Public Capital, private economic activity and spillover effect: a region by region analysis of the industry and construction sectors in Spain.

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Abstract

This paper presents a study of the impact of the public infrastructure on private activity of industry and construction sectors for the Spanish regions from 1980 to 1993. Using a cost function approach, we derive short and long-term effects of public and private capital investments on output, but the possibility of the existence of spillover effect is always considered.

Key Words: Public infrastructure, spillover effects, cost function, productivity.
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1. Introduction

Over the last few years a number of studies have been carried out analyzing the possible relation between public investment in infrastructures and economic activity. The different approaches taken and econometric methods and data used have led to inconclusive and even contradictory results. Thus, while some studies claim that the effect of public capital on economic activity is positive and similar to that of private capital, other studies find no evidence to support this [1]. In any case, we can see that the most pessimistic results are to be found in these analyses which use information broken down by region, raising the suspicion that using a sample of this type the effects of public capital are not being adequately measured. Thus, the almost insignificant effects of public capital on private economic activity revealed in studies carried out with regional data is interpreted as evidence of the fact that a part of the effects of public infrastructure are dispersed into other regions.

The aim of this study is to evaluate the impact which the variation in public infrastructure has on private activity in the industry and construction sectors of the Spanish Autonomous regions, by means of a cost function estimate,[2] taking into account at all times the potential spillover effects generated by public capital in the regions. It can be observed how, in effect, the impact of public capital which is recorded in a traditional analysis without spillover effects, based in this case on a cost function estimate, is very low and even negative, if nothing is done to resolve the problem caused by using a small geographical area as a unit of reference. Nevertheless, the results obtained for public capital productivity increase considerably when

[1] See de la Fuente (1996)

[2] A brief review of the literature on the topic, as web as of some critical comments received for the traditional approach of the production function can be found in draper and Herce (1994), De la Fuente *et al.*(1994), Pfähler, Hoffman and Bönte (1996) or Sturm (1998).

some adjustments are made, either to the variable representing public capital endowment or to the model itself.

Two proposals for ways in which to measure public capital spillover effects among Autonomous regions are put forward: one of them consists of integrating in the model a single public capital variable which represents both the public capital belonging to each region and the spillover effects; in the other proposal two independent variables are integrated into the model, one relating to public capital belonging to each region and the other representing the capital spillover effects of the other regions. Although the results are very similar, they are not equivalent. Thus, if a weighted combination of a network type capital from the rest of the regions (as in the first proposal) is added to the public capital endowment of each Autonomous region the marginal benefit obtained by companies in capital 'stock' increases is positive and similar to those reached in the analyses which use collected data. If, in the function estimate a further independent variable is included, defined as the capital endowment of the remaining regions (the second proposal), the effects are also positive but greater, a difference which could be of vital importance if the shadow prices are used to analyze the possibility of a larger investment in public capital. The measurement of the spillover effects is, therefore, important and determines the results, and as such the interpretation and political exploitation of it require a certain amount of caution.

In the next section a brief presentation is given of the theoretical model taken as the base and a description is provided of the various different indicators to be obtained regarding the productivity of public capital, both in the short and long term. Following this, we discuss the spillover effects of public capital among regions and how to measure them and integrate them in the model. Finally, the results are set out and a conclusion is drawn.

2. Theoretical model

The approach adopted in this study takes as its base a cost function estimate in which public capital is regarded as an exogenous productive factor or beyond the control of companies and without a direct cost attributable to private companies. The basic idea is that by considering public capital as yet another productive factor, unremunerated, this will affect company cost structure, influencing private factor productivity as well as factor demand, with the expected result that a greater public infrastructure endowment makes it possible to produce the same *output* quantity at a lower cost.[3]

Let us suppose that company technology is expressed in the following function for short-term production:

$$X = F(V, K_p, K_I, t) \tag{1}$$

where V is the vector of variable *input*, K_p and K_I are the private and public capital *stocks* respectively, t represents technology, and X is *output*. Assuming that companies do not make the best choice for private capital *stock* in the short term, and that public infrastructure affects production as an unpaid exogenous factor, the total short-term cost can be expressed in the following way:

$$C(P, P_{K_p}, K_p, K_I, t, X, \lambda) = G(P, K_p, K_I, t, X, \lambda) + P_{K_p} K_p =$$

$$= \min_V \left\{ \sum_i P_i V_i \ s.a.\ F(\lambda V, \lambda K_p, K_I, t) = X \ dados\ K_p, K_I \right\} + P_{K_p} K_p \tag{2}$$

[3] We owe the theoretical basis of this line of research to Diewert (1986). Some of the studies which take the duality approach are the ones carried out by Bernt and Hansson (1991) in the case of Sweden, Seitz and Licht (1995), Conrad and Seitz (1994) or Seitz (1994) for Germany and Lynde and Richmond (1992), Nadiri and Mamuneas (1194) or Morrison and Schwartz (1996) for the U.S.A. In the case of Spain, we should make a special mention of the studies carried out by Boscá, Escribá and Dabán (1999), Boscá, Escribá and Murgui (2001), Avilés, Gómez and Sánchez Maldonado (2001) and Moreno, López-Bazo and Artís (2002). This section is based on our own adaptation of work by De la Fuente (199), Morrison and Schwartz (1996) and Seitz (1994).

where P_{Kp} is the market price or private capital user cost, P is the price vector of variable *inputs*, and λ is an auxiliary parameter of scale which is used to establish a cost elasticity – *output* elasticity relation.

The Lagrange associate to the problem of minimization of costs in the short term is:

$$\Gamma = \sum_i P_i V_i + \mu\left[X - F(\lambda V, \lambda K_p, K_I, t)\right] \tag{3}$$

and the prime order conditions for the variable factors appears thus:

$$\frac{\partial \Gamma}{\partial V_i} = P_i - \mu \frac{\partial F}{\partial V_i} = 0 \qquad P_i = \mu F_i \quad \forall i \tag{4}$$

where the multiplier μ is the company short-term marginal cost:

$$\frac{\partial C}{\partial X} = \frac{\partial G}{\partial X} = \frac{\partial \Gamma}{\partial X} = \mu \tag{5}$$

In the short term, a measurement of the returns to scale is the cost elasticity regarding company *output*, which is defined as the ratio of the marginal cost to the average cost:

$$\varepsilon_{CX} = \frac{\partial C}{\partial X}\frac{X}{C} = \frac{CMg}{CMe} = \frac{\mu}{C/X} \tag{6}$$

This short term cost elasticity is related to the *output* elasticity with regard to the *input* variables. Thus, for a unit value of the parameter λ we would get:

$$\frac{\partial C}{\partial \lambda}\frac{1}{C} = -\frac{1}{C}\left(\mu \sum_i F_i V_i + \mu F_{K_p} K_p\right) =$$

$$= -\frac{1}{C}\left(\sum_i P_i V_i + \mu F_{K_p} K_p\right) = -\sum_i S_i - \frac{\mu F_{K_p} K_p}{\frac{C}{X} X} =$$

$$= -(\sum_i S_i + \varepsilon_{CX}\varepsilon_{XK_p}) \tag{7}$$

where prime order conditions of the short term cost minimization problem have been used, and S_i is defined as the share in the total cost of the value of the *input* variable V_i. Equating the second and last terms:

$$\sum_i S_i + \varepsilon_{CX}\varepsilon_{XK_p} = \frac{\mu}{C}\left(\sum_i F_i V_i + F_{K_p} K_p\right) =$$

$$= \frac{\mu}{C / X}\frac{\sum_i F_i V_i + F_{K_p} K_p}{X} = \varepsilon_{CX}(\sum_i \varepsilon_{XV_i} + \varepsilon_{XK_p}) \tag{8}$$

from which:

$$\varepsilon_{CX} = \frac{\sum_i S_i}{\sum_i \varepsilon_{XV_i}} \tag{9}$$

The public and private capital *stocks* affect the variable costs of the companies. Thus, the shadow prices are defined as cost savings deriving from the changes in capital levels:

$$Z_{K_p} = -\frac{\partial G}{\partial K_p} = -\frac{\partial \Gamma}{\partial K_p} = \mu F_{K_p} \qquad Z_{K_I} = -\frac{\partial G}{\partial K_I} = -\frac{\partial \Gamma}{\partial K_I} = \mu F_{K_I} \tag{10}$$

And, in so far as the capital share in the total cost is concerned:

$$S^*_{K_P} = Z_{K_p}\frac{K_p}{C} \qquad S^*_{K_I} = Z_{K_I}\frac{K_I}{C} \tag{11}$$

Observe how, in these shares, the value of private and public capital is determined by the shadow prices of each and not by their market value.

