

Charlot, Sylvie; Schmitt, Bertrand

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Public Infrastructure and Economic Growth in France's Regions

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PUBLIC INFRASTRUCTURE AND ECONOMIC GROWTH IN FRANCE 'S REGIONS

Sylvie Charlot

UMR INRA-ENESAD Rural sociology and economics,

26 boulevard Dr Petitjean, BP 1607, 21000 Dijon

e-mail: charlot@enesad.inra.fr

Bertrand Schmitt

UMR INRA-ENESAD Rural sociology and economics,

26 boulevard Dr Petitjean, BP 1607, 21000 Dijon

e-mail: schmitt@enesad.inra.fr

Abstract: In this paper, theoretical results from endogenous growth models (Barro, 1990) are used to examine the role of public infrastructure in regional growth in France. Two main questions are addressed: (i) does public infrastructure have any effect on regional growth? (ii) can public infrastructure reduce disparities between regions? Production functions with three inputs (private capital and employment, public capital) are estimated from regionalised series of public and private sectors capital using panel data econometrics methods for the 22 regions of France for the period 1982-1993. A Cobb-Douglas production function highlights a positive impact of public capital on regional growth, even if we take into account of data-related effects and of possible simultaneity in determining regional output and regional public capital. Introduction of a trans-log form for evaluating region-specific elasticities shows that the positive effect of public capital increases with the regional wealth. In France then, while public capital seems to stimulate regional growth, it apparently doesn't reduce interregional disparities.

JEL classification: R11, H54, C23

1. Introduction

Among the issues of regional development and its policy tools is the question of how public capital investment affects regional growth. Such questions has often focused on the role of transport infrastructure and its implications in terms of lower transport costs for goods and of accessibility (Gasser and Navarre, 1991; Bonnafous, 1993; Fritsch, 1997). Yet, the analysis of public spending effects on growth is recently reviewed by endogenous growth theories (for an overview see Barro and Sala-I-Martin, 1995). Some endogenous growth models focus on positive externalities generated by public services and therefore by public spending (Barro, 1990). There are externalities because public services can affect the productivity of firms without those firms directly bearing the costs. These are productive public services then in the sense that, for given private inputs stocks, they reduce firms' production costs or increase output levels.

During the same decade several empirical studies sought the effects of public infrastructure on both national and local growth, especially at the US state scale. Initial national (Aschauer, 1989) and regional (Munnell, 1990) investigations based on three-inputs production functions indicated that public expenditure had a positive effect on firms' output or productivity. However, the statistical robustness of those initial findings was questioned (Eberts, 1990; Gramlich, 1994). One issue concerns the measurement of the eviction effect engendered by public investment and the sense of the statistically observed relation. The econometric techniques used were also contested, leading to the initial results being revised downwards.

As concerns the sense of causality of the relation, the argument is that while public infrastructure may be productive, it is financed by taxes and is therefore dependent on taxpayers' income and so on production. We have to consider this simultaneity when we want to measure the net effect of public investment on growth. Such bias is classically corrected by simultaneous equations models (Duffy-Deno and Eberts, 1991; Tatom, 1993; Ford and Poret, 1991). In the case of the United States, introduction of this correction greatly reduces and even totally cancels out the positive effect of public capital on growth.

The second important criticism of the initial studies revealing a positive effect of public expenditures on growth relates to the common trend of the variables, how they change over time. Tatom (1993) claims the relation identified by Aschauer (1989) or Munnell (1990) merely reflects common trends of production and of public investment during the analyzed period, i.e. their concomitant pattern of change. These are serious limits of the tested model and of the results obtained by the ordinary least squares method (OLS). To take into account of the time series dimension of variables it is necessary to

work on their stationarity, the change in their distribution over time. After correction for this bias, the effect of public investment on growth in the United States disappears (Tatom, 1991, 1993; Hulten and Schwab, 1991).

