

**INFRASTRUCTURES AND PRODUCTIVITY
IN THE SPANISH REGIONS***

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ABSTRACT

The aim of this paper is to analyse the role of public capital, the types of infrastructures in which it is invested, and their territorial distribution in the gains in productivity of the private sector in the Spanish regions in the period 1964-1991 using panel data techniques to control for unobserved state-specific characteristics.

The results obtained show how the infrastructures most directly linked to the productive process present a significant and positive effect on productivity. They also show the importance of the network effect of the infrastructures of a productive nature as well as a decrease in the elasticity associated with such infrastructures as development progresses.

KEY WORDS: Productivity, infrastructures and economic development.

RESUMEN

El propósito de este artículo es analizar el papel del capital público, los tipos de infraestructura en las que éste es invertido y su distribución territorial en las ganancias de productividad del sector privado en las Comunidades Autónomas españolas durante 1964-1991. Se usa para ello técnicas de datos de panel con el fin de controlar las características específicas de cada región.

Los resultados obtenidos muestran cómo las infraestructuras más directamente vinculadas al proceso productivo presentan un efecto significativo y positivo sobre la productividad. También destacar la importancia de los efectos tipo red de las infraestructuras productivas así como la reducción en la elasticidad asociada a las mismas, como consecuencia del proceso de desarrollo.

PALABRAS CLAVE: Productividad, infraestructuras y desarrollo económico.

1.- INTRODUCTION

The aim of this paper is to analyse the importance of the stock of public capital, the types of infrastructures in which it is invested, and their territorial distribution in the gains in productivity of the private sector in the Spanish regions.

Earlier studies (Mas, Maudos, Pérez and Uriel (1993) and (1994a)) analysed the effects of public capital on the Gross Value Added (GVA) and the productivity of the Spanish regions. The first referred to the industrial sector (excluding construction and energy products), while the second considered as a whole the private sector of the economy. In both studies the period analysed was 1980-1989 and the source of information was "*Contabilidad Regional de España*" [Spanish Regional Accounts] published by the I.N.E. [National Statistical Institute].

The study here presented expands the earlier analyses, considering a longer period, 1964-1991, for which it uses the information on GVA and regional employment provided by the *Banco de Bilbao Vizcaya* (BBV) in its "*Riqueza Nacional de España y su distribución provincial*" [National Wealth of Spain and its distribution by provinces]. The series used of private and public capital were estimated by the *Instituto Valenciano de Investigaciones Económicas* and will be proximately published by *Banco de Bilbao-Vizcaya* Foundation (Mas, Pérez and Uriel (1995)). The longer period studied will enable the importance of public capital in the gains in productivity to be analysed from a long-run perspective¹.

Section 2 considers the relation among infrastructures, growth and productivity in the light of the contributions of recent specialized literature. Section 3 analyses the capacity of public capital to account for the gains in productivity of the Spanish regions. Section 4 is devoted to analysing the "network effect" associated with certain types of infrastructures, and to analysing how the importance of public capital is different depending on the phase of economic development. Section 5 presents the main conclusions of the study.

¹BBV provides two-yearly information for the odd years since 1955, except for the years 1960, 1962 and 1964. However, the series of private and public capital are available from 1964 to 1991 so the analyzed period is 1964-1991.

2. THE ROLE OF INFRASTRUCTURES IN GAINS IN PRODUCTIVITY

Although some authors² had already suggested that certain types of public capital could be considered as relevant inputs in the production process, it was Aschauer in 1989 who explicitly included public capital in the production function. In particular, on the basis of a Cobb-Douglas production function with private inputs and public capital, Aschauer's study revealed the importance of the stock of public capital in explaining the evolution of productivity.

The original study by Aschauer, with obvious implications for political economy, generated a flood of studies whose most substantial contributions have already been described in other papers³. However, it is appropriate to specify some of the conclusions of the debate occurring in the United States, in order to situate properly the analysis carried out in the following sections.

1. The estimations made by Aschauer (1989) at the national level led to the following conclusions:

- Public capital had a positive and significant effect on private output and total factor productivity, the estimated elasticity being 0.39.
- The composition of this public capital was shown to be relevant, the basic infrastructures (fundamentally those of transport, energy and water and sewer facilities) showing the closest relationship to productivity. On the other hand, other types of public capital, such as that devoted to health, education or to services of a general nature (police, justice, administration, etc.) were less relevant from this same point of view.

2.- The level of geographical disaggregation adopted in the estimation had a decisive influence on the magnitude of the elasticities estimated, which decreased progressively as the geographical focus narrowed. Thus, in the testing at U.S. state level carried out by Munnell (1990a and 1990b), Eisner (1991) and García-Milá and McGuire (1992), the elasticity of

² See Meade (1952).