The sign value of the shadow prices depends on the ratio of substitutability or complement of the fixed *input* to the variable *input* .Thus, expressing the variable cost function as the value of the conditioned demands of variable factors:

$$G(P,K_p,K_I,t,X,\lambda)=\sum_i P_i V_i(P,K_p,K_I,t,X,\lambda) \tag{12}$$

the shadow prices can be rewritten as:

$$Z_{K_p}=-\sum_i P_i\frac{\partial V_i}{\partial K_p} \qquad Z_{K_I}=-\sum_i P_i\frac{\partial V_i}{\partial K_I} \tag{13}$$

If all the *inputs* variables are substitutes of public (private) capital, then the public(private) capital shadow price will be positive,and an increase in the capital endowment will result in a reduction in the variable costs of the companies.The opposite will be the case if the input variables are complements of the capital. If one of the variable factors is a complement of the capital the shadow price will only be positive if the substitutability ratio of the fixed *input* to the rest of the variable factors exceeds the complementary effect.

The cost elasticity relating to the *output* is thus related to the *output* elasticities with regard to the private and public capital:

$$\varepsilon_{XK_p}=F_{K_p}\frac{K_p}{X}=\frac{\mu F_{K_p}K_p}{C}\frac{C/X}{\mu}=\frac{S^*_{K_p}}{\varepsilon_{CX}}$$

$$\varepsilon_{XK_I}=F_{K_I}\frac{K_I}{X}=\frac{\mu F_{K_I}K_I}{C}\frac{C/X}{\mu}=\frac{S^*_{K_I}}{\varepsilon_{CX}} \tag{14}$$

Let us now consider the long term total cost function, once the companies are able to adjust the private capital *stock* , given the level of public capital:

$$C^L(P,P_{K_p},K_I,t,X,\lambda)=\min_{K_p} C(P,P_{K_p},K_p,K_I,t,X,\lambda)=$$

$$=\min_{K_p}\left\{G(P,K_p,K_I,t,X,\lambda)+P_{K_p}K_p\right\} \tag{15}$$

The prime order conditions for this problem are:

$$\frac{\partial C}{\partial K_p}=\frac{\partial \Gamma}{\partial K_p}+P_{K_p}=-\mu F_{K_p}+P_{K_p}=0 \qquad P_{K_p}=\mu F_{K_p} \tag{16}$$

where μ remains the Lagrange multiplier for the problem of short term minimization. The previous condition defines implicitly the long term private capital demand:

$$K_p^L(P, P_{K_p}, K_I, t, X) \tag{17}$$

Here, where the short and long term cost curves are tangents, cost elasticities relating to the *output* will be equal:

$$\varepsilon_{CX}^L = \frac{\partial C^L}{\partial X}\frac{X}{C^L} = \frac{\partial C}{\partial X}\frac{X}{C} = \frac{\mu}{C/X} = \varepsilon_{CX} \tag{18}$$

However, in the long term, this elasticity also reflects the degree of returns to scale in all of the variable factors under company control:

$$\frac{\partial C^L}{\partial \lambda}\frac{1}{C^L} = \frac{\partial C}{\partial \lambda}\frac{1}{C} = -\frac{1}{C}\left(\mu\sum_i F_i V_i + \mu F_{K_p} K_p\right) = -\frac{1}{C}\left(\sum_i P_i V_i + P_{K_p} K_p\right) = -1 \tag{19}$$

from which:

$$1 = \frac{\mu}{C/X}\frac{\sum_i F_i V_i + F_{K_p} K_p}{X} = \varepsilon_{CX}\left(\sum_i \varepsilon_{XV_i} + \varepsilon_{XK_p}\right) \tag{20}$$

and so we can express the following:

$$\varepsilon_{CX}^L = \frac{1}{\sum_i \varepsilon_{XV_i} + \varepsilon_{XK_p}} \tag{21}$$

With the aim of obtaining these results, it is necessary to specify a cost function and proceed to the formulation of an estimate in order to subsequently calculate the cost elasticities and shadow prices, *output* elasticities and marginal products, as well as the returns to scale and the complement or substitutability relations between *inputs*.

3. Spillover effects

Space conceived as a network of nodes has the property that an investment made in one place will the *output* in many other points of the network. One of the clearest examples that comes to mind is that of public investment in roads. In order to measure the effects of this type of infrastructure the question of the demarcation of the regional or territorial area under consideration is the determining factor. Following the theoretical model described in the previous section, public capital is an exogenous productive factor unremunerated by companies. On the other hand, in our study the sample units are the Spanish Autonomous regions. As such, the public capital endowment of each region can be used without cost by the companies operating in the region. But is this the only public capital used by the companies in a region in their productive activities ? For example, the Autonomous region of La Rioja Pero ¿es éste el único capital público que utilizan las empresas de una región en su actividad productiva?. Por ejemplo, la Comunidad Autónoma de La Rioja owns public capital physical endowment, but in order to enable production to go ahead and to sell the resulting *output*, the companies of La Rioja not only make use of the roads of the Rioja region but, in all probability, also make use of the roads, ports and airports of Madrid, Catalonia, or Aragon. This example leads us to question the way in which an adequate quantification is achieved of the capital endowment that companies in each of the Spanish regions really put to effective use, in other words, the effective capital *stock* which should be attributed to each of them.

3.1 A brief review of the literature.

In the Spanish literature on the subject, some authors have attempted to resolve the problem of the regional attribution of public capital. Mas *et al.* (1994), taking as their approach the estimate of a production function, calculate the regional *output* elasticity with regard to public capital, where the regional capital *stock* is the amount of physical capital situated in the region plus that located in the neighbouring and adjacent regions. The results for the public capital coefficient, of the order of 0.2 and 0.3, are higher than those which the same authors obtain when they do not take into account the public capital *stock* of the neighbouring regions.

On the other hand, Corugedo *et al.* (1994), also in a production function estimate, insert simultaneously as regressors into the regional *output* equation, the capital of their own region and that of the neighbouring regions, and find that while the coefficient of the former is practically zero, the latter is very high, around 0.39.

Taking a similar line, the work carried out by Chicote (1995) is worth mentioning. This author attempts attempts to analyze the problem of the aggregation level, by means of both cost and production functions. To achieve this he puts the Autonomous regions into five groups and carries two types of exercise. Firstly, into the function to be estimated, instead of the public capital belonging to each Autonomous region he inserts the one belong to its respective group, and then that of the Nation. In a second exercise, he carries out estimates, not for the Autonomous regions but rather for the regional groups. In the first exercise his aim is to register the effects which the capital in nearby regions has on a particular region. And in the second his objective is to analyze what can be observed in the existing studies, that is: the smaller the basic unit of analysis is, the lesser tends to be the effect of public capital. The results are that, on the one hand, the *output* elasticities in relation to the public capital of each region are relatively low, but when the group public capital is inserted into the function the effect increases considerably. By contrast, once the public capital of the entire nation is introduced into the function, the effect turns out not to be significant. The author concludes that if one wants to measure the impact of the infrastructure on the level of economic activity of a region, the relevant variable is not the one referring to the region's own capital nor to the capital of the nation as a whole, but rather that of the group of regions which are most related to it.

