Productivity and Infrastructure in the Italian Regions

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Abstract

I address the issue of whether public infrastructure play any role in determining factor productivity in the Italian regions. To this end, a new data set on Italian regional capital is used for the first time. The empirical analysis, carried out using panel data econometric techniques, leads to the conclusion that the role of public capital is significant, the more so for those categories of public goods, such as roads and railways, that form the so called «core» infrastructure.

As a policy implication of the empirical evidence, it is argued that an effort should be made to increase investments in infrastructure. This indication seems to be particularly relevant for the Italian Mezzogiorno, as a geographically disaggregated analysis indicates.

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Keywords:

Infrastructure, productivity, Italian regions, panel data

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1. Introduction

The public debt affecting the Italian economy is an obvious reason of concern for economists and policy makers alike. Jappelli - Ripa di Meana (1990) argue that policies whose goal is to reduce the debt to output ratio cannot abstract from the role of infrastructure. If they influence output significantly, then, cutting public capital investments, by reducing future potential output, could even worsen the debt problem. On the other hand, if public capital is not very important in determining productivity, policy makers most important concern should be the size, more than the composition, of the budget cuts that they make.

Public debt reduction is an important question in the Italian context of binding post-Maastricht "stability pact" criteria. However, the interest in the relationship between infrastructure and output or, more to the point, factor productivity, is not limited to this issue. In the United States, much attention has been dedicated to the analysis of the causes of the productivity slowdown that has occurred between the seventies and the nineties. A whole thread of the literature, starting from the seminal paper of Aschauer (1989), has tried to impute such a decline in factor productivity growth to the decline in public investments.

Aschauer (1989) shows the results of various regressions of different concepts of factor productivity on factor inputs, including public capital, for the U.S. as a whole. The results are quite astounding: public capital seems to be highly significant in influencing productivity, with positive output elasticities of around 0.35. Similar results are found by Munnell (1990a) who, again for the U.S. as a whole, finds elasticities of output with respect to public capital of comparable magnitudes.

The first wave of works on the topic left the impression that public capital was indeed very important in determining productivity, and its modest growth became a prominent candidate to explain the productivity slowdown. After a first phase of enthusiasm, however, some caution was asked for by other less-optimistic results. Holtz-Eakin (1994) criticizes the econometric analysis carried out by Munnell (1990b), who uses a panel of U.S. state data, and argues that, in a cross-state analysis of productivity, state specific effects are potentially important. Holtz-Eakin then rejects the hypothesis that individual state effects are not relevant and does not find a significant role of public capital. The same result also emerges when different econometric techniques, such as instrumental variables panel estimation and estimation using "long differences" of the data, are used.

Similar results are found by Garcia Mila - McGuire - Porter (1996), and by Holtz-Eakin - Schwartz (1994), who develop a neoclassical growth model "à la Solow" that incorporates infrastructure as one of the production inputs. However, no consensus view has emerged until now. Pereira - Flores de Frutos (1999), for example, using a VAR model on US data, conclude that infrastructure are an important factor of production.

To better interpret the existing empirical evidence, some preliminary observations are in order. Not to find any role for public capital, in an empirical analysis based on the estimation of production functions, should not lead to the conclusion that public capital is irrelevant. First, the likely effect of infrastructures could be on variables that are not considered in the usual definitions of output. Better quality of life subsequent to the creation of a public park, or more free time following the creation of a modern and uncongested transportation system, would represent such a case. Moreover, public capital could be effective, but with a delay with respect to its formation. An example is provided by network infrastructure, whose benefits, for the greatest part, can be reaped only after network completion. Also, certain effects of public capital are indirect, since they influence other factors of production. An adequate public capital stock may encourage private investments through business location decisions, and may also affect technical progress, when public investments, say, in schools, favors human capital formation[2].

[2] When the territorial dimension of the analysis is relatively small, however, even a significant

These cautioning words help explain why the empirical evidence signaling a conspicuous role for public capital, after controlling for other factors, had generally been interpreted as indicating a shortcoming in the level of current public investments.

