the coefficients. In each case, it appears that the null hypothesis of stability of coefficients across regimes cannot be rejected. Here, we also consider the possibility of groupwise heteroskedasticity of the following form:

$$\varepsilon \sim iid\left(0, \begin{bmatrix} \sigma_{\mathrm{C}}^2 I_{78} & 0 \\ 0 & \sigma_{\mathrm{P}}^2 I_{67} \end{bmatrix}\right) \tag{8}$$

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[6] The robustness of the results to alternative choices of regimes is left for future research.

The estimation results are provided in table 6 below. They are very similar qualitatively and quantitatively to the previous ones.

[Table 6 around here]

Section 4 - Conclusion

This paper brings new insights into the evaluation of the impact of structural funds on the regional growth process. The role of increasing returns in the formation of agglomeration is now widely admitted (Krugman, 1995; Fujita and Thisse, 2002). While increasing returns are at the core of recent developments in endogenous growth theory, empirical studies still debate the issue of allowing for the presence of increasing returns. Moreover, empirical estimations of β-convergence are often interpreted as evidence supporting the existence of diminishing returns. However, as Fingleton (2001) argues, β-convergence is not a formal test for the presence or absence of increasing returns but rather a signal that data are consistent with neoclassical theory. Therefore, we argue in this article that one has to pay a close attention to the eventual presence of increasing returns when estimating regional growth. To that purpose, we base our estimation on an augmented specification of Verdoorn's law, which measures the impact of the technological gap, density, accessibility and European structural funds. Given the geographic nature of our data, we use spatial econometrics to achieve reliable statistical inference. We pay particular attention to the potential endogeneity of our explanatory variables and apply the appropriate specifications when necessary. The estimates obtained confirm the presence of increasing returns to scale in the regional productivity process. They also indicate a significant and positive impact of the technical gap, regional density and the spatial lag variable. The accessibility variable is never significant. The relationship between gains in accessibility and economic development still requires considerable empirical investigation especially given the variations in transportation demands by sector, differences in the productive structure of each region and the hub-and-spoke nature of the European transportation network (Vickerman, 1991, 1996; Vickerman et al. 1999).

This paper has proposed five novelties in the estimation process of the impact of the funds: 1) we do not only consider the sum of the funds, but look at their impact by cohesion objective; 2) we assess the impact of structural funds (coming form the EU Commission) and of total project costs, which include the additional funds the targeted region and/or the country it belongs to must provide; 3) we test whether the impact of the funds is lagged in time; 4) we have tested whether the structural funds variable is endogenous. Potential risk comes from the EU regional policy allocation mechanism: structural funds level depend, to some extent, on previous levels of regional per capita GDP and 5) we have used a spatial econometric approach to include the spillover effects that occur when the funds are allocated to a region.