More recently, Moreno *et al.* (1997) consider the possibility of spillover effects existing between regions, taking as their starting point an expanded Cobb-Douglas production function. In this sense, the authors corroborate by means of spatial econometric instruments the existence of spatial correlation in the terms of error. To the contrary, Martínez (2000 y 2001), also making use of a production function, incorporates into each region a measurement of the spillover effects of the infrastructures located in other regions, finding no evidence of the existence of such effects. Furthermore, the author notes that the spillover effects can reduce the growth rate of , *per capita* income, by causing a *crowding-out* effect from private investment.

The studies referred to focus on the production function estimate approach. Nevertheless, in recent years several authors have begun to use a cost function.[4] One study in this area which does pay attention to the spillover effects is that carried out by Gil,Pascual and Rapún (1998). Instead of including the public capital of each region, these authors incorporate a weighted combination of capital located in all the regions, where the weightings are determined by the flow of commerce between them. In their study, the *output* elasticity in relation to public capital varies between 0.12 and 0.09, depending on whether or not these spillover effects are taken into account.

3.2 Measurement proposal

In this study a reformulation is applied of the one contained in the work of Holtz-Eakin and Schwartz (1995). Thus, the real or effective infrastructure endowment of a region can be

[4] It is worth noting the studies carried out by Boscá, Escribá and Dabán (1999), Boscá, Escribá and Murgui (2001), and Moreno, López-Bazo and Artís (2002), in which the authors analyze the effect of public infrastructures on the production of the industry sector, the private productive sector and the industry sector respectively, in the Spanish regions, by means of a cost function estimate approach. However, in these studies the authors do not at any time consider the existence of spillover effects.

defined as the group of services deriving from the infrastructure which can be effectively used in a region, regardless of whether they are situated in the area or not.

Let us suppose that the public capital effective *stock* of region $i, K_{I_i}^e$, is *produced* by the physical stock of region i, K_{I_i}, and the physical *stocks* of the remaining, $K_{I_{-i}}$. Thus, the effective capital of region *i*, would take the following general form:

$$K_{I_i}^e = f(K_{I_i}, K_{I_{-i}}) \tag{22}$$

Allowing a Cobb-Douglas type specification for $K_{I_i}^e$, the effective endowment of public capital in region *i* would be:[5]

$$K_{I_i}^e = K_{I_i} \prod_j K_{I_j}^{\beta_{ij}} \qquad i \neq j \tag{23}$$

where the parameter β_{ij} measures the effective *stock* elasticity of region *i* in relation to the physical *stock* of region *j*. Special attention should be paid, in this formulation, to the fact that the increase in physical *stock* in region *i* affects its effective endowment by one hundred per cent. Thus:

$$\beta_{i,j} = \frac{\partial K_{I_i}^e}{\partial K_{I_j}} \frac{K_{I_j}}{K_{I_i}^e} \qquad \beta_{i,i} = \frac{\partial K_{I_i}^e}{\partial K_{I_i}} \frac{K_{I_i}}{K_{I_i}^e} = 1 \tag{24}$$

These elasticities could be disaggregated into two parts: δ_{ij} or the intensity with which capital *j* affects region *i*, and W_{ij}, which would be defined by the characteristics peculiar to regions *i*, *j* (surface area of each region, geographical proximity, population, etc.). Thus, $\beta_{ij} = \delta_{ij} W_{ij}$. Applying logarithms, the expression (23) would be set out in the following way:

[5]This type of functional form, with an elasticity of substitution which is constant and equal to 1, would be suitable if we assume that the public capital *stocks* of the different regions are complementary, in the sense that if the capital endowment of a region increases that would increase the capital productivity in the rest of the regions.

$$\ln K_{I_i}^{e} = \ln K_{I_i} + \sum_{j} \delta_{ij} W_{ij} \ln K_{I_j} \qquad i \neq j \tag{25}$$

In matrix notation, and assuming a constant parameter δ for all the regions, we would arrive at the expression used by Holtz-Eakin and Schwartz (1995) to specify the effective infrastructure endowment for roads in American states: [6]

$$K_{I\,Nx1}^{e} = K_{I\,Nx1} + \delta W_{NxN} K_{I\,Nx1} \tag{26}$$

where the idea considered is that the effective public capital in each region would be the result of the sum of the physical *stock* of the region and the capitals of the remaining regions,these being multiplied by some factor of real influence which also incorporates the relevant features of the regions.[7] If δ equals zero, there would be no spillover effects and the effective endowment of a region would match its physical endowment; if δ is greater than zero, there would be postive spillover effects and, therefore, the effective endowment of public capital of a region would be greater than its physical endowment; in the extreme case that δ should equal 1, the effective capital endowment of a region would be the sum of the physical *stock* of the region and a weighted combination of the *stocks* of the rest of the regions.

In this study we carry out a cost function estimate applying three different hypotheses: firstly, we assume that $\delta = 0$, in other words, we impose the non-existence of spillover effects;

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[6] These authors use specifically the following expression:

$$K_{I\,Nx1}^{E} = K_{I\,Nx1} + \delta W_{NxN} K_{I\,Nx1}^{E}$$

where the effective capital of a region depends on its physical *stock* and on the **effective** *stocks* of the remaining regions regiones, which means that the infrastructures of the neighbouring regions influence the effective endowment of that region.This fact can overestimate the effective endowment of each region, in so far as its own capital can have an influence on the effective endowment of those neighbouring regions, as being previously calculated, it would be doubly considered.

[7] W_{NxN} is the weighting matrix of the network type capital of the regions. The simplest and most frequently used is the one known as the neighbourhood matrix, that is, if i and j are two adjacent regions, then the elements of the matrix W_{ij}=W_{ji}=1 and 0 in the opposite case. Other matrices related to this one can be found in the work of Holtz-Eakin and Schwartz (1995) and Kelejian and Robinson (1995). In this study we use a matrix based on the inportance of the flow of commerce between regions, contiguity and access time, more fully explained in the Appendix. However, several exercises with alternative definitions for W_{NXN} were carried out and the results obtained were very similar to those presented in this study.

secondly, we suppose the opposite case in which $\delta = 1$; thirdly, we impose a specific value for parameter δ. The first two cases are relatively simple: in the first, in the cost function to be estimated only the *stock* of physical public capital located in the region itself is regarded as the effective endowment of public capital of region *i*; in the second case, the effective capital *stock* of region *i* would be the sum of the capital belonging to the region plus the weighted combination of the rest of the public capital located in the remaining regions; in the third case, given that we do not know the value of δ we are unable to calculate, *a priori*, the effective endowment of capital, and so we would proceed in an indirect manner. Thus, in this third case, in the cost function to be estimated we include a further variable among the exogenous ones, which incorporates the spillover effects, K_D. We therefore obtain, on the one hand, the saving in variable costs achieved by the companies of each region as a result of their physical *stock* of capital and, on the other, the saving in costs due to spillover effects. The sum of both shadow prices enables us to calculate the total impact on the variable costs of the public capital, comparable to that obtained when $\delta = 1$, which could give us an idea of closest value of δ.

4. Estimate of the model

We propose a production model with four productive factors: work, intermediate consumption, private capital and public capital. The variable short term factors are the work factor, L (with price w), and the intermediate *inputs*, M (with price q_M). The fixed short term factors are the levels of private capital (K_p) and public capital (K_I). The production value is given the designation X and the technical progress is registered by means of a trend el progreso técnico se recoge mediante una tendencia (t). [8]

[8] Other authors consider the added value to be a production variable. In these last cases, the intermediate consumption cannot be included in the model. However, in the study carried out by Díaz (1998) some results are presented which show the importance of using the production value, rather than the added value, in the calculation of sectoral and regional productivity.

In this way, the short term variable cost function would take the following form:De esta forma, la función de coste variable a corto plazo tendría la forma:

$$cv = cv(w, q_M, X, t, K_I, K_p) \tag{27}$$

In the estimate of the short term variable cost function the transcendental logarithmic functional form was the one chosen. The basis for this choice lies in the flexibility of this function to adapt to any type of productive technology without requiring the setting of restrictions *a priori* on the return to scale, allowing both substitutability and complementary relations between the factors considered in the model.

