Chapter 6

The Impact of Infrastructure on Regional Economic Growth: some Indications for the EU Enlargement

Annex

1. INTRODUCTION

In the context of the European Union (EU) the interest of public capital analysis has grown given the increase of the funds assigned to finance infrastructure investment projects in less-developed regions in order to promote growth and hence the convergence and cohesion within the territories of the EU. It is well known that in response to the different levels of income and welfare observed in the EU after the accession of Greece, Spain and Portugal, the European institutions adopted a group of measures to achieve the real integration of peripheral areas within the Community. Among these measures, basic infrastructure investments in Objective 1 regions accounted for 35% of the total expenditure for the Structural Funds between 1989 and 1993. The further enlargement of the European Union is likely to exacerbate some regional problems in the Union given that the GDP per capita of the mean CEEC is approximately 40% of the EU average. These economies are characterised by a predominance of primary and secondary activities, with industry highly concentrated in specific locations together with an insufficient infrastructure endowment. A restructuring process is claimed in them in order to assure the conditions for future growth. The regions which do not undergo necessary restructuring, could pay the price of recession anyhow, and would be deprived of the potential for future growth. Only these backward regional units which would be able to undergo restructuring would have some chances for catching up with more affluent regions.

Notwithstanding the importance that EU ascribed to infrastructure, it was more a matter of conviction than the result of analytical studies; indeed, the real effects of these investments are far from being clearly identified. Most studies analysing the infrastructure impact on regional growth show that the relationship between the two is positive. However, the public capital elasticity estimated in a Cobb-Douglas function, which is the most common specification in these studies, is sometimes too large to be credible (Aschauer, 1989)[1]. Consequently the results have been partially discredited (Holtz-Eakin, 1994; Garcia-Mila et al, 1996). In this chapter we present some new advances on the real link effect of public capital on productivity and economic growth, and discuss the implications that can be extracted for regional policy.

[1] Some papers analysing the effect of public infrastructure through the estimation of a cost function are Morrison and Schwartz (1996), Morrison and Siegel (1997), Moreno et al. (2002), Boscá et al (2002) and Moreno et al. (2003). All of them obtain a positive shadow price for public capital.

Initially, in order to understand the impact of public infrastructure on economic growth we describe the capitalization process that the Spanish regions have undergone during the period under analysis in order to analyse its correspondence to the geography of economic activity. We will focus our attention on the importance of the spatial dimension in infrastructure impact, since we believe that this dimension is an essential factor in the study of productivity impacts of infrastructure investments. This way, we start the study of such relationship with a mapping of economic activity and the distribution of the infrastructure endowment in Spanish regions by means of a deep exploratory spatial analysis based on several global indicators of spatial dependence. The analysis is carried out for different time periods starting from the mid sixties up to the final nineties.

Secondly, it is assumed that the effect of infrastructure on productivity depends on the various types of public infrastructure. Different categories of basic infrastructure may not have the same kind of impact on output since they are thought to pursue different purposes: local infrastructure enhances economic activity in the area where they are located, whereas transport and communication infrastructure may produce both positive benefits in the area where they are located and spillovers to other regions. These spillovers can be either positive or negative. The positive spillovers would be caused by the connectivity characteristic of most transport public capital. This network characteristic supposes that any piece of a network is related and subordinate to the entire network, increasing the interrelationships between regions. Hence, part of the infrastructure benefits (if they really exist) would felt beyond the limits of the region where it is located. Alternatively, the negative spillover would arise from factor migration, in the sense that transportation infrastructure in one region could have a negative effect in those other regions that are the region's closest competitors for labour and mobile capital. In this chapter we will check which of these two hypotheses on the spillover effect of transport infrastructure is prevalent in the case of the Spanish regions.

Additionally, we will also obtain conclusions on whether the link between growth and public capital depends on the level of economic development in the region under consideration, on the amount of the existing public capital stocks and the way infrastructure is articulated in its location relative to other factors. If the results indicate that there appear to be decreasing returns for public capital, we will be able to conclude that it is a factor with a threshold level which, once reached, reduces returns. In other words, infrastructure may have a significant role during part of the period under analysis but with a decreasing trend in time so that it would not persist with the same strength in the future.

The empirical analysis in order to give answer to the above questions will rely on the effect of the public capital stock on the growth of Spanish regional economies (NUTS III level) during the period 1965-1997. It is worth remembering that both the level of government capital endowment and the level of economic activity in most Spanish regions in the early sixties were far below that of other European economies and that both figures have undergone a significant increase during the period under consideration, specially after the accession to the EU. To a certain extent, it has been argued that admission countries stand, relative to the EU15 average member, in the same position in which about twenty years ago, Greece, Portugal and Spain stood in relation to the then older members of the EU. Boldrin (2003) upon a number of aggregate statistics (GDP per capita, labor productivity, share of employment in agriculture and openness of the economy) demonstrates that the macroeconomic conditions in CEEC are similar to those of previous entrants and the gains from joining the EU will be probably comparable to those experienced by the previous three newcomers. Even some cultural and historical features resemble very much those of Spain at the time of accession to the EU: about a decade has elapsed since the previous regime collapsed and a number of changes have already been implemented. Among the differences of the present environment are that current level of economic integration within the EU is much higher than it was in the eighties and that the CEEC will enter a larger and richer market than the early entrants did (Boldrin and Canova, 2003), features which should, in any case, benefit CEEC and should facilitate their integration. Another potential difference consists on the fact that the level of infrastructure stock in the present accession countries may differ from the level of public capital in Spain at the time of accession. Due to the lack of monetary data on infrastructure stocks in the accession countries, we can not conclude whether this is a real difference or not. But we know that the level of infrastructure endowment in the Spanish case at the moment of accession had considerable increased if compared with the levels at the seventies and early eighties so that all the benefits coming from the infrastructure investment effort in this country were not only due to the entrance in the EU. Therefore, the previous experience of Spain can provide, to a certain extent, guidance as to what may happen to the new entrants. Empirical results in the paper may be understood as the effect of infrastructure on the takeoff of less-developed economies which are opening and modernizing their productive structure as a consequence of their entrance in the EU.

The paper is organized as follows. The second section presents the model specification based on the idea that competition among regions may appear when the endowment of public infrastructure is increased. Section 3 describes the database and its main spatial features. The empirical results for the industrial sector in the Spanish regions are presented and discussed in section 4. Finally, some concluding remarks and suggestions for policy makers are given in section 5.