Only recently has the availability of time series public capital data allowed for empirical studies of the Italian case of the types mentioned. Without the availability of time series data, the empirical analysis was confined to cross-sectional data. Bracalente - Di Palma (1982) compute a series of indexes to measure infrastructure for the Italian regions for the year 1977. Using both OLS analysis and rotated-factor regression analysis, they find that public capital is significant in explaining regional development. The determination of the direction of causality, however, remains an open question in that work.

Acconcia - Del Monte (1999) also use cross-sectional data, to find a positive relationship between regional growth and the endowment of infrastructure.

Jappelli - Ripa di Meana (1990) for the first time use time series data and estimate reduced-form equations for output, where private consumption and public investment are used as regressors. The estimated coefficient of public investments is significant and bigger than the coefficient of private consumption; the authors interpret this result as evidence in favor of the hypothesis that the effect of public capital is important in determining output. Acconcia - Del Monte (1999) estimate growth regressions also using public investment data and an initial benchmark for capital stock similar in nature to the one in Bracalente - Di Palma (1982), and five-year averages of the data[3]. Forni - Paba (1999), using provincial level data and growth regressions, obtain contrasting results depending on which proxy they chose for public capital.

Picci (1997) for the first time uses aggregate public capital stocks data, derived from Rossi et al. (1993) - Picci (1995b), to estimate a number of regressions for the post World War 2 period, and for the between-war period, similar to the ones considered by Aschauer (1989) and Munnell (1990a). He also concludes that the role of public capital is important. La Ferrara - Marcellino (1999) use regional public capital data from Picci (1995b) to estimate production and cost functions, and in most cases find that public capital is significant.

In this paper, I take again on the empirical problem using panel data estimation techniques. The choice of methods is in part motivated by a criticism that has been leveled against previous analyses that use aggregate data. Holtz-Eakin (1994) explains the contrasting empirical results for the United States by suggesting that aggregate data are not very informative, in a context where both output and public investment growth rates have declined over the '60s and the '70s. Many time series are chachterized by similar diminishing growth rates over that sample period and, for this reason, their correlation could be spurious and unrelated to the presence of any causal link.

This explanation could also apply to much of the evidence gathered so far for Italy, given that both the work of Picci (1997) and Jappelli - Ripa di Meana (1990) are based on aggregate data. In order to avoid these possible criticisms, we here use for the first time the data base on regional public capital developed by Bonaglia - Picci, 2000[4].

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positive effect of public capital would carry an ambigous interpretation. In principle, the role of infrastructure could be explained by business relocation decisions that simply redistribute private inputs from places with less public capital to better equipped areas, within what would could be charachterized as a zero sum game. Boarnet (1997) considers this possiblity and, using California counties data, finds that redistribution of this kind does take place.

[3] Their benchmark capital stock, however, is only available for the year 1970, while the estimating period starts in 1965. The authors claim that results do not change sensibly by omitting those first five observations. For a criticism on using n-year averaged data, see Attanasio - Picci -Scorcu (2000).

[4] A similar case in favor of panel data, and against the traditional "Barro-type growth regressions", has been made in the growth literature. See, among others, Caselli - Esquivel - Lefort (1996).

Regional data also allow for the evaluation of dissimilarities in the role of infrastructure between different parts of the country. This possibility seems to be particularly appealing in the Italian context of strong economic inequalities between northern and southern regions, and of the resulting need to develop the knowledge that is necessary to make well informed policy recommendations to address such a problem.

Time series regional data, as opposed to the cross-sectional evidence used in the existing studies based on growth regressions, also obviously provide a much richer information base for applied analysis, because they also allow for an assesment of the variation of the data in its time series dimension.

With respect to the work of La Ferrara - Marcellino (1999), who also use regional data from 1976 to 1991 within a panel data framework, the present analysis taps on a richer information set, ranging from 1970 to 1995. More degrees of freedom, in turn, allow for more precise conclusions at the geographically disaggregated level.

