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Public infrastructure, private capital and the performance of manufactures: short and long run effects

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ABSTRACT:
In the present paper the cost reductions associated with infrastructure and private capital provision are examined through the application of the duality theory. This theoretical framework allows us to determine a wide range of public capital effects both in the short and long term. This way, it is observed how public capital directly affects costs in the short run while presenting an indirect channel in the long run through its effect on private capital. The model is applied to the Spanish regions for twelve manufacturing sectors during the eighties. The best specification is chosen based on the results of several statistics, rejecting the existence of a long run equilibrium for inputs demand, so that private capital is obtained to be a quasi-fix input in the short run. Both public and private capital seem to have reduced manufacturing costs though with a high sectoral and regional variability.

Keywords: Public Infrastructure, Long-run vs. Short-run Equilibrium, Manufacturing Costs

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1. INTRODUCTION

Theories derived from the classical school consider transport and other infrastructure as important elements in any area's production function, increasing the efficiency of the production system and estimulating private activity. Notwithstanding the assumed importance of public infrastructure, the magnitudes of its gains are far from being clearly determined. Initially, most studies focused on public capital impact on output and productivity through the use of neoclassical production functions.[1] Results in these initial studies generally support a positive effect of public capital, but the range of results is too large to be conclusive and many deficiencies were found thereafter. For example, in the work of Aschauer (1989) an unforseen result was that public capital has a substantially higher impact on output than private capital itself, which is a nonsensical result. Private capital is supposed to be directly devoted to the production process while public investment in infrastructure also plays other roles like reducing disparities and other social objectives that would hardly be reflected in domestic product measures. Therefore, several works have called into question the plausibility of the results of these initial studies due to econometric and specification problems. When these problems were accounted for, some negative results appeared, making us think that the optimistic conclusions of the initial works could had a weak foundation (Holtz-Eakin, 1994; Garcia-Mila *et al*., 1996).

Nevertheless, it is unthinkable that the gross national product would remain the same if roads, harbors, bridges and airports were taken out of the system. For this reason, the difficulty of assigning a quantitative role to public capital has been argued by some authors (Mullen *et al*., 1996, De la Fuente, 1996) as being a consequence of both the emphasis that most studies put on the direct effect of infrastructures and the rigidity of the production function. On the one hand, instead of thinking that public capital has no impact on productivity or output, we should pay more attention to the indirect infrastructure's role supposing changes on traditional inputs. On the other hand, the production function has been considered inaccurate due to the restrictions imposed on the technology and the firms' behavior and for not taking into account private input prices which would affect the intensity in which they are used. In order to overcome this twofold problematic issues the use of the duality theory has been suggested. The use of the duality theory through the estimation of cost and profit functions allows us to examine the complementary or substitutability relationship among private and public factors as well as the marginal effect of infrastructure on the firms cost structure.

The present paper pursues the same line of research, the main purpose of which is to enable a better understanding of the linkage between the publicly provided input and the nature of the manufacturing production process. The considered methodology is a cost function that allows us to disentangle the total effect of public capital into the different effects on the various private factors. Among the studies that have used cost functions aggregated with public capital we can point out those from Berndt and Hansson (1991) for the Swedish case, Morrison and Schwartz (1992, 1996) and Nadiri and Mamuneas (1994) for the US, Conrad and Seitz (1992), Seitz (1995) and Seitz and Licht (1995) for the German economy and Sturm (1997) for the Netherlands, and Aviles *et al.* (1997a, 1997b) for Spain. However, this paper extends these approaches to the consideration of several topics which are commonly avoided.

On the one hand, when analyzing public capital effect through the use of duality theory one may use either a long-run cost function or a variable cost function. In the former case, one is assuming that all factors of production can be costlessly adjusted so that the firm instantaneously determines long run factor demands. In the latter, it is considered that adjustment costs beyond the control of the firm do not allow inputs to adjust instantaneously to their long run equilibrium levels. Rather that assuming these ideas a priori, in the present paper we use the test developed by Schankerman and Nadiri (1986) to acknowledge into the possible divergence of private capital from its static equilibrium values. This way, the most appropriate cost model according to the Spanish manufacturing characteristics will be taken into consideration.

Second, if private capital turns out to be a quasi-fixed input, we will distinguish between two different effects of public infrastructures on costs: first, by a direct channel affecting variable costs and second, by an indirect one that comes from changes in the private capital intensities. Former papers using cost functions only consider the short run effect of public capital with the exception of Morrison and Schwartz (1996) which considers a long run effect through output adjustments. However, in the present paper we are able to measure the long run effects of public infrastructure since the quasi-fixed input is allowed to adjust in response to public capital changes in the long run. This long run cost effect through altering capital intensities has been considered in Nadiri and Kim (1996) and Bernstein and Yan (1997) to estimate the effects of R&D spillovers on the cost and production structure. However, as far as we know, it has not yet been used when computing public infrastructure effects on production costs.

We think that this latter point is specially important for the study of the impact of infrastructure investments. Improvements in the endowments of public capital may have two effects. It increases profitability of the production process in the existing firms and, as a consequence, it makes more attractive the location of new activities in the area. Then, we define a short run effect that is experienced by firms that are already producing. This is due to cost reduction in variable inputs as a consequence of the new public capital stock. Further, we define a long run effect by which higher profitability encourages new investments in private capital that increase the plant of the existing firms or cause more firms operating in the economy. This is in line with the theoretical ideas in Martin and Rogers (1995) and Ciccone and Hall (1996), that may also provoke sectoral restructuting in the economy.

Finally, empirical models to study the impact of infrastructures on growth suffer from strong multicollinearity. As stated in Chunrong and Cassou (1997) this may cause misleading conclusions on the significance and size of the effect. The problem is exhacerbated when applying the duality theory because of the use of very general functions (such as the translog) which include a large number of parameters. In order avoid this problem, we increase the cross-section variability by descending to a regional and sectoral level at the same time. This way, we also yield additional insights about the variability of public capital effects across economic sectors and regions. In fact, Seitz and Licht (1995) claim that their results obtained from the estimation of a cost function in the regional German case could be affected by the great differences existing in the sectoral structure of manufacturing industry across the federal states in Germany. Going on with these ideas, the present paper takes into consideration both a sectoral and regional disaggregation in the Spanish case during the eighties.

The paper is outlined as follows. In the second section the conceptual model based on duality theory is presented as well as the public capital elasticities. Section third describes the empirical specification and the econometric issues. The database and the empirical results are subsequently presented and discussed in section 4. Finally, some concluding remarks and suggestions for further research are given in section 5.

2. THEORETICAL FRAMEWORK: FIRM BEHAVIOR MODEL WITH PUBLIC CAPITAL

Short and Long Run Cost Functions

A cost function is a mathematical representation of the cost-minimizing problem faced by firms (Chambers, 1988). In this framework, it will be possible to explicitly include public capital in order to take into account the cost effect of this kind of external factor.

Let's consider a production function, where Y is the output and X_i ($i=1,...,r$) the i-th input:

$$Y = f(X_1, X_2, \ldots, X_r) \tag{1}$$

It is assumed that the firm is constrained to accept a vector of input prices, $P_1,...,P_r$, so that the optimization problem that firms face consists in deciding the amount of inputs that minimizes the cost for producing a given output, $\overline{Y}$. Then, we can obtain a group of demand functions for private inputs:

$$X_i = f_i(P_1, \ldots, P_r, \overline{Y}) \tag{2}$$

Being X_i^* the optimum amount of input, the level of optimum cost, that is, the solution to the optimization problem yields a cost function that is dual to the production function, being dependent on input prices and output:[2]

$$C^*(P_i, Y) = \sum_i P_i \cdot X_i^* = f(P_1, \ldots, P_r, \overline{Y}) \tag{3}$$

where * denotes values at the equilibrium.