2. MODEL SPECIFICATION

2.1 Theoretical economic background

Although there is consensus on the need for a certain level of infrastructural provision, once this level is reached, different results and conclusions are obtained. In this regard, some authors do not deny the existence of a link between publicly provided inputs and economic growth, but do not find evidence for it. For instance, Holtz-Eakin (1994) and Garcia-Milà et al. (1996) criticize the initial findings on positive infrastructure effects in the US case on econometric grounds, presenting estimations of regional production functions that use standard techniques to control for state-specific characteristics, revealing essentially a zero role for public capital. Furthermore, Crihfield and Panggabean (1995) using a neoclassical growth model observe that public capital has a weak effect on growth in per capita product of US metropolitan economies both by means of indirect action (factor markets) and by direct action (rates of public investment). Ciccone and Hall (1996) reach the same conclusion when explaining differences in labour productivity across US states in a model that accounts for spatial density effects.

On the other hand, Martin and Rogers (1995) and Holtz-Eakin and Lovely (1996) have highlighted the mechanism by which infrastructure affects firms and markets. Through the construction of general equilibrium and Krugman type models, their findings reveal that public infrastructure has no direct effect on increasing aggregate productivity, but alters it through increases in the number and variety of manufacturing establishments, concluding that infrastructure plays a subtle role in changing the relative attractiveness of location for firms. Besides, according to the results obtained in the Martin and Roger's study, a larger infrastructural endowment will not necessarily enhance convergence, due to the different effect of domestic and international infrastructures on industrial location. Improvements in domestic infrastructure in a poor region will always bring firms to those regions (mainly when the cost is assumed by a third party). However, firms will tend to relocate in high activity regions when international public capital is improved and when poor regions have a low level of domestic infrastructure. Therefore, in early stages, the use of public investment to deepen an integration process may increase disparities, since regions with weak competitive positions may be adversely affected (Rietveld, 1995). In that way, the increasing disparities can be clearly seen since, for instance, the high-speed rail and highways have augmented accessibility between central regions, and the end of the regulation policies in air transport have reinforced the primacy of the main airports in Europe (De Rus et al, 1995).

2.2 The model

The basic specification model used in this chapter is based on a classical production model which relates output (Y) with the amounts of labour (L) and private capital (K) aggregated with public capital (G) in which the region is the unit of analysis:

$$Y = f(L, K)\, g(G)$$

and where the factors of production meet the following conditions:

$$\begin{aligned} &g'(G) > 0 \\ &f_K > 0;\ f_{KK} < 0 \\ &f_L > 0;\ f_{LL} < 0 \end{aligned}$$

In the model public infrastructure is assumed to be complementary to labour and capital. If the markets are competitive and the factors of production are mobile, each factor will be paid its marginal revenue product, given a certain amount of public capital, whose choice is considered to be external to the firms of the regions:

$$\begin{aligned} \frac{\partial Y}{\partial L} &= f_L(L, K)\, g(G) \\ \frac{\partial Y}{\partial K} &= f_K(L, K)\, g(G) \end{aligned}$$

The factor prices, once the supply and demand for each input are equilibrated, is equal to their respective marginal revenue, so that:

$$p_L = p_Y \; f_L(L,K) \; g(G)$$
$$p_K = p_Y \; f_K(L,K) \; g(G)$$

where p_Y, p_L and p_K are the prices of output, labor and capital, respectively.

Following the ideas in Boarnet (1998) and focusing on the effect of an increase in public capital, let us suppose that a region i increases its endowment of public capital. Under the reasoning above, the price of labour and capital in region i increase accordingly, so that if those factors are perfectly mobile, the factor-price differential would induce labour and capital migration from other regions to region i. This migration would imply a new output level in region i:

$$Y_i = f(L_i + \Delta L, K_i + \Delta K) \; g(G_i + \Delta G)$$

along with a lower output level in the regions losing production factors. In other words, the increase in public capital increases output in region i and decreases it in the other regions, with some labour and capital migrating from those other regions to region i. Therefore, migration of inputs would imply output increases in regions with good endowments of public capital and output decreases in the others.[2]

According to the ideas outlined by the model above, there is an intuition for negative output spillovers associated to public infrastructure, since mobile factors would move to the region with good infrastructure endowments, so that the total output in one region would depend positively on its stock of infrastructure and negatively on the stock of infrastructure in other regions.

On the contrary, there are reasons to believe that public infrastructure, in particular that devoted to transportation, may have a positive impact not only in the region where it is located but also in the geographically close ones. This is due to the network characteristic of some infrastructure, in which any piece is subordinate to the entire network, increasing the interrelationships between regions. The importance of this spatial dimension in infrastructure

[2] Some extensions to the case where factors of production are imperfectly mobile are given in detail in Boarnet (1998).

studies was considered after noting the reduction in public capital effect when descending to the territorial level (Deno and Eberts, 1989; Eberts, 1990; Munnell, 1990; Garcia-Milà and McGuire, 1992). It made economists suspect the existence of spillover effects that would spread public capital impact among the rest of the regions, especially the nearest ones. This result can be due either to the network characteristic of some infrastructures, or to the fact that regions are administrative delimitations, so that linkages forward and backward are cut, attributing regions with an inadequate infrastructural effect. Thus, some studies of the regional Spanish case (e.g. Mas et al., 1996) have demonstrated that effects on productivity depend not only on the infrastructure itself but also on the overall provision throughout the country, especially in the contiguous regions. However, Holtz-Eakin and Schwartz (1995) obtain no evidence in favour of the idea that the US highway stock has significant effects on productivity across states and Kelejian and Robinson (1997) obtain a negative spillover effect of infrastructure, which would be in line with the migration reasoning given in the model above. Summing up, the fact is that there is no empirical consensus on the existence/absence of spillovers in the infrastructure impact as well as on its sign.

The goal of the paper will be to test for the sign of the spillover of public infrastructure. With this aim, we can rewrite the production function for a region i after including the spatial spillover as:

$$Y = f(L,K)\, g(G,G_{\rho})$$

where G_{ρ} is public capital infrastructure in the other regions, which will be reflecting the spillover impact of infrastructure. If a positive spillover existed, we could think that the closer the two regions, the stronger the interaction between them. On the other hand, in the case of prevalence of a negative spillover, it seems natural to think that the spillover would be stronger across regions that are close substitutes as locations for production. There are several possibilities in the way this closeness is considered: through physical proximity, through economic similarity, or a mixture of both.

Independently of the reasoning underlying the closeness across regions, the empirical model we will estimate is based on the log-linear Cobb-Douglas aggregate production function in which public capital is disaggregated into two main components (local and transportation) as well as including a spillover variable for the transportation component:

$$\log(Y_{it}) = \beta_0 + \beta_1 \log(L_{it}) + \beta_2 \log(K_{it}) + \beta_3 \log(G\_local_{it}) + \beta_4 \log(G\_trans_{it}) + \beta_5 \log(G\_trans_{\rho it}) + \varepsilon_{it} \quad (1)$$

where log denotes logarithm. In the estimation of the equation above, the calculation of the spillover variable will be computed using the idea of a spatial lag given in Spatial Econometrics (Anselin, 1988): $G_{\rho it} = W \cdot G_{it}$. Different definitions for closeness will be used in order to construct the weigh matrix W that will reflect the infrastructure spillover in order to test its sign and magnitude.