The variable cost function is, therefore, expressed in the following terms:

$$\begin{aligned} \ln cv = & \sum_{i=1}^{17} D_i + \beta_1 t + a_1 \ln w + a_2 \ln q_M + b_1 \ln X + b_2 \ln K_I^e + b_3 \ln K_P + \\ & + \frac{1}{2}\beta_{11} t^2 + \frac{1}{2} c_{11} \ln w^2 + \frac{1}{2} c_{22} \ln q_M{}^2 + \frac{1}{2} e_{11} \ln X^2 + \frac{1}{2} e_{22} \ln K_I^{e^2} + \frac{1}{2} e_{33} \ln K_P{}^2 + \\ & + h_{12} \ln w \ln q_M + d_{11} \ln w \ln X + d_{12} \ln w \ln K_I^e + d_{13} \ln w \ln K_P + d_{14} \ln wt + \\ & + d_{21} \ln q_M \ln X + d_{22} \ln q_M \ln K_I^e + d_{23} \ln q_M \ln K_P + d_{24} \ln q_M t + e_{12} \ln X \ln K_I^e + \\ & + e_{13} \ln X \ln K_P + e_{14} \ln X t + e_{23} \ln K_I^e \ln K_P + e_{24} \ln K_I^e t + e_{34} \ln K_P t \end{aligned} \tag{28}$$

where each variable has a referential value for each region and year. On the other hand, this function must be of a grade one homogeneity, concave, continuous and not decreasing in the variable factor prices, with the aim of ensuring that it approximates any arbitrary cost function of the companies. objeto de asegurar que aproxima cualquier función de costes arbitraria de las empresas. Consequently, in order that the cost function is of a grade one homogeneity in the variable *input* prices, verification must be made of the following restrictions or conditions of homogeneity:

$$\begin{aligned} & a_1 + a_2 = 1 \qquad c_{11} + h_{12} = 0 \qquad c_{22} + h_{12} = 0 \\ & d_{11} + d_{21} = 0 \quad d_{12} + d_{22} = 0 \qquad d_{13} + d_{23} = 0 \\ & d_{14} + d_{24} = 0 \end{aligned} \tag{29}$$

in which case, the cost function may be expressed in an alternative way, such as:

$$\begin{aligned}\ln\frac{cv}{q_M} &= \sum_{i=1}^{17} D_i + \beta_1 t + a_1 \ln\frac{w}{q_M} + b_1 \ln X + b_2 \ln K_I^e + b_3 \ln K_P + \\ &+\frac{1}{2}\beta_{11}t^2 + \frac{1}{2}c_{11}(\ln\frac{w}{q_M})^2 + \frac{1}{2}e_{11}\ln X^2 + \frac{1}{2}e_{22}\ln K_I^{e^2} + \frac{1}{2}e_{33}\ln K_P{}^2 + \\ &+d_{11}\ln\frac{w}{q_M}\ln X + d_{12}\ln\frac{w}{q_M}\ln K_I^e + d_{13}\ln\frac{w}{q_M}\ln K_P + d_{14}\ln\frac{w}{q_M}t + \\ &+e_{12}\ln X\ln K_I^e + e_{13}\ln X\ln K_P + e_{14}\ln X\,t + e_{23}\ln K_I^e\ln K_P + \\ &+e_{24}\ln K_I^e t + e_{34}\ln K_P\, t\end{aligned} \tag{30}$$

Moreover, making use of Shephard's motto, we obtain the following equation of share in the work factor costs:[9]

$$s_L = a_{11} + c_{11}\ln\frac{w}{q_M} + d_{11}\ln X + d_{12}\ln K_I^e + d_{13}\ln K_P + d_{14}t \tag{31}$$

Before embarking upon the estimate, a verification was carried out on the homogeneity conditions in prices specified in function (29), in order to impose such restrictions on the model and simultaneously estimate the reformulation of the cost function in equation (30) and the equation concerning share in work factor as expressed in (31). To achieve this, the starting point taken was the cost function expressed in (28), in which fictitious variable were applied to each region. To obtain a sample referring to the sales side of the Agriculture, Industry, Construction and Services sectors, the values of statistic *F* rejected the above mentioned conditions, and so the sample was limited to the sectors of Industry and Construction.[10]

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[9]The share function in the intermediate *input* costs can be calculated as $s_{Mi,t} = 1 - s_{Li,t.}$

[10] The values obtained of statistic *F* when the sample was limited to the sectors of Industry and Construction were *F*(7,194)=11,4245 for the first hypothetical estimate, *F*(7,194)=10,8454 for the second and *F*(8,160)=8,4398 in the third case. In all three cases the hypothesis of homogeneity in prices was rejected, although by a slim margin, and consequently the decisión was taken to continue working and impose the conditions mentioned above in the estimating process.

The next step was to contrast the joint significance of the fictitious variables included in the model for each region, rejecting the null and void hypothesis of non-significance.[11] On the other hand, the complexity of the functional form chosen, with its high number parameters to estimate, led us to consider using, instead of a specific fictitious variable for each region, a fictitious variable to represent a group of them, the groupings made on the grounds of similarities in geographical features and of variables such as *per capita* income and public capital/*output* ratio. Nevertheless, the only cases in which these groupings were accepted were those relating to the Balearic and Canary Islands, the Basque Country, Navarre and La Rioja, and Valencia and Murcia.[12]

Finally, we proceeded to estimate the equation system formed by the cost function (30) and the work factor share equation (31), once the price homogeneity restrictions had been imposed for the case of the sample made up of the 17 Autonomous regions and for the sectors of industry without energy and construction within the period 1980-1993. The estimate was carried out as a system of equations apparently unrelated (SURE), following the method of maximum verisimilitude in the estimate of parameters, so that the estimate should be invariable in the chosen share equation.[13] In Table 1 the estimated parameters are set out in the three versions.In all the cases, the cost function met the theoretical conditions of not be decreasing and concave in the factor prices.[14] As can be observed, generally speaking, the estimated coefficients are significant, although given the complexity of the function the sign and the magnitude lack informative valuefrom an economic point of view. When the spillover effects are introduced as

[11] The values of statistic F constructed to contrast the homogeneity of the independent term were, in the three cases considered, $F(16,194)$=6,3558, $F(16,194)$=8,3190 y $F(14,160)$=16,2988, respectively.
[12] In order to contrast the similarity of the model with these three groups against the model with all the dummies the F test was used. In the three cases the groups were accepted, given that the values of the statistic were: $F(4,194)$=1,0337, $F(4,194)$=1,0275 ans $F(3,160)$= 3,5725.
[13] See, for example, Green (2000).

an independent variable, some of the parameters of the model lose precision in the estimate.[15] Once the cost function parameters have been estimated, these are used to calculate the group of indicators described in the section relating to the theoretical model.

[TABLE 1]

5. Results

In Table 2 we can see the average values of the productive infrastructure shadow prices for each of the Autonomous regions.[16] The results shown in the first column do not take into account the spillover effects, those in the second column follow the hypothesis δ=1; and in the tirad column the value δ is unknown.

[TABLE 2]

If we observe the first column, the results reveal, in general terms, an negative impact, albeit limited, of public capital on private activity. These unfavourable results are consistent with those obtained by other authors when they carry out an analysis using data disaggregated at regional level. Furthermore, although the results are negative for all the Autonomous regions (except Cantabria) the magnitude differs according to the region. The average value obtained of –0.089 indicates that an increase of K_I by one peseta would raise the variable costs by 0.089 pesetas.[17] These results could indicate that many regions appear excessively inflated regarding

[14] The results confirm the existence of positive conditioned demands of the variable factors, and the signs of price elasticity reveal the concavity of the function.

[15] In this case all the variables related to the spillover effects (K_D), which are shown in bold print in Table 1 at the bottom of the first column should be added to the estimated cost function. To see the formation of this variable, consult the Appendix.