Finally, in studies of American states, urban areas or regions, variables are observed in time and space. Holtz-Eakin (1994) reports that using ordinary least squares on this type of data overlooks the possibilities of a common trend between the variables and the impact of regional characteristics in explaining productivity (their endowment in natural resources, size, location, climate, etc.). Some studies concerning American states or urban areas used panel data econometrics methods and allowed for time series and cross-sectional dimensions (in these cases the individuals are regions). They found that public sector investment has no effect, or even in some instances a negative effect, on local growth (Holtz-Eakin, 1994; Evans and Karras, 1994; Andrews and Swanson, 1995; Moomaw *et al.*, 1995).

Thus when statistical methods more suited to the analyzed series are used, public spending seems to have a lesser effect on local growth in areas of the United States. In Europe and in France, there are just few studies concerning this issue at local level, particularly because few data sets are available. For example, regional public capital is not recorded in any official data base. However, pioneering work by Fritsch (1995) has put together such series and, with particular specifications, shown that in France public capital has a positive effect on regional growth.

In view of the importance of regional development policy in France, two questions of the role of public infrastructure in regional growth are addressed:

- Does public sector capital have any effect on regional growth? Is there a public capital externality, as endogenous growth models assume?
- Do public sector investments reduce regional disparities, which may be seen as one goal of the regional development policy?

This paper addresses these two questions in three stages. First, we estimate a Cobb-Douglas regional production function with three inputs using panel data techniques and attempting to evaluate the presence of public capital externality. Secondly, the same form of production function is introduced in a simultaneous equations system, where the second equation explains the stock of regional public capital by the regional output and the local taxation rate. This second stage of estimation specifies the direction of causality of the 'regional growth - public infrastructure' relation. In the third and final stage we test a trans-log function which is more flexible than the Cobb-Douglas function. The trans-log function distinguishes between public-sector capital production elasticities by region and indicates to what extent public investment can reduce regional disparities.

In addition to series on regional gross product (GDP) and regional employment from the French national statistics office (INSEE, 1995), our analyses are based on original regional series of public and private sectors capital. We built them with data from Capital Accounts (INSEE, 1994), Tax Department and Public Accounts Department (construction of series is detailed in appendix). For some technical reasons (change in the national accounting base in 1980), the present study concerns regional GDP for the period 1982-1993.

2. A Cobb-Douglas production function with public capital as input

Endogenous growth models with public capital externalities (Barro, 1990) are usually based on production function with three inputs, two of which are private factors (labour and private sector capital) and the third, public infrastructure, is financed by the public sector. The Cobb-Douglas function is the most frequently used. It gives a direct reading of production elasticities and returns to scale and allows easy discussion of whether public capital externalities are present or not. This factor yields externalities if returns to scale are decreasing or constant for private factors and increasing for private and public factors as a whole (Barro, 1990).

Then the regional production function takes the following form:

$$Y = AK^{\mathbf{a}}L^{\mathbf{b}}Kpu^{\mathbf{g}}\mathbf{e} \quad (1)$$

where Y is the vector of Y_{rt} , the GDP for region r at period t ; K , L and Kpu are, respectively, the stock of private sector capital, labor and the stock of public capital associated with region r and period t ; \mathbf{e} is the error-term.

After linearising by logarithmic transformation, the model takes the following form and can be estimated using econometric techniques for linear models:

$$\log Y = \log A + \mathbf{a} \log K + \mathbf{b} \log L + \mathbf{g} \log Kpu + \log \mathbf{e} \quad (2)$$

The aim is to test the model of endogenous growth with public capital which, because of the existence of public capital externalities, considers that returns to scale are constant in private inputs ($\mathbf{a} + \mathbf{b} = 1$) and increasing for private and public inputs together ($\mathbf{a} + \mathbf{b} + \mathbf{g} > 1$). For this reason production was estimated first with no constraint on parameters and then with a constraint of constant returns to scale on private inputs. Table 1 shows the results for the 22 regions of France for the period 1982-93 using classical panel data econometric methods.