³ See Munnell (1992), Mas, Maudos, Pérez and Uriel (1993), and Draper et al. (1994)

public capital was half that corresponding to the federal level. A similar reduction occurred when the metropolitan area was considered. Duffy-Deno and Eberts (1989) and Eberts (1989) estimated elasticities of output with respect to infrastructures of less than 10%, far from the 40% initially estimated by Aschauer for the U.S.A. as a whole.

The reduction in the elasticities estimated for public capital as the level of geographical disaggregation increases is accounted for by the presence of "spillover effects" generated by the network feature of a large part of the infrastructures considered (transport, energy and water and sewer facilities). This typology implies that the effects on the productivity of a region depend not only on the stock of public capital located there, but also on the network as a whole throughout the territory, and especially on the endowments of the neighbouring regions (Hulten y Schwab (1991)).

However, Holtz-Eakin and Schwartz (1995) argue that although the estimated elasticity is larger in aggregate studies "no research has targeted specifically the spillover hypothesis". With this purpose, and using a specific type of public capital, state highways, the results obtained by Holtz-Eakin and Schwartz do not support this hypothesis.

3. Further, as Hulten and Schwab (1992) pointed out, the network feature of most of the infrastructures should lead to different expectations of their impact depending on the level of development and the amount of public capital already accumulated. According to these authors, the effects of increases in public capital will be greater in the first stages of development, when the stock of public capital is still relatively low, than in mature societies. Therefore, estimations of time series such as those carried out by Aschauer would tend to overestimate the current impact of the growth in public capital.

4. Holtz-Eakin (1994) shows how the estimation procedure affects the relevance of the effect of public capital on private sector productivity. This author argues that only estimates of production function that do not include unobserved state-specific characteristics (individual effects) find substantial productivity impacts of the public capital. However, and in word of Holtz-Eakin, "it would be wrong to conclude from his analysis that stock of public capital provides no benefits...Instead, future research in this area should be devoted to making more precise the microeconomic linkage between the provision of infrastructures and the nature of the production process".

From the review of the main questions posed by the analysis and the empirical evidence with reference to the economy of the United States can be appreciated the lack of

unanimity in the quantification of the importance of public capital⁴. Also apparent is the depth with which the different dimensions of the problem have been treated in the case of America.

In the case of Spain, several studies have recently been published analysing the influence of the stock of capital in infrastructures on productivity on a national level (Argimón *et al.* (1994), Bajo *et al.* (1993) and Gonzalez-Páramo (1995)), at regional level (Mas, Maudos, Pérez and Uriel (1993, 1994a and c) and at provinces level (Mas, Maudos, Pérez and Uriel (1995)). Although these studies differ in the series used, the types of public capital considered, and in the period analysed, the result common to all of them is also the illustration of the importance of public capital in explaining the evolution of productivity, the elasticity of public capital being greater in nationwide studies than in those of regional scope.