[16] The Balearic and Canary Islands have been removed from the results shown, given that both regions could not be considered in the case where δ has a value greater than zero, there being no information available to calculate the spillover effects. See Appendix.

[17] Boscá, Escribá and Dabán (1999), obtain shadow prices for the industry sector that are very low and close to zero in most of the Autonomous regions, with negative results being registered for the Balearic and Canary Islands, Castile-La Mancha, Extremadura and La Rioja, the average value being 0.067. Moreno, López-Bazo and Artís (2002) estimate a shadow price of 0.087 for industry. In Boscá, Escribá y Murgui (2001), the shadow prices for the private productive sector are positive and higher, settling on average at around 0.267. Our results are less favourable than the ones mentioned above, although it is worth pointing out that our sample does not include services designated for sale, which make up more than half the GDP in most of the regions. In this sense, the authors of this study show that if the sample is extended to include the private productive sector, even when the

their K_I endowment in relation to the existing industrial and construction activity. In this sense, if we compare the shadow prices with the public capital user cost, which we shall assume to be zero, it would not be an optimal measure to make additional investment in the Spanish economy, and less so in those regions which show more negative shadow prices (Madrid, Catalonia, Galicia or Valencia), since in all the cases the shadow prices are lower that the public capital cost. This conclusion, which is neither favourable nor credible, leads us to believe that the true impact of the infrastructures is not being registered, and that, therefore, it would be misleading to pursue a detailed analysis of the results obtained in this manner.

The second column shows the average values for public capital shadow prices, this time referring to the estimate which includes the spillover effects. The differences registered between these results and the previous ones are very pronounced. Thus, the fringe benefits for companies, when a variable correcting the spillover effects is used, show a positive and significant in costs in all the Autonomous regions. In this case, the national average is situated at 0.211. These results have two implications: first, they confirm the existence of positive externalities deriving from the infrastructures which extend beyond regional boundaries; and second, that the impact of the infrastructure on economic activity is not as limited as other recent studies claim. However, in this type of analysis the interpretation of the results is made more complicated when deciding upon which region it would best to continue investing in or not, since these shadow prices register the impact of public capital which the region *effectively* benefits from, whether it takes as its starting point the region's physical endowment or the physical endowment of the rest of the regions. For example, the public infrastructure shadow price which appears in the second column of Table 2 for the region of La Rioja is 0.075 and for Catalonia, 0.495. The infrastructure is more

spillover effects were not considered, the public capital shadow price was positive, at around 0.046, and the private capital shadow price was 0.111.

productive in Catalonia since the cost saving implied for companies is appreciably higher. It could, therefore, be concluded that more public funds ought to be directed towards creating an infrastructure in Catalonia when compared with La Rioja. Furthermore, with a fixed budget reserved for public investment, more should be invested in Catalonia and less in La Rioja. However, in this case the effective capital of each region is a combination of its own physical capital and that corresponding to the rest of the regions, and consequently, to increase the effective endowment of public capital in Catalonia could mean increasing its physical endowment or the physical endowment of the regions which enjoy close economic relations with Catalonia. (La Rioja is one of such regions). In so far as La Rioja is concerned, reversing investment in this region could be achieved by reducing the public capital *stock* located in the region or that of the regions whose public capital affects the activity of La Rioja (Catalonia being one of these).

If we compare these results (Z_{KIE}) with the previous ones (Z_{KI}), it could be thought the physical capital particular to each of the regions was not productive, while that of the neighbouring regions was. In this sense, it needs to be specified that the total positive effect registered in Z_{KIE} is not divisible into these two differentiated effects. Z_{KIE} reflects the effect that a region uses its own capital as a productive factor, the productivity of which depends on the capital of the other regions, and the effect that this same region uses as a productive factor the capital *stock* located in other regions, the benefit of which also depends on its own physical endowment.

In the tirad column of Table 2, the shadow prices collected from a region's own public capital and from spillover effects are equally postive and significant, providing, once again, corroboration of the existence of positive externalities of public capital and the fact that the infrastructures lower the private costs of production. However, it can also be seen that the values of the shadow prices are greater than in the previous case: in fact, the national average is 0.484 as opposed to the previous value of 0.211. This difference in results can have important implications when drawing conclusions regarding the specific benefits of increasing the public capital endowment in Spain. On this point, it should be remembered that in this estimate no specific value has been assumed for δ. Thus, if we compare these results with those of the first column we could conclude that the public capital of a region exerts positive externalities over other regions and that, therefore, δ will be greater than zero. será mayor que cero. On the other hand, if we compare these results with those obtained in the second column, we can see how the shadow prices obtained are greater in all the Autonomous regions, and consequently one might think that δ will also represent values lower than the unit. In other words, the effective endowment of public capital appears to be of a lesser quantity than the calculated one in the extreme case where $\delta = 1$, so that this lower effective endowment shows greater fringe benefits. Thus, we can conclude that if we wish to register the spillover effects of public capital, the use of the effective endowment of capital as a sum of the capital itself and of a weighted combination of the capital of the rest of regions, excessively inflates the amount of the endowments that a region effectively uses, for which lower values are erroneously obtained for public capital productivity. Nevertheless, as has been previously mentioned, when spillover effects included as an independent variable in the model, the estimate loses precision, in comparison with the case where δ=1. For this reason the majority of the results presented in this study refer to a unit value of δ. In any case, with the exception of the shadow price values, the results were very similar.[18]

The laast column shows the shadow prices of private capital for a value δ=1. These are positive and significant, oscillating between 0.6 in La Rioja and 0.052 in Cantabria.Private

[18] For details see Table 3.

investment appears more productive in La Rioja, Galicia, Madrid, Murcia and Navarra, while the opposite can be said in the cases of the Basque Country, Cantabria and Asturias. The average shadow price is 0.233.[19]

Table 3 shows the *ouput* elasticities in relation to public and private capital respectively.

[TABLE 3]

When spillover effects are not considered, the *output* elasticities in relation to public capital are negative in all the Autonomous regions (except in Cantabria). The average value rests at –0.032 and the regions with the worst results are Andalusia, Extremadura, Castile-Leon, Castile-La Mancha and Galicia. In the second column, when spillover effects are considered and the value of δ is assumed to be the unit, all the elasticities are postive, so that the average impact of the infrastructures is 0.133, positive and, therefore, greater than in the previous case. This elasticity shows a great variability across the Autonomous regions. The highest elasticities correspond to Extremadura, Castile-La Mancha and Andalusia. On the other hand, if we examine the third column of results, which correspond to the case in which the value of δ is unknown, the average elasticity 0.124, very similar to the previous one, with the regions of Madrid, Murcia, Valencia and Catalonia showing the greatest values.

The elasticity of private capital is 0.067, making it, therefore, positive but more limited than that obtained in the study carried out by Boscá, Escribá and Dabán (1999) for the industry sector, which rests at around 0.13. However, our own result is a reasonable one if we consider that it includes internediate consumption as an additional production factor. In any case, this average elasticity is particularly low given that the values presented by the regions of the

[19] In the existing studies which focus on the industrial sector, the shadow price for private capital is 0.266 (Boscá, Escribá and Dabán. (1999) and 0.0287 (Moreno, López-Bazo and Artís (2002)).

Cantabrian coast are so small, these regions registering during the period of the sample-taking a clear falling trend in private investment.

Table 4 also shows the *output* elasticities relating to each of the factors considered short term variables, that is, work and intermediate *input*, as web as returns to scale, for a unit value of the parameter δ, where e is defined as the ratio of average cost to marginal cost of companies in the short term. As such, the estimated short term returns to scale in all the regions, except Cantabria, clearly follow a falling trend. The average rests at around 0.86.