Panel data have two dimensions: a cross-sectional dimension — which is a spatial one here since the individuals observed are regions — and a time-series dimension. Analysis of such data can

discriminate an "cross-sectional effect" and a "time-series effect" in economic phenomena. Four main estimators can be used to compute a relation in this context (Greene, 1997). The first is obtained by simple regression using ordinary least squares (OLS) of all the variables. The total variance is used in this case. A second estimator is obtained by simple regression on the computed means of endogenous and exogenous variables over the period for each individual. This is the *between* estimator which is not used here because of the small number of observations (22 regions). A third method consists in applying OLS to a model with variables transformed by calculating deviations from the individual mean, which controls the characteristics specific to each individual that are not introduced in the estimated relation. This is called the *fixed effects model* as opposed to the *random effects model*. The random effects model assumes individual constant terms are randomly distributed across cross-sectional units. Unlike in the fixed effects model, OLS estimator is not consistent and the generalised least square (GLS) technique is then required. An Hausman test is used to choose between fixed and random effects models.

Table 1 - Cobb-Douglas production function with three inputs (All French regions, 1982-1993)

	Unconstrained model			Constrained model ($\mathbf{a} + \mathbf{b} = 1$)		
	OLS	Fixed effects	Random effects	OLS	Fixed effects	Random effects
Number of observations	264	264	264	264	264	264
Intercept	1,401 ** (7,78)		0,657 * (2,406)	1,816 ** (13,31)		-0,795 ** (-4,08)
Private sector capital	0,322 ** (15,59)	0,207 ** (6,44)	0,251 ** (8,83)	0,320 ** (15,19)	0,207 ** (6,43)	0,338 ** (13,04)
Labor	0,592 ** (18,04)	0,918 ** (10,35)	0,565 ** (19,70)	0,680	0,793	0,662
Public capital	0,158 ** (5,96)	0,317 ** (15,021)	0,294 (15,24)	0,070 ** (9,78)	0,321 ** (15,27)	0,212 ** (13,52)
R ²	0,992	0,999	0,990	0,645	0,960	0,960
Hausman test (Chi-square value)	-		23,731	-		72,638

t-values in brackets.

** : significant at the 1 % level; * : significant at the 5 % level.

In the unconstrained model, parameters determined by the ordinary least squares (OLS) are consistent with those classically found: production elasticity of private sector capital is closed to 0.3, labor elasticity is slightly less than 0.6, and public capital elasticity 0.16. Returns to scale are therefore decreasing for private factors (the sum of elasticities is equal to 0.914) and slightly increasing for all three factors (the sum of elasticities is equal to 1.072).

The fixed effects model results show labor elasticity is strengthened and public capital elasticity becomes very high. It exceeds that of private sector capital, what it is surprising. We will discuss that further. In the random model results, labour elasticity is close to that found with OLS while public capital elasticity is mid-way between the values found for the previous specifications. Hausman test leads to choose a specification with fixed effects rather than random effects. It seems that there are specific regional effects. And when these effects are controlled, the employment level and, to a lesser extent, the public capital stock determine the level of regional output. Returns to scale for all factors are largely increasing, with the sum of elasticities equal to 1.44.

Introducing a constraint of constant returns in the private inputs does not change the elasticity of private capital estimated from the model estimating by OLS. However in this case, employment elasticity is higher than before (close to 0.7). The contribution of public capital to regional production falls, even if it remains significantly positive. Variance explained by the model with constraints is far greater than that explained by the unconstrained model. The unconstrained model therefore seems the best specification, as confirmed by Fischer test for comparing the two specifications.¹

With fixed effects model parameters are very stable whatever the model, unconstrained or constrained, we use. The only exception is the employment elasticity of which the value is closer to classical value but is nonetheless close to 0.8. Hausman test shows a preference for the fixed effect to the random effect model and Fisher test leads to choose the constrained model rather than the unconstrained model.² It is important to observe, in this specification that the tests lead us to use, public capital has a very strong and highly significant impact on production.

Finally, the nature of the data used and the results of Hausman and Fisher tests lead us to use to retain the fixed effects model with constraint on private inputs returns to scale. Then labor elasticity is in the order of 0.8; private sector capital elasticity is 0.2 and public capital elasticity 0.3. Returns to scale in the private and public inputs are therefore strongly increasing.