Estimation results indicate that the impact of the total funds (costs) is always significant, but always negative and very small (10^{-5}). This result is in tune with the ones of Ederveen et al. (2006). When these variables are split by objective, the coefficient associated to objective 1 funds (costs) is significant, negative, and also very small (10^{-5}), while that associated with objective 2 is not significant. The non-significance of the funds split by objective is also fund in Dall'erba and Le Gallo (2004) and Rodriguez-Pose and Fratesi (2004). There are a couple of elements that may explain these results. First, the temporal lag we have allowed is not necessarily long enough to allow for the full impact of the funds on growth. Indeed, a significant part of the funds finance transportation infrastructures and various incentives to delocation in the poor areas (such as tax breaks) that do not necessarily affect the location process of companies in the short-run. While we have tested here for a 5 year lag and Rodriguez-Pose and Fratesi (2004) use a lag of up to 7 years, it may still be too early to capture the full impact of the funds. On the other hand, we can also claim that the agglomeration process has intensified over the last two decades and is too strong to be counterbalanced by financial incentive promoting relocation in the poor areas. By definition, the poor areas are not necessarily able to offer the level of skilled labor, infrastructure and accessibility that companies seek. Following the Ederveen et al. (2006) idea, we recognize that several explanatory variables may be missing in the specification we use. In other words, the efficiency of the funds may be affected by some conditions we have not captured in our models, because of lack of the necessary data at the regional level. For instance, several recent contributions have focused on the issue of conditionality of international aid to poor countries (Burnside and Dollar, 2000; Mosley et al. 2004; Collier and Dollar, 2004). As noted by Dall'erba (2005), beyond this apparent desire to reduce interregional income inequalities, EU aid is not necessarily correlated with the development gap or development potential. In that sense, the European authorities may have tried to reach too many objectives through regional funds allocation. Only objective 1 funds are truly devoted to the poorest regions. Objectives 2 and 3 concern aid for industry restructuring that affect mostly regions that were formerly prosperous, while the remaining objectives (objective 4 for the adaptation of the labor force, objectives 5 for agricultural structures and objective 6 for low density regions) tend more to promote “social cohesion”. Finally, because of the necessity of meeting the requirements of the Single Market, nearly one-third of structural funds have been devoted to transportation infrastructures. However, the economic geography literature shows that transportation infrastructures do not systematically benefit the region where they are implemented, especially when they are used as regional development instruments (Martin and Rogers 1995; Vickerman 1996). Without this type of infrastructure, poor regions are not attractive, but their construction is not necessarily growth-enhancing. This is because of potential delocation effects in the core areas that allow a company to benefit from increasing returns, because the European transportation network tend to be built between and within core areas where the demand for transport is highest, and because several other factors, in addition to infrastructure endowments, act on the location decisions of the firms (Vickerman et al., 1999).

Our results open the door to a more detailed and technical estimation of the funds in the future, as more data will become available and a greater need for a reform of their implementation process became obvious with the 2004 and 2007 enlargements.

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Table 1. OLS estimation results of the Verdoorn's law model 1989-1999

	Model with structural funds		**Model with total costs**	
	Total structural funds	**Structural funds by objectives**	**Total costs**	**Total costs by objectives**
Constant	-0.199 (0.065)	-0.261 (0.017)	-0.178 (0.104)	-0.248 (0.022)
Output growth rate	0.675 (0.000)	0.683 (0.000)	0.696 (0.000)	0.699 (0.000)
Technological gap	$3.5.10^{-3}$ (0.000)	$3.7.10^{-3}$ (0.000)	$3.3.10^{-3}$ (0.000)	$3.6.10^{-3}$ (0.000)
Density	5.10^{-5} (0.007)	$5.7.10^{-5}$ (0.003)	$4.8.10^{-5}$ (0.011)	$5.6.10^{-5}$ (0.004)
Accessibility	$6.33.10^{-6}$ (0.485)	$1.0.10^{-5}$ (0.260)	$7.0.10^{-6}$ (0.432)	$1.0.10^{-5}$ (0.240)
Obj. 1	**Total**: $-6.6.10^{-5}$ (0.000)	$-6.1.10^{-6}$ (0.000)	**Total**: $-3.2.10^{-5}$ (0.000)	$-3.2.10^{-5}$ (0.000)
Obj. 2		$1.7.10^{-4}$ (0.340)		$4.0.10^{-5}$ (0.474)
Adjusted R^2	0.613	0.607	0.614	0.610
σ_ε^2	0.142	0.143	0.142	0.143

Notes: There are $N = 145$ observations. *p*-values are in brackets.

Table 2. OLS estimation results of the Verdoorn's law model 1989-2004

	Model with structural funds		**Model with total costs**	
	Total structural funds	**Structural funds by objectives**	**Total costs**	**Total costs by objectives**
Constant	-0.158 (0.224)	-0.228 (0.079)	-0.147 (0.264)	-0.213 (0.100)
Output growth rate	0.582 (0.000)	0.592 (0.000)	0.596 (0.000)	0.599 (0.000)
Technological gap	$3.5.10^{-3}$ (0.002)	$3.8.10^{-3}$ (0.000)	$3.4.10^{-3}$ (0.002)	$3.7.10^{-3}$ (0.001)
Density	$7.1.10^{-5}$ (0.002)	$7.8.10^{-5}$ (0.000)	$6.9.10^{-5}$ (0.002)	$7.6.10^{-5}$ (0.000)
Accessibility	$1.8.10^{-5}$ (0.090)	$2.1.10^{-5}$ (0.043)	$1.9.10^{-5}$ (0.071)	$2.1.10^{-5}$ (0.038)
Obj. 1	**Total**: $-5.3.10^{-5}$ (0.002)	$-4.7.10^{-5}$ (0.017)	**Total**: $-2.5.10^{-5}$ (0.003)	$-2.5.10^{-5}$ (0.010)
Obj. 2		$3.4.10^{-4}$ (0.119)		$7.5.10^{-5}$ (0.257)
Adjusted R^2	0.529	0.534	0.528	0.531
σ_ε^2	0.169	0.168	0.166	0.169