In such a framework, we are assuming that all factors of production can be costlessly adjusted so that the firm instantaneously determines long run factor demands. Nevertheless, rather than assuming that all inputs adjust instantaneously to their long run equilibrium values, there are reasons to believe in the absence of such an adjustment mechanism for some factors. We can think of costs of investment and disinvestment, price controls and regulations, credit rationing and institutional constraints that are beyond the control of an individual firm in the short-run. Based on these ideas, we adopt a framework that distinguishes variable from quasi-fixed inputs, where the latter adjust only partially to their full equilibrium levels within one time period. Therefore, we consider short run cost functions apart from long run cost functions. In the former ones, the presence of some inputs fixed at values other than their full equilibrium level implies that there are adjustment cost associated with changing the quasi-fixed factors. In this case, the goal of the firm is to minimize the cost of variable factors conditional on a given stock of quasi-fixed factors. In the latter, all inputs are in any period at their full equilibrium values.

Specifically, the variable cost function we are using in this paper is specified as follows:

$$VC = VC(P_L, P_{M,} \bar{Y}; \bar{K}p, Kg) \tag{4}$$

where we consider two variable private inputs, labor (*L*) and intermediates (*M*) which appear in the cost function through their prices, $P_{L,}$ and P_M respectively; and a quasi-fixed input, private capital ($\bar{K}p$); $\bar{Y}$ is output and *Kg* is public capital (external input).[3]

The total short-run cost function is the sum of the variable cost and the cost of the existing private capital:

$$SC = VC + P_{Kp}\,\bar{K}p \tag{5}$$

Public infrastructure is therefore considered as an unpaid fixed input in the production process, on which firms have little or null control.[4] Therefore, this cost function permits the combination of internal scale economies in the production process due to private inputs (both variable and quasi-fixed) and the external scale economies, if existing, provided by the public input. That is, scale economies in cost function are now outlined including this new argument, so that publicly provided infrastructure could affect the shape of the average cost curve. As far as this specification goes, after increasing or improving public capital endowment, firms will adjust the decisions on the amounts of the different private inputs used in the production process according to the substitutive or complementary relationship each one of them maintain with infrastructures, and given the existing amount of quasi-fixed inputs. This will be the short run effect of infrastructure investments in the production process. Firms will decide the optimal amount of physical capital for the new endowment of public capital as well. Then, in the long run investments in infrastructure may have an additional effect through decisions of allocation of private capital and the consequent cost reduction effects of private capital.

Assuming that variable input prices are exogenous to the producer, and applying Shephard's Lemma (Chambers, 1988), it is possible to obtain the unique vector of the different variable inputs that minimize costs (cost-minimizing demands):

$$X_i = \frac{\partial VC}{\partial P_i} = f(P_L, P_M, \bar{Y}, \bar{Kp}, Kg) \quad (6)$$

Furthermore, we can calculate each factor share (Z_i), that is, the percentage of the cost supposed by the *i*-th input:

$$Z_i = \frac{P_i \cdot X_i}{VC} = \frac{\partial \ln VC}{\partial \ln P_i} = \frac{\partial VC}{\partial P_i}\frac{P_i}{VC} \quad (7)$$

Equation set (5) and (7) constitutes the solution to what can be defined as the short run equilibrium related to variable factors, constrained to fixed values for Y, Kp and Kg.[5] That is, the preceding functions, and consequently the short run solution, are not independent of the quasi-fixed factors. From these functions we can obtain the required short run elasticities, as in the case in which private capital is supposed to be at equilibrium.

On the other hand, the long-run demand for quasi-fixed factors, Kp^* in our case, is given by the envelope conditions. Minimizing total short run cost for Kp:

$$\frac{\partial SC}{\partial Kp} = \frac{\partial VC}{\partial Kp} + P_{Kp} = 0$$

$$-P_{Kp} = \frac{\partial VC}{\partial Kp} \quad (8)$$

That means that demand for Kp depends on prices of variable inputs, the fixed quantities of output and public capital, and its own price. Let

$$Kp^* = g(P_L, P_M, P_{Kp}, \bar{Y}, Kg) \quad (9)$$

be the solution to (8). Substituting (9) into (5), we get the long run cost function:

$$C^* = VC^*(P_L, P_{M,} \bar{Y}, g(P_L, P_M, P_{Kp,}, \bar{Y}, Kg), Kg) + P_{Kp,}\, g(P_L, P_M, P_{Kp,}, \bar{Y}, Kg) = f^*(P_L, P_M, P_{Kp,}, \bar{Y}, Kg) \quad (10)$$

Thus, equations (5), (6) --or (7)-- and (9) characterize the long-run equilibrium. From them, long run elasticities will be obtained. From (10) it is worth noting that Kg may affect long run cost in different ways: by a direct channel affecting variable cost, and by an indirect channel throught its effect on Kp. The latter will include an extra effect on variable cost, by complementarity/substitutability between private capital and variable inputs, and the direct effect of Kp on the long run cost.

Short and Long Run Cost Elasticities

From the functions previously described it is possible to asses the impact of public capital investments on short and long run costs of production. This effect will be measured by elasticities of cost, input demand and output with respect to the stock of infrastructures. In this sense, the change in short run cost due to a marginal addition to the infrastructure stock is the short run cost elasticity to Kg:

$$\varepsilon_{SC\,Kg}^{SR} = \left.\frac{\partial SC}{\partial Kg}\frac{Kg}{SC}\right]_{Kp=\bar{Kp}} = \left.\frac{\partial VC}{\partial Kg}\frac{Kg}{SC}\right]_{Kp=\bar{Kp}} \qquad (11)$$

where superscript SR denotes short run. Though not specified during all the analysis, the output is always supposed to be fixed, so that all the elasticities are computed considering a fixed amount of Y ($\bar{Y}$).

Hence, it is possible to obtain measures of the short run implicit willingness of private manufactures to pay for public capital, which is known as (short run) *infrastructure shadow price*. It is defined as the value of savings experienced by firms as a result of increasing infrastructure endowment. As long as this value is positive, firms benefit from having additional infrastructures, since they permit obtaining short run cost savings and hence productivity improvements.[6] Short run infrastructure shadow price may be specified as follows:

$$S_{Kg}^{SR} = -\left.\frac{\partial SC}{\partial Kg}\right]_{Kp=\bar{Kp}} = \varepsilon_{SC\,Kg}^{SR}\left(-\frac{SC}{Kg}\right) \qquad (12)$$

In fact, the measure will be positive as long as public capital supposes benefits in terms of substitution relationships with variable inputs, in other words, as long as public infrastructure represents efficiency changes in terms of decreases in variable inputs use and thus variable costs. Hence, following Nadiri and Mamuneas (1994), it can be said that firms will adjust their production decisions with respect to their own factors according to the relationship between them and public sector capital. This is what these authors call *the factor bias effect* of public capital, which can be computed as the short run infrastructure elasticity of the conditional demand for variable inputs:

$$\varepsilon_{X_i\,Kg}^{SR} = -\left.\frac{\partial X_i}{\partial Kg}\frac{Kg}{X_i}\right]_{Kp=\bar{Kp}} \qquad i = L, M \qquad (13)$$

The relationship between public capital and variable inputs can be of substitutability or complementarity, that is, public capital can be factor saving ($\varepsilon^{SR}_{XiKg}<0$), using ($\varepsilon^{SR}_{XiKg}>0$) or neutral ($\varepsilon^{SR}_{XiKg}=0$). Thus, as stated before, a positive shadow price would imply a net substitutive relationship between public capital and variable inputs. In other words, if there is an increase in the publicly provided input and it is substitutive (complementary) to variable inputs, the infrastructure increase will reduce (increase) industrial variable costs and, therefore, the shadow price will be positive (negative). Specifically, based on the variable cost function and differentiating it with respect to public capital, we decompose the cost saving effect provided by public capital into the effects on the demand for the considered variable factors:

$$S^{SR}_{Kg} = -\left.\frac{\partial SC}{\partial Kg}\right]_{Kp=\bar{K}p} = \sum_i -P_i \left.\frac{\partial X_i}{\partial Kg}\right]_{Kp=\bar{K}p} \tag{14}$$

where it is shown how infrastructures shadow price is dependent on the value of the relationships between public capital and variable inputs.