The elasticity values obtained are surprising. Employment elasticity seems higher than what is classically found in the literature. This may be explained in part by the method of regional GDP calculation by INSEE. Regional distribution of output between different plants of the same firm is carried out "proportionally to the payroll" (Dejonghe and Vincenau, 1996, p. 22). This probably overestimates the relation between GDP and employment at regional level. As we retained the model

¹ The probability of using the unconstrained model whereas the constrained model is better specified is less than 1%. $F(1,261)$ is 11.9 while its critical value is 6.63 at the 1% level of significance.

with constraint $a + b = 1$, the way regional GDP is calculated may also account for the relative weakness of private sector capital elasticity.

This remark may help to answering the questions raised by the fact that public capital is proportionally higher in our estimate than private capital. Our results are nonetheless close to those found by Aschauer (1989) and Munnell (1990) (who did not use panel data econometrics), and which were severely criticized by Gramlich (1994) and Tatom (1993). If public capital elasticity is greater than private capital elasticity, economic agents should not have any questions about financing public capital through taxation. However, this reasoning is only valid if individuals are able to measure the benefits they derive from public sector investments. But if public capital affects production, this effect is brought about by an externality, which, by definition, is not taken into account by the agents. It is not therefore a direct effect. In France, where there is extensive public sector, high elasticity of production relative to public capital is less surprising.

Beyond these remarks, the fact remains that the public capital elasticity obtained in our study is high (0.3) and close to the "stratospheric" values for which Gramlich (1994) criticises Aschauer (1989) and Munnell (1990). Further investigations on longer series are necessary to confirm this parameter value. However, it is worth noting that in France public capital seems to have a positive effect on regional output levels although just how large an effect is difficult to say.

3. Causality of the relation between public infrastructure and regional growth

In the previous section we assumed that public and private inputs explained regional output. One of the main criticisms addressed to studies on the role of public capital in regional development relates to the causality of the relation. If a region is rich and productive, it is able to finance a large stock of public capital. The region's wealth thus determines most of the public capital stock (Herrera, 1996). Estimations of production functions as in the previous section cannot alone determine the direction of cause and effect of the relation between regional output and public capital.

Following Duffy-Deno and Eberts (1991) we have sought to determine the causality of the relation between public capital and production by constructing a simultaneous equations model, i.e. a system where the variables explained are interdependent. For this, the local taxation rate of each region is introduced to explain the region's ability to invest in public capital. The model of simultaneous equations takes the form:

² $F(1.239) = 2.3$ for a critical value of 2.71 at the 10% level of significance.

$$\left\{ \begin{array}{l} \log(Va_{tr}) = a_1 + a_2 \log(L_{tr}) + a_3 \log(K_{tr}) + a_4 \log(Kpu_{tr}) \quad (3) \\ \log(Kpu_{tr}) = b_1 + b_2 \log(Va_{tr}) + b_3 tximp_{tr} \quad (4) \end{array} \right.$$

where $\log(Va_{tr})$ is the logarithm of GDP of region r at period t ,
 $\log(L_{tr})$ is the logarithm of employment of region r at period t ,
 $\log(K_{tr})$ is the logarithm of private capital of region r at period t ,
 $\log(Kpu_{tr})$ is the logarithm of public capital of region r at period t ,
 $tximp_{tr}$ is the mean local taxation rate of region r at period t .

This model involves estimating a three-inputs Cobb-Douglas regional production function where the stock of public capital is explained by the output of a region and the mean local taxation rate, in order to account for the role of local taxation in public sector investment in a given region. Such a model can be estimated by instrumental variables methods such as three-stage least squares, 3SLS (Maddala, 1992; Greene, 1997).

Before estimating the model, we test the exogeneity of endogenous variables. This is designed to test for the presence or absence of dual causality between the endogenous variables of the model. We used exogenous test with estimations of the augmented regression, based on the specification test of Hausman (Maddala, 1992; Greene, 1997). This involves the estimations of the different equations, introducing together the estimate value of the tested variable obtained with the regression on the instruments and its observed value. If the coefficients of the estimated variables are significantly different from zero, the hypothesis of exogenous variables is rejected.