[TABLE 4]

Table 5 shows the elasticities of the variable factor demand in relation to short term fixed factors, as web as the price elasticities of the work and intermediate *input* demands. The relation between the fixed and variable factors is one substitutability although in all the Autonomous regions we can see that, while public capital shows greater savings in intermediate *input*, private capital does so in work. Thus, these substitutability relations between the level of employment and public capital validate the claim that both public and private investment must be sufficiently high to imply a high *output* expansion which would signify an increase in the employment level. Finally, we can observe that the appreciable demand for work in relation to its price gives rise to the expected sign, and is greater in comparison with the intermediate *input*.

[TABLE 5]

Finally, in Table 6, we can see the results relating to the *output* elasticities with respect to long term private capital, as web as the impact that public infrastructure has on the private capital endowment, and the *output* elasticity with respect to public capital, once the previous long term effect has been taken into account. The Table also shows the results on long term returns to scale in all the factors considered variable. In particular, special note should be made of the complementary relation between long term public and private capital. Thus, an increase in the public infrastructure *stock* of 1% would raise private capital *stock* by an average of 0.273%. This positive effect of public capital on private capital *stock* in the long term implies a greater impact of public infrastructure on long term *output*, as compared with the short term. As such, the estimated impact of public capital on the production level is almost 0.4 in terms of elasticity.Furthermore, the returns to scale in work factors, intermediate consumption and private capital are very close to the constant returns in practically all the Autonomous regions of Spain.

[TABLE 6]

6. Final considerations

In this study we have analysed the impact of public infrastructure on private activity in the industry and construction sectors of the Spanish economy using the cost function estimate approach. As we have endeavoured to explain, the use of data disaggregated to regional level implies the need to pay special attention to the measurement and specification of the spillover effects of infrastructures between regions. Our results confirm the existence of positive externalities deriving from spatial infrastructures, and that the impact of infrastructure on economic activity is not as limited as other studies propose. Thus, on average, the value of *output* elasticity with respect to the effective endowment of public capital lies between 0.124 and 0.133, presenting in the long term a value ostensibly greater of up to 0.384.

On the other hand, we have observed that the procedure by which the measurement of the spillover effects is resolved can affect the results obtained on shadow prices and, therefore, specific economic policy decisions which can be deduced from these results. As such, the existence of spillover effects and the impossibility of achieving an exact measurement of these effects appear to diminish the validity of studies which use regional samples to analyse the quantitative effects of public capital.

However, the recommendations of economic policy at regional level which can be drawn from these studies are not clear and direct. When these can be done, the non-existence of spillover effects is being imposed which means that measurement of the public capital endowment of each region is not be carried out in an adequate manner and consequently we must distrust any kind of policy recommendation which is based on these types of studies. On the contrary, when public capital of each Autonomous region is approximated in a more realistic way, the recommendations of regional policy regarding public investment do not make immediate sense. And so, the results which we are attempting to make relevant in this study regarding public capital, are not those of each of the Autonomous regions separately, but rather those relating to the group of them as a whole, given that the regions are interconnected through public capital.

Appendix. The Data

In order to estimate the cost function, use has been made of information relating to the Spanish Autonomous regions between 1980 and 1993 and referring to the sectors of industry without energy and construction. The availability of the data has been possible thanks, on the one hand, to the creation of the database BD.MORES[20] by the Budgetary Programming and Analysis Department of the Ministry of Economy and Inland Revenue Service which contains estimates of relevant variables for regional analysis, and on the other hand, to the BBV-IVIE Foundation, from which we have collected the series of public and private capital *stocks* by regions. The period of study in our paper has been determined by the data relating to intermediate consumption.

[20] We are grateful to Teresa Dabán for her invaluable assistance in obtaining all the information required from the BD:MORES. All the data originating from this database appeared in constant pesetas for the year 1980, and consequently it was necessary to proceed to a change of base to the year 1986 so that they would be homogenous with the series of public and private capital *stock*.

Production Value (X): This refers to the sum of the Gross Value Added to the cost of factors in 1986 constant pesetas and the Intermediate Consumption also in 1986 constant pesetas. In this way the production Value valued at producer prices is obtained. The GVA to the factor cost is taken from the BD:MORES:

Intermediate Consumption (M): This refers to the value of intermediate goods and services used in the production process. The data used is taken from the work of Díaz (1998), entitled "Series of Intermediate Consumption by Branches of Activity and Spanish Regions. 1980-1993)". This variable is the one that has, as has been mentioned, determined the study period up to 1993.

Intermediate Consumption Price Index (q_M): In identifying this variable the GVA implicit deflator has been used, which is obtained as a ratio of GVA to the factor cost in current pesetas and the GVA to the factor cost in 1986 constant pesetas.

Salary paid to the work force (w): This has been taken from the BD.MORES, specifically from the concept of work Income in 1980 constant pesetas and the number of employees. For its use in obtaining the estimate, the concept of Income was divided by the total number of employees in each region and for the sectors of Industry and Construction.

Variable Cost (cv): Refer to the costs incurred by companies in the productive process, in our case, those deriving from the work factor and from the intermediate materials. Therefore it is produced as the sum of work income and intermediate consumption.

Private Capital Stock (K_P): The data derive from the series produced by the IVIE. The private capital series are available by region, and equally by productive sector and are shown in millions of 1986 pesetas. They have recently been issued in constant 1990 pesetas.

Public Capital Stock (K_I): The concept of public capital used in this study refers to the productive infrastructure or that directly related to productive activity. Thus, this variable is produced as the sum of *stocks* in roads, hydraulic infrastructures, urban structures, ports, railways and airports. This *stock* is the sum of the territorialized and non-territorialized total, the latter distributed according to each region's share in the total national geographical surface area.In this category are included roads, railways, ports and hydraulic infrastructures.

Public capital stock-Spillover effects: For each region this variable is a weighted sum of network type capital relating to transport (roads, railways, ports and airports) of the rest of the regions. To produce the weighted matriz, the starting hipótesis was that the relevant infrastructures for a region are the ones pertaining to those regions with which the former has commercial relations. As such, if region *i* maintains an important flow of commerce with a destination located in region *j*, it will make greater use of the network type infrastructure located in region *j*, egardless of whether it is situated nearby or not. Furthermore, the geographical distance is taken into consideration. Thus, it seemed important to consider that, although public capital is public property supposedly free, the further it is from a region, the more 'costs' its use will imply for companies operating in that Autonomous region, and as such the previous weightings are divided by distance in access time.

The weightings are expressed in the following manner:

$$W_{ij} = \frac{F_{ij}}{D_{ij} FC_{ij}}$$

where F_{ij} is the ratio which measures the importance of comercial flow originating in region *i* and bound for region *j*, in relation to the total volume of commerce of the region of origin, *i*. In order to calculate this ratio, information taken from the 3rd III Transport of Goods by Road Survey, produced by the Ministry of Transport, Tourism and Communications in 1989 was used.

D_{ij} is the access time between regions *i*, *j*. To calculate this, information taken from the CAMPSA Guide was used. Specifically, that relating to distance measured in access time by the fastest roads running between the provinces of Spain. The use of detailed information at provincial level was required to calculate the average access time between two Autonomous regions, a more authentic measurement than if distances between regional capital cities were used, especially in the case of regions with a greater surface area.

Finally, FC_{ij} is a factor which reflects the closeness between regions, which in addition penalizes the distance between regions. The factor was produced as an indicator which acquires values equal to 1 when two regions are adjacent and a value greater than 1 when they are not, more specifically a value equal to the average distances in time with the rest of the regions.