Moreover, it is commonly thought that increases in public capital stocks will intensify private economic performance. The impact of infrastructure on the short run level of production can be computed as the infrastructure elasticity with respect to output thanks to the application of the envelope theorem (Chambers, 1988):

$$\varepsilon^{SR}_{YKg} = \left.\frac{\partial Y}{\partial Kg}\frac{Kg}{Y}\right]_{Kp=\bar{K}p} = \frac{S^{SR}_{Kg}}{\left.\frac{\partial SC}{\partial Y}\right]_{Kp=\bar{K}p}}\frac{Kg}{Y} \tag{15}$$

From which we can obtain the magnitudes of the returns to scale as:

$$RTS^{SR} = \frac{1}{\varepsilon^{SR}_{SCY}} = \frac{1}{\left.\frac{\partial \ln SC}{\partial \ln Y}\right]_{Kp=\bar{K}p}} \tag{16}$$

Finally, although not directly related to public capital, in case of private capital not being in its long-run equilibrium level, the same exact effects that have been presented for public capital can be obtained for the private input, since it should be considered as a quasi-fixed factor. Therefore, we can compute ε^{SR}_{SCKp}, s^{SR}_{Kp}, ε^{SR}_{XiKp} and ε^{SR}_{YKp}.

Regarding long run effects of public capital, they are obtained in much the same way as the described above for the short run. However, variations in cost and variable inputs demand caused by changes in the stock of private capital as response to variations in infrastructure endowment must be added to the short run effect. It should be noted that this latter effect may foster the short run effect or, on the contrary, may balance or even inverse it. In this sense, the total or long run cost elasticity to Kg:

$$\varepsilon^{LR}_{SC\,Kg} = \left.\frac{\partial SC}{\partial Kg}\frac{Kg}{SC}\right]_{Kp=Kp^*} = \varepsilon^{SR}_{C\,Kg} + \varepsilon_{SC\,Kp}\,\varepsilon^{LR}_{KpKg} \tag{17}$$

where

$$\varepsilon^{LR}_{KpKg} = \frac{d\ln Kp^*}{d\ln Kg} = \frac{\partial \ln Kp^*}{\partial \ln Kg} + \sum_i \frac{d\ln Kp^*}{d\ln X_i}\cdot\frac{\partial \ln X_i}{\partial \ln Kg} = \varepsilon_{Kp^*Kg} + \sum_i \varepsilon_{Kp^*Xi}\cdot\varepsilon_{XiKg}$$

where superscript LR denotes long run. The $\varepsilon_{Kp^*\,Kg}$ is obtained from equation (9), while the $\varepsilon_{Kp^*\,Xi}$ is computed using a system of derivatives of implicit functions from equations (7) and (9).[7] Finally, $\varepsilon_{Xi\ Kg}$ is the short run factor bias effect. In this model, ε^{LR}_{KpKg} adquires special relevance as it summarises the attraction effect of the public capital investments. That is, to what extend improvements in public capital endowments in an economy enhance private activity. Obviously, this is one of the main objectives when public investments aims at spurring economic development.

Long run *shadow price* of infrastructures and factors bias will be evaluated in Kp^* as well, that is, they will include changes in variable inputs due to movements in private capital stock as a result of the new infrastructure endowment:

$$S^{LR}_{SCKg} = \varepsilon^{LR}_{SC\,Kg}\left(-\frac{SC}{Kg}\right) = -\frac{dSC}{dKg} = \sum_i -P_i\,\varepsilon^{LR}_{X_i\,Kg} \tag{18}$$

where:

$$\varepsilon^{LR}_{X_i\,Kg} = \frac{d\ln X_i}{d\ln Kg} = \varepsilon^{SR}_{X_i\,Kg} + \varepsilon_{X_i\,Kp}\,\varepsilon^{LR}_{Kp\,Kg} \qquad i = L,M \tag{19}$$

with $\varepsilon_{Xi\ Kg}$ and ε_{XiKp} as in the short run and $\varepsilon^{LR}_{Kp\,Kg}$ as expressed above. It can be observed how the long run substitution/complementary relationships may be decomposed into both a direct effect ($\varepsilon^{SR}_{X_i\,Kg}$) and an indirect one, which is the interaction between relationship of private-public capitals and the substitution/complementary relationship between variable inputs and the quasi-fixed factor.

The same will apply to the output elasticity to Kg in the long run, that now will consider variations in output due to the adjustment to the optimal private capital stock:

$$\varepsilon_{YKg}^{LR} = \frac{dY}{dKg}\cdot\frac{Kg}{Y} = \frac{S_{Kg}^{LR}}{\varepsilon_{SCY}^{LR}\cdot\frac{SC}{Y}}\;\frac{Kg}{Y} \tag{20}$$

where ε_{SCY}^{LR} is:

$$\varepsilon_{SCY}^{LR} = \frac{d\ln SC}{d\ln Y} = \frac{\partial \ln SC}{\partial \ln Y} + \frac{\partial \ln SC}{\partial \ln Kp}\cdot\frac{d\ln Kp^{*}}{d\ln Y} = \varepsilon_{SCY}^{SR} + \varepsilon_{SCKp}\,\varepsilon_{KpY}^{LR} = \tag{21}$$

$$where \quad \varepsilon_{KpY}^{LR} = \frac{d\ln Kp^{*}}{d\ln Y} = \frac{\partial \ln Kp^{*}}{\partial \ln Y} + \sum_i \frac{d\ln Kp^{*}}{d\ln X_i}\cdot\frac{\partial \ln X_i}{\partial \ln Y} = \varepsilon_{Kp^{*}Y} + \sum_i \varepsilon_{Kp^{*}i}\cdot\varepsilon_{XiY}$$

obtaining $\varepsilon_{Kp^{*}Y}$ from equation (9), and $\varepsilon_{Xi\,Y}$ from equation (7) for both variable inputs.

Most of these elasticities in the long run can be obtained for private capital as well though the explanation is different in this case. So, private capital will have not only a direct effect on costs in the short run but also an indirect one through adjustments in variable inputs in response to private capital variations:

$$\varepsilon_{SCKp}^{LR} = \frac{d\ln SC}{d\ln Kp} = \frac{\partial \ln SC}{\partial \ln Kp} + \sum_i \frac{\partial \ln SC}{\partial \ln X_i}\cdot\frac{d\ln X_i}{d\ln Kp} = \varepsilon_{SCKp}^{SR} + \varepsilon_{SCX_i}\,\varepsilon_{X_iKp}^{LR} \tag{22}$$

where ε_{SCXi} is obtained through the system of derivatives of implicit functions from equations (7) and (9) as stated aboved, and ε_{XiKp} from equation (7) for both inputs. The rest of long run effects for private capital are obtained in much the same way as for the public capital case though the bias effect of private capital in the long run, that is, the effect of private capital on the variable inputs is exactly the same one as in the short run.

3. EMPIRICAL SPECIFICATION AND ECONOMETRIC ISSUES

Empirical Specification

The empirical work to test the effect of public capital endowment on the performance of the manufactures is based on a translog cost function, a general second degree polynomial in logs, with the following form:

$$\begin{aligned}\ln VC = {} & \beta_0 + \ln P_M + \beta_L \ln\frac{P_L}{P_M} + \beta_Y \ln Y + \beta_{Kp}\ln Kp + \beta_{Kg}\ln Kg + \beta_T t + 0.5\Big[\beta_{LL}\ln^2\frac{P_L}{P_M} + \\ & + \beta_{YY}\ln^2 Y + \beta_{KpKp}\ln^2 Kp + \beta_{KgKg}\ln^2 Kg + \beta_{TT} t^2\Big] + \beta_{LY}\ln\frac{P_L}{P_M}\ln Y \\ & + \beta_{LKp}\ln\frac{P_L}{P_M}\ln Kp + \beta_{LKg}\ln\frac{P_L}{P_M}\ln Kg + \beta_{LT}\ln\frac{P_L}{P_M}t + \beta_{YKp}\ln Y\ln Kp \\ & + \beta_{YKg}\ln Y\ln Kg + \beta_{YT}\ln Y\,t + \beta_{KpKg}\ln Kp\ln Kg + \beta_{KpT}\ln Kp\,t + \beta_{KgT}\ln Kgt\end{aligned} \tag{23}$$

where t is a time trend which summarises technological change , as in, for instance, Morrison and Schwartz (1996).