Table 2 - Exogeneity test of GDP and public capital

	Initial model		Fixed effects model	
	GDP	Public Capital	GDP	Public capital
Fischer test (F)	10,14	3,264	0,015	2,143
Degrees of freedom	(1,259)	(1,260)	(1,259)	(1,260)

When variables are not transformed to allow for the nature of data, the results of such tests (Table 2) lead to conclude that GDP and public capital are endogenous (respectively at the 1% level and at the 10% level).³ Three-stage least squares method is therefore required to estimate this system. When

³ Critical values of F (1.259) and F (1.260) are 6.63 at the 1% threshold, 3.84 at the 5% threshold and 2.71% at the 10% threshold.

variables are transformed to obtain a fixed effect model, the variables explained there is no more endogeneity. It is not therefore necessary to use the 3SLS method for estimating the model.

Then three estimations were made. Their results are shown in Table 3: the first is by OLS on untransformed variables, the second solves the same model with 3SLS and the third is OLS estimates only of the fixed effects model (3SLS is not necessary).

Table 3 – Simultaneous equations model (All French regions, 1982-1993)

	Initial model		Fixed effects model
	OLS	3SLS	OLS
Three inputs production function equation			
Intercept	1,40 ** (7,79)	2,06 ** (7,76)	
Labor	0,59 ** (18,04)	0,71 ** (15,52)	0,92 ** (10,82)
Private capital	0,32 ** (15,59)	0,31 ** (14,92)	0,21 ** (6,73)
Public capital	0,16 ** (5,96)	0,04 (0,93)	0,32 ** (15,70)
R ²	0,99	0,99	0,89
Root MSE ⁴	0,08	0,08	0,03
Public capital equation			
Intercept	1,17 ** (5,47)	1,13 ** (5,28)	
GDP	0,86 ** (83,88)	0,86 ** (83,64)	1,29 ** (18,35)
Taxation rate	0,04 ** (13,36)	0,04 ** (13,40)	0,03 ** (8,03)
R ²	0,96	0,96	0,84
Mean square error root ⁵	0,14	0,14	0,06

t-values in brackets.

** : significant at the 1 % level; * : significant at the 5 % level.

Results for the public capital equation show that, whatever the model specification and the econometric method, the stock of regional public capital is largely explained by the regional GDP and the taxation rate, with relatively high R². This confirms that there is a causal link between the level of public capital and regional output.

Results for the production function are identical, of course, for OLS estimates and, as seen above, public capital has a positive effect on regional production. On the other hand, the use of the 3SLS estimator on untransformed variables greatly modifies the production function parameters: public capital elasticity is no longer significantly different from zero and employment elasticity comes to 0.7. The parameter associated with private sector capital is significant and remains stable at 0.3.

⁴ The root of mean square error, compared with the mean of the variable explained, indicates the quality of estimation: the more reliable it is, the better quality the estimation.

The positive effect of public capital on regional growth apparently vanishes then when the effect of regional wealth on the level of public capital is controlled. Nonetheless, such a result is obtained with a specification of the model that does not control the effects specific to each region. This is an important limitation given the nature of the data involved. When allowance is made for this, the 3SLS method, designed to correct simultaneity bias does not seem necessary and the previous result of a positive effect of public capital is maintained.

4. Inputs substitution and regional production elasticities: the trans-log function

The functional form chosen in the previous estimations, although consistent with the theoretical model of growth, is not flexible. Inputs are considered to be substitutable and production elasticity for each factor is considered to be identical for all regions over the entire period. The trans-logarithmic production function is, from this point of view, much more flexible than the Cobb-Douglas function. It also removes assumptions that inputs can be substituted and production is homogeneous.

A trans-logarithmic production function takes the following general form (Christensen et al., 1973):

$$\log Y = a_0 + \sum_i a_i \log X_i + \sum_i \sum_{j \geq i} b_{ij} (\log X_i \log X_j) \quad (5)$$

Then production elasticity relative to each input is:

$$\frac{d \log Y}{d \log X_i} = a_i + \sum_{j > i} b_{ij} (\log X_j) + 2b_{ii} (\log X_i) \quad (6)$$

Elasticities are therefore no longer fixed and identical for all regions and periods. Input elasticity does not depend only on the quantity of the factor available any more but also on the quantities of the other inputs available in the region in each period.