[TABLES A.1 & A.2]

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Cuadro 1. Parámetros estimados. Sistema de ecuaciones simultáneas (SURE). [a]

(*t*-ratios en paréntesis)

Parámetros	Caso 1º ($\delta = 0$)	Caso 2º ($\delta = 1$)	Caso 3ª ($\delta \neq 0, \delta \neq 1$)
β_1	-0.0343 (-2.70)	-0.1772 (-9.23)	-0.2829 (-6.30)
a_1	0.2180 (5.35)	0.3104 (5.20)	-0.8862 (-10.81)
b_1	-1.1971 (-4.04)	-0.1482 (-0.38)	2.5790 (3.06)
b_2	-0.2939 (-1.14)	3.1795 (8.44)	0.5993 (1.24)
b_3	1.0515 (4.78)	-0.8123 (-2.17)	-1.8168 (-2.54)
β_{11}	0.0054 (21.27)	0.0066 (20.46)	0.0061 (23.16)
c_{11}	0.0714 (6.24)	0.1071 (11.84)	0.0911 (9.85)
e_{11}	0.2328 (2.11)	0.3013 (2.96)	0.1633 (1.72)
e_{22}	0.0473 (1.12)	-0.4036 (-8.91)	0.0716 (1.54)
e_{33}	0.1181 (1.59)	0.2362 (2.89)	0.1541 (2.29)
d_{11}	-0.0533 (-4.30)	-0.0012 (-0.09)	-0.044 (-5.19)
d_{12}	0.0335 (6.29)	0.00514 (0.84)	0.039 (10.75)
d_{13}	0.0289 (2.57)	-0.0079 (-0.64)	0.0261 (3.29)
d_{14}	0.0033 (4.13)	0.0055 (6.63)	0.012 (2.15)
e_{12}	0.0579 (1.51)	0.0598 (1.47)	-0.0719 (-2.03)
e_{13}	-0.1251 (-1.34)	-0.2734 (-3.03)	-0.0950 (-1.17)
e_{14}	-0.0105 (-4.29)	-0.0111 (-3.81)	-0.0012 (-0.41)
e_{23}	-0.0805 (-2.36)	0.0948 (2.60)	-0.0679 (-1.92)
e_{24}	-0.0052 (-3.51)	0.0089 (4.33)	-0.0010 (-0.61)
e_{34}	0.0117 (5.00)	0.0085 (3.33)	0.0049 (1.95)
$Ln\ K_D$	--	--	1.554 (1.60)
$Ln^2 K_D$	--	--	-0.1847 (-2.34)
$ln(w/q_M).lnK_D$	--	--	0.0730 (12.82)
$lnX.lnK_D$	--	--	-0.1251 (-2.13)
$lnK_I.lnK_D$	--	--	0.0226 (0.43)
$lnK_D.lnK_P$	--	--	0.1499 (2.84)
$lnK_D.t$	--	--	0.0123 (3.70)

[a] Periodo muestral: 1980-1993. 1º y 2º caso: 17 CCAA, nº obs: 238. 3º caso: 15 CCAA, nº obs: 210. Los coeficientes estimados para las dummies específicas para cada región son significativos y pueden verse en el cuadro A.2. del Apéndice.

Cuadro 2. Precios sombra del capital público y del capital privado (t-ratios en paréntesis).

Regiones	Z_{KI} $\delta=0$	Z_{KIE} $\delta=1$	$Z_{KI}+Z_{KD}$ $\delta\neq 0$ y $\delta\neq 1$	Z_{KP} $\delta=1$
Andalucía	-0.128 (-2.55)	0.414 (6.50)	0.508 (0.68)	0.226 (2.59)
Aragón	-0.068 (-2.78)	0.200 (7.39)	0.226 (3.55)	0.123 (1.90)
Asturias	-0.041 (-0.88)	0.124 (4.53)	0.235 (3.34)	0.070 (1.25)
Cantabria	0.047 (0.43)	0.068 (3.70)	0.164 (1.54)	0.052 (0.87)
C-León	-0.102 (-2.75)	0.294 (6.90)	0.395 (1.37)	0.237 (3.03)
C-La Mancha	-0.055 (-2.26)	0.177 (7.62)	0.202 (1.94)	0.161 (2.48)
Cataluña	-0.207 (-1.65)	0.495 (3.49)	1.672 (2.31)	0.229 (2.99)
Valencia	-0.129 (-2.38)	0.338 (5.27)	0.894 (4.02)	0.237 (3.58)
Extremadura	-0.035 (-1.903)	0.091 (7.85)	0.010 (0.38)	0.136 (1.30)
Galicia	-0.130 (-3.56)	0.263 (6.16)	0.528 (4.86)	0.388 (4.42)
Madrid	-0.193 (-1.39)	0.293 (3.18)	1.398 (5.11)	0.333 (4.33)
Murcia	-0.076 (-2.62)	0.143 (7.12)	0.145 (2.25)	0.331 (4.27)
Navarra	-0.065 (-1.57)	0.068 (2.94)	0.209 (2.58)	0.281 (4.99)
País Vasco	-0.066 (-0.65)	0.116 (1.38)	0.603 (1.48)	0.080 (1.50)
La Rioja	-0.079 (2.30)	0.075 (4.59)	0.072 (1.20)	0.600 (6.03)
Media	**-0.089 (-2.31)**	**0. 211 (4.14)**	**0.484 (2.17)**	**0.233 (3.58)**

Cuadro 3. Elasticidades del *output* a corto plazo.

Regiones	ε_{XKI} $\delta=0$	ε_{XKIE} $\delta = 1$	$\varepsilon_{XKI} + \varepsilon_{XKD}$ $\delta \neq 0$ y $\delta \neq 1$	ε_{XKP} $\delta = 1$
Andalucía	-0.052	0.193	0.085	0.063
Aragón	-0.039	0.185	0.122	0.041
Asturias	-0.011	0.081	0.089	0.030
Cantabria	0.013	0.064	0.087	0.025
C-León	-0.054	0.186	0.081	0.066
C-La Mancha	-0.046	0.198	0.074	0.050
Cataluña	-0.029	0.097	0.180	0.069
Valencia	-0.032	0.129	0.182	0.070
Extremadura	-0.055	0.312	0.130	0.039
Galicia	-0.046	0.151	0.168	0.097
Madrid	-0.027	0.077	0.217	0.093
Murcia	-0.031	0.173	0.187	0.091
Navarra	-0.023	0.044	0.078	0.092
País Vasco	-0.010	0.030	0.092	0.034
La Rioja	-0.043	0.081	0.086	0.146
Media	**-0.032**	**0.133**	**0.124**	**0.067**

Cuadro 4. Elasticidades del *output* y rendimientos a escala a corto plazo ($\delta = 1$).

Regiones	ε_{XL}	ε_{XCI}	e^{a}
Andalucía	0.281	0.514	0.795
Aragón	0.330	0.542	0.872
Asturias	0.339	0.618	0.957
Cantabria	0.366	0.645	1.011
C-León	0.290	0.530	0.819
C-La Mancha	0.334	0.526	0.860
Cataluña	0.311	0.499	0.809
Valencia	0.306	0.516	0.822
Extremadura	0.355	0.513	0.868
Galicia	0.296	0.513	0.809
Madrid	0.314	0.501	0.815
Murcia	0.295	0.547	0.842
Navarra	0.316	0.586	0.902
País Vasco	0.364	0.566	0.930
La Rioja	0.239	0.606	0.845
Media	**0.316**	**0. 548**	**0.864**

[a] Nótese como e =CMe/μ, donde μ es el coste marginal de las empresas.

Cuadro 5. Elasticidades de la demanda de factores variables respecto a los factores fijos y elasticidades precio de la demanda a corto plazo ($\delta = 1$, *t*-ratio en paréntesis).