The conclusions of the analysis are as follows. The role of public capital is significant, the more so for those categories of public goods, such as roads and railways, that form the so called «core» infrastructure. The role of public capital increased over time, and is of unequal magnitude across macro-regions. As a policy implication of the empirical evidence, I conclude that an effort should be made to increase investments in infrastructure.

The paper is structured as follows. The next section is dedicated to the presentation of the data, whose collection is described in greater detail in an appendix to the paper. Section 3 presents the empirical model, and Section 4 the results. Section 5 concludes.

2. The data.

One of the highlights of the empirical analysis is the use of new data on regional capital stocks covering the years from 1970 to 1995[5]. Public capital stocks have been computed using the perpetual inventory technique. The necessary regional public investments time series have been obtained by apportioning the national aggregate to the Italian regions. The procedure is similar to the one used in the United States to obtain a break-up of the aggregate data at the state level (c.f. Munnell, 1990b), and is explained in details in an appendix to the paper, derived from Bonaglia - Picci (2000). The stock is divided into seven categories of goods, also described in the appendix. Public capital stock is gross capital, as it usually is in this kind of analyses.

Net private capital also has been taken from Bonaglia - Picci (2000), who use a permanent inventory technique for its computation. It consists of buildings and of machinery and transportation goods. Output is regional gross product, and labor is regional units of labor. The source of both is a Prometeia's data base, based on ISTAT and CCIAA sources[6].

Table 1 shows the average growth rate for different sub-periods of output, output per labor unit, labor units, private and public capital, for Italy as a whole and for its five "macro-regions"[7]. Output has grown more in the North-East and in the South then elsewhere. Within

[5] A previous version of these data, covering the years from 1970 to 1991, was in Picci (1995b). Bonaglia - Picci (2000) extend the availability of the public capital data to include the years from 1992 to 1996 and, building on previous unpublished work by Bonaglia, substitute and extend the coverage of regional private capital stocks to 1995. La Ferrara - Marcellino (1999) also use Bonaglia's unpublished private capital data.

[6] I thank Massimo Guagnini and Prometeia for allowing me to use the data.

[7] Italy is divided into twenty regions, sometimes, for descriptive purposes, re-grouped into five macro-regions. These are: North-West (Piemonte, Valle d'Aosta, Lombardia and Liguria); North-East (Trentino Alto-Adige, Veneto, Friuli Venezia-Giulia and Emilia-Romagna); Center (Toscana, Umbria, Marche and Lazio); South (Abruzzi, Molise, Basilicata, Puglia, Calabria and Campania) and Islands (Sicilia and Sardegna). Two further aggregations are sometimes used: "North", indicating North-West and North-

sub-periods, and with respect to the national average, the South performed relatively well during the first and the last part of the sample perriod, and underperformed between '79 and '87. Roughly the same picture emerges if we look at labor productivity. The Islands, with growth rates never very dissimilar to the national average, tended to slightly improve their relative performance over time. Over the whole sample period, only the North-West grew below the national average, while the North-East distinguished itself as the best performer. Looking at output per labor unit, on the other hand, indicates that only the North-East and the South performed above the national average. These results, overall, are consistent with the ample empirical evidence denying the presence of growth rate convergence between the less developed Mezzogiorno and the rest of Italy (c.f., Paci - Pigliaru, 1995).

Labor units increased by little and rather evenly across Italy, with the exception of the '90s, when they slightly decreased. Private capital increased sensibly, mostly in the North-East, in the Center and in the South. However, most of the growth occurred during the first part of the period considered. This is particularly true for Southern and Insular Italy, with the latter even experiencing a slight decrease of the capital stock during the '80s[8].

Public capital has increased by less. The average growth rate over subperiods decreased from 3% between 1971 and 1978 to 2% between 1988 to 1995. Figure 1 shows that the decrease in the growth rate of public capital was particularly marked in the early '70s, the early '80s and the early '90s.

With respect to public capital growth, macro-regions fared unevenly. The Mezzogiorno did well during the 70s. Later, its public capital grew less than the national average. At the end of the time period considered, no doubt also as a results of the "mani pulite" (or "clean hands") judicial inquiries on public officials' corruption, public capital growth came close to zero in the Mezzogiorno.