The trans-log function with three inputs takes the following form in this context:

$$\begin{aligned} \log Y = & a_0 + a_1 \log L + a_2 \log K + a_3 \log Kpu + \\ & b_{11} (\log L^2) + b_{22} (\log K^2) + b_{33} (\log Kpu^2) + \\ & b_{12} (\log L \log K) + b_{13} (\log L \log Kpu) + b_{23} (\log K \log Kpu) \end{aligned} \quad (7)$$

This model was estimated without constraint for all French regions over the period 1982-93. The results are shown in Table 4.

Hausman test indicates the fixed effects model should be chosen. As with the Cobb-Douglas function, there seem to be significant regional effects. For the fixed effects model, the coefficient of the crossed-

product terms are invariably positive and significant, the three inputs considered are therefore substitutes.⁵ In this sense, the Cobb-Douglas function is not completely unsuitable for our study, even if, when OLS estimates are made, private capital appears complementary to both public capital and to employment.

**Table 4 - Three inputs trans-log production function with three inputs
(All French regions, 1982-1993)**

	OLS	Fixed effects	Random effects
Number of observations	264	264	264
Intercept	-0,166 (-0,00)		8,296 ** (3,37)
K	4,507 ** (6,08)	2,294 ** (3,53)	0,690 (1,37)
L	-4,695 ** (-5,57)	-8,433 ** (-5,44)	-1,384 * (-2,09)
Kpu	-0,705 (-0,71)	1,220 * (2,27)	0,325 (0,69)
L ²	0,0055 (1,12)	0,031 * (2,04)	0,033 ** (3,87)
K ²	0,112 (1,75)	-0,254 ** (-3,01)	0,014 (0,215)
Kpu ²	0,0244 (0,30)	-0,253 ** (-5,54)	-0,092 * (-2,53)
K * Kpu	-0,359 ** (-3,75)	0,241 * (2,35)	0,026 (0,30)
Kpu * L	0,449 ** (3,61)	0,269 * (2,20)	0,206 * (2,03)
K * L	-0,146 (-1,41)	0,226 * (2,10)	-0,105 (-1,33)
R ²	0,995	0,999	0,991
Hausman test (Chi-square value)			57,296

t-values in brackets.

** : significant at the 1 % level; * : significant at the 5 % level.

Production elasticities of each input cannot be directly observed in the case of trans-log production functions and require further calculation (the principle of this is recalled above, cf. equation 6). Mean input elasticity is calculated for each region for the OLS estimator and the fixed effect model (Table 5). Even so the elasticities obtained with the trans-log form must be interpreted with care. They are very sensitive to the period of observation and the unit of measurement of regional input endowments.⁶

The trans-log functional form nevertheless shows regional disparities in production elasticities of the different factors. Elasticities calculated from OLS but, above all, for fixed effects model confirm the strong impact of employment on production in all regions. Elasticity of this factor may vary in OLS from 0.51 for Franche-Comté⁷ to 1.2 for Ile-de-France, emphasising the over-productivity of labour in this region (this is also the only region where private sector capital elasticity is slightly negative).⁸ We

⁵ Parameter b_{ij} with $i \neq j$ gives an indication of the substitution between factors: if $b_{ij} > 0$, factors i and j are substitutable; if $b_{ij} < 0$, factors i and j are complementary.

⁶ Fritsch (1995) finds very different results to ours for the period 1978-1989 and with series constructed differently.

⁷ Excluding Corsica where it is only 0.2.

⁸ Labour elasticities here are always very high while private capital elasticities are often low. A number of technical arguments for this are presented above.

also obtain a high labor elasticity and a low private sector capital elasticity for certain wealthy regions such as Rhône-Alpes and PACA. By contrast, private sector capital elasticity is comparatively high in Champagne, Haute-Normandie and Basse-Normandie as well as in Alsace, Picardie and Limousin.

