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Public Capital in the Private Sector of Italian Economy*

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Abstract

This paper investigates how the services of public capital affect the different sectors of private economy in Italy. For this purpose, we use a trans-logarithmic cost function which includes infrastructure's services as a quasi-fixed free input. This approach allows to measure the effects of public capital in terms of cost reduction, productivity and distortion in the use of private inputs of production. We find that that the effects vary across industries and that major benefits are observed in Manufacturing and Energy. The sectors that obtain less benefits are Trade and Transport.

Keywords: Public capital, economic sectors, SURE.

JEL classification: C21, C30, D24, H41, H54, R11, R15.

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1 Introduction

Any kind of economic activity would not be possible without the State was, in some way, involved. In fact,it is a shared conviction that public capital plays a significant role in the productive system of the economy. And, on the other hand, there is not agreement on quantification and intensity of this effect. This work focuses on the impact that public capital, in the form of public infrastructure, has on different economic sectors.

Adam Smith has already noted the difficulties for private individuals to provide public infrastructure and how important they are for market activities, indicating in the function of government the responsibility to meet these needs. In the Italian academic tradition, Antonio De Viti de Marco explicitly talks about public goods as intermediate goods used in private business. Taxation on these activities, he explains, would be the right means to repay the State in the same way that other inputs.

For many years economic research had not been more interested in these topics, perhaps because of the lack of available data for empirical analysis. In the '80s, then, Ratner and especially Aschauer have given these issues a high visibility by being able to quantify the impact of public capital, including it in a production function as another input. From a theoretical point of view they argue that public capital has both a direct and an indirect effect on the private output. The former arises because public capital is an input in production function and the latter because it increases the productivity of the other inputs.

The interest in these works was such that many scholars started to study the so called "public capital hypothesis" in order to explain the acceleration or deceleration of growth in modern economies. Aschauer, on the basis of his work, argues that the U.S. slowdown in the second half of the 70s was due to the sharp fall in public investments. Since then, there have been many works that have dealt with this research following, on the one hand, the increasing availability of data and, on the other hand, the development of econometric techniques.

Italian Academic literature is now enriched with a frequent publication which mainly focuses on the issues of the regional differences and types of infrastructure. North-South dualism, characteristic of the Italian economy, is a fertile ground for analysis of growth and its determinants. At the same time, few studies, but not only for Italy, investigate the public capital hypothesis at sectoral level. This work fits into this line of research and finds its justification in the absence, in the Italian Academic literature, of an adequate discussion of the role of public capital in the different private sectors. All studies, in fact, leave separate these two issues, taking care of only one or the other. Among the many possible references, we mention here only Maroccu, Paci and Pala (2001) for the sectoral analysis and Paci, Saddi (2002) for that on public capital.

What we will try to understand is how public capital affects the productivity of private sectors. This approach seems quite relevant, because the impact of public capital at aggregate level can hide large differences across sectors. In fact, the aggregate level of analysis is not able to show the differences and the real effects of infrastructures on the industries[1]. For example, a positive effect of public capital could result in wide benefit to all economic sectors or to hide an opposite affection on some industries.

In their early works, Aschauer (1989) and Munnel (1990a), using a Cobb-Douglas production function, estimate the elasticity of output with respect to public capital to be around 0,3-0,4 for the aggregate U.S. economy. On the other hand, many studies, using data at State level (or regional level in European countries), report estimated coefficients of little value or not statistically significant. Munnel himself (1990b) and other authors like Eisner (1991) or Garcia-Milla and Mcguire (1992) estimate elasticity always under 0,2. At the beginning of 90's, other scholars[2] started to use models in first differences instead of levels mainly because of unit root issue in time series. The outcome of their estimations have considerably reduced the results of models in levels, showing very small or even negative values. These unexpected outcomes are explained by the problems themselves generated by a production function expressed in first differences[3]. In fact, according to many authors, specifications in first differences, although they offer some advantages, destroy the long-term relationships between the variables, which are exactly what the models are built to capture. The large differences between the results produced a general debate about the theoretical and econometric framework used, in particular, the Cobb-Douglas production function, which seemed to be too much limited because of constraints on technology and

[1] Industry will be always used as synonym for economic sector.

[2] For example Tatom (1991), Evans e Karras (1994) and Holz-Eakin (1994).

[3] Other problems of using a production function, as well as in the cost side approach, came from the not always perfect exogeneity of the explanatory variables. To avoid this problem, instrumental variables are often used.

the poverty of information used by the production approach. Indeed, in this way, the role played by prices of production factors in the choices of firms is ignored. For these reasons, it is reasonable to discard the first framework and move to a richer approach by cost side, using a more flexible specification, usually a translogaritmic functional form.

The economic sectors considered in this work are eight: 1) Agriculture; 2) Manufacturing Industry; 3) Energy; 4) Construction; 5) Trade; 6) Hotels and restaurants; 7) Transport and communications; 8) Other business services. An analysis is also carried out at the level of Aggregate Economy, which is the sum of the previous eight sectors and represents the total economy excluding financial intermediation and other business service activities[4].