The three first definitions of the W matrix will rely on the idea that geographical proximity matters in the interaction across regions. The first one (W_{bin}) will be a physical contiguity matrix, giving rise to a binary and symmetric matrix where its elements would be 1 in case of two regions being in contact and 0 otherwise. The second one will be the inverse of the distance (W_{dist}), and the third one will consist on the inverse of the square of the distance (W_{dist2}).

The definition based on physical proximity presents certain problems: firstly, the symmetric character of the contiguous matrix is debatable, because it supposes that the influence that region j receives from region i is the same as that received by i from j, whereas the influence between two regions is not always reciprocal in its intensity; secondly, because interrelationships are not only due to geographical proximity. For these reasons, even though the contiguity matrix seems to be the best suited matrix in the study of the infrastructure effects, we also used other criterions. Specifically, a fourth matrix will be constructed following the reasoning that the more similar the economies of two regions, the higher the weights of the W. For our purposes, we will allow for agglomeration economies through the consideration of the density of population, in persons per square Kilometre in 1981. In order to exhibit similarity in density of population, the weights of the W matrix are constructed as follows:

$$w_{ij} = \frac{1}{\left|Density_i - Density_j\right|}$$

This way, the weight matrix (W_{dens}) would reflect similarity in density of population between two regions, irrespective of the proximity they maintain.

Finally, we will take into account a matrix based on the fact that economically powerful regions may have a greater impact on the others than a poor one, although weighting this power according to the distance between regions. Thus, the matrix will display higher values for the weights in the case of a high value added in region j and physical proximity to region i (W_{va_d}, W_{va_d2}):

$$w_{ij} = \frac{VA_j}{d_{ij}} \text{ or } w_{ij} = \frac{VA_j}{d_{ij}^2}$$

3. DATA AND SPATIAL EXPLORATORY ANALYSIS

Data refer to the 50 regions of Spain (NUTS III level, known as provinces) for the period 1965-1997, with two main sources. Value Added at factor cost and labour (total number of employees) are obtained from "Renta Nacional de España y su Distribución Provincial" [National Wealth of Spain and its distribution by provinces, BBVA] published every two years. Series of private and public capital stocks are taken from "El Stock de Capital en la Economía Española" [The Capital Stock in the Spanish Economy].[3] As local public capital we have considered water and sewage facilities and urban structures. For the transportation component we consider the stock of roads and highways, railway, harbours and maritime signalling and airports. All variables are expressed at constant prices of 1986, having 17 temporal biennial observations and 50 cross-section observations.

This section attempts to describe the capitalization process that the Spanish regions have undergone during the period under analysis in order to examine its correspondence to the geography of economic activity. An interesting way to analyse the geographical distribution of production and public capital (its two components, local and transportation) across Spain is to have a look at the maps to start comparing visually both distributions. The first two

[3] These stocks have been calculated by using the Perpetual Inventory Method (see Mas *et al.*, 1995). Thus, we use data gathering public capital stocks (not investments) in monetary terms.

distributions (see maps 1 to 6 corresponding to value added per capita and transportation infrastructure) appear to have some similarities, due to the clear dualism between the north-east and south, although some specific differences are worth pinpointing. Most rich regions correspond to the north-east quadrant (provinces of Catalonia, Vasc Country, Navarra and the Balearic Islands plus the capital region in the center, Madrid) which also accumulates much transportation infrastructure endowment per capita. However, some other regions with a high stock of public capital per capita are among some of the poor regions, but still concentrated in the north half of the Spanish peninsula. The south of Spain corresponds without doubt to the provinces with lower value added per capita together with a bad endowment of transport infrastructure. However, this low endowment of transportation public capital per capita is also true for regions such as Madrid and Barcelona, in which according to their level of economic activity per capita, the stock of public transportation infrastructure per inhabitant is low. It is also interesting to highlight that whereas the pattern of economic activity does not show important changes through time, the distribution followed by transportation public capital has undergone a deeper centralization in the north-east quadrant. In the other hand, with respect to local public infrastructure, we observe that its distribution has little to do with that of economic development.

The degree of dispersion of value added and the two types of infrastructure in per capita terms, is shown in Figure 1, where the coefficient of variation for these magnitudes is plotted. The dispersion of economic activity is remarkably lower than that of public capital. Although an important convergence process is experienced in both magnitudes, some differences in their dynamics are interesting to highlight. The convergence process in economic activity (the CV has decreased from 0.34 in 1965 to 0.21 in 1997) has taken place almost without interruption during the whole period. Transportation public infrastructure, however, presents several important changes. Whereas the coefficient of variation slightly decreased in the late sixties it increased considerably during the seventies. However, the eighties marked an important structural change with this respect, since the coefficient of variation decreased from 0.57 in 1965 to 0.36 in 1997. The highest degree of dispersion is observed for local public capital, with a little increase in the late sixties and a permanent and important decrease in the rest of the period under consideration (from 1.06 to 0.57 at the end of the period). This reduction in the disparities can be argued to be a result of the policy of cohesion and restructuring that the Spanish economy has been undertaking during the last decades, especially after the accession to the EU.

Suspecting that spillovers may appear both in the regional economic activity and in the location of regional infrastructure, it is of importance to test the presence of this effect in the distribution of the variables that are going to appear in our model. Specifically, the presence of a spatial dependence process implies that the value of a variable at a geographical point is functionally related to the value of the same variable in other locations, $Y_i = f(Y_1, Y_2, ..., Y_N)$. In the case of spatial autocorrelation being positive, similar characteristics would be spatially concentrated; if it is negative, the phenomenon would be disseminated throughout the space. In order to test the presence of global spatial dependence in the variables used in our paper, the standardized Moran's I statistic (Moran, 1948) is used. In the test the null hypothesis is spatial independence, and the weight matrix representing the interaction between regions has been chosen on the basis of geographical contiguity.

As for the analysis of spatial dependence the use of the Moran index (see Table 1) shows a clear rejection of the null hypothesis of absence of spatial autocorrelation with a positive value of the statistic for all the variables under consideration except for local infrastructure. Production activity measured as value added per capita appears to be strongly and positively correlated in space, confirming the picture of spatial clustering given by the map. Moreover it seems that the value of the Moran index is increasing through time signalling possibly an increasing level of spatial dependence in all the variables under consideration. The same conclusions are obtained both for private and transportation capital per capita. On the contrary, local infrastructure presents a non-significant value of the Moran’s I test, pointing to a randomly distribution of this vairable in the space.