3. PUBLIC CAPITAL AND PRODUCTIVITY IN THE SPANISH REGIONS

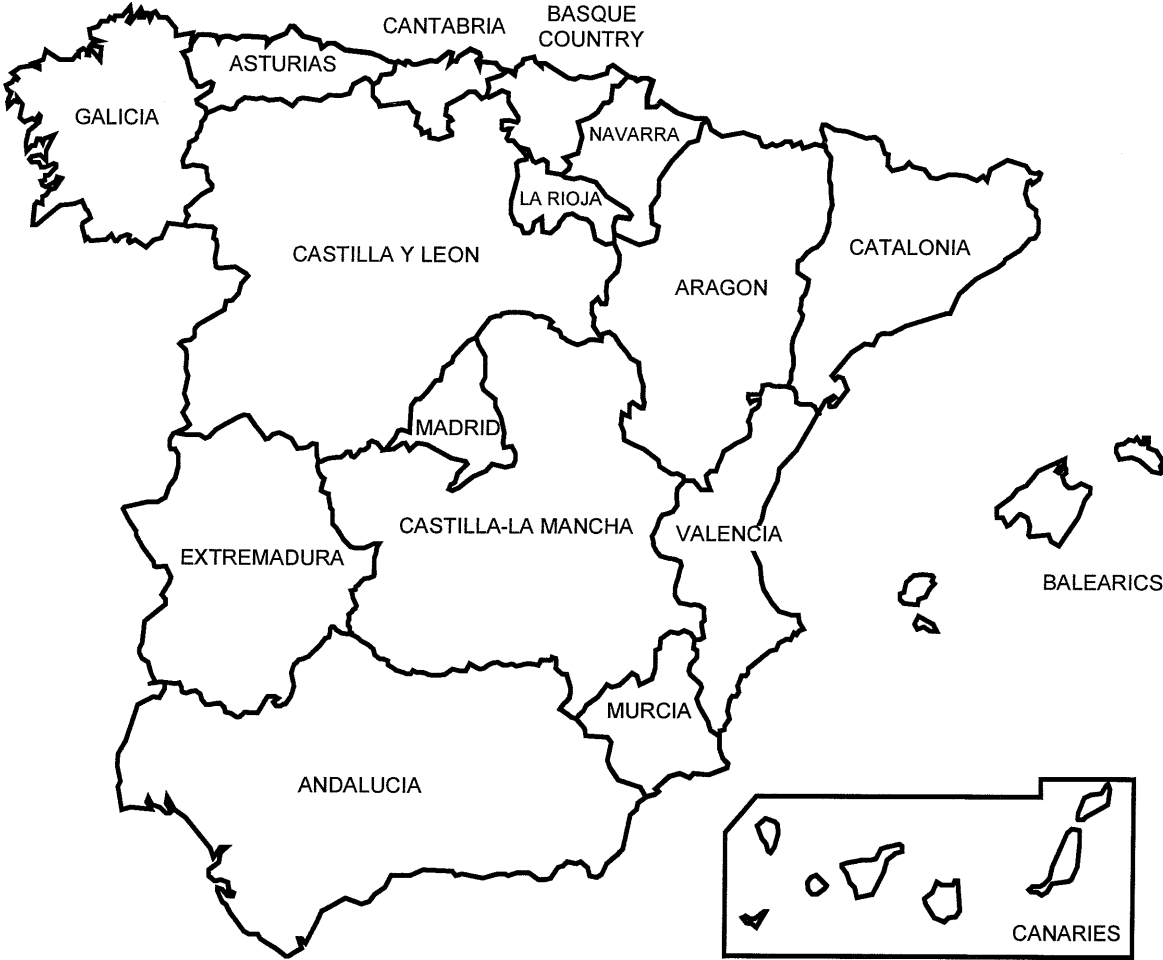
The central point of this study is to analyse whether the public capital endowments of each region of Spain favour the increase in productivity of the private sector operating in that territory, and also whether the composition of public capital is important in this respect. Furthermore, it is also important to determine whether the endowments of each region are the only ones which count for its productivity, or on the contrary, those of neighbouring regions are also significant.

Recently the *Instituto Valenciano de Investigaciones Económicas* (IVIE) has carried out the estimation of series of private and public capital at autonomous community (regional) level (see figure 1). The estimation of the stock of public capital was initially published by the IVIE in 1993 and some of its results can be seen in Mas, Pérez and Uriel (1993). The complete series corresponding to the period 1964-1991 will shortly be published by the Banco Bilbao-Vizcaya Foundation (Mas, Pérez and Uriel (1995)). The procedure followed in the estimation is the one habitually used in all countries which estimate their stocks of capital: the permanent inventory method. This method obtains the stock of capital on the basis of the accumulation of the investment made, taking into account certain patterns of depreciation and

⁴ See in Gramlich (1994) a recent review.

withdrawal. The definition of public capital refers to the Public Administration as a whole, consisting of the State, the Social Security Institutions and the Territorial Administrations (Autonomous Communities -regions- and Local Councils)⁵. The level of disaggregation of the estimation is as follows: a) roads and motorways; b) ports and maritime signalling; c) water and sewage facilities; d) urban structures; e) health; and f) education.

FIGURE 1
THE SPANISH AUTONOMOUS COMMUNITIES



⁵ The definition of public capital adopted in this paper corresponds, following Gramlich (1994), to the version that focuses on ownership and includes just the tangible capital stock owned by the public sector.

Through the estimation of a production function we can investigate whether there are statistical regularities in the relationships between each region's public capital stock and the gains in productivity of any of the private factors of production. In this way, we can identify the role of the infrastructures in the diffusion of what we measure as technical progress, or in other words limit the importance of exogenous technical progress.

Let us assume, as in most of the studies mentioned in section 2, that the technology underlying the aggregate production function is Cobb-Douglas, where the output of region i in the year t depends on the amount of labour and capital (public and private) used:

$$Y_{it} = A_{it} L_{it}^{\alpha} K_{it}^{\beta} G_{it}^{\gamma} \quad (1)$$

where:

$$A_{it} = A_{i0} e^{gt} \quad (2)$$

in which:

Y_{it} = private output (Gross Value Added at factor cost (GVAcf)) (excluding the energy sector) of region i in the year t at constant prices (pesetas of 1990).

L_{it} = employment in the private sector (excluding the energy sector) of region i in the year t .