The previous sectors will be analyzed in order to quantify the effect for public capital in a framework defined by the cost-side approach. This allows for a more complex analysis than the production approach, although, in the same way, presents the disadvantage of demanding more data. The choice of a translog cost function meets the need for greater flexibility than that allowed by Cobb-Douglas. In this way it becomes possible to account for interaction between explanatory variables and to quantify the cost reduction determined by public capital and increased productivity of private inputs. Moreover, it allows for check the distortion in the use of inputs determined by the availability of public capital.

The work will be organized as follows: section 1 gives a short of literature; section 2 defines the econometric model used. Section 3 describes the data used. Section 4 presents the results of empirical estimates. The last section concludes the work with a brief summary on the results and suggesting some directions for further investigations.

2 The model

Data and his sources will be presented in the next section, now teoretical framework used by econometric model will be definied. It is possible to imagine each sector as a singol agent, that produces only one good using private inputs and public capital, which optimizes his behaveur according to the given input prices and technological

[4]Financial sector, because of the particular nature of his activities, and public sector are excluded. Even the mining industry, which anyway represents a very small economy, is not considered. In 1995 The Aggregate Economy, so defined, is 73% of GDP.

costraints. As already stated, we use the dual approach to the production, where the public capital is an unpaid input factor. Y is the value added of the industry, while p is the prices vector of two private inputs: labour (X_l) and capital (X_k). Public capital services embedded in production process are expressed by Z and the deterministic variable t is a proxy for evolution of technology during the time. The generic cost function we refer is than definied as $CT = C(Y, p, t; Z)$. Summation of products of each input time his price is egual to the cost of production[5]: $CT = p_i * X_i$, where $i = l, k$ and X_i are the inputs quantities which minimize costs. The production fuction related to the prevoius cost function would be: $Y = p(X, t; Z)$. The variables Y, p, Z, X and CT change by time in different way for each economic sector. For hipotesys, the services of public capital enter freely in the productive combination of private industries, because those take avantages from public capital. It seems reasonable to assume that each economic sector not directly uses the entire amount of public capital stock, but a share of the services, provided by it, in a quantity proportional to the level of own net production. This prospective, which is already widely used in literature[6], finds its justification in a number of reasons. As shown by Hulten (1990), the intensity of exploitation of public infrastructure depends on the level of activity: if the number of vehicles increases, for a fixed number of roads, there will be an increase in their rate of utilization. Moreover, the use of a public good is shared with many other users and, therefore, subject to congestion: the maximum number of vehicles that can transit for a given road is limitated. It follow that the firms, although not having the power to choose the level of available infrastructure, can choose which ones to use (Shah 1992). Feehan and Batina (2003), in a theoretical model, consider the benefits procured by the public goods as a rent that the primary factors of production seek to gain. According to this logic, the authors derive an optimal taxation based on profits of the industry or, alternativley, on the inputs used in production process. As already mentioned, De Viti de Marco (1888) recognizes the production of income as a proxy for the use of public goods and services. Each unit of income would arise, therefore, already burdened by a percentage due to the State as a provider of general services for this production. The taxes, proportional to the production, would be related to these services, in the same way that the salary is the

[5] We don't take in account intrmedium goods, but only remunaration of productive factors.

[6] In particular see: Paul S. (2003) Effects of public infrastructure on structure and productivity in the private sector, The Economic Record, vol. 79, no.247, december, 446-4461.

amount paid to employees for their work. Indeed it is possible, at least in principle, consider the taxes levied by the state as compensation for the services provided, but as a first approach, we consider these as free input. This choice is usually justified in the literature noting that firms, while supporting taxation and receiving public services, are not able to choose the desired level of public capital in the same way they choose, for example, the labour force. Therefore, in the spirit of Paul (2003), we consider the services of public capital as unpaid factor of production and the ability of each industry to benefit from these directly related to the level of own production. The ratio of activity level of each sector to total production (GDP) will be used as weighted index of using public services by an industry, which must be multiplied by the total stock of public capital G. In this way we can define $Z = u * G$, where $u = Y/GDP$, where u varies for each industry. This approach needs the hypotesys that each industry utilises the public capital in the same proportion with sectoral value added. The intuition behind this assumption is very simple. If a firm uses ten trucks and another uses only one truck on the same road, the former will benefit form public capital services ten times the latter. A different approach, very common in literature, to represent the utilization rate of public capital from productive sectors is to use the degree of capacity utilization[7], but, anyway, the series of this data is not available at the level of industry for Italian economy.

The firms have an advantage in cost saving that depends on their ability to substitute inputs purchased on the market with those provided by State and by the increasing in productivity of the formers because the availability of the latters. The effect of this cost reduction is measured by $A_g = \eta_{cg}$, where $\eta_{cg} = (\partial \ln C/\partial \ln G)$ is the elasticity of cost with respect to public capital. The signs of η_{cg}, defined in economic literature as dual measure, is negative if the public infrastructure is cost-saving. Since there is a dual relationship between the cost side and the production side, there will be a corresponding and direct effect on productivity (primal measure) measured by $B_g = (\partial \ln Y/\partial \ln G)(G/Y) = \eta_{yg} = -A_g \div \eta_{cy}$, where η_{cy} is the elasticity of cost with respect to output[8]. The two measures are equivalent only in the case of constant returns to scale, otherwise, the direct measurement of productivity can be derived from a model of cost function, while the reverse is not always possible, if the function is not homothetic[9].