Notes: There are $N = 145$ observations. *p*-values are in brackets.

Table 3. Spatial autocorrelation test results estimated by OLS and weights matrix D(1)

	Model with structural funds		**Model with total costs**	
	Total structural funds	**Structural funds by objectives**	**Total costs**	**Total costs by objectives**
Moran's *I*	2.809 (0.004)	2.350 (0.018)	2.725 (0.006)	2.798 (0.005)
LMERR	4.525 (0.033)	2.710 (0.099)	4.291 (0.038)	4.213 (0.040)
R-LMERR	2.270 (0.131)	1.395 (0.237)	1.912 (0.156)	2.544 (0.110)
LMLAG	2.256 (0.133)	1.315 (0.251)	2.381 (0.122)	1.715 (0.190)
R-LMLAG	0.002 (0.958)	$6.7.10^{-4}$ (0.979)	0.002 (0.956)	0.046 (0.829)

Notes: There are N = 145 observations. p-values are in brackets. Moran's *I* is Moran's *I* test adapted for regression residuals (Cliff and Ord, 1981). *LMERR* stands for the Lagrange Multiplier test for residual spatial autocorrelation and *R-LMERR* for its robust version. *LMLAG* stands for the Lagrange Multiplier test for spatially lagged endogenous variable and *R-LMLAG* for its robust version (Anselin *et al.*, 1996).

Table 4. 2SLS estimation results of the Verdoorn's law model 1989-2004

	Model with structural funds		**Model with total costs**	
	Total structural funds	**Structural funds by objectives**	**Total costs**	**Total costs by objectives**
Constant	-0.109 (0.413)	-0.173 (0.193)	-0.103 (0.442)	-0.165 (0.213)
Output growth rate	0.508 (0.000)	0.517 (0.000)	0.521 (0.000)	0.520 (0.000)
Technological gap	$3.5.10^{-3}$ (0.002)	$3.7.10^{-3}$ (0.001)	$3.3.10^{-3}$ (0.003)	$3.6.10^{-3}$ (0.001)
Density	$7.1.10^{-5}$ (0.002)	$7.8.10^{-5}$ (0.000)	$6.8.10^{-5}$ (0.002)	$7.6.10^{-5}$ (0.000)
Accessibility	$1.3.10^{-5}$ (0.230)	$1.6.10^{-5}$ (0.143)	$1.5.10^{-5}$ (0.157)	$1.7.10^{-5}$ (0.106)
Obj. 1	**Total**: $-6.1.10^{-5}$ (0.000)	$-5.7.10^{-5}$ (0.005)	**Total**: $-2.8.10^{-5}$ (0.001)	$-2.8.10^{-5}$ (0.004)
Obj. 2		$2.8.10^{-4}$ (0.199)		$6.6.10^{-5}$ (0.326)
σ^2	0.172	0.171	0.172	0.172
Sq. corr	0.539	0.547	0.540	0.545
Hausman test	5.843 (0.016)	6.900 (0.009)	5.610 (0.019)	7.270 (0.007)
LMERR	5.722 (0.017)	3.999 (0.045)	5.555 (0.018)	5.523 (0.019)

Notes: There are N = 145 observations. p-values are in brackets. *2SLS* indicates the use of the instrumental variables. The individual Hausman statistic of exogeneity of the growth of manufacturing output variable is distributed as a χ^2 with 1 degree of freedom.