This functional form permits the consideration of a great range of substitution possibilities while accommodating to any production technology without being necessary to impose a priori restrictions on returns to scale.[8] We have introduced intermediates price as a relative factor to ensure that the function is homogeneous of degree one in factor prices. Besides, any kind of a priori returns to scale are imposed. For ease of notation, the variables in equation (23) and subsequents do not carry indices either for the period of time, industries or regions.

Applying Shephard's Lemma to equation (23) we obtain the share equations for variable inputs. For the two variable factors we consider, only one equation is independent, given that factor shares sum to one. Thus, we have:

$$Z_L = \frac{P_L \cdot L}{VC} = \frac{\partial \ln VC}{\partial \ln P_L} = \beta_L + \beta_{LL} \ln \frac{P_L}{P_M} + \beta_{LY} \ln Y + \beta_{LKp} \ln Kp + \beta_{LKg} \ln Kg + \beta_{LT}\, t$$
$$Z_M = 1 - Z_L \qquad (24)$$

Therefore, the short-run equilibrium is denoted by equations (23) and (24). On the other hand, the long-run equilibrium condition for private capital can be expressed as:

$$-Z_{Kp} = -\frac{P_{Kp} \cdot Kp^*}{VC} = \frac{\partial \ln VC}{\partial \ln Kp} = \beta_{Kp} + \beta_{KpKp} \ln Kp + \beta_{LKp} \ln \frac{P_L}{P_M} + \beta_{YKp} \ln Y + \beta_{KpKg} \ln Kg + \beta_{KpT}\, t \qquad (25)$$

The long-run equilibrium is represented by equations (23), (24) and (25). From the estimation of these equations we will obtain the main effects of public and private capital both in the short and long term.

Econometric Issues

For empirical implementation purposes the models have to be imbedded within a stochastic framework. To do this we consider that errors in cost and variable factors demands are due to errors in optimization and that the relation in the long run represents unanticipated information which becomes available after the time the investment decision is made. The models specified in equations (23)-(24) and (25) are then estimated using iterative Zellner techniques for Seemingly Unrelated Regression (SUR) equations since it is likely that the error terms across equations will be correlated.

An additional econometric issue is the pooling of the time series for the Spanish regions with all their manufacturing sectors. We want to account for unobservable sectoral and regional differences without imposing the way in which these differences should be introduced in the model, either as a fixed effects model through the introduction of dummies or as an error components model considering these effects as part of the error term. In order to choose the appropriate method of estimation, we use the Hausman test with the null hypothesis of uncorrelation between individual effects and explanatory variables which indicates the adequacy of considering an error components model (Baltagi (1995), pp.68).

Two theoretical aspects commented in section 2 are going to be tested in our model: an investigation into departure of quasi-fixed inputs from their static equilibrium levels and the validity of the Shephard's Lemma.

First, being aware of the short-run fixity of some inputs such as private capital in the present case, the distinction between short- and long-run functional forms must be well accounted for. With this purpose, we use the test developed by Schankerman and Nadiri (1986) to acknowledge into the possible divergence of quasi-fixed factors from their static equilibrium levels. Let's consider β_0 the parameter estimates vector in the cost function equation alone (eq. 23), β_1 the parameter vector in the demand (or share) functions for variable inputs (eq. 24) and β_2 the parameter vector obtained from the estimation of the quasi-fixed inputs (eq. 25). The test is constructed under the null hypothesis that the fixed factors are at their static equilibrium levels, so that $\beta_2 \subset \beta_0$. In fact, if considering the partition of the vector $\beta_0 = (\beta_0^1, \beta_0^2)$ where the elements of β_0^1 appears in (23) but not in (25) under the null, then one can specify the null hypothesis as $\beta_2 = \beta_0^2$. This way, the estimator of the long run equilibrium model (let's say $\hat{\beta}$) imposes the restriction implied by the test, whereas the estimator of the short-run equilibrium model (say $\tilde{\beta}$) does not impose any restriction. The constraint estimator $\hat{\beta}$ is consistent under the null but not under an alternative hypothesis, while the unconstrained estimator $\tilde{\beta}$ is consistent under both the null and the alternative. Schankerman and Nadiri (1986) construct a Hausman test, based on a comparison of the values in $\hat{\beta}$ and $\tilde{\beta}$ testing the null that firms are in the long run equilibrium:

$$N(\tilde{\beta} - \hat{\beta})' \hat{V}^{-1} (\tilde{\beta} - \hat{\beta}) \sim \chi^2_q \quad (26)$$

where N is the number of observations, $\hat{V}$ is the consistent estimator of V, with V = V_1 - V_2, being V_1 the asymptotic covariance matrix for $\tilde{\beta}$ and V_2 the asymptotic covariance matrix for $\hat{\beta}$. The test is distributed as a chi-square with degrees of freedom being equal to the number of restrictions, q.

Second, neoclassical production theory implies that the derived cost share equations are related to the cost function, so that parameters in (24) are, therefore, the same as those in (23). In most of the empirical works using duality theory, these restrictions associated to the Shephard's Lemma are imposed a priori without being previously tested. If these restrictions were not true one would be in fact rejecting some assumptions of the neoclassical theory of production such as the cost-minimizing behavior among others. As a result, from a statistical point of view one would be imposing values on the estimates which are against the data, so that, if the parameters of the derived cost share equation could not be considered the same as those of the cost function, the calculation of the effects obtained from them would not be accurated. To avoid this problem, we test for the validity of the Shephard's Lemma in the cost function which means testing for the consistency within the model. In order to implement the test we consider that β_0 is the parameter estimates vector in the cost function equation that appear in the demand functions for variable inputs, while β_1 is the parameter vector in the share functions for variable inputs. This way, the null hypothesis would indicate that the neoclassical theory is accepted since the share and cost equations yield the same parameters, $\beta_0 = \beta_1$. The parameter set has to be consistent with the theory which depends on the specific functional form considered. Since we use a translog form, the parameter set will be such that symmetry and linear homogeneity in variable inputs are satisfied. In our case we impose these conditions in the especification itself so that it is not necessary to further concern about. The alternative hypothesis is $\beta_0 \neq \beta_1$. The test we use is the traditional test for linear restrictions of the coefficients of SUR models given in Judge *et al.* (1988, pp. 457-459), which is distributed as a χ^2 with as many degrees of freedom as the number of restrictions, that is, the number of parameters in β_1.

4. EVIDENCE FOR THE SPANISH CASE

Data

The data used for the empirical implementation are annual data on output, prices and quantities of private inputs in 12 manufacturing sectors of the 15 regions of Spain (NUTS II level, without the island regions) from 1980 to 1991. Data have been obtained from two main sources. First, output, intermediates, labor costs and number of workers employed are obtained from the Encuesta Industrial (Industrial Survey) produced by the Instituto Nacional de Estadística (INE, Spanish Statistical Office). Second, series of private and public capital stocks are taken from "El Stock de Capital en la Economía Española" (The Capital Stock in the Spanish Economy, FBBV, 1995), where private capital data are given with a maximum desegregation of 13 sectors. Therefore, though data on Encuesta Industrial are given for 89 manufacturing sectors, our empirical implementation fails to consider more than 13 sectors.[9] However, due to the high sectoral and territorial desegregation of the data in the Encuesta Industrial and for confidentiality reasons the INE provides missing values when it is necessary to comply to the statistical secret guaranteed by the survey. The incidence of missing data in the 13 manufacturing sectors at a regional level is only important in the sector gathering office equipment, precision and optics, so that we finally decided not to consider it.[10] Thus, the twelve manufacturing sectors finally considered in the present study are shown in table 1:

Data provided by the Encuesta Industrial are given in nominal values, being necessary the use of sector-specific producer price indices to deflate them. The Programa de Investigaciones Económicas (Economic Research Program) supplied us with this deflactor (Jaumandreu and Jiménez, 1992). Since the deflation is initially made for 89 sectors and then we aggregate to 12 sectors, we ensure that the real input series are deflated after considering the importance of each sector in each group. All variables are then used at constant 1990 prices.