K_{it} = stock of private productive capital (excluding the energy sector) of region i in the year t at constant prices (pesetas of 1990).

G_{it} = stock of public capital at constant prices (pesetas of 1990) of region i in the year t .

g = growth rate of exogenous technological progress.

Expressing (1) in logarithmic terms, and calling $a_i = \text{Ln } A_{i0}$:

$$\text{Ln}Y_{it} = a_i + gt + \alpha \text{Ln}L_{it} + \beta \text{Ln}K_{it} + \gamma \text{Ln}G_{it} \quad (3)$$

On the basis of the estimation of the general equation (3) we are interested in 1) estimating the effects of public and private capital on labour productivity at regional level, without imposing restrictions on the type of returns in the production function, 2) analysing the importance of the composition (productive/social) of the stock of public capital, and 3) discussing whether the influence of public capital depends only on the infrastructures installed in a particular region or also on the endowments of the adjoining regions.

In order to test the type of returns to scale, both in private inputs and total inputs, involved in the production process, we can reparametrize equation (3) so that

$$\ln(Y_{it}/L_{it}) = a_i + gt + (\alpha + \beta + \gamma - 1)\ln L_{it} + \beta \ln(K_{it}/L_{it}) + \gamma \ln(G_{it}/L_{it}) \quad (4)$$

In (4), the lack of significance of the coefficient accompanying employment ($\alpha + \beta + \gamma - 1$) will be an indicator of the presence of constant returns to scale in all inputs (private and public). Equally it is possible to reparametrize equation (3) in such a way that we can test the type of returns associated with the private inputs:

$$\ln(Y_{it}/L_{it}) = a_i + gt + (\alpha + \beta - 1)\ln L_{it} + \beta \ln(K_{it}/L_{it}) + \gamma \ln(G_{it}) \quad (5)$$

where the lack of significance of the coefficient accompanying the labour input ($\alpha + \beta - 1$) will indicate the existence of constant returns to scale in private inputs.

To analyse the role of public capital in the case of Spanish regions⁶ the above expressions have been used, constructing an econometric model with panel data referring to the period 1964-1991. Following Holtz-Eakin (1994) we assume that country specific characteristics are time-invariant.

Table 1 shows the results obtained from the estimation of the production function, using the fixed effects model. It can be interpreted that the fixed effects (a_i) reflect the particular set of circumstances which influence the productive results of each region and are not captured by the factors specified in the production function: from weather conditions to the productive structure, use of technology, etc.

⁶ See in Mas, Maudos, Pérez and Uriel (1994b and 1995), the importance of public capital in the convergence among Spanish regions and provinces.

TABLE 1: TOTAL PUBLIC CAPITAL AND PRODUCTIVITY

VARIABLES	(1)	(2)	(3)	(4)
Trend	0.0173 (8.8400)	0.0178 (9.1931)	0.0173 (8.8400)	0.0174 (9.4354)
Ln(L)it	0.0586 (1.6314)		-0.0111 (-0.2337)	
Ln(K/L)it	0.4191 (14.5249)	0.3982 (15.3472)	0.4191 (14.5249)	0.4227 (17.3592)
Ln(G/L)it	0.0697 (2.3147)	0.0711 (2.3501)		
Ln(G)it			0.0697 (2.3147)	0.0651 (2.8648)
R2	0.8443	0.9841	0.8443	0.9843
Sum of squared residuals	0.4864	0.4924	0.4864	0.4866
Std. error of regression	0.0473	0.0475	0.0473	0.0472

NOTES:

- (a) Source: GVA and employment (L): BBV
Private capital (K) and Public capital (G): BBV-IVIE (1995)
- (b) Sample: 1964-1991
- (c) Dependent Variable: Ln(GVA/L)it
- (d) Fixed Effects Model
- (e) t-statistic in parentheses

In the first column appears the estimation of the unrestricted equation (equation (4)), i.e. not imposing the existence of constant returns to scale, whether in all inputs or in private inputs. The lack of significance, at usual significance levels, of the parameter accompanying the labour input (0.0586, with a t-statistic of 1.6314) allows us not to reject the existence of constant returns in all inputs ($\alpha + \beta + \gamma = 1.0586$). Consequently, the second column of table 1 shows the results of the estimation with this restriction imposed. The results obtained show that public capital affects positively the productivity of the private sector, with an elasticity of 0.0711 (and a t-statistic of 2.3501).

In order to test the types of returns to scale associated with private inputs, the third column of table 1 shows the results of the estimation of equation (5). The elasticity of the parameter accompanying the labour input (-0.0111 with a t-statistic of -0.2337) allows us not to reject the existence of constant returns in private inputs ($\alpha + \beta = 0.9889$). Imposing this restriction (column (4)), the elasticities associated with labour (α) and with private capital (β) being 0.5773 and 0.4227 respectively.