Most of the increase of the capital stock - both private and public - in the Mezzogiorno occurred during the first part of the time period considered. During the '80s, with the dismission of the "Cassa del Mezzogiorno" (a state agency aimed at the development of the Mezzogiorno), both public and private investments were significantly reduced. On average, the highest growth in infrastructure took place in the North-East and in the North-West, with the rest of the country lagging behind. After the end of the 70s, the infrastructure gap between North and South increased.

Again with respect to public capital, not only there are significant differences in its growth rates across macro-regions: the composition of the stocks is also different. Table 1. and Figure 2 show the ratio between the "core" and the non-core component of public capital[9]. After peaking in the mid-seventies, the ratio diminished continuously until the end of the period. Also of interest is the absolute difference between macro-regions, the Mezzogiorno having a smaller fraction of core public capital overall: not only the growth rate of the public capital stock was lower in the southern parts of Italy, also, the increase that did take place was due more to non-core capital goods.

A further question regards the dispersion of the growth rates across regions. We compute the coefficient of variation for the whole cross section of the twenty Italian regions, and for the

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East, and "Mezzogiorno", including South and Islands.

[8] Responsible for this decrease is for the most part Sardegna, that during the second part of the '70s and part of the '80s experienced modest investment rates compared to the levels of the late '60s to mid '70s.

[9] By core public capital we mean those infrastructure that are more strictly linked with the production process. Referring to the categories of goods contemplated by the data described in the appendix, these are: roads and airports, railroads and subways, ports, electrical lines and water (riverplanning, etc.), telecommunications. Non-core public capital is a residual component, including hospitals, public buildings (with schools among them), and other residual items.

different macro-regional aggregation. Table 1 shows average coefficients of variations of different sub-periods, while Figure 3 shows the same data, but considering the further aggregation of North and Mezzogiorno. Overall growth rate dispersion tended to increase over time, reflecting the decreasing growth rates in the Mezzogiorno. Within macro-regions, no clear pattern emerges. By comparing Table 1 with Figure 3, we note that the high dispersion of the North-West and the North-East is lower once the two are considered jointly.

3. The empirical analysis.

The empirical analysis is carried out by estimating a production function that includes public capital among the regressors. The estimated equation is:

$$[1] \qquad y_{rt} = \alpha_0 + \alpha_1 l_{rt} + \alpha_2 k_{rt} + \alpha_3 kp_{rt} + \varepsilon_{rt}$$

where y is output, l are labour units, k is private capital, kp is public capital, and variables are in logs. In the empirical analysis, we will consider the possibility that *kpub* is split into its core and non-core components, as defined before. The r and t subscripts indicate, respectively, region and time. The error term has the following structure:

$$\varepsilon_{rt} = f_r + \delta_t + \eta_{rt}$$

where f_r is a region specific time invariant component, δ_t is a time specific component, and η_{rt} is a idiosincratic i.i.d. error.

Different specification of the models - and, as we have seen, often different results - follow from different assumptions about the error term. Not considering f_r gives pooled OLS, the technique used by Munnell (1990a). Assuming that f_r cannot be considered as fixed, a "random effect" estimation technique has to be used instead. In the present case, our attention is on a defined set of regional units, whose choice is not the result of a sampling process. For this reason, fixed effects, each one of which is determined by the time invariant regional characteristics, seem to be better suited in the case at hand. However, I also consider the possibility that effects are random[10].

4. The results.

Columns A and B of Table 2 show the results for pooled OLS and fixed effects estimates of regional production functions for the Italian regions[11]. In the pooled OLS regression results, the estimated coefficient for public capital is negative and significant. The F-test on the null hypothesis that all fixed effects are equal (that is, that there are no fixed effects) is strongly rejected (see "Test1" at the botton of Table 2). As in Holtz-Eakin (1994) we are led to conclude that the OLS pooled regression does not provide consistent estimates. Assuming fixed effects, on the other hand, delivers an estimated public capital elasticity that is very high, and comparable to the results in Picci (1997) that are based on aggregate data[12].