Table 1. Description of the industrial groupings

1	Metallic minerals and first transformation of metals (9-11)
2	Non metallic minerals and products (12-18)
3	Chemistry (19-30)
4	Metallic products and metalwork (31-35)
5	Agricultural and industrial machinery and equipment (36-37)
6	Electric machinery and material (39-40)
7	Transports material (41-45)

8	Food products, alcohol, drinks and tobacco (47-64)
9	Textiles, leather and shoes (54-74)
10	Paper and derivatives and printing (80-82)
11	Rubber and plastic derivatives (83-84)
12	Wood, cork and derivatives and other manufactures (75-79, 85-89)

NOTE: *In brackets the correspondence to group data from Encuesta Industrial (FBBV, 1995)*

Price for employment (P_L) is obtained by dividing labor costs by the number of employments. The index price of intermediate inputs (P_M) is measured by dividing the nominal intermediate input series by the constructed real intermediate input series. The rental rate of private capital (P_{Kp}) is computed as $P_{Kp} = q(r+d)$, where q is the private capital investment deflator obtained from FBBV (1995), r is the discount rate for more than two years government bonds, and d is the private capital depreciation rate, the latter calculated according to the formula $d_t = 1 - \frac{Kp_t - I_t}{Kp_{t-1}}$, with I_t as private capital investment.[11] All data except interest rate, depreciation rates and private capital investment deflator have been computed region-specific. Private capital is measured by the total net capital stocks of manufacturing industry in each region. Public capital stock includes the net monetary stock of core infrastructures, that is, roads and highways, railway, harbors and maritime signaling, airports, water and sewage facilities and urban structures.[12] Since public infrastructures are not supposed to have an immediate effect on industrial activity, the public capital stock variable enters the model with one period lag.

Main Results

In order to select the appropriate model we implement the two tests signalled above. The value of the test proposed by Schankerman and Nadiri (1986) is highly significant(value of 338914.5), indicating strong rejection of static equilibrium for private capital and thus, rejection of the assumption of long-run equilibrium. The appropriate model to estimate is therefore the set of equations (23) and (24) while equation (25) is estimated without imposing the long run restrictions. Nevertheless, when testing the validity of the Shephard's Lemma in the cost function it is obtained that the restriction is rejected with a value of 76.37. As far as we know, most of the empirical works do not test the validity of this lemma whereas the ones testing this hypothesis have strongly rejected it (Appelbaum, 1978 for the USA; Domenech (1993) for the Spanish banking sector), so that it seems to be that the duality theory does not work very well in practice. Therefore,since the Shephard's Lemma is rejected for the Spanish manufacturing sector, it would be more adequate to estimate the cost function alone. However, following Morrison and Schwartz (1996) it should be thought that the utilization of the restricted SURE model imposes structure and robustness to the model, while increasing efficiency. This way, imposing the restrictions among the parameters of the two first equations and estimating by Zellner techniques we should obtain more reasonable parameters from an economic viewpoint.

The results for the estimation of the cost function and the function for private capital are shown in tables 2 and 3, respectively. In both, the null of joint non significance of the parameters of public capital is strongly rejected. Moreover, since we are interested in assessing on the variability of infrastructure effects across manufacturing sectors and regions, we have implemented several F-homogeneity tests in order to get a sense of the necessity of considering specific sectoral and regional effects. Then, we compare the previous model with three alternative models: without any kinds of effect (test 2), without regional effects (test 3) and without sectoral effects (test 4). The null hypothesis that the coefficients of the dummies are zero is rejected in all three cases, suggesting that both intersectoral and interregional differences are present in the cost level and in the equilibrium capital share for the Spanish case. Therefore, according to these results we could think that the same input endowments and factor prices may cause different regional/sectoral cost levels due to the technology and efficiency characterising industries in each region. In fact, this seems to be the case of the regions of Spain, since several studies analyzing scale economies, market power or technological levels for Spain have obtained great differences across industries and regions (Suárez, 1992; Velázquez, 1993; De La Fuente, 1996; Moreno *et al*., 1998). Given these findings, it could be thought of the adequacy of the individual estimation of the cost function for each sector (considering regional and time variability) and for each region (considering sectoral and time variability). Nevertheless, in doing so we face the problem of the high degree of multicollinearity that functions considering cross-products of the variables encounter. For this reason, we rather prefer estimating the functions with the whole panel data set in order to increase variability while controlling for regional and sectoral differences through the consideration of different levels in the intercept term. This way, the estimates obtained will be reliable, and still we can obtain specific elasticities for public capital and scale economies for each region and sector, offering interesting conclusions for the orientation of policy making referred to public capital investments.

Based on the resulting estimated parameters, the effects mentioned in section 2 about public and private capital effects on economic performance are measured by calculating the required derivatives. Even though all the indicators below have been measured for each region and sector in every year, we only present some general averages. Concretely we present four averages: regional, sectoral, temporal and global averages. They have been obtained by weighting the elasticity of each observation by the rate that the output in this specific observation represents over the global output in the region, sector or time period, respectively.

The cost elasticity with respect to public capital in the short run, $\varepsilon_{Ckg,}$ (table 4) has a negative average (-0.059) indicating that when public capital stock increases 1%, the percentage decrease in private production cost is 0.059%. This indicates that in general terms Spanish manufactures did benefit from a reduction in costs with public capital increases during the eighties, with small changes among regions and a higher variation across sectors. In this sense it should be pointed out the large value for the Food and Beverage industry(S8)[13]. Furthermore, this elasticity has slightly increased with time, showing how the reductions in costs due to public infrastructure have continued during the considered period. Besides, Andalucia is the region presenting the lowest cost reduction from infrastructure while La Rioja seems to be the one benefiting the most, though the difference among them is not high. In general terms, it can be concluded that the cost elasticity with respect to infrastructure obtained in the Spanish case is in line with the ones reported in studies for American and German economies as shown in table 8:

Table 8. Some results on cost elasticity with respect to public capital (without distinction short-long term)

	Morrison and Schwartz (1992)	*Nadiri and Mamuneas (1994)*	*Seitz and Licht (1995)*	*Seitz (1995)*
	Regional	*Sectoral*	*Regional*	*Urban*
Aver.	-0.049	-0.129	-0.216	-0.127
Max.	0.049	0.0234	-0.018	N/A
Min.	-0.169	-0.2113	-0.357	N/A

This way, the measures of the implicit willingness of private sector to pay for infrastructures according to the values of savings experienced by an industry in the short run follow the same pattern as the one described for the former elasticity, with a positive price average. A positive sign for infrastructures shadow price in the short term implies a net substitutive relationship between public capital and variable inputs. This can be observed analyzing the type of relationship between public capital and each variable factor, in other words, obtaining the infrastructure elasticity of the conditional demand for labor and intermediates. On average, from the results it can be concluded that infrastructure capital is labor saving and intermediates using for all regions and sectors during the whole period. Indeed, in the literature there has been a general conclusion in favor of a substitutability relationship between labor and public capital (Berdnt and Hanson, 1991; Nadiri and Mamuneas, 1994; Seitz and Licht, 1995) indicating that public infrastructure investment allows firms to produce the same output with lower labor costs. However, two aspects are worthy pointing out: first, the elasticities for labor are bigger than for intermediates indicating that public capital effect reducing labor can be of a certain importance (with a global average of -0.035) while the effect on intermediates is relatively low (0.009); second, the variability across sectors, regions and time periods for intermediates elasticity is really low.