However, as described in section 2, the effect of public capital on productivity is different depending on its composition. Thus, with the aim of testing this differential effect, equation (3) was estimated, distinguishing between productive public capital and social public capital.

$$\ln Y_{it} = a_i + gt + \alpha \ln L_{it} + \beta \ln K_{it} + \gamma_1 \ln GP_{it} + \gamma_2 \ln GS_{it} \quad (6)$$

where:

GP_{it} is the productive public capital stock of the region i in the year t , which includes roads, water infrastructures, ports and urban structures (in constant pesetas of 1990)

GS_{it} is the social public capital stock of the region i in the year t , which includes health and education (in constant pesetas of 1990).

Thus, productive public capital is more directly linked to the productive process and is composed by the basic infrastructures. On the other hand, social public capital can be less relevant in the exploitation of the productivity gains, being a question to test.

Once again, it is possible to reparametrize equation (6) in order to test the type of returns to scale both in all inputs (equation (7)) and in private inputs (equation (8)).

$$\begin{aligned} \ln(Y_{it}/L_{it}) = & a_i + gt + (\alpha + \beta + \gamma_1 + \gamma_2 - 1)\ln L_{it} + \beta \ln(K_{it}/L_{it}) + \\ & + \gamma_1 \ln(GP_{it}/L_{it}) + \gamma_2 \ln(GS_{it}/L_{it}) \end{aligned} \quad (7)$$

$$\begin{aligned} \ln(Y_{it}/L_{it}) = & a_i + gt + (\alpha + \beta - 1)\ln L_{it} + \beta \ln(K_{it}/L_{it}) + \\ & + \gamma_1 \ln(GP_{it}) + \gamma_2 \ln(GS_{it}) \end{aligned} \quad (8)$$

Table 2 shows the results of the estimation of equations (7) and (8). In this case, the existence of increasing returns to scale in all inputs ($\alpha + \beta + \gamma_1 + \gamma_2 = 1.0735$) is not rejected (column 1), whereas the hypothesis of constant returns to scale in private inputs (1.0151) cannot be rejected statistically (column (2)). Results imposing this last restriction are reported in column (3).

TABLE 2: PRODUCTIVE VS. SOCIAL PUBLIC CAPITAL

VARIABLES	(1)	(2)	(3)
Trend	0.0174 (8.9756)	0.0174 (8.9756)	0.0173 (9.4062)
Ln(L)it	0.0735 (2.0281)	0.0151 (0.3062)	
Ln(K/L)it	0.4508 (12.9423)	0.4508 (12.9423)	0.4443 (16.1502)
Ln(GP/L)it	0.0831 (3.0474)		
Ln(GS/L)it	-0.0247 (-1.0424)		
Ln(GP)it		0.0831 (3.0474)	0.0863 (3.4292)
Ln(GS)it		-0.0247 (-1.0424)	-0.0212 (-1.0236)
R2	0.9846	0.9846	0.9846
Sum of squared residuals	0.4775	0.4775	0.4778
Std. error of regression	0.0470	0.0470	0.0469

NOTES: see Table 1

(a) GP = productive public capital

GS = social public capital

With respect to public capital, the results obtained in earlier studies are confirmed: the infrastructures considered to be "productive" have a positive effect, more significant than the infrastructures of a "social" character. In particular, the elasticity of labour productivity with respect to public capital of a productive character (*GP*) is around 8%, this elasticity being negative, although not significant, in the case of public capital of a social character (*GS*).⁷

The value of the elasticity of productive public capital is similar to that obtained in similar studies for other countries (Duffy-Deno and Eberts 1989, Eberts 1989, Munnell 1990b, Eisner 1991) when the economic areas considered are not too extensive, such as other states or the metropolitan areas of the U.S.A.. Also, the elasticity of public capital in infrastructures is less than that of private capital, in agreement with the above-mentioned studies.

However, the elasticity of productive public capital is smaller than that obtained in Mas, Maudos, Pérez and Uriel (1994a) also at regional level. Three are the possible causes: 1) in Mas, Maudos, Pérez and Uriel (1994a) the sector under analysis is the total private sector (including energy sector); 2) the estimation of private capital stock is different⁸, and 3) the period analysed is longer in the present paper.

4. INFRASTRUCTURES, NETWORK EFFECT AND ECONOMIC DEVELOPMENT

In order to test the "spillover effect" or "network effect" indicated above, and concentrating on the role of productive public capital, table 3 shows the results of a new estimation of the production function, adding to the productive public capital of each region

⁷ This result is consistent with the one obtained in other studies. See Aschauer (1989), Munnell (1992) and Mas, Maudos, Pérez and Uriel (1994a) for a review.