[7] For these issues see Nadiri and Mamumeas (1994) and Paul *et al.* (2003).

[8] Elasticity of scale is $\mu = (\partial \ln C/\partial \ln Y)^{-1}$.

[9] If the production function is not homothetic, the parameter of scale obtained as the sum of the

The main assumptions implicit in the cost function are: 1) the output Q is predetermined and thus exogenous; 2) the vector of input prices p_i is exogenous because given from the market[10]; 3) public capital is an intermediate good that is provided free to all productive sectors by the State. In this way the firms of a sector, for every given level of production, choose the optimal combination of inputs taking in account their market prices. Shepard's Lemma gives the optimal demand functions for inputs conditional to the prices: $L = (\partial \ln CT / \partial \ln w_l)$, $K = (\partial \ln CT / \partial \ln w_l)$. A cost function, to meet the conditions of regularity, should be homogeneous of degree one in input prices, which implies $S_k + S_l = 1$, where $S_i = (p_i X_i)/CT = C_i/CT$ is the cost share of input i. Therefore, considering the prices of inputs, we have $S_l = p_l L/CT$ and $S_k = p_k K/CT$, which imply the so-called *input cost-share equations*: $S_i = (\partial \ln C_i / \partial \ln p_i)(p_i/C_i) = (\partial \ln CT / \partial \ln p_i)$. Differentiating the cost function with respect to the output, according to Hotelling's lemma, we have the function of marginal cost (supply finction): $\lambda = (\partial \ln CT / \partial \ln Y)$, where λ is the Lagrange Multiplier that rapresets the shadow price of inputs. Under assumption of perfect competition[11], λ is equal to the price of output p_y, and could then be written: $S_y = p_y Q/CT = Y/CT$.

The cost function approach also allows to see if the input demand functions are biased by the availability of public capital. The elasticity of demand with respect to public capital input can be decomposed in into one direct effect an one indirect: $\epsilon_{ig} = (\partial \ln X_i / \partial \ln G)(G/X_i) = \epsilon_{sig} + \eta_{cg}$. The former term ($\epsilon_{sig}$) is the elasticity of input cost-share with respect to the public capital and shows the distortion in the use of that input, while the latter (η_{cg}) expresses the neutral effect of G on the demand for inputs. The public capital distors towards overuse of factor i if $\epsilon_{sig} > 0$, underuse if $\epsilon_{sig} < 0$ and is neutral if $\epsilon_{sig} = 0$. Direct and indirect effect could be of equal or opposite sign, determinating Marginal Rate of Technical Substitution between each private input and infrastructures' services in the productive process In fact, the public capital and the input i are subtitutes, complementary or indipendent if, respectively, ϵ_{ig} is less than, greater than or equal to 0.

coefficients of the output elasticity of inputs is not exactly equal, in absolute value, to η_{cy}.

[10] Chambers (1988) provides a complete definition of economic assumptions for any given generic cost function.

[11] Perfect compatition is a stong assumption, but widely used in this kind of letterature. On the other side, it is perfectly compatible with the assumption of linear homogeneity in prices needed for the econometric estimation.

A translogarithmic function is used in the empirical implementation. This yields substantial benefits attributable to the abundance of interaction variables in its specification[12]. The cost function is approximated by a second order Taylor series expansion where public capital is treated as a quasi-fixed input. The translogarithmic cost function is specified as follows:

$$\ln CT = \alpha_0 + \alpha_y \ln Y + \frac{1}{2}\alpha_{yy} (\ln Y)^{\,2} + \sum \beta_i \ln p_i$$

$$+\frac{1}{2}\sum \beta_{ij} (\ln p_i \ln p_j) + \sum \beta_{iy} (\ln Y \ln p_i) + \delta_z \ln Z$$

$$+\delta_{zi} (\ln Z \ln p_i) + \gamma_t t + \gamma_{it} (t \ln p_i) + \gamma_{ty}(t \ln Y) \qquad (1)$$

Equation (1) is subject to the standard restrictions of linear homogeneity and symmetry in prices:

$$\sum \beta_i = 1, \;\; \sum \beta_{iy} = \sum \beta_{zi} = 0, \;\; \sum \beta_{ij} = \sum \beta_{ji}$$

The cost function used in the estimation is given by equation (1) subject to the specified restrictions:

$$\ln(CT/p_k) = \alpha_0 + \alpha_y \ln Y + \alpha_{yy}\frac{1}{2} (\ln y)^{\,2} + \beta_l \ln(p_l/p_k)$$

$$+\beta_{ll}\frac{1}{2} \ln(p_l/p_k)^2 + \beta_{ly} [\ln Y \ln(p_l/p_k)] + \delta_z \ln Z$$

$$+\delta_{lz} [\ln Z \ln(p_l/p_k)] + \gamma_t t + \gamma_{lt} [t \ln(p_l/p_k)] + \gamma_{yt}(t \ln Y) \qquad (2)$$

Share equations of inputs are derived by applying Shepard's lemma to equation (2):

[12]Further proof of the advantages of the translogarithmic form within the class of flexible functions is available in Guilkey et al. (1983).