4. EMPIRICAL ANALYSIS

According to some theoretical studies such as Holtz-Eakin and Lovely (1996) industry benefits more than the rest of productive sectors from the improvement in the endowment of public infrastructure. In the same line, some previous applied works for the Spanish economy (Moreno et al., 1997) have demonstrated that public capital has a greater role in industrial productivity than in any other economic sector, especially in the period they consider (1965-1991) in which Spain experienced processes of growth and liberalization. Some arguments in favour of this idea is that public capital may increased the accessibility of firms and reduce costs, making this expansion process possible. Following these ideas, we estimate the production function for the industrial sector.

The availability of observations of several regions at different points in time permits estimation by panel data techniques. These techniques present the advantage of including in the specification of the error term both a regional specific component controlling for the unobservable characteristics of each region in a way that each one enters the function depending on its own peculiarities (resource endowment, industrial mix, etc.), and a time specific component accounting for the changes in the overall economy in each period reflecting cyclical effects and changes in the technology.[4] In order to choose the most accurate estimation method among the different possibilities the theory of panel data offers, a Haussman test is considered together with a F-statistic to check the necessity of introducing regional and temporal effects. The use of either the fixed and the random effects models may provide better estimates than the OLS method, since they take into account the characteristics of each region that are likely to be present in any regional study. In fact, Holtz-Eakin (1994) and Garcia-Milà et al. (1996) argue that the initial studies of public capital impact that did not control for regional effects obtained a large, positive and significant coefficient for public capital because they used the wrong estimation method. Hence, the positive relationship between regional growth and infrastructure in some studies could be the result of a spurious correlation, as a result of not considering these controls. Therefore, we consider the method of estimation that better suit our data according to the tests signalled above. The fixed effect model is the one chosen.

The results of the estimation of the different models are shown in Table 2. In all of them it can be concluded that private capital and labour elasticities are approximately 0.24 and 0.78, according to what is indicated by the theory. Therefore, constant returns to scale are not rejected for private inputs (being equal to 1.02), while slightly increasing returns are obtained for all productive productive inputs (around 1.12), concluding that both public capital components (local and transportation) are important for regional productivity since the external economies they generate permit obtaining slight increases in returns.

The parameter accompanying local public capital seems robust given its constant significance with a value of around 0.06, so that an increase of 1% in the stock of local public capital would increase value added by 0.06%, a modest but significant effect. On the other hand,

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[4] The inclusion of a linear trend as an approximation to the level of technology was initially considered in our work. However, this alternative was rejected and the use of time effects preferred, since time dummies may also reflect technological change as well as other possible effects common to all regions in each year.

transportation infrastructure is also significant although of a somewhat lower value than the local one, varying between 0.03 and 0.05. In conclusion, although public capital seems to have had a positive impact on Spanish productivity growth, this impact is lower than that reported in earlier public capital studies, and indeed in line with the most recent ones, which conclude that the role of infrastructure is a subtle one. Also, in contrast to what happens in the US economy (Holtz-Eakin, 1994; Garcia-Milà et al., 1996) where controlling for state effects reduces or invalidates public capital impact, in the Spanish case the use of panel data techniques presents credible values, not only for public capital elasticities, but also for labour and private capital shares. In our belief, this could be due to the fact that at the beginning of the period under consideration Spanish regions were lacking in infrastructure; as the provision increased, it had a positive influence on productivity growth. Conversely, with large initial infrastructure endowment, the US states would have reached a saturation point.

We test the sign and magnitude of the public capital spillover through the analysis of the estimated value of the β_5 coefficient in equation (1). The geographic neighbour public infrastructure is significantly negative in all the cases considered. The value of the coefficient ranges between the -0.10 for the case of the physical contiguity matrix up to the -0.19 in the case of the inverse of the distance. Therefore the negative value of the impact of public infrastructure in transportation of region i on the other regions would exceed the positive impact that this infrastructure has in region i. Not only the closeness concept seems to support the negative spillover hypothesis, but also with the other three weight matrices, based on similarities across regions, the spillover effect results significantly negative with a similar magnitude than the one specified before. In seems therefore, that the negative spillover of infrastructure seems to dominate its network characteristic. This result would be in line with the ones obtained for the states of the US in Boarnet (1998) and in Kelejian and Robinson (1997).

Additionally, it is commonly accepted that the output effect of an increase in the public capital stock depends on the size of the existing endowment, the degree of its congestion, and the level of economic development in the region. Hence, on the one hand, additions to infrastructure networks would not have the same impact on output growth as the construction of the network (presence of decreasing returns for public capital). On the other hand, adding capacity to an uncongested endowment would not affect private productivity, while the benefits from an increase in the amount of public capital would be large when congestion is high. These issues can be analysed by estimating the marginal effect of output to public capital (∂Y/∂G). These marginal effects are computed from the results obtained with the estimation of equation 1 and the use of Wbin for the spillover effect. As observed in Table 3, there appear to be decreasing returns for both types of public capital, since the regional average value decreases with time. This decrease is higher in the case of local infrastructure, where the return has constantly diminished from .024 to .013, a 44% decrease. In the case of transportation capital, the decrease represents a 27%, ranging down from 0.073 to 0.053. Hence, it could be said that although infrastructure in Spain has had a significant role during the period analysed, it has decreased with time, and is unlikely to persist with the same strength in the future. In fact, it can be observed that the highest decrease is observed after 1987, that is, after the accession of Spain to the EU. This is probably due to the fact that public capital at the end of the eighties and the beginning of the nineties was getting close to the level needed so as not to hinder economic development.

With respect to the returns obtained for each province, as a time average, Table 4 shows that the ones with higher returns for transportation infrastructure are Valladolid, Barcelona, Alicante, Valencia, Madrid, Murcia, Álava and Vizcaya. All these regions present high returns with non-high relative public capital stocks, though with the highest value added per capita. In other words, it could be inferred that these regions had an important endogenous potential that could still be exploited by providing more infrastructures (certain bottleneck problems in infrastructure use). It is also the case for local public capital, so that their potentiality is still being developed. In these regions it seems that infrastructures permit prompting the private activity so that public investments should accommodate ongoing spatial economic developments. On the other hand, we observe how some provinces, such as Almería, Málaga, Cuenca, Badajoz, Las Palmas and Tenerife have relative low sizes of public capital and low elasticities. They are not among the most industrialised provinces in Spain, then although the public sector has provided a better infrastructure to stimulate them, these regions have not combined increases in public capital with other factors such as an adequate industrial mix, human capital, business culture, or connexions with dynamic centers, etc. In other words, although with a little stock of public capital per capita, they have not benefited from the public capital stock to attract dynamic economic activity, which is a proof of the necessary, although not sufficient, condition of public capital.

In figures 2 to 7, the time average for the returns is plotted against the time average of the stock of public capital both for the transportation and local capital. A clear negative relationship between both variables is obtained. This is true for the endowment of public capital per unit of private capital and per unit of output. Again we find evidence of the existence of decreasing returns to public capital which are already working in the Spanish case.