All these results concerning infrastructure have equally been obtained for private capital (table 5). In general terms, it can be said that although there is also a significative difference across regions and sectors, the average of the estimated elasticity of production cost with respect to private capital stock is -0.064, being always negative. Thus, there is a cost reducing effect associated with the supply of private capital, being higher for the cases of Rioja and Galicia and lower for Cantabria. As a consequence, private capital shadow price is always positive, decreasing from early to mid eighties and increasing again after 1987, when the Spanish economy experienced a period of economic boom. This positive shadow price can be explained by a net substitutive relationship that is disentangled in a substitution relation with intermediates and a positive relationship between private capital and labor. Once again, there are differences across regions and sectors which are small, specially in the case of intermediates.

Nevertheless, as signalled in section 2, public capital may influence private costs and input demands in the long term through changes in private capital, which is considered to be fixed in the short term. According to the results in table 4, the elasticity of costs with respect to public capital in the long run slightly decreased if compared to the short run value, though it increased in some regions (significantly in Cataluña) while being almost equal in some other regions (Cantabria, Madrid and Murcia). If we disentangle this general long-run effect, we observe that increases in public infrastructure have led to global increases in private capital stock (what we have called locational effect of public capital) with an average elasticity of 0.076 in the short run and 0.060 in the long run (table 6). And increases in private capital have supposed general percentage decreases in costs given the negative average elasticity of cost to private capital of 0.064. Therefore, in general terms, we would expect a long-run cost elasticity with respect to public capital that would be higher that the short-run one. However, since we are obtaining a weighted average and there are regions and sectors with a negative attraction of private capital when increasing public infrastructure, here comes the lower value in the long run. This way, there are significant variations across regions and sectors that are worthy considering. There are only some regions and sectors where public capital has been able to attract private investment in the long run like La Rioja, País Vasco, Cataluña and Cantabria, specially in sectors of Chemistry (S3), Metalwork (S4) and Electric material (6). In the rest of the regions, public capital has diminished private capital stock. Therefore, public capital has not been able to attract private investment in all the Spanish regions and industries during the eighties. This result supports our belief on the necessity of considering a separate effect for different regions and industries. According to this result above, the long-run shadow price for public capital is pretty similar to the short-run one.

Also in the long run, the elasticities of private inputs demands with respect to public capital have decreased in general terms if compared to the short-run ones, while maintaining the same sign (table 4). Nevertheless, the variability is very big among regions and sectors so that it is difficult to get general conclusions in those cases. Once again, the same pattern than in the short term is obtained, that is, a lower value for public capital influence on intermediates than on labor and a low variability across sectors and regions for intermediates. This result makes us think about the fact that intermediates is a factor that depends more on the business cycle than in its relationship with the rest of inputs.

In the long term, the global average cost elasticity with respect to private capital (table 5) has increased, turning into a positive value. However, this weighted average hides interesting conclusions for some regions, sectors and time periods. In this sense, even though most regions obtain positive values for this elasticity in the long run, some others like Valencia, Madrid, Castilla-Mancha, Asturias and Aragón and sectors 2 (Non-metallic minerals) and 11 (Rubber and plastic) present negative values which are higher in the long run. Furthermore, we should keep in mind that we are dealing with aggregate economies. Then, if public capital enhances and attracts private activity, the aggregate cost measures for an industry in a given region will be higher the larger the stock of public capital, even when it would cause decreases at the firm level.

Finally, in table 7 we show the elasticities concerning output. Specifically, the elasticity of output with respect to public capital has an average of 0.079, with small differences across regions and increasing along with time. This value is very similar to the one obtained for public capital elasticity when using the production function framework for the Spanish economy (Mas *et al*, 1998; Moreno *et al.*, 1998), validating the results herein obtained. Besides, the elasticity of output with respect to public capital has grown in the long run and becomes more variable than in the short run. The explanation for this result is found in the fact that the returns to scale in the long run are higher that in the short run.

5. CONCLUSIONS

In the present paper we have theoretically derived the long run effects of public infrastructure on cost and production performance from a dual approach. Previous works aiming at analysing those effects have just considered short run responses through adjustments in variable inputs and considering private capital at its equilibrium level. On the contrary, herein we have allowed for infrastructure endowment to interact with private capital, that has been supposed to be a quasi-fixed input. The motivation has been the belief that infrastructures may alter the performance of an economy not only through effects on variable inputs (short run) but also through a locational effect, by which it may increase the total amount of private capital in the economy. Furthermore, the effects of private capital have also been derived for the short and long run. It allows to compare the contribution to cost saving of both types of capital.

Applied to the Spanish regional manufactures, the present paper has estimated a cost function in a translog form, based on the results of several statistics, rejecting the accuracy of the Shephard´s Lemma as well as the existence of a long run equilibrium for private capital. The dual approach leads us to conclude that, in average, increasing the stock of infrastructure has had a positive impact in terms of increasing the efficiency (decreasing costs) of production. Even though this result is obtained both in the short and long run, in the latter case its magnitude is smaller. This is due to the fact that, in average, increases in private capital, as a consequence of improvements in infrastructure endowments, has increased aggregate activity and then total costs in the representative economy.

Further, regional and sectoral variability of all the effects is far from being negligible, basically in the latter. As a consequence, conclusions on the effects of infrastructure investments based on aggregate results may be misleading. These differences in sectoral responses would support the sectoral restructuring advocated by some theoretical models on the impact of publicly provided inputs of production.

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[1] See Munnell (1992) and Gramlich (1994) for a review of the main studies of infrastructure impact on development.

[2] See Chambers (1988) for detailed description of cost function properties.

[3] A shortcoming in the model is that public capital does not alter relative input prices since they are exogenous.

[4] It could be argued that firms do influence the amount of public capital they can use through voting with the feet, for example. For the present, in this paper we will assume that this influence is not important.

[5] The use of demand functions or factor share functions is equally correct. So, alternatively, we could talk about the set (5) and (6).

[6] In this framework we are considering that public capital is not paid by firms, since it is supposed to be an exogenous input. Nevertheless, even though firms don't face the direct costs of accumulating this input, firms do pay for infrastructures in terms of taxes, so that there would exist a social costs for getting an adequate public capital provision. From this perspective, the shadow price obtained through this theoretical model will exaggerate the social impact of public infrastructures.

[7] In which cost and Kp responses to variations in variable inputs (L and M) are determined simultaneously.

[8] Guilkey et al. (1983) demonstrates the translog form superiority over alternate functional forms in Monte Carlo studies. However, some other studies about public capital effects have considered other functional forms, such as a Generalized Leontief or a Generalized Cobb-Douglas restricted cost function. In this sense, it would be worthy studying the sensitivity of the results to the different specifications.

[9] Both capital stocks are calculated by using the perpetual inventory method. For more information, see FBBV (1995).

[10] The percentage of missing values for regions with respect to the total value at a national level is less than 2 % for all considered variables in almost all sectors, ranging between 3 % and 5 % for sectors of Chemistry and Food

and drinks, and being more that 5 % for sector of Office equipment, precision and optics. In order to avoid a negative incidence of missing data in the results referred to this latter sector, it has not been considered in the study. In a similar way, we only consider 15 out of the 17 regions in Spain given the missing values for Balearic and Canary Islands in several sectors. However, discarding these two regions will have a minimal repercussion in our analysis since the industrial activity in them is really scarce and their economic performance depends on the international business cycle even more that in the Spanish one. Besides, the spillover effects among the islands and the other regions are thought to be minimal.

[11] Following the idea given by Berndt and Hansson (1991), corporate taxes are not included in the private capital price measure. For further information on factor prices for capital inputs, see the concept of the user cost of capital developed by Jorgenson (1963).

[12] Basic public infrastructures have been demonstrated to have a positive impact on regional productivity in the Spanish regions (e.g. Mas *et al.*, 1997) , in contrast to social public infrastructures whose effect is not as clear.

[13] This sector presents extreme values in several of the elasticities that have been computed.