$$S_l = \beta_l + \beta_{ll} \ln(p_l/p_k) + \beta_{ly} \ln Y + \delta_{zl} \ln Z + \gamma_{lt} t \tag{3}$$

$$S_k = (1 - \beta_l) - \beta_{ll} \ln(p_l/p_k) - \beta_{ly} \ln Y - \delta_{zl} \ln Z - \gamma_{lt} t \tag{4}$$

While the marginal cost equation is derived by applying Hotelling's lemma:

$$S_y = \alpha_y + \alpha_{yy} Y + \beta_{ly} \ln(p_l/p_k) + \gamma_{yt} t \tag{5}$$

The cost function is computed in a multiple system with factor demand equations and supply equation (marginal cost equation)[13]. This approach provides a more efficient use of available information. We apply Zellner's SURE [14](seemingly unrelated regressions) which allows residuals correlations between the equations of the system[15]. Equations (3) and (4) are linearly dependent, thus, we need to eliminate one to avoid singularity in the variance-covariance matrix.

3 Data and variables

We use data provided by Istat for the time period from 1970/71 to 1998/99. Capital stock time series are combined with data provided by Crenos. Public capital stock data are available in the Picci (1997) database. Further details on data sources and their integration are available in the appendix. We use the following variables, measured in 1995 euro prices. Output is value added. Private capital is measured as time lagged private capital stock given that Istat data refers to year end values and thus the stock is effectively available in the subsequent year. This also applies to Picci's public infrastructure data which uses the permanent inventory method to built stock from public investment. Labour is measured as standard dependent and independent labour units. Annual salary is measured as Returns from dependent labour divided by dependent labour units. Independent labour is set at the dependent

[13] We follow the approach presented by Paul (2003), but, in our model, we include also the marginal cost equation.

[14] We adopt an iterative computation procedure which converges to the likelihood function and such that, if the model is corrected specified, the choice of share equation to be eliminated becomes irrelevant.

[15] There would otherwise be no reason for adopting a separately computed system of equations.

labour value. This is a necessary simplification widely used in the literature. The price of private capital is measured by cost of utilisation as defined in Berndt and Hansson's (1992) well-known equation: $p_k = d_k(a + r - i)$. The sum in brackets is capital depreciation and the real interest rate, d_k is the investment deflator. The rate of depreciation for each type of capital goods is computed by depreciation divided by capital stock. We use ten year Treasure bond interest rates net of inflation. The investment deflators are defined by the ratio of current to constant price investment values.

As previously mentioned, public infrastructure services are measured as $Z = u{*}G$. This value is indexed to 100 in base year (1995). Factor prices are normalized to one in the same year. Table 1 provides descriptive statistics for the intermediate year 1984/85 as well as the average rates of output and capital growth by labour unit for the whole time period. It is immediately apparent that four of the eight sectors are *labour-intensive*, and only two are *capital-intensive*. This may be attributable both to high labour costs typical of the Italian economy and to the relatively low capital/labour unit ratio. Energy and Other business services[16] industries are the only exceptions. Specifically, the latter is characterised by a very high capital stock subject to lower growth rates over time than labour. All other sectors are subject to an increasing capital/labour ratio over time. There are marked differences in average value added growth by industry. Differences in output and input growth rates suggest that different sectors may have evolved along very diverse paths both in terms of input and output choices as well as productivity growth.

4 Empirical results

4.1 The Aggregate Economy

The model, made up of the cost function (2) and equations (3) and (5), is computed for the Aggregate Economy using Zellner's seemingly unrelated regression method. Table 2 reports the results for the Aggregate Economy. Tables 4a and 4b report the results by economic sector. Most parameters are statistically significant and behave as expected in terms of sign. The condition of linear homogeneity in input is always

[16] The high capital stock in this sector is attributable to the value of property assets in the real estate sector.

Table 1

Descriptive statistics for Economic Sectors

ECONOMIC SECTORS	Y	CT	S_l	S_k	K	L	$\dot{Y}$	$\dot{K/L}$
Agriculture	24065	31538	0.28	0.72	109566	2440	0.83	4.34
Manufacturing	150000	122000	0.77	0.23	254757	5276	3.21	2.77
Energy	19170	13959	0.55	0.45	95807	165	1.95	2.53
Construction	44337	30136	0.85	0.15	35703	1590	0.57	1.72
Trade	94000	74775	0.88	0.12	65693	3662	2.97	2.98
Hotels and restaurants	25945	23872	0.89	0.10	22415	966	1.52	1.88
Transp., storage, commununication	39783	46599	0.74	0.26	106210	1366	4.29	3.07
Other business services	123000	73816	0.39	0.61	1111019	1186	3.68	-2.3
Aggregate Economy	547000	457000	0.74	0.26	1806413	16680	2.60	2.54

Notes: average public stock capital growth rate=2.43%. Public stock capital=449000.

Monetary values are expressed in millions of Euros at 1995 constant prices, labour units in thousand units, year 1985 and average growth rates.

Y=output, CT=total costs, K=private stock capital, L=standard labour unit.

satisfied. At the same time, increasing in input prices or in output does not yield cost reductions. Public capital has a negative coefficient, whereas the output coefficient is positive. Statistical goodness of fit is confirmed by high R^2 values as well as the joint parameter significance test and low standard errors. The Breusch-Pagan test refutes the null hypothesis of no correlation between the residuals of different equations. In other words, the SURE model yields better results than independent estimation of each equation. Tests for residual autocorrelation and normality, although not reported in the tables, are satisfactory. Output is the only explanatory variable such that the effective exogeneity is uncertain. Hausman test excludes the hypothesis of endogeneity of this variable. The model includes a time trend t as a proxy for technological progress, which interacts with output and factor prices. Significance tests for these parameters confirm that including a time trend in the model is necessary and correct.