Our analysis so far has considered a model which includes public capital in the region and public capital in close regions as separate regressors. However, in some other papers (Mas et al, 1996, Kelejian and Robinson, 1997) an indirect test to check the existence of spillovers is used based on the comparison of two regressions. In a first one, a Cobb-Douglas production function is estimated aggregated with the region's own public capital stock. In a second one, the same production function is estimated aggregated with the effective capital stock (G^E), consisting of:

$$G_i^E = G_i + \sum_{j \neq i}^{N} G_j$$

Thus, if the output elasticity of public capital is higher using G^E than using G, this is interpreted as evidence of a positive spillover of public infrastructure. These authors did not consider the possibility of a negative spillover effect due to competition among regions. There are two potential drawbacks in this way of considering the spillover effect of public capital. First, underlying is the assumption that public capital in the region i has the same effect on its output than the public capital located in the closer regions. Second, Álvarez-Pinilla (2003) shows that this way of obtaining the spillover depends on the distribution of public capital and not because of the real existence of a spillover. He demonstrates that when one aggregates output and public capital across regions, the output elasticity of public capital increases if there is a spillover effect, but this is not necessarily true when one only aggregates public capital and not output, which is what is done when considering this effective measure of public capital in a production function.

In Table 5 we present the estimation results with the effective stock of public capital introduced in the way these authors have suggested in order to check whether our results in Table 2 are also corroborated in such other way. We observe that the elasticity of the effective stock of public capital is not significant in most cases. There is only one exception, which refers to the consideration of a weight matrix based on the similarity across regions according to their density. In such a case, the value of the elasticity is significant though with a very small value. Therefore, the lack of significance of this effective measure of public capital stock would be reflecting a combination of the positive effect that transportation infrastructure in region i has on its output, mixed up with the negative effect that a high transportation infrastructure in its closest regions has on its output. As a conclusion, results in tables 2 and 5 reinforce the existence of a negative spillover effect of public capital.

Finally, as a consequence of the presence of a global spatial association process in the variables considered in our regressions, some kind of spatial dependence may appear in them. For this reason, and aware of the important problems it can suppose, such as the invalidation of standard econometric techniques (Anselin, 1988), we test whether a remaining problem of spatial dependence is present in the model. The Moran's I test for the estimated errors is obtained to test the null hypothesis of lack of spatial residual correlation. In all cases the assumption of spatial independence is not rejected. Therefore, our results would not be affected by a remaining problem of spatial dependence in the error term.

5. MAIN CONCLUSIONS

According to our result on the existence of a positive but modest impact of public infrastructure on industrial output, it can be concluded that new developments in the EU policies should renew interest in ensuring that infrastructure policy should, at least, not hinder economic development. This could be especially relevant for CEEC, less developed than others in Europe and with lower endowments of public capital, whose main purpose is to reduce disparities in relation to them. Given the similarities observed between Spain at the time of accession and the CEEC at the present time, similar to what happened in Spain, there seems to be still a potential for industry for getting output benefits from public capital, both from local and transportation infrastructure, although these benefits tend to decrease with the increases in the stock of public capital. Notwithstanding the complexity of the link infrastructure-growth, in our belief, there is little support for a special and important role for infrastructures in prompting aggregate productivity, but there is little question that they are an ingredient for long term economic development, it being a requisite for potential activity in a region. Therefore, it does not seem desirable, from a political point of view, that the process of decreasing public deficit, one of the main objectives of EU countries, should mean a cut in public infrastructure policy.

Our results also indicate that a region's output is negatively related to the stock of transportation infrastructure on other regions, in line with the results obtained for the US in Kelejian and Robinson (1997) and Boarnet (1998). This negative output spillover from transport public capital can be due to the fact that when input factors are mobile, transportation infrastructure in one region can draw industrial production away from other regions. In other words, regions with similar infrastructure would compete for mobile factors of production. Therefore, in early stages, the use of public investment to deepen an integration process may increase disparities, since regions with weak competitive positions may be adversely affected. Politically, the presence of negative spillovers would imply that regions could use infrastructure as a competitive tool for attracting factors of production and thus increasing their own industrial output at the expense of the other regions. In such a case, each region would try to provide more infrastructures that it would have otherwise provided. Therefore, EU regional policy should have this result in mind, since the possibility that the decision that public capital should be supplied by a local entity could imply an excess of infrastructure endowment with some negative spillover effects.

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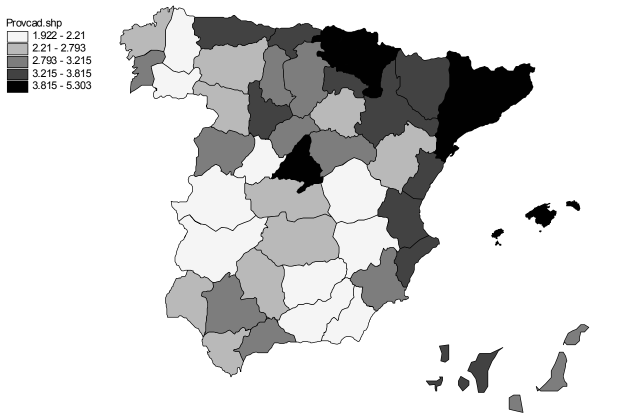
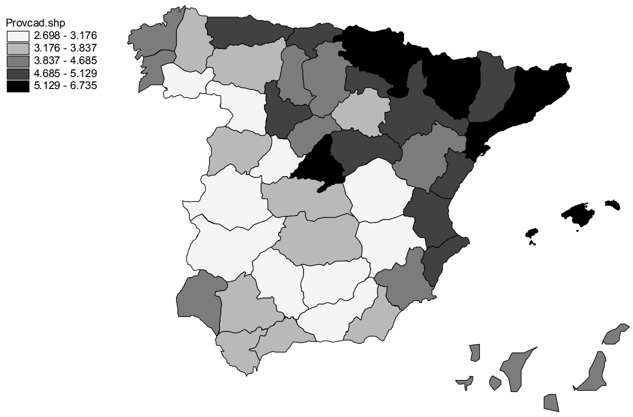
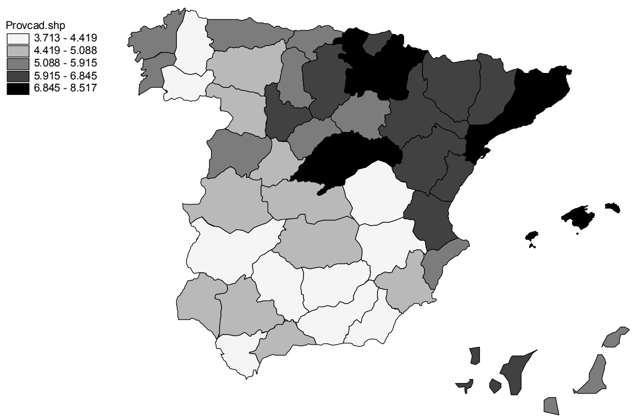
Map1. Value added per capita. 1965-1973. Annual average