Table 5. FGS2SLS estimation results of the Verdoorn's law model 1989-2004;
Spatial error model with D(1) weights matrix

	Model with structural funds		**Model with total costs**	
	Total structural funds	**Structural funds by objectives**	**Total costs**	**Total costs by objectives**
Constant	-0.229 (0.148)	-0.245 (0.119)	-0.230 (0.146)	-0.242 (0.121)
Output growth rate	0.528 (0.000)	0.529 (0.000)	0.538 (0.000)	0.541 (0.000)
Technological gap	$4.6.10^{-3}$ (0.000)	$4.6.10^{-3}$ (0.000)	$4.6.10^{-3}$ (0.000)	$4.6.10^{-3}$ (0.000)
Density	$6.8.10^{-5}$ (0.001)	$7.0.10^{-5}$ (0.001)	$6.7.10^{-5}$ (0.001)	$7.0.10^{-5}$ (0.001)
Accessibility	$1.8.10^{-5}$ (0.355)	$2.0.10^{-5}$ (0.317)	$1.9.10^{-5}$ (0.332)	$1.9.10^{-5}$ (0.325)
Obj. 1	**Total**: $-5.1.10^{-5}$ (0.011)	$-5.9.10^{-5}$ (0.013)	**Total**: $-2.3.10^{-5}$ (0.015)	$-2.9.10^{-5}$ (0.010)
Obj. 2		$5.5.10^{-5}$ (0.827)		$3.4.10^{-5}$ (0.654)
λ	0.798 (0.000)	0.799 (0.000)	0.797 (0.000)	0.799 (0.000)
σ^2	0.177	0.177	0.177	0.177
Sq. corr	0.445	0.447	0.444	0.451

Notes: There are *N* = 145 observations. *p*-values are in brackets. *FGS2SLS* indicates the use of the Fingleton and Le Gallo (2006) estimation method with instruments defined by the 3-group and its spatial lag for growth of manufacturing output. *Sq. Corr.* is the squared correlation between predicted values and actual values.

Table 6. FGLS estimation results of the Verdoorn's law model 1989-2004;
Spatial error model with D(1) weights matrix and groupwise heteroskedasticity

	Model with structural funds		**Model with total costs**	
	Total structural funds	**Structural funds by objectives**	**Total costs**	**Total costs by objectives**
Constant	-0.219 (0.172)	-0.222 (0.165)	-0.227 (0.158)	-0.225 (0.156)
Output growth rate	0.538 (0.000)	0.540 (0.000)	0.549 (0.000)	0.552 (0.000)
Technological gap	$4.5.10^{-3}$ (0.000)	$4.4.10^{-3}$ (0.000)	$4.5.10^{-3}$ (0.000)	$4.4.10^{-3}$ (0.000)
Density	$6.7.10^{-5}$ (0.003)	$6.9.10^{-5}$ (0.003)	$6.7.10^{-5}$ (0.004)	$6.9.10^{-5}$ (0.003)
Accessibility	$1.5.10^{-5}$ (0.447)	$1.6.10^{-5}$ (0.427)	$1.6.10^{-5}$ (0.407)	$1.6.10^{-5}$ (0.422)
Obj. 1	**Total**: $-5.0.10^{-5}$ (0.005)	$-6.0.10^{-5}$ (0.003)	**Total**: $-2.2.10^{-5}$ (0.008)	$-3.0.10^{-5}$ (0.003)
Obj. 2		$-1.5.10^{-6}$ (0.994)		$8.4.10^{-6}$ (0.907)
λ	0.802 (0.000)	0.804 (0.000)	0.801 (0.000)	0.804 (0.000)
$\sigma^2_{periphery}$	0.024 (0.000)	0.023 (0.000)	0.024 (0.000)	0.023 (0.000)
σ^2_{core}	0.038 (0.000)	0.038 (0.000)	0.038 (0.000)	0.038 (0.000)
Sq. corr	0.445	0.447	0.444	0.450

Notes: There are *N* = 145 observations. *p*-values are in brackets. *FGS2SLS* indicates the use of the Fingleton and Le Gallo (2006) estimation method with instruments defined by the 3-group and its spatial lag for growth of manufacturing output. *Sq. Corr.* is the squared correlation between predicted values and actual values.

Figure 1. 2-way split of our sample according to G-I* stat on the initial manufacturing productivity gap (compared to Groningen).