Table 3 reports on the impact of public capital on the Aggregate Economy. There is evidence of a productivity relapse. The cost elasticity is estimated at -0,4009 and the productivity coefficient equals 0,3109, where both results are statistically significant. The elasticity of cost with respect to output is 1,2406. This value is greater than unity and thus indicates the presence of modest diseconomies of scale. We can compare these results with other that report estimations for the Italian economy. La Ferrara and Marcellino (2004) estimate the shadow value[17] of public capital equal to -0,029 using a regional panel dataset over a similar length of time. This very lower result could be attributed to the different functional forms used: they adopt a Cobb-Douglas instead of our translog function. In order to test for the opportunity of reducing our function to a Cobb-Douglas form, we performed a test χ^2 restricting the relevant parameters to zero. The choice of the translog form is corroborated by the rejection of the null hypothesis. A further difference is their adoption of public capital stock as a proxy for the measure of services provided by it. Picci (1999), in a fixed effect panel model at regional level, estimated a public capital elasticity of 0,35 which is comparable to our results and to his previous estimations based on aggregated data in Picci (1997). Demetriades, Mamuneas (2000), in an intertemporal optimization framework, estimate that output elasticity of Italian public infrastructure capital is 0,59 in the short run and 0,58 in the long run, which is almost the double of our estimated productivity coefficient, although not very far in absolute value. Kamps

[17]Shadow value is the change in variable costs due to a marginal variation in an input.

(2004) adopts a Cobb-Douglas production function for OECD countries' aggregate economies including public sector net capital as an input. In this study, output elasticity is equal to 0,153 using a constructed time series of public capital and is 0,498 using a national dataset, but the estimate based on OECD data rises further to 1,749. Those results are seem compatible with our estimation. The same author, using the same data for a VAR approach in Kamps (2005), observes a long-run elasticity of Italian GDP with respect to public capital of 1,73. Di Giacinto, Micucci and Montanaro (2009), in a VAR model at regional level, find that the long term effects on GDP of regional public capital is 0,62. According to Bronzini, Piselli (2009), which apply panel cointegration techniques at regional level, the long run elasticity of public capital with respect to the output is 0,19. Finally, Marroccu and Paci (2007) estimate a production functions with the inclusion of intangible input. They find the elasticity of 0,150 for the public capital and egual to 0,096 for economic infrastructures, when these are isolated with respect to "other infrastructures".

The impact of public capital on input demand is a sum of distortion and neutral effects. According to our results, the negative distortion for the labour factor is equal to -0,23. The effect is positive and equal to 0,73 for private capital, although not significant. The input demand elasticity is -0,63 for labour and 0,33, but not significant, for private capital. Thus, public capital is a substitute for the former and a complement for the latter. Paul (2003), studying Australian economy, finds costant return to scale and that public capital is a substitute for both labour and private capital.

Table 2

SURE model estimates for the Aggregate Economy

Parameters	Value
α_y	2.8781 (1.1357)
α_{yy}	-0.0579 (0.0425)
β_l	0.2593 (0.4621)
β_{ll}	0.0214 (0.0057)
β_{ly}	0.0528 (0.0084)
δ_z	-0.2055 (0.1149)
δ_{lz}	-0.1754 (0.1003)
γ_t	0.2465 (0.0430)
γ_{lt}	-0.0130 (0.0028)
γ_{yt}	-0.0094 (0.0015)
α_0	-28.493 (15.269)
Cost function	
R^2	0.99
RMSE	0.02492
Wald test	$\chi^2(10)$=141126
H_0:γ_t=γ_{lt}=γ_{yt}=0	$\chi^2(3)$=68.62
Labour cost-share equation	
R^2	0.97
RMSE	0.02261
Wald test	$\chi^2(4)$=2272.99
H_0:γ_{lt}=0	$\chi^2(1)$=21.53
Marginal cost equation	
R^2	0.96
RMSE	0.02818
Wald test	$\chi^2(3)$=656.263
H_0:γ_{yt}=0	$\chi^2(1)$=36.52
Breusch-Pagan test	$\chi^2(3)$=11.465
H_0:α_{yy}=β_{ll}=β_{ly}=δ_{lz}=γ_{lt}=γ_{yt}=0	$\chi^2(6)$= 2546.3

Note: standard errors in brackets

Table 3

Impact of public capital on input demand and productivity: Aggregate Economy

Statistics	Value	s.e.
Dual measure: η_{cg}	-0.4009	(0.1650)
Primal measure: η_{yg}	0.3109	(0.1147)
Cost elasticity w.r.t. output: η_{cy}	1.2406	(0.1418)
Elasticity of scale	0.8060	
Input distortions for public capital		
Labour: $\delta_{lz}/sl = \epsilon_{s\,\mathrm{lg}}$	-0.2304	(0.0499)
Capital: $\delta_{kz}/sk = \epsilon_{skg}$	0.7344	(0.4328)
Input demand elasticity w.r.t. public capital		
Labour: ϵ_{lg}	-0.6308	(0.1579)
Capital: ϵ_{kg}	0.3340	(0.3525)

Note: measured as average values, standard errors in brackets

4.2 Economic sectors

Tables 4a-b display the results at industry level. Results for all the economic sectors seem plausible, with the exception of the last one In fact, the estimates for Other business services are peculiarly unsatisfactory, because the value of the salary parameter seems implausible. This is probably attributable to the poor adaptability of specific sector characteristics to the adopted methodology. Again, diagnostic tests support the choice of a translog functional form.for all sectors.