Table 5 - Mean regional elasticities of the three inputs (1982-1993)

Region	OLS elasticities			Fixed effects elasticities		
	L	K	Kpu	L	K	Kpu
Ile-de-France	1,18	-0,09	-0,25	2,41	-0,03	0,51
Champagne	0,52	0,50	-0,55	1,17	0,10	0,45
Picardie	0,58	0,45	-0,54	1,30	0,07	0,45
Haute Normandie	0,57	0,49	-0,64	1,40	-0,07	0,50
Centre	0,71	0,33	-0,45	1,48	0,11	0,43
Basse Normandie	0,54	0,47	-0,50	1,17	0,15	0,43
Bourgogne	0,62	0,40	-0,47	1,25	0,18	0,38
Nord-Pas-de-Calais	0,89	0,19	-0,46	1,78	0,05	0,37
Lorraine	0,72	0,35	-0,54	1,52	0,03	0,40
Alsace	0,57	0,47	-0,58	1,33	0,02	0,47
Franche-Comté	0,51	0,52	-0,59	1,09	0,12	0,38
Pays de Loire	0,87	0,18	-0,35	1,61	0,21	0,33
Bretagne	0,87	0,15	-0,29	1,51	0,32	0,27
Poitou	0,68	0,33	-0,41	1,21	0,31	0,28
Aquitaine	0,81	0,22	-0,35	1,52	0,23	0,35
Midi-Pyrénées	0,80	0,23	-0,35	1,46	0,26	0,31
Limousin	0,54	0,46	-0,45	0,81	0,44	0,17
Rhône-Alpes	1,00	0,08	-0,39	2,02	0,02	0,41
Auvergne	0,68	0,35	-0,44	1,17	0,31	0,24
Languedoc	0,80	0,23	-0,36	1,33	0,35	0,21
PACA	0,97	0,10	-0,36	1,81	0,15	0,31
Corse	0,19	0,77	-0,63	0,16	0,50	0,12
France	1,75	-0,59	-0,01	3,28	-0,01	0,40

Elasticity of public capital from OLS estimates is always negative, contrary to the results obtained with the same method for a Cobb-Douglas production function. On the other hand, the fixed effect model leads to consistently high, positive public capital elasticities, whatever the region. There are marked variations in elasticity between regions: it seems that the more developed regions are, the greater the impact on production of public capital. The elasticity of public capital appears to be an increasing function of the level of wealth of the region: public capital elasticity is 0.51 in Ile-de-France but only 0.17 in Limousin.⁹ It should be noticed finally that public capital elasticity is generally higher than private sector capital elasticity in the more developed regions, whereas private sector capital has a greater impact in less developed regions.

⁹ Regional elasticities of public capital obtained with the trans-log function are even higher than those found for all the regions with the Cobb-Douglas function. Such values become difficult to interpret and only the differences can then be analysed.

Although trans-log function estimations can confirm the positive effect of public capital on regional growth (when region-specific characteristics are controlled), this effect does not necessarily entail a reduction in disparities between regions in terms of production. Public capital investment policy seems to favour the development of regions that are already rich. However, it is worth noting that it also acts positively on the growth of less well-to-do regions, even if its impact is of more limited scope than in rich regions.

5. Conclusion

To deal with the question of the role of public capital in regional growth we used in this paper a production function approach. To test the existence of public capital externality at a regional level of analysis we introduced the public capital as an input. We used French regional data for the period 1982-1993 and panel data econometric methods to treat both time-series and cross-sectional dimensions. Two forms of production function were tested: the Cobb-Douglas function, classically used in this type of approach, and the more flexible trans-logarithmic function.

Our results first shown the non-negligible role played by public capital stock in regional growth, even if we used a simultaneous equations model to allow for any eviction effect may, with certain reservations, reduce its scope. As endogenous growth models suggest (Barro, 1990), public capital does therefore engender a positive externality in all French regions over the study period. This conclusion is similar to that of Fritsch (1995), for different period and series, but contrasts with the results obtained by the same methods in the United States: Holtz-Eakin (1994) or Andrews and Swanson (1995) show that the introduction of fixed effects in the relation between growth of US states and public capital reduces or cancels out the impact of public capital. This divergence in results can be explained by differences in the structure of public capital in these two countries. While U.S. public capital is mainly formed by road infrastructure, in France the share of educational infrastructure is higher.¹⁰ Garcia-Mila and MacGuire (1992) show that education has a greater effect on the output of US states than transport infrastructure. To test this hypothesis, it would be helpful to break down regional stocks of public capital by function.