⁸ In Mas, Maudos, Pérez and Uriel (1994a) the stock of private capital used comes from Calabuig *et al.* (1994).

TABLE 3: NETWORK EFFECT OF PUBLIC CAPITAL

VARIABLES	(1)	(2)
Trend	0.0168 (9.0625)	0.0152 (7.5283)
Ln(L)it	0.0674 (1.8845)	0.1069 (2.8289)
Ln(K/L)it	0.4285 (15.5709)	0.4059 (14.1304)
Ln(GP/L)it	0.0771 (2.8916)	
Ln(GPa/L)it		0.1411 (3.4802)
R2	0.9845	0.9848
Sum of squared residuals	0.4799	0.4721
SE	0.0470	0.0466
	Fixed Effects	Fixed Effects
	Galicia -1.0298	Extremadura -1.7492
	Extremadura -1.0006	C-Mancha -1.6506
	C-León -0.8974	Galicia -1.6375
	C-Mancha -0.8899	C-León -1.5844
	Andalucía -0.8483	Cantabria -1.5315
	Asturias -0.7882	La Rioja -1.4904
	Cantabria -0.7678	Aragón -1.4728
	Aragón -0.7615	Asturias -1.4714
	Murcia -0.6593	Murcia -1.4493
	B. Country -0.6404	Andalucía -1.4219
	Canaries -0.6373	Navarra -1.3001
	C. Valenciana -0.6286	C. Valenciana -1.2883
	Navarra -0.6231	B. Country -1.2568
	La Rioja -0.6142	Catalonia -1.1307
	Catalonia -0.5639	Canaries -1.0614
	Balearics -0.5467	Madrid -1.0164
	Madrid -0.3989	Balearics -0.9081

NOTES: see Tables 1 and 2

(a) GPa = productive public capital including that of adjacent regions

the stock of productive public capital of geographically adjacent regions (*GPa*)⁹. The value of this elasticity is 0.1411 (column 2), clearly higher than that obtained when only the productive public capital of each region is considered, 0.0771 (column 1). Therefore, in the light of the results obtained, we can conclude that the growth in elasticity associated with public capital, when both the public capital of each region and that of the neighbour regions are taken into account, is a favourable indicator for the acceptance of the hypothesis of the spillover effect.¹⁰

On the other hand, the positive and statistically significant value of the parameter accompanying the labour input in the estimation of the production function when adjacent productive public capital (*GPa*) is included (0.1069 with a t-statistic of 2.8289) allows us to accept the existence of increasing returns to scale in all inputs as a consequence of the increase in the value of the elasticity associated with public capital (0.1411). The elasticities associated with labour (α) and with private capital (β) are 0.5599 and 0.4059 respectively, values very similar to those obtained when only the productive public capital of each individual region is considered.

The lower part of table 3 shows the fixed effects specific to each region (a_i) in increasing order. In column 1, outstandingly low values are associated with the regions of Galicia, Extremadura, Castilla-León, Castilla-La Mancha and Andalucía, and outstandingly high ones with Madrid, the Balearics, and Catalonia.¹¹

⁹ Holtz-Eakin and Schwartz (1995), instead of adding the public capital of the neighboring regions to the own capital of each region, introduce these two components separately. However, in the Spanish case we can not introduce the two components separately since in two regions the stock of public capital of the neighboring regions is zero (the islands Balearics and Canaries) and we estimate the production function in logarithmics.

We only consider the effect of geographically adjacent regions (not several "rings") since in the majority of the regions if we add the stock of public capital of the second "ring" we obtain the stock of public capital of Spain (the number of regions in Spain is only 17)

¹⁰ In Mas, Maudos, Pérez and Uriel (1994a), which uses as its source of information on production and employment the "*Regional Accounts*" of the I.N.E., and on private capital (Calabuig *et al.* (1994) the same results are obtained. In particular, an elasticity of 0.31 is obtained in association with neighbouring productive public capital as against a value of 0.20 when only the productive public capital of each individual region is considered.

¹¹ A similar ranking is obtained in Mas, Maudos, Pérez and Uriel (1994c) when the effect of public capital on total factor productivity is analysed.

A result which deserves special attention is the fixed effects specific to each region obtained when the role of the public capital of neighbouring regions is taken into account (column 2), in comparison with the values obtained by considering only the public capital of each individual region (column 1). In the model which expressly considers the stock in adjacent regions, the fixed effect should be less, since part of the external effects associated with the public capital of the surrounding territory will be reflected in the estimated parameter corresponding to this "expanded" public capital. This result is obtained by comparing the magnitude of the fixed effects in columns 1 and 2, which are always less in the second case. Also notable is the variation in the order of the estimated fixed effects corresponding to the island territories of the Balearics and the Canaries. In both these cases, since the criterion used for defining adjacent public capital is geographical, the value of capital of these regions continues to be only their own, enabling them to rise to the top places in the ranking.