Public capital effects on productivity are given in Tables 5. The results differ substantially by industry, but are nearly always statistically significant. Cost elasticity varies from -0,1978 for Transport and communications to -1,6961 for Manifacturing, which is a wide range around the value we found for Aggregate Economy (-0,40) There is a slightly lower direct effect on productivity, varying between 0,1228 for Trade to 1,3886 for Manifacturing. In fact, cost elasticity with respect to output, in Table 5, is nearly always slightly above unity, displaying negligible diseconomies of scale (μ). Agriculture (0,8662) and Transport and Communications (0,8840) are the only exceptions. Tables 6 and 7 analyse the behaviour of input demand by different sectors. Public capital tends to reduce labour in Agriculture, Manufacturing, Energy and slightly in Construction. In these sectors private capital demand exceeds its optimal level. The opposite is true in other sectors. Specifically, there is a very strong tendency towards capital underutilisation in the Hotels and Restaurant sector (-3,8339). Table 8 provides input demand elasticity by economic setor. Public capital is a substitute for both private productive factors in practically all industrial sectors. The complementarity of public capital with a private input – namely, capital – is peculiar to the Energy sector. Labour demand elasticity with respect to infrastructures is neutral – not statistically different from zero – for nearly half the sectors, but is rilevant in the other sectors: Energy, Manifacturing, Other business services and Agricolture. Our results are, in general, complatible with calculations provided by Paul (2003) for Australian economy, although specific sectoral results are quite different. Anyway, we can agree with him when he concludes that an increase in public capital leads to a decline in demand for both private inputs in most of industries. In our calculations, in particular, there is evidence of negative inpact on the employment of some sectors. On the other side, Demetriades and Mamuneas (2000) find evidence that public capital has a positive effect on private inputs.

Tavola 5

The impact of public capital on productivity by economic sector and elasticity of scale

Economic sector	Dual measure	Primal measure	η_{cy}	μ
Agriculture	-0.9971 (0.0961)	1.1511 (0.0881)	0.8662 (0.0834)	1.1544
Manufacturing	-1.6961 (0.1395)	1.3886 (0.0731)	1.2214 (0.1126)	0.8187
Energy	-1.1071 (0.1555)	0.8001 (0.2711)	1.3836 (0.1658)	0.7227
Construction	-0.6657 (0.1813)	0.4722 (0.0233)	1.4098 (0.1539)	0.7093
Trade	-0.1628 (0.1082)	0.1228 (0.0824)	1.3251 (0.0329)	0.7546
Hotels and restaurants	-0.9757 (0.1301)	0.8868 (0.4194)	1.1003 (0.0402)	0.9088
Transport, stor. and comm.	-0.1978 (0.1648)	0.2238 (0.1833)	0.8840 (0.0123)	1.1312
Other business services	-0.7568 (0.1520)	0.4813 (0.0158)	1.5723 (0.5404)	0.6360