¹⁰ Roads represented almost one third of U.S. civil public capital in 1991 and educational structures less than 15% (Tatom, 1993; Gramlich, 1994). In France the distribution by main non-military investment sector programmes given by the public accounts department showed for that same year that education and training received 30% of state investment as against 24% for transport and telecommunications (INSEE, 1995). Even if term-by-term comparison of these data calls for caution, the differences are sufficient to suggest the greater importance of transport networks in public investment policy in the United States compared with France.

Even if results need to be handled with care, estimations using the trans-log function suggest public capital plays only a moderate role in reducing regional disparities. Industrial regions, which also have a high degree of urbanisation, seem to benefit more intensely from positive effects of public investment. Investment in public capital appears to be able to promote national growth, reinforcing the dynamism of regions having attained a high level of development. However, it does not seem to be capable to counteract forces that concentrate activities and regional growth and may even contribute to these effects. Thus our results raise doubts about the impact of development policies designed to balance regional dynamics through public sector investment.

The surprising level of elasticities obtained with the series and methods have been commented upon several times: high elasticity for labor, low elasticity for private sector capital and very high elasticity for public capital. Further inquiry is necessary to confirm these findings. Some improvement could be made by increasing the length of the series used. Other improvement might be made to the way the series are constructed, especially with regard to that constructed by INSEE for regional output. Moreover, the break down of public capital by type of function (transport, educational infrastructure, etc.) or by the type of financing agency (central or local government) could further debate on the levels of public capital elasticity obtained.

Finally the presence of fixed effects, in all our estimations, emphasises the importance of regional characteristics in the relation between output and public capital. When these characteristics are controlled, the impact of public capital in explaining regional GDP is enhanced. We can think that many explanatory factors for the regional production level are missing from the relation tested. There is cause to investigate these factors and in particular the impact of interregional mobility of inputs and agglomeration economies.

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APPENDIX: DESCRIPTION AND CONSTRUCTION OF REGIONAL DATA

Some data in this paper are from INSEE (French Institute of Statistical and Economic Studies) regional accounts (INSEE, 1995). This is the case for regional GDP and employment. As the regional accounts do not include indicators of private and public capital stocks, these were constructed for the 22 regions of France for the period 1982-1993.

1. For private capital stock, the INSEE draws up a detailed annual Capital Account and has constructed a long series of such accounts to be integrated in the National Accounts (INSEE, 1994). The national private capital stock we used here includes reproducible assets, excluding housing, for all sectors except public sector. Local business tax returns provide an approximation of the capital stock of firms located in a region. The rental value of capital (land or otherwise) held by firms is one component of the gross base for local business tax. It was considered that the rental values liable to land tax and rental values of "plant and equipment" provide a suitable approximation to the capital used. They were used as an indicator of the inter-regional distribution of national private capital. The two-year gap between company returns and the actual holding of these values was allowed for.

2. National public capital stock was based on reproducible assets, except for housing, in the public sector available in the Capital Accounts (INSEE, 1994). Although INSEE does not directly provide regional stocks of public capital, the Public Accounts Department does report investments by local authorities and central government in each of the 22 regions since 1971. Regional investment by central government in this series is very incomplete (about 75% is broken down among regions). Regional stocks of public capital cannot be reconstituted from these investments. However, they can provide an approximation of the relative weight of each region in public investment as a whole. For this reason the national stock of public capital of a year t is divided among regions in proportion to the sum of investment by central government and local authorities in the region between 1971 and the date t in question. These investments are deflated and depreciated linearly at 5%.¹¹

3. As a supplement to the previous two indicators, information provided by the Tax Department is used to reconstitute local taxation rates which are evaluated from communal bases and the products of four local taxes: built land tax, unbuilt land tax, housing tax and business tax. The mean rate of regional taxation is measured by the ratio between the sum of products of the four taxes and the sum of the bases of the same taxes.

¹¹ This depreciation rate corresponds to a 20-year life-time for public capital. With a depreciation rate of 2%, giving a 50 year life-time, the results for regional stocks of public capital are much the same.