As Hulten and Schwab (1992) pointed out, the network feature of a large part of public infrastructures should lead one to expect a different effect on productivity depending on the level of development and the size of the stock of capital already accumulated. It is to be expected that in the initial stages of development, in which the stock of capital is relatively small, the effects of increases in this stock will be greater than at the stage of more advanced development with larger amounts of public capital.

With the aim of testing the relationship between the phase of development and the importance of public capital, table 4 shows the results of the recursive estimation of the most general production function¹², taking 1964-1973 as the initial period and subsequently expanding the sample until the whole of the period under study, 1964-1991, is covered.

¹² We do not include the social public capital in the estimation as it is not statistically significant.

TABLE 4: ECONOMIC DEVELOPMENT AND PUBLIC CAPITAL

VARIABLES	1964-1973	1964-1975	1964-1977	1964-1979	1964-1981
Trend	-0.0004 (-0.0631)	0.0111 (1.5465)	0.0077 (1.3067)	0.0024 (0.5365)	0.0043 (1.1976)
Ln(L)it	0.3235 (3.3295)	0.2169 (2.1927)	0.2530 (3.0040)	0.2901 (4.1330)	0.2696 (5.0227)
Ln(K/L)it	0.6552 (6.7575)	0.4621 (4.8401)	0.5052 (6.1408)	0.5847 (8.7386)	0.5638 (10.5760)
Ln(GP/L)it	0.1404 (2.6354)	0.1469 (3.0002)	0.1362 (3.0245)	0.1324 (3.3071)	0.1309 (3.6024)
R2	0.9679	0.9657	0.9713	0.9760	0.9802
Sum of squared residuals	0.0818	0.1403	0.1679	0.1911	0.2121
SE	0.0357	0.0416	0.0413	0.0407	0.0400

VARIABLES	1964-1983	1964-1985	1964-1987	1964-1989	1964-1991
Trend	0.0145 (4.5871)	0.0181 (7.1231)	0.0194 (9.3435)	0.0194 (10.6105)	0.0168 (9.0625)
Ln(L)it	0.1348 (2.8444)	0.1054 (2.5021)	0.1243 (3.1967)	0.1159 (3.2294)	0.0674 (1.8845)
Ln(K/L)it	0.4228 (9.2665)	0.3827 (10.5695)	0.3882 (12.9123)	0.3978 (14.5684)	0.4285 (15.5709)
Ln(GP/L)it	0.1270 (3.6445)	0.1176 (3.7097)	0.0959 (3.3081)	0.0845 (3.1281)	0.0771 (2.8916)
R2	0.9806	0.9828	0.9843	0.9857	0.9845
Sum of squared residuals	0.2819	0.3163	0.3497	0.3814	0.4799
SE	0.0435	0.0436	0.0437	0.0436	0.047

NOTE: see Tables 1 and 2

In all the sub-periods considered¹³ the existence of increasing returns in all inputs, as well as the statistically significant positive effect of public capital of a productive nature, are accepted. Figure 2 reflects the evolution of the elasticity associated with the latter. It can be appreciated that, starting with an elasticity of 0.1404 for the sub-period 1964-1973, this decreases progressively as more recent observations are added to the estimation, until an elasticity value of 0.0771 is reached for the whole period. Consequently, a profile of the elasticity such as the Figure presents supports Hulten and Schwab's hypothesis of the relationship between public capital and economic development.