Note: elasticities measured as average values, standard errors in brackets

Table 4a

SURE models by economic sector

Parameters	Agriculture	Manufacturing	Energy	Construction
α_y	0.1993 (1.6451)	-1.3574 (1.2696)	0.6384 (2.1847)	0.0915 (1.8282)
α_{yy}	0.0379 (0.0689)	0.1098 (0.0497)	0.0358 (0.0924)	0.0596 (0.0747)
β_l	1.7216 (1.0838)	0.8868 (0.4623)	0.9127 (0.7536)	-0.1979 (0.4537)
β_{ll}	-0.2387 (0.0056)	0.0403 (0.0052)	0.1348 (0.0095)	0.0153 (0.0041)
β_{ly}	-0.0313 (0.0319)	0.0254 (0.0184)	0.0581 (0.0342)	0.0561 (0.0159)
δ_z	-0.9044 (0.6612)	-1.5972 (0.1357)	-0.5716 (0.1772)	-0.6234 (0.1570)
δ_{lz}	-0.1304 (0.1269)	-0.1536 (0.0771)	-0.4151 (0.0519)	-0.0465 (0.0713)
γ_t	0.2603 (0.0974)	0.4162 (0.0560)	0.2764 (0.1181)	0.2966 (0.0508)
γ_{lt}	0.0051 (0.0014)	-0.0067 (0.0018)	-0.0052 (0.0015)	-0.0069 (0.0006)
γ_{yt}	-0.0133 (0.0041)	-0.0158 (0.0021)	-0.0115 (0.0049)	-0.0124 (0.0020)
α_0	14.341 (19.972)	31.309 (16.363)	0.9267 (25.782)	7.2224 (22.295)
Cost function				
R^2	0.739	0.997	0.997	0.999
RMSE	0.3975	0.0383	0.0393	0.0330
Wald test	$\chi^2(10)$=130019	$\chi^2(10)$=68821	$\chi^2(10)$=44636	$\chi^2(10)$=161518
H_0:γ_t=γ_{lt}=γ_{qt}=0	$\chi^2(3)$=2350.4	$\chi^2(3)$=56.74	$\chi^2(3)$=38.88	$\chi^2(3)$=176.46
Labour cost-share equation				
R^2	0.674	0.967	0.992	0.963
RMSE	0.0833	0.0178	0.0230	0.0132
Wald test	$\chi^2(4)$=2595.59	$\chi^2(4)$=810.60	$\chi^2(4)$=3878.99	$\chi^2(4)$=855.76
H_0:γ_{lt}=0	$\chi^2(1)$=12.60	$\chi^2(1)$=12.80	$\chi^2(1)$=10.78	$\chi^2(1)$=117.27
Marginal cost equation				
R^2	0.344	0.847	0.641	0.915
RMSE	0.13156	0.0455	0.1153	0.0457
Wald test	$\chi^2(3)$=14.59	$\chi^2(3)$=155.77	$\chi^2(3)$=54.37	$\chi^2(3)$=295.74
H_0:γ_{lq}=0	$\chi^2(1)$=10.57	$\chi^2(1)$=54.65	$\chi^2(1)$=5.44	$\chi^2(1)$=36.05
Breusch-Pagan test	$\chi^2(3)$=53.877	$\chi^2(3)$=40.33	$\chi^2(3)$=9.297	$\chi^2(3)$=6.889
H_0:α_{yy}=β_{ll}=β_{ly}=δ_{lz}=γ_{lt}=γ_{yt}=0	$\chi^2(6)$=2948.6	$\chi^2(6)$=912.61	$\chi^2(6)$=3920.74	$\chi^2(6)$=1071.38

Note: standard errors in brackets

Tavola 4b

SURE models by economic sector

Parameters	Trade	Hotels and restaur.	Transp., stor., comm.	Other bus. services
α_y	-0.1827 (1.6835)	-0.4291 (1.2139)	3.5253 (1.4586)	2.0688 (0.5471)
α_{yy}	0.0579 (0.0672)	0.0723 (0.0507)	-0.1124 (0.0610)	-0.0281 (0.0220)
β_l	-0.4406 (0.3068)	0.8962 (0.4286)	0.5111 (0.3079)	-13.605 (1.0283)
β_{ll}	0.0133 (0.0030)	0.0236 (0.0036)	0.0129 (0.0042)	0.1843 (0.0060)
β_{ly}	0.0418 (0.0108)	-0.0641 (0.0141)	0.0041 (0.0060)	0.6072 (0.0465)
δ_z	-0.2599 (0.1544)	-1.4527 (0.1721)	-0.3077 (0.1474)	-0.4494 (0.1357)
δ_{lz}	0.0985 (0.0405)	0.3689 (0.0740)	0.1005 (0.0859)	-0.3756 (0.0507)
γ_t	-0.0177 (0.0495)	0.2173 (0.0526)	0.0062 (0.0025)	0.3992 (0.1311)
γ_{lt}	-0.0104 (0.0011)	-0.0087 (0.0011)	-0.1530 (0.0642)	-0.0039 (0.0009)
γ_{qt}	0.0002 (0.0018)	-0.0079 (0.0021)	-0.0204 (0.0036)	-0.0148 (0.0049)
α_0	12.577 (21.212)	19.434 (14.589)	-26.524 (17.540)	-16.435 (7.0234)
Cost function				
R^2	0.998	0.999	0.999	0.840
RMSE	0.0401	0.0213	0.0431	0.0332
Wald test	$\chi^2(10)$=361211	$\chi^2(10)$=244779	$\chi^2(10)$=98383	$\chi^2(10)$=56592
H_0:γ_t=γ_{lt}=γ_{yt}=0	$\chi^2(3)$=87.74	$\chi^2(3)$=143.76	$\chi^2(3)$=41.08	$\chi^2(3)$=117.12
Labour cost-share equation				
R^2	0.984	0.966	0.970	0.939
RMSE	0.0085	0.01251	0.0269	0.0317
Wald test	$\chi^2(4)$=1791.82	$\chi^2(4)$=890.08	$\chi^2(4)$=2020.3	$\chi^2(4)$=4110.98
H_0:γ_{lt}=0	$\chi^2(1)$=79.59	$\chi^2(1)$=61.24	$\chi^2(1)$=30.95	$\chi^2(1)$=15.64
Marginal cost equation				
R^2	0.455	0.283	0.211	0.634
RMSE	0.0437	0.0502	0.0395	0.6398
Wald test	$\chi^2(3)$=22.06	$\chi^2(3)$=25.07	$\chi^2(3)$=6.47	$\chi^2(3)$=200.92
H_0:γ_{ly}=0	$\chi^2(1)$=0.01	$\chi^2(1)$=13.45	$\chi^2(1)$=6.14	$\chi^2(1)$=8.93
Breusch-Pagan test	$\chi^2(3)$=13.798	$\chi^2(3)$=3.653	$\chi^2(3)$=15.429	$\chi^2(3)$=44.793
H_0:α_{yy}=β_{ll}=β_{ly}=δ_{lz}=γ_{lt}=γ_{yt}=0	$\chi^2(6)$=1808.20	$\chi^2(6)$=891.39	$\chi^2(6)$=2288.3	$\chi^2(6)$=4247.94