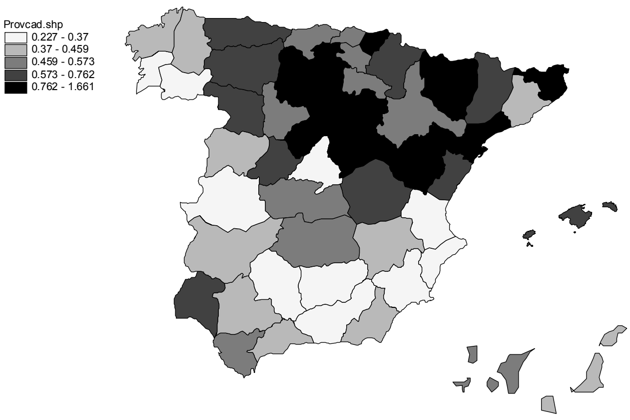
Map 2. Value added per capita. 1975-1983. Annual average



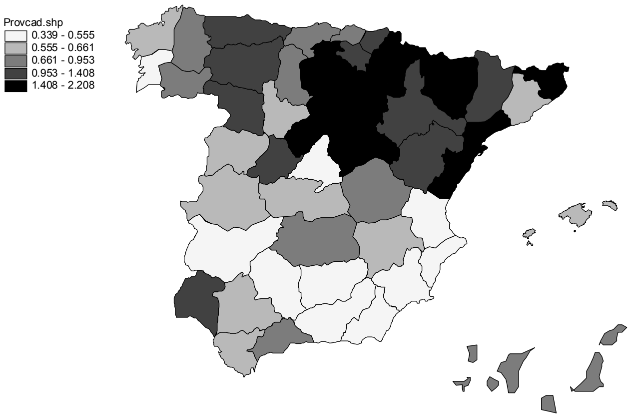
Map 3. Value added per capita. 1985-1997. Annual average



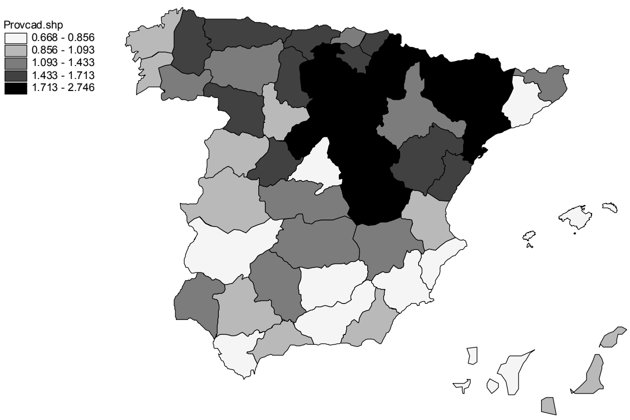
Map 4. Transport infrastructure pc. 1965-1973. Annual average



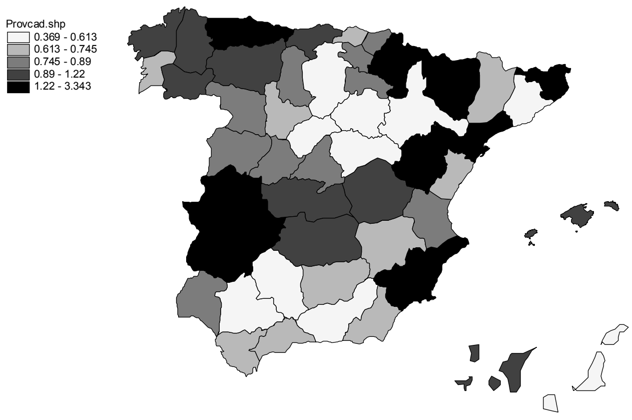
Map 5. Transport infrastructure pc. 1975-1983. Annual average



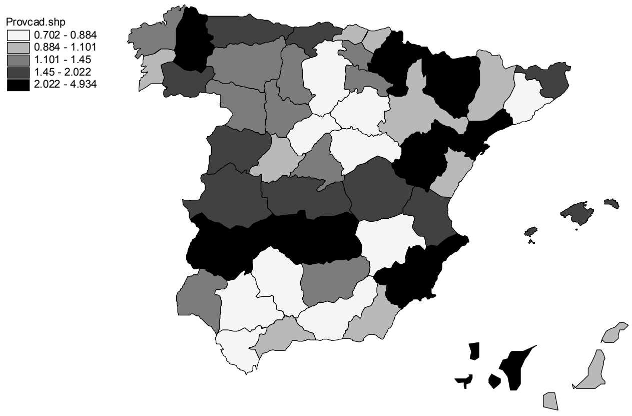
Map 6. Transport infrastructure pc. 1985-1997. Annual average