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Table 2. Estimation for the cost function

Parameter	Coefficient	t-Statistic
β_0	1.244	0.401
β_L	0.310	3.676
β_Y	1.190	17.453
β_{Kp}	-0.279	-4.218
β_{Kg}	-0.138	-0.262
β_t	-0.103	-3.992
β_{LL}	0.073	16.262
β_{YY}	0.019	4.990
β_{KpKp}	0.015	3.840
β_{KgKg}	0.008	0.341
β_{TT}	0.004	22.775
β_{LY}	-0.066	-23.193
β_{Lkp}	0.057	19.844
β_{LKg}	-0.007	-1.050
β_{LT}	-0.001	-1.705
β_{YKp}	-0.030	-3.946
β_{YKg}	-0.019	-3.046
β_{YT}	-0.002	-2.453
β_{KpKg}	0.019	3.240
β_{KpT}	0.002	2.194
β_{KgT}	-0.001	-0.276

R^2 for the model: 0.995

Specification Tests:

(1) F(3,2083)= 11.63
(2) F(25, 2083)= 335.63
(3) F(14, 2083)= 8.45
(4) F(11, 2083)= 82.08

Total number of observations: 2160
The coefficients of the dummies are not reported

Table 3. Estimation for the Z_{Kp} function

	Coefficients	t-statistics
β_{Kp}	0.175	0.126
β_{KpKp}	-0.130	-50.191
β_{Lkp}	-0.011	-1.145
β_{Ykp}	0.119	54.695
β_{kpKg}	-0.011	-0.865
β_{kpT}	-0.006	-8.683

R^2 for the model: 0.331

Specification tests:

(1) F(1,2104)= 10.30
(2) F(25, 2104)= 23.62
(3) F(14, 2104)= 23.11
(4) F(11, 2104)= 38.07

Total number of observations: 2160
The coefficients of the dummies are not reported

Table 4. Public Capital Effects

	SHORT RUN				LONG RUN			
	ε_{cKg}	S_{Kg}	ε_{LKg}	ε_{MKg}	ε_{cKg}	S_{Kg}	ε_{LKg}	ε_{MKg}
GLOBAL AVERAGE								
	-0.059	0.023	-0.035	0.009	-0.053	0.021	-0.018	0.005
REGIONAL AVERAGE								
AND	-0.051	0.016	-0.040	0.009	-0.031	0.010	-0.097	0.009
ARA	-0.062	0.014	-0.035	0.009	-0.043	0.010	-0.137	0.037
AST	-0.056	0.029	-0.031	0.009	-0.024	0.012	-0.136	0.059
CANT	-0.065	0.028	-0.035	0.009	-0.064	0.028	0.046	-0.039
C-L	-0.062	0.020	-0.040	0.009	-0.044	0.014	-0.112	0.019
C-M	-0.060	0.014	-0.043	0.009	-0.020	0.004	-0.191	0.022
CAT	-0.057	0.027	-0.035	0.009	-0.078	0.038	0.150	-0.021
VAL	-0.058	0.017	-0.034	0.009	-0.031	0.009	-0.115	0.021
EXT	-0.058	0.010	-0.036	0.009	-0.049	0.008	-0.075	0.020
GAL	-0.062	0.018	-0.043	0.009	-0.065	0.019	-0.024	0.002
MAD	-0.065	0.027	-0.028	0.010	-0.061	0.026	-0.062	0.009
MUR	-0.068	0.024	-0.040	0.009	-0.062	0.022	-0.052	0.017
NAV	-0.070	0.022	-0.040	0.009	-0.051	0.016	-0.146	0.021
PV	-0.053	0.021	-0.027	0.010	-0.044	0.018	-0.007	0.005
RIO	-0.073	0.021	-0.047	0.009	-0.060	0.017	-0.089	0.026
SECTORAL AVERAGE								
S1	-0.065	0.029	-0.055	0.011	-0.055	0.024	-0.084	0.016
S2	-0.056	0.009	-0.027	0.011	-0.025	0.004	-0.040	0.020
S3	-0.060	0.019	-0.048	0.010	-0.065	0.021	0.083	-0.008
S4	-0.075	0.019	-0.029	0.013	-0.082	0.021	0.101	-0.053
S5	-0.038	0.006	-0.012	0.006	-0.031	0.005	-0.043	0.022
S6	-0.045	0.010	-0.015	0.007	-0.062	0.014	0.036	-0.020
S7	-0.110	0.046	-0.047	0.016	-0.092	0.038	-0.096	0.035
S8	-0.291	0.150	-0.246	0.035	-0.184	0.095	-0.743	0.099
S9	-0.064	0.020	-0.026	0.010	-0.045	0.014	-0.073	0.027
S10	-0.040	0.008	-0.018	0.007	-0.034	0.007	-0.049	0.019
S11	-0.030	0.004	-0.014	0.005	-0.024	0.003	-0.050	0.017
S12	-0.044	0.006	-0.018	0.007	-0.026	0.003	-0.090	0.036
TEMPORAL AVERAGE								
1980	-0.056	0.024	-0.028	0.010	-0.049	0.021	-0.047	0.014
1981	-0.055	0.023	-0.029	0.010	-0.029	0.012	-0.144	0.045
1982	-0.055	0.021	-0.031	0.010	-0.039	0.015	-0.083	0.024
1983	-0.055	0.022	-0.033	0.009	-0.041	0.016	-0.119	0.035
1984	-0.055	0.021	-0.035	0.009	-0.031	0.012	-0.092	0.005
1985	-0.056	0.021	-0.037	0.009	-0.042	0.016	-0.077	0.003
1986	-0.057	0.021	-0.037	0.009	-0.035	0.013	-0.096	0.031
1987	-0.060	0.023	-0.037	0.009	-0.040	0.016	-0.119	0.018
1988	-0.062	0.025	-0.038	0.009	-0.054	0.022	-0.108	0.007
1989	-0.064	0.026	-0.039	0.009	-0.042	0.017	-0.152	0.033
1990	-0.064	0.026	-0.038	0.009	-0.052	0.021	-0.041	-0.000
1991	-0.065	0.025	-0.038	0.009	-0.186	0.071	0.857	-0.157

Table 5. Private Capital Effects

	SHORT RUN				LONG RUN	
	ε_{cKp}	S_{Kp}	ε_{LKp}	ε_{MKp}	ε_{cKp}	S_{Kp}
			GLOBAL AVERAGE			
	-0.064	0.130	0.286	-0.075	0.105	-0.211
			REGIONAL AVERAGE			
AND	-0.051	0.104	0.326	-0.072	0.291	-0.595
ARA	-0.061	0.135	0.289	-0.074	-0.292	0.652
AST	-0.013	0.011	0.250	-0.077	-0.661	0.565
CANT	-0.020	0.023	0.283	-0.075	0.127	-0.148
C-L	-0.069	0.198	0.322	-0.072	0.095	-0.272
C-M	-0.074	0.154	0.353	-0.072	-0.590	1.236
CAT	-0.075	0.167	0.287	-0.075	0.424	-0.941
VAL	-0.076	0.165	0.280	-0.074	-0.498	1.080
EXT	-0.048	0.088	0.296	-0.075	0.267	-0.492
GAL	-0.086	0.232	0.348	-0.072	0.562	-1.509
MAD	-0.071	0.156	0.230	-0.078	-0.061	0.134
MUR	-0.096	0.215	0.329	-0.072	0.591	-1.321
NAV	-0.077	0.184	0.326	-0.074	0.125	-0.301
PV	-0.025	0.028	0.217	-0.080	0.158	-0.178
RIO	-0.085	0.224	0.384	-0.071	0.135	-0.355
			SECTORAL AVERAGE			
S1	-0.001	0.001	0.447	-0.092	0.342	-0.271
S2	0.005	-0.006	0.217	-0.088	-0.874	1.029
S3	-0.007	0.010	0.393	-0.079	0.040	-0.060
S4	-0.064	0.105	0.233	-0.102	0.277	-0.454
S5	-0.033	0.085	0.097	-0.047	0.032	-0.081
S6	-0.044	0.096	0.125	-0.055	0.113	-0.246
S7	-0.117	0.326	0.383	-0.128	0.305	-0.845
S8	-0.489	1.268	2.004	-0.286	0.419	-1.088
S9	-0.087	0.193	0.214	-0.081	0.049	-0.108
S10	-0.023	0.037	0.146	-0.055	0.103	-0.166
S11	-0.018	0.025	0.113	-0.040	-0.143	0.205
S12	-0.048	0.097	0.149	-0.060	0.011	-0.021
			TEMPORAL AVERAGE			
1980	-0.079	0.140	0.229	-0.079	0.236	-0.417
1981	-0.074	0.128	0.237	-0.078	0.107	-0.184
1982	-0.073	0.123	0.250	-0.077	0.078	-0.132
1983	-0.059	0.107	0.269	-0.076	-0.005	0.009
1984	-0.059	0.108	0.288	-0.075	0.199	-0.362
1985	-0.065	0.121	0.304	-0.074	-0.061	0.113
1986	-0.077	0.145	0.301	-0.074	-0.154	0.290
1987	-0.051	0.108	0.300	-0.074	-0.237	0.501
1988	-0.061	0.140	0.310	-0.073	-0.040	0.091
1989	-0.063	0.150	0.316	-0.073	-0.016	0.038
1990	-0.054	0.130	0.313	-0.073	0.128	-0.310
1991	-0.057	0.135	0.313	-0.073	1.022	-2.431