Note: standard errors in brackets

Table 6

Input distorsion by economic sector

Economic sector	Labour	Capital
Agriculture	-0.4532 (0.3944)	0.1831 (0.0321)
Manufacturing	-0.1975 (0.0242)	0.6912 (0.4196)
Energy	-0.9939 (0.4230)	1.3457 (1.3118)
Construction	-0.0535 (0.0042)	0.3580 (1.1478)
Trade	0.1093 (0.0079)	-0.9912 (-0.9912)
Hotels and restaurants	0.3805 (0.0295)	-3.8339 (1.7948)
Transport, storage and comm.	0.4055 (0.0314)	-4.0857 (1.9127)
Other business services	0.1376 (0.0311)	-0.3736 (0.2399)

Note: measured as average values, standard errors in brackets

Table 7

Input demand elasticity by economic sector

Economic sector	Lavoro	Capitale
Agriculture	-1.4503 (0.8151)	-0.8139 (0.1303)
Manufacturing	-1.8937 (0.1376)	-1.0049 (0.3474)
Energy	-2.1010 (0.2532)	0.2386 (0.9950)
Construction	-0.7193 (0.0454)	-0.3076 (0.1292)
Trade	-0.0534 (0.1010)	-1.1540 (0.3054)
Hotels and restaurants	-0.5702 (0.4450)	-5.6158 (1.7462)
Transport, storage and communication	-0.0602 (0.1426)	-0.5715 (0.0943)
Other business services	-1.7905 (0.1091)	-0.1665 (0.1425)

Note: measured as average values, standard errors in brackets

5 Conclusions, limitations and outline for further research

The empirical results provide clear evidence of the impact of public infrastructure on various economic sectors with different intensity An usefull result of this study is to provide an empirical estimation of the effect of public services on each economic sector of Italian economy. Specific sectors such as Energy and Manufacturing seem to benefit from public infrastructure more than other sectors. Surprisely, the effect is weeker in the sectors of Trade and Transport. There are no significant economies or diseconomies of scale. Public services have a positive impact in all industries by way of the substitutability of public capital and other factors of production. Specifically, in low capital intensity sectors, infrastructure exerts a substantial negative distortion of private capital demand. It is important to note that, for Aggregate Economy, both distortion and demand elasticity for private capital were positive and not significant, suggesting a neutral effect of public capital, while .it is negative in the other sectors. Moreover, labour demand elasticity with respect to public capital is significant in only half the sectors and the distortion has opposite sign in different sectors.

Our results are obteined performing a cost side approach at sectoral level, where free public services are calculated from the total public capital stock, without using information regards to regional public capital and type of infrastrucure. More robust estimations could given by a panel approach which take in account both sectoral and regional dimension. Furthermore, our static approach, which implys the strong theoretical assumption[18] that production always meets optimal demand for inputs, could be replaced by a more sofisticated dynamic approach as, for example, in Demetriades and Mamuneas (2000).

In the empirical implementation of this model, we don't take in account the taxes paid by the sectors. It could be done subtracting sectoral taxation from the output of each industry as in Moreno, López-Bazo, Artìs (2002) or explicitly including it as variable, for example, in a VAR approach.

From policy point of view, our study contributes to better understand the relationship between private sectors production and public services. This seems rilevant in order to quantify and compare the benefits (free services and capital) earned and costs (taxation) supported by each industry.

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6 Appendices

6.1 Appendix A - Data sources

Output (value added) Value added is drawn from Istat National Accounts at constant 1995 prices.

Labour Standard labour unit are taken from National Accounts (Istat)

Private Capital Private capital stock is drawn from Istat National Accounts time series at constant 1995 price for the time period 1980/81 to 1998/99. Previous years were computed by integrating the Istat datasets with time series computed by Crenos. These are available on their website.

Public capital Public capital data is a time series of the stock of public infrastructure measured by Picci and available on the internet. This time series is constructed by applying the permanent inventory method to the historical time series of public investment. To adjust to constant 1995 prices, a fixed investment deflator from the construction industry was applied (Istat data source).

Price of labour Salary was computed as the ratio of returns for dependent labour (1995 prices) to standard labour units. Both are derived from Istat national accounts.

Price of capital The cost of capital was computed using Istat national accounts data except the nominal interest rate for ten year multiannual Treasury bonds (source: Treasury Department – Economics and Finance Office). Capital depreciation was measured by the economic discounting of capital stock for four types of capital goods subsequently reaggregated using their relative weights.

6.2 Appendix B - Economic sector classification

Tavola B - Classification of economic activities (ATECO)

Code	ATECO sectoral description	Economic sector
A+B	Agriculture, hunting and forestry + Fishing	Agriculture
D	Manufacturing	Manufacturing
E	Electricity, gas and water supply	Energy
F	Construction	Construction
G	Wholsale and retail trade: repair of motor vehicles, motorcycles and personal and household goods	Trade
H	Hotels and restaurants	Hotels and restaurants
I	Transport, storage and communication	Transp., storage, comm.
K	Real estate, renting and business activities	Other business services