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[10] For a description of the econometric techniques employed, see, among others, Baltagi, (1995)

[11] All estimates (with the exclusion of the cross section regression that uses "long differences") of the data include common time effects.

[12] For comparison, the cross-sectional estimated public capital elasticity in Acconcia - Del Monte (1999) ranges between 0.1 and 0.22, depending on the value assumed for the private capital output elasticity. La Ferrara - Marcellino (1999), using an approach similar to ours and data ranging from 1976 to 1991, obtain an estimated elasticity equal to 0.30.

Random effects estimates, shown in column C, also indicate that public capital is significant, even if the estimated elasticity is now of a more modest magnitude. A Hausman test, however, rejects the null hypothesis that the regional effects are uncorrelated with the right-hand side variables of the regression. In this case, random effects estimates are biased, while fixed effects estimates are still consistent.

Fixed effects estimates of elasticities on private factors of production are compatible with prior knowledge. In particular, the sum of the estimated elasticities of the private factor is very close to one. In columns D and E of Table 2 we estimate the production function, again including fixed effects, imposing the presence of constant returns to scale in private inputs and in all inputs respectively. In both cases, the estimated public capital elasticity remains numerically very close to the one obtained with the unconstrained model. The hypothesis of constant returns to scale in private inputs only is not rejected, while the hypothesis of constant returns to scale in all inputs, i.e., including public capital, is strongly rejected.

Column A of Table 3 considers the unconstrained model again, but with public capital split into its core and non-core component, in order to evaluate their relative importance. According to intuition, we find that core infrastructures are more important in determining output, with an estimated elasticity of 50%. Contrary to intuition, non-core infrastructures enters the production function with a negative, although very small, and significant coefficient. I do not comment on this result for the moment; later on, empirical evidence on the macro-regional break-up of such an estimate will be helpful in clarifying it.

The correlation between public capital and output could be spurious, in case both series have a common trend. Bhargava - Franzini - Narendranathan (1982) propose an extension of the Durbin-Watson test, for the hypothesis of no serial correlation of the errors, to deal with panels of data. Their test can also be used to evaluate the hypothesis that the errors have a unit root. In this case, first differenced data should be considered in the analysis (see also Gramlich (1994) and Garcia-Mila - McGuire -Porter (1996)).

The value of the test statistic, shown in the lower part of Table 2, in all cases leads to reject the null hypothesis of unit root. Nevertheless, the estimation has been carried out, and the results are shown in column B of Table 3. Public capital is still significant in the estimated equation, even if its estimated elasticity is now below 20%. Note that with differenced data we use a pooled OLS estimator: fixed effects with differenced data would imply, against intuition, that regional *growth rates* are influenced by regional fixed effects. Formal testing on the significance of fixed effects, whose P-values are shown in the lower part of Table 3, corroborate this choice[13].

Column C of Table 3 also shows the results of the statistical model estimated in first differences, but in a "second order translog" specification, that is, with squared and cross-product inputs added. Squared terms should capture any non-linear effects of productive inputs. Cross-product terms are aimed at capturing effects such as crowding out between the production inputs and, more generally, any effect of an input that manifests itself indirectly by influencing other inputs.

Both squared terms and cross-product terms are not significant in the estimated equation. This is true both individually, and when they are considered jointly, (see "Test 3" and "Test 4" in

[13] Griliches - Hausman (1986) argue that looking at transformations of the data (such as first and longer differences) different from the one implied by fixed effects, allows for an evaluation of the presence of errors in variables. Dissimilarities between different sets of results would indicate the presence of errors in variables. Estimation with twice and thrice lagged differences confirms the basic robustness of the results. The estimated coefficients for the private inputs remain very similar to the ones of the differneced equation; the estimated public capital elasticity becomes lower (equal to 0.136 and to 0.112 for the two and three lagged differences, respectively), but still highly significant (with t-statistics equal, respectively, to 2.77 and to 2.73). The full set of results is available from the author.

the lower part of the Table)[14]. Also note that the coefficients on private and on public capital, although positive, are now insignificant. Multicollinearity might have a role in the general loss of significance of the estimated coefficients of this translog specification. Note however that a test of the joint significance of the four terms involving public capital (in levels, squared, and in cross-products; see "Test 2" at the bottom of Table 3), leads to reject the null hypothesis of no significance with a P-value of 7%.