Map 7. Local infrastructure pc. 1965-1973. Annual average



Map 8. Local infrastructure pc. 1975-1983. Annual average



Map 9. Local infrastructure pc. 1985-1997. Annual average

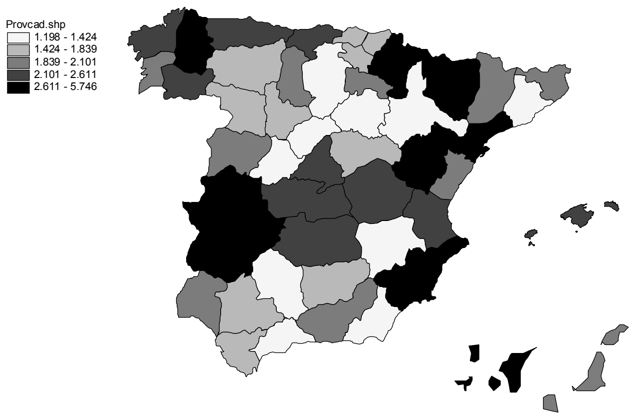


Figure 1. Coefficient of variation. Spanish provinces

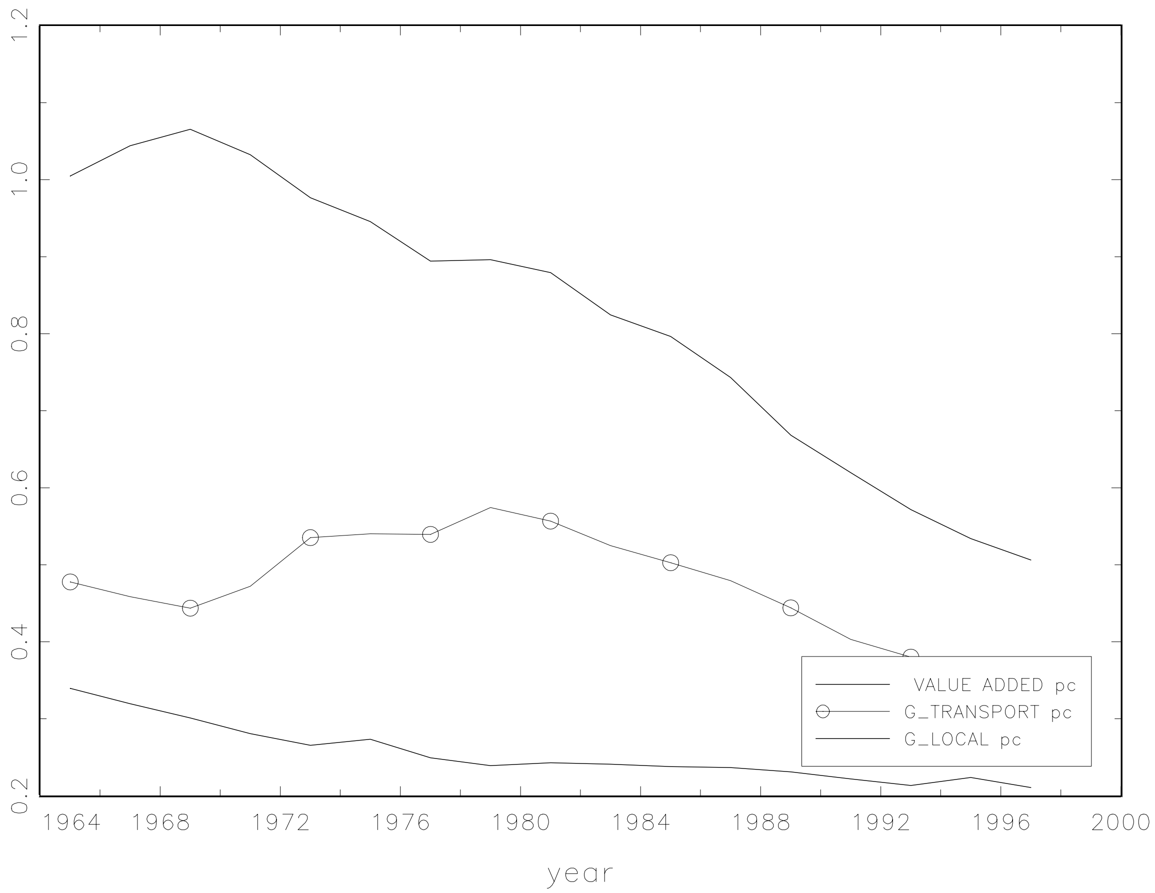


Table 1. Moran's I test for spatial autocorrelation

Period		1965-1973		1975-1983		1985-1997	
Variable	**W**	**Z-value**	**Prob**	**Z-value**	**Prob**	**Z-value**	**Prob**
VA pc	1st order contiguity	6.255	0.000	6.838	0.000	7.509	0.000
K pc	1st order contiguity	6.409	0.000	7.237	0.000	6.829	0.000
G_trans pc	1st order contiguity	4.144	0.000	5.889	0.000	5.026	0.000
G_local pc	1st order contiguity	-0.049	0.960	0.125	0.900	0.651	0.515

Table 2. Estimation results

		Wbin	Wdist	Wdist2	Wva_d	Wva_d2	Wdens
L	0.779 (0.046)**	0.786 (0.046)**	0.782 (0.046)**	0.784 (0.04)**	0.782 (0.046)**	0.784 (0.046)**	0.784 (0.046)**
K	0.248 (0.026)**	0.242 (0.026)**	0.245 (0.026)**	0.244 (0.026)**	0.245 (0.026)**	0.244 (0.026)**	0.239 (0.026)**
G_local	0.058 (0.012)**	0.062 (0.012)**	0.058 (0.012)**	0.058 (0.012)**	0.058 (0.012)**	0.059 (0.012)**	0.065 (0.012)**
G_trans	0.029 (0.017)*	0.049 (0.018)**	0.038 (0.018)**	0.041 (0.018)**	0.037 (0.018)**	0.042 (0.018)**	0.037 (0.017)**
W*G_trans		-0.104 (0.033)**	-0.189 (0.107)*	-0.105 (0.050)**	-0.189 (0.107)*	-0.105 (0.050)**	-0.101 (0.042)**
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99

Table 3. Returns to transport and local public capital. Regional average (returns based on the estimation with Wbin)

	Return G_trans	**Return G_local**
1965	0.073	0.239
1967	0.07	0.226
1969	0.074	0.229
1971	0.078	0.228
1973	0.08	0.228
1975	0.078	0.233
1977	0.071	0.216
1979	0.073	0.221
1981	0.073	0.209
1983	0.07	0.18
1985	0.066	0.174
1987	0.07	0.173
1989	0.069	0.168
1991	0.062	0.155
1993	0.053	0.136
1995	0.053	0.134
1997	0.053	0.133

Table 4.Returns to public capital.Time average. (returns based on the estimation with Wbin)

	Region	**Return G_transport**	**Return G_local**
1	Almería	0.035	0.108
2	Cádiz	0.064	0.118
3	Córdoba	0.055	0.092
4	Granada	0.048	0.07
5	Huelva	0.059	0.196
6	Jaén	0.064	0.088
7	Málaga	0.036	0.064
8	Sevilla	0.058	0.155

9	Huesca	0.04	0.027
10	Teruel	0.064	0.138
11	Zaragoza	0.085	0.199
12	Asturias	0.082	0.427
13	Baleares	0.058	0.231
14	Las Palmas	0.039	0.068
15	Santa Cruz de Tenerife	0.041	0.093
16	Cantabria	0.086	0.344
17	Ávila	0.019	0.06
18	Burgos	0.05	0.232
19	León	0.055	0.103
20	Palencia	0.058	0.107
21	Salamanca	0.077	0.081
22	Segovia	0.023	0.13
23	Soria	0.017	0.068
24	Valladolid	0.12	0.414
25	Zamora	0.029	0.056
26	Albacete	0.046	0.047
27	Ciudad Real	0.06	0.238
28	Cuenca	0.022	0.025
29	Guadalajara	0.051	0.063
30	Toledo	0.061	0.169
31	Barcelona	0.191	0.597
32	Gerona	0.07	0.245
33	Lerida	0.054	0.088
34	Tarragona	0.063	0.353
35	Alicante	0.145	0.237
36	Castellón	0.069	0.193
37	Valencia	0.123	0.196
38	Badajoz	0.031	0.034
39	Cáceres	0.058	0.064
40	La Coruna	0.078	0.359
41	Lugo	0.041	0.1
42	Orense	0.05	0.099
43	Pontevedra	0.081	0.368
44	Madrid	0.125	0.266
45	Murcia	0.12	0.17
46	Navarra	0.069	0.383
47	Álava	0.154	0.33
48	Guipúzcoa	0.098	0.589
49	Vizcaya	0.151	0.578
50	La Rioja	0.06	0.191

Table 5. Estimation results

	Wbin	Wdist	Wdist2	Wva_d	Wdens
L	0.806 (0.046)**	0.779 (0.046)**	0.779 (0.046)**	0.787 (0.046)**	0.796 (0.046)**
K	0.239 (0.026)**	0.248 (0.026)**	0.248 (0.026)**	0.246 (0.026)**	0.243 (0.026)**
G_local	0.064 (0.012)**	0.058 (0.012)**	0.058 (0.012)**	0.059 (0.012)**	0.061 (0.012)**
$(G\_trans)^E$	-0.046 (0.032)	0.035 (0.021)*	0.029 (0.017)*	0.031 (0.032)	-0.001 (0.037)**
R^2	0.99	0.99	0.99	0.99	0.99

Figure 2

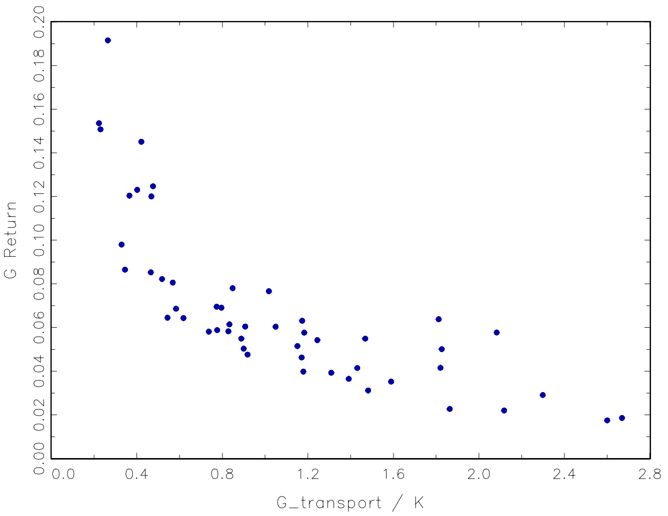


Figure 3

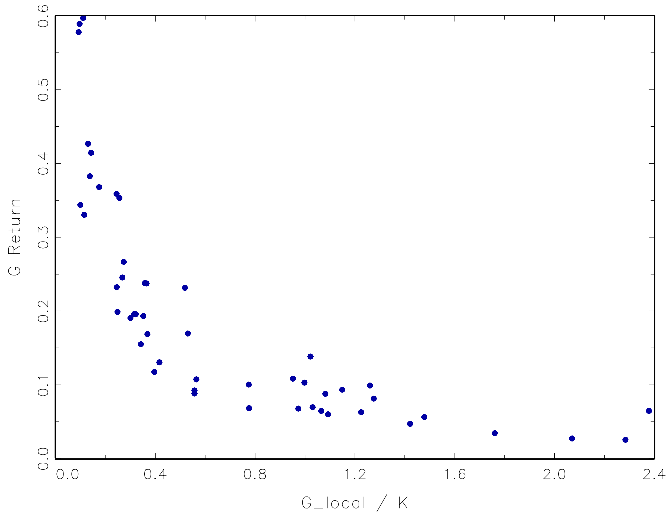


Figure 4

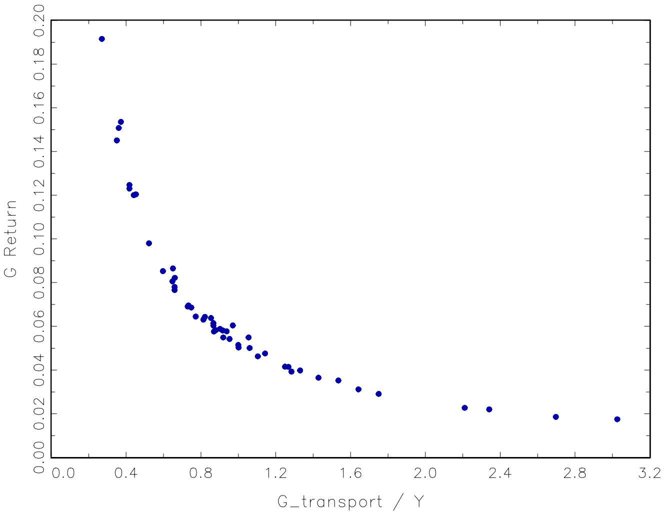


Figure 5

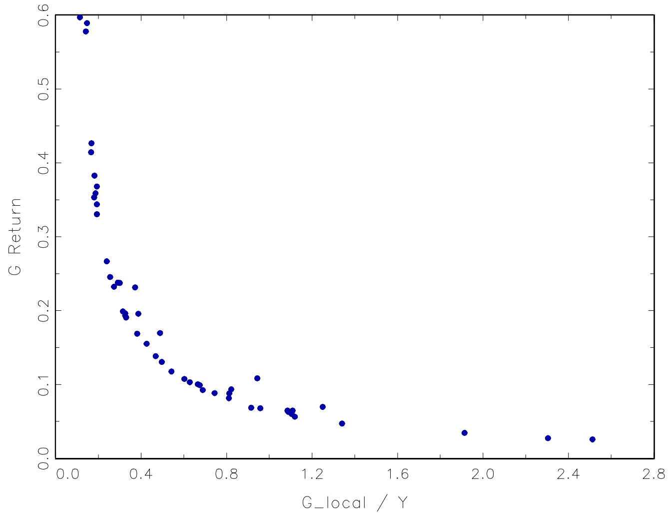


Figure 6

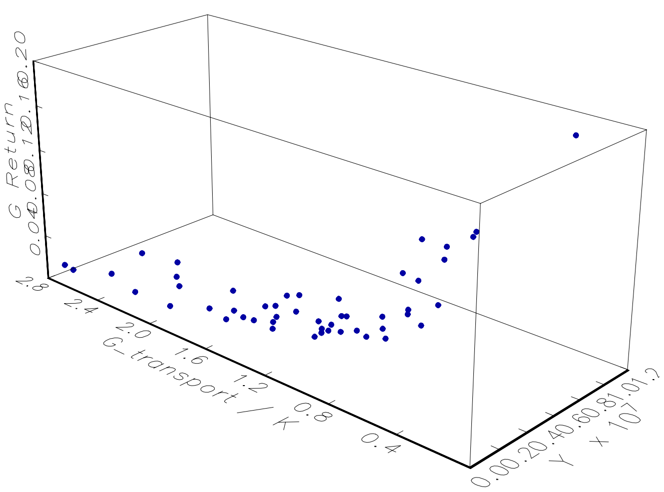


Figure 7