Table 6. Locational Effects

	$\varepsilon_{KpKg(LR)}$	$\varepsilon_{KpKg(SR)}$	ε_{KpL}	ε_{KpM}	ε_{LKg}	ε_{MKg}
GLOBAL AVERAGE						
	0.060	0.076	-0.876	-2.167	-0.035	0.009
REGIONAL AVERAGE						
AND	-0.048	0.049	1.420	-10.343	-0.040	0.009
ARA	-0.372	-0.149	6.834	-1.564	-0.035	0.009
AST	-0.597	0.025	25.402	-3.480	-0.031	0.009
CANT	0.538	0.586	1.763	-0.467	-0.035	0.009
C-L	-0.156	-0.150	-0.548	-0.634	-0.040	0.009
C-M	-0.229	-0.053	3.726	2.474	-0.043	0.009
CAT	0.453	0.303	-7.514	-3.436	-0.035	0.009
VAL	-0.172	-0.045	1.973	2.574	-0.034	0.009
EXT	-0.138	-0.153	-0.934	-3.044	-0.036	0.009
GAL	0.077	-0.038	-3.680	-0.446	-0.043	0.009
MAD	-0.028	0.082	2.500	-2.792	-0.028	0.010
MUR	-0.101	-0.204	-1.822	-0.479	-0.040	0.009
NAV	-0.199	-0.062	0.232	-11.906	-0.040	0.009
PV	0.066	-0.023	-3.532	2.970	-0.027	0.010
RIO	-0.219	-0.169	1.496	0.654	-0.047	0.009
SECTORAL AVERAGE						
S1	-0.067	-0.031	1.737	1.992	-0.055	0.011
S2	-0.102	0.535	28.048	3.862	-0.027	0.011
S3	0.276	0.589	3.285	-21.427	-0.048	0.010
S4	0.762	0.639	-6.777	-2.486	-0.029	0.013
S5	-0.184	-0.186	-0.398	-0.557	-0.012	0.006
S6	0.307	0.320	-1.736	-5.441	-0.015	0.007
S7	-0.237	-0.400	-4.886	2.283	-0.047	0.016
S8	-0.994	-0.785	2.214	-2.297	-0.246	0.035
S9	-0.221	-0.203	0.179	-1.333	-0.026	0.010
S10	-0.150	-0.157	-0.158	-0.656	-0.018	0.007
S11	-0.159	-0.009	4.880	-1.785	-0.014	0.005
S12	-0.356	-0.312	0.930	-2.077	-0.018	0.007
TEMPORAL AVERAGE						
1980	-0.056	-0.159	-5.615	-2.208	-0.028	0.010
1981	-0.456	-0.444	-1.007	-3.202	-0.029	0.010
1982	-0.192	-0.162	1.151	-0.538	-0.031	0.010
1983	-0.342	-0.245	3.277	-0.630	-0.033	0.009
1984	-0.004	0.181	0.640	-19.610	-0.035	0.009
1985	0.035	0.016	-3.260	1.957	-0.037	0.009
1986	-0.268	-0.081	8.562	2.904	-0.037	0.009
1987	-0.149	-0.030	2.238	-0.059	-0.037	0.009
1988	-0.030	0.042	0.323	-2.758	-0.038	0.009
1989	-0.333	-0.240	2.238	-1.227	-0.039	0.009
1990	0.106	0.197	1.401	-4.932	-0.038	0.009
1991	2.412	1.834	-20.456	4.301	-0.038	0.009

Table 7. Output Effects

	$\varepsilon_{YKg(SR)}$	ε_{YKp}	ε_{CY}	$\varepsilon_{YKg(LR)}$	$\varepsilon_{YKp\ (LR)}$	$\varepsilon_{CY(LR)}$
GLOBAL AVERAGE						
	0.079	0.086	0.739	0.112	-0.767	0.407
REGIONAL AVERAGE						
AND	0.071	0.070	0.724	0.501	-7.136	0.135
ARA	0.082	0.079	0.756	0.079	0.109	0.308
AST	0.075	0.013	0.746	0.062	-0.038	0.593
CANT	0.083	0.022	0.781	0.003	0.221	0.568
C-L	0.084	0.094	0.738	0.024	0.205	0.360
C-M	0.078	0.094	0.773	0.150	-0.604	0.262
CAT	0.078	0.104	0.721	0.052	-0.184	0.418
VAL	0.077	0.101	0.747	0.108	-0.261	0.669
EXT	0.073	0.059	0.799	0.356	0.675	-0.085
GAL	0.081	0.112	0.768	0.257	-2.212	0.330
MAD	0.088	0.096	0.735	0.111	-0.184	0.749
MUR	0.084	0.118	0.809	-0.008	0.563	-0.423
NAV	0.091	0.098	0.776	0.012	0.475	0.347
PV	0.073	0.034	0.719	-0.062	1.032	0.263
RIO	0.090	0.105	0.806	0.091	0.955	0.514
SECTORAL AVERAGE						
S1	0.088	-0.003	0.960	0.080	-1.698	0.789
S2	0.075	-0.006	0.815	0.097	0.112	0.577
S3	0.081	0.010	0.846	0.037	-0.086	0.452
S4	0.098	0.083	0.945	0.030	1.130	0.989
S5	0.050	0.044	0.422	0.046	-0.123	0.411
S6	0.059	0.058	0.504	0.039	0.219	1.021
S7	0.148	0.158	1.236	0.208	-0.234	0.108
S8	0.376	0.630	3.376	0.891	-4.852	-0.821
S9	0.081	0.111	0.804	0.151	0.832	0.119
S10	0.054	0.031	0.519	0.049	-0.109	0.471
S11	0.040	0.023	0.384	0.053	-1.364	0.327
S12	0.056	0.061	0.587	0.056	-0.208	0.565
TEMPORAL AVERAGE						
1980	0.077	0.108	0.727	0.240	-0.502	0.457
1981	0.076	0.101	0.731	-0.196	1.139	0.376
1982	0.074	0.098	0.736	0.070	0.090	0.593
1983	0.075	0.079	0.742	0.109	-0.365	0.451
1984	0.074	0.079	0.748	0.154	-1.306	0.442
1985	0.074	0.086	0.750	-0.065	1.250	0.600
1986	0.077	0.102	0.747	0.019	0.219	0.553
1987	0.080	0.068	0.744	0.971	-11.850	0.562
1988	0.084	0.081	0.742	-0.112	1.595	0.586
1989	0.086	0.084	0.740	0.033	0.345	0.478
1990	0.087	0.072	0.733	0.053	0.213	0.377
1991	0.089	0.076	0.727	0.064	-0.031	-0.596