As a further check on the robustness of the results obtained until now, I also consider the model expressed in «long differences», that is, the differences between the (logs) of the last and first observed values in the sample. Regressions using long differences are a way to obtain estimates that are based on the cross-sectional variability of the data, unlike fixed effects estimates that hinge upon the variation of the data in its time series dimension. It is well known, in panel data analysis, that the two types of variation do not necessarily deliver similar results. Column D of Table 3 shows that, in the present case, no such problem arises. The estimated coefficient of public capital is smaller than before, but still sizable and significant.

4.1 Disaggregate analysis.

A further question that can be addressed using regional data regards the geographic uniformity of the estimated public capital elasticity. There are at least a couple of reasons for such a disaggregated analysis. First, given the differences in public capital formation at the macro-regional level that have been emphasized in the data section, it is interesting to know whether public capital elasticities are geographically uniform. The formulation of any policy implication would obviously benefit from such a knowledge, since, instead of being defined in terms of a national average, it could be tailored to the characteristics of the different (macro-)regions. Moreover, geographic disaggregation will allow for a more informed interpretation of the negative and significant «no-core» public capital elasticity that has been found at the aggregate level (see Column A of Table 3)[15].

Table 4 shows estimated elasticities for the North-East, the North-West, the Center, Mezzogiorno, and Italy as a whole. For the time being, let us confine our attention to the full-sample estimates. Public capital elasticities, as estimated by fixed effects OLS, are always significant. They are lower in the North then in the rest of Italy. They are very high in the Center and, to a lesser extent, in the Mezzogiorno[16]. These results are broadly confirmed by also considering the average of the individual regional estimates[17].

The last two columns of Table 4 show the fixed effects macro-regional estimates of core

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[14] In Picci (1997) an (aggregate) 2nd order translog production function was also estimated. As in the present case, squared and cross-product terms were found to be non-significant. The signs of the estimated coefficients were the same as those here obtained for all variables, with the exception of squared private capital and of the interaction between labour units and public capital.

[15] There is a further reason that justifies carrying out separate analyses for different geographic areas. In Picci (1995a) doubts are cast on the quality of the public capital data stocks for the regions of the Italian Mezzogiorno and for Liguria. I estimated the same relations shown in Table 2 excluding those regions. The results (that are available upon request) show that public capital elasticity is still highly significant, even if slightly smaller than in the full-sample case. This is true both for the equation in levels and in first differences. In the translog specification, the variables involving public capital are not jointly significant anymore, unless core public capital is used as a regressor instead of aggregate infrastructures, in which case they are. To summarize, by excluding the Mezzogiorno regions and Liguria, the conclusions on the significance of public capital are somehow attenuated, but not fundamentally changed.

[16] Acconcia - Del Monte (1999), within their growth regression set-up, find that the impact of public investments is higher in low-income regions - typically, Southern regions - somehow confirming our findings.

[17] Only in two cases (Trentino-Alto Adige and Friuli Venezia Giulia) negative (but very small and non significant) estimates of public capital elasticities were obtained.

and non core public capital elasticities. Two comments are in order. First, in all cases, the core capital estimated elasticity is the highest of the two. This confirms, at the macro-regional level, the conclusion already reached for Italy as a whole: core infrastructure matter more than other types of public capital. Second, only in one case – the North-East – we obtain a negative estimate of the non-core public capital elasticity. This result somehow (geographically) confines the problem of interpreting the negative estimated elasticity that we found at the national level. Further attention at the specific characteristics of the North-Eastern regions could provide useful insights to interpret this result.

The content of Table 1 and of Figure 2 indicate that in all macro-