5. CONCLUSIONS

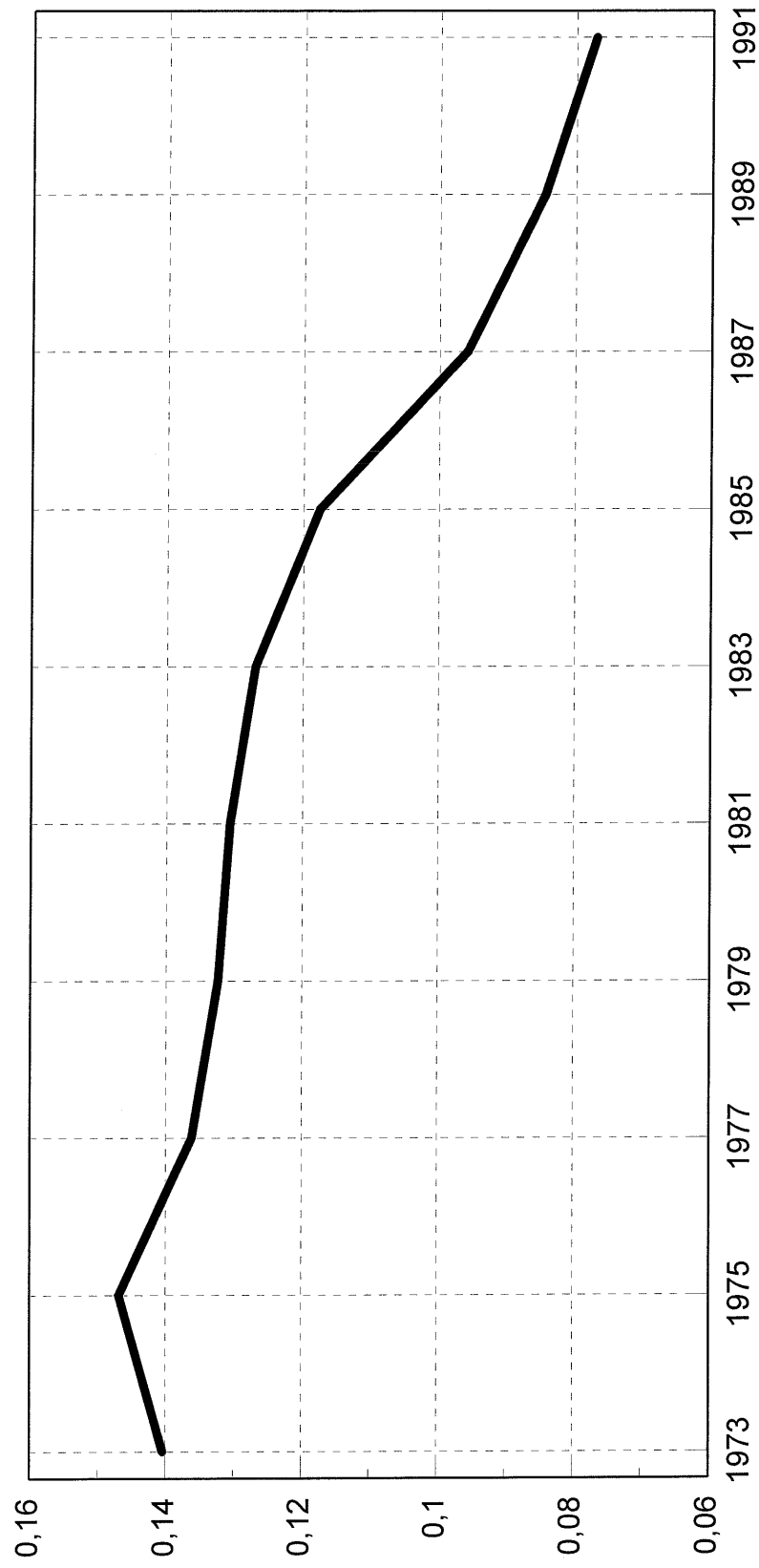
The aim of this paper has been to provide empirical evidence of the importance of certain forms of public capital in the gains in productivity of the regions of Spain in the period 1964-1991 using panel data techniques to control for unobserved regional-specific characteristics.

From this long-run perspective, the conclusions obtained may be summed up as follows:

1. The regional stock of public capital is shown to be relevant in accounting for the gains in productivity of the private sector of the economy, and the infrastructures directly linked to the productive process (roads, water and sewer facilities, urban structures and ports) present a significant positive effect which cannot be established in the case of the social infrastructures (education and health). Nevertheless, it must be pointed out that the role of infrastructures of a social character, and particularly education, need to be analysed in greater detail and in a dynamic context, because their effect is produced through their contribution to the improvement of human capital.

¹³ BBV provides information about GVA and employment every two years.

Figure 2: Recursive estimation of the productive public capital elasticity



2. The elasticity of labour productivity to the stock of productive public capital is greater in the estimations where the stock of public capital considered includes that belonging to each individual region and that of the neighbouring ones. This result may reflect the externalities associated with the network feature of infrastructures of all the regions (spillover effect), since in many infrastructures the state of the network as a whole counts as much as that of each of the parts. Consequently, from the point of view of efficiency, the importance of considering the territorial distribution of infrastructures with a less local horizon than is sometimes used must be underlined.

3. Given the network feature associated with certain forms of public capital, the effect of these infrastructures on the productivity of the Spanish regions has decreased over time. The analysis carried out shows a reduction in the elasticity associated with productive public capital as more recent observations are added to the estimation. Therefore, the observation of powerful effects of public capital on productivity in the past does not imply that these will persist with the same intensity in the future.

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