Regiones	ε_{LKIE}	ε_{MKIE}	ε_{LKP}	ε_{MKP}	ε_{ww}	ε_{qMqM}
Andalucía	-0.357 (-5.83)	-0.380 (-6.75)	-0.144 (-2.07)	-0.109 (-2.67)	-0.343 (-13.4)	-0.188 (-13.4)
Aragón	-0.334 (-6.29)	-0.356 (-7.72)	-0.098 (-1.48)	-0.064 (-1.91)	-0.338 (-14.1)	-0.206 (-14.1)
Asturias	-0.138 (-3.21)	-0.161 (-5.20)	-0.081 (-1.12)	-0.046 (-1.24)	-0.343 (-13.4)	-0.188 (-13.4)
Cantabria	-0.103 (-2.47)	-0.125 (-4.41)	-0.069 (-0.89)	-0.034 (-0.74)	-0.342 (-13.6)	-0.194 (-13.7)
C-León	-0.331 (-5.94)	-0.353 (-7.18)	-0.147 (-2.19)	-0.112 (-3.31)	-0.343 (-13.4)	-0.188 (-13.4)
C-La Mancha	-0.353 (-6.65)	-0.375 (-7.95)	-0.115 (-1.86)	-0.082 (-2.51)	-0.335 (-14.3)	-0.213 (-14.4)
Cataluña	-0.178 (-3.03)	-0.200 (-3.69)	-0.157 (-2.34)	-0.123 (-3.09)	-0.337 (-14.3)	-0.210 (-14.3)
Valencia	-0.231 (-4.49)	-0.253 (-5.52)	-0.157 (-2.52)	-0.123 (-3.85)	-0.340 (-13.9)	-0.201 (-13.9)
Extremadura	-0.533 (-7.35)	-0.555 (-8.12)	-0.090 (-1.25)	-0.057 (-1.13)	-0.329 (-14.8)	-0.227 (-14.8)
Galicia	-0.256 (-5.17)	-0.278 (-6.51)	-0.197 (-3.03)	-0.163 (-4.92)	-0.340 (-13.7)	-0.197 (-13.8)
Madrid	-0.130 (-2.59)	-0.152 (-3.44)	-0.197 (-3.04)	-0.164 (-4.88)	-0.336 (-14.3)	-0.211 (-14.3)
Murcia	-0.289 (-5.86)	-0.312 (-7.54)	-0.184 (-2.82)	-0.149 (-4.91)	-0.343 (-13.2)	-0.185 (-13.3)
Navarra	-0.064 (-1.69)	-0.087 (-3.74)	-0.185 (-2.84)	-0.150 (-7.40)	-0.343 (-13.2)	-0.185 (-13.3)
País Vasco	-0.045 (-0.94)	-0.067 (-1.66)	-0.090 (-1.32)	-0.057 (-1.49)	-0.335 (-14.5)	-0.215 (-14.5)
La Rioja	-0.118 (-2.74)	-0.144 (-5.26)	-0.275 (-3.56)	-0.235 (-7.20)	-0.334 (-10.3)	-0.133 (-10.5)
Media	**-0.230 (-3.76)**	**-0.254 (-5.11)**	**-0.146 (-2.38)**	**-0.111 (-3.60)**	**-0.339 (-13.6)**	**-0.196 (-13.8)**

Cuadro 6. Elasticidades del *output* respecto del capital privado y capital público, efecto del capital público sobre el capital privado y rendimientos a escala a largo plazo ($\delta = 1$) .

Regiones	ε_{XKP}	ε_{KPKI}	ε_{XKI}	e^L
Andalucía	0.141	0.269	0.367	0.936
Aragón	0.184	0.305	0.360	1.056
Asturias	0.261	0.328	0.407	1.218
Cantabria	0.295	0.336	0.416	1.306
C-León	0.143	0.266	0.344	0.962
C-La Mancha	0.173	0.293	0.363	1.033
Cataluña	0.160	0.258	0.488	0.969
Valencia	0.157	0.259	0.389	0.979
Extremadura	0.155	0.319	0.337	1.023
Galicia	0.123	0.233	0.333	0.932
Madrid	0.145	0.233	0.391	0.96
Murcia	0.137	0.242	0.347	0.979
Navarra	0.175	0.240	0.366	1.077
País Vasco	0.262	0.314	0.498	1.192
La Rioja	0.119	0.199	0.348	0.964
Media	**0.175**	**0.273**	**0.384**	**1.039**

Cuadro A.1. Matriz de ponderaciones

	Destinos Andalucía	Aragón	Asturias	Cantabria	C-León	C-Mancha	Cataluña	Valencia	Extremad.	Galicia	Madrid	Murcia	Navarra	Pais Vasco	La Rioja
Origen															
Andalucía	0,000	0,006	0,002	0,001	0,019	0,147	0,026	0,037	0,391	0,003	0,085	0,275	0,002	0,004	0,001
Aragón	0,006	0,000	0,002	0,004	0,091	0,025	0,451	0,134	0,001	0,003	0,035	0,003	0,187	0,034	0,023
Asturias	0,004	0,003	0,000	0,338	0,407	0,004	0,006	0,005	0,001	0,164	0,030	0,001	0,004	0,032	0,001
Cantabria	0,005	0,008	0,239	0,000	0,161	0,002	0,014	0,004	0,000	0,002	0,031	0,000	0,015	0,515	0,005
C-León	0,010	0,041	0,125	0,047	0,000	0,023	0,013	0,013	0,010	0,087	0,420	0,003	0,007	0,171	0,029
C-La Mancha	0,044	0,008	0,001	0,001	0,030	0,000	0,007	0,190	0,044	0,001	0,643	0,026	0,001	0,002	0,001
Cataluña	0,012	0,214	0,002	0,002	0,008	0,006	0,000	0,686	0,001	0,002	0,028	0,008	0,011	0,014	0,005
Valencia	0,013	0,065	0,001	0,001	0,007	0,216	0,393	0,000	0,001	0,002	0,040	0,256	0,002	0,003	0,001
Extremadura	0,495	0,004	0,002	0,000	0,065	0,315	0,012	0,007	0,000	0,002	0,088	0,006	0,001	0,003	0,000
Galicia	0,012	0,005	0,483	0,004	0,395	0,010	0,012	0,012	0,002	0,000	0,046	0,004	0,001	0,012	0,001
Madrid	0,026	0,012	0,003	0,004	0,210	0,652	0,015	0,036	0,013	0,004	0,000	0,009	0,004	0,011	0,002
Murcia	0,246	0,002	0,001	0,000	0,003	0,098	0,014	0,615	0,001	0,000	0,018	0,000	0,001	0,002	0,000
Navarra	0,001	0,146	0,002	0,004	0,010	0,001	0,018	0,005	0,000	0,001	0,005	0,001	0,000	0,395	0,409
Pais Vasco	0,006	0,019	0,012	0,175	0,244	0,003	0,024	0,007	0,000	0,002	0,041	0,002	0,298	0,000	0,167
La Rioja	0,002	0,023	0,002	0,010	0,057	0,001	0,011	0,002	0,000	0,001	0,003	0,000	0,704	0,184	0,000

Cuadro A.2. Variables ficticias (t-ratios en paréntesis).

Parámetros	Caso 1º ($\delta = 0$)	Caso 2º ($\delta = 1$)	Caso 3ª ($\delta \neq 0$, $\delta \neq 1$)
One	10.073 (8.57)	-6.7897 (-3.80)	-10.340 (-1.51)
D2 Aragón	0.0321 (1.71)	-0.0551 (-3.32)	0.0033 (0.04)
D3 Asturias	0.0590 (2.44)	-0.0857 (-2.73)	-0.0781 (-0.92)
D6 Cantabria	-0.0284 (-1.23)	-0.1664 (-4.52)	-0.1213 (-1.58)
D7 Castilla-León	0.0548 (5.12)	0.0055 (0.45)	-0.024 (-0.68)
D8 Castilla-La Mancha	0.0579 (3.41)	-0.066 (-3.69)	-0.0774 (-1.35)
D9 Cataluña	-0.0460 (-1.97)	-0.1799 (-6.390)	-0.0196 (-0.29)
D11 Extremadura	-0.0315 (-0.96)	0.02635 (0.69)	0.0582 (0.61)
D12 Galicia	0.102 (5.08)	-0.0763 (-3.95)	0.0399 (0.53)
D13 Madrid	-0.0195 (-0.64)	-0.2250 (-7.88)	-0.0860 (-0.96)
D Valencia-Murcia	0.0626 (3.00)	-0.1124 (-5.49)	0.048 (0.64)
D P.Vasco-Navarra-Rioja	0.0508 (2.26)	-0.1595 (-4.69)	-0.1562 (-2.06)
D Baleares-Canarias	-0.0117 (-0.54)	-0.2872 (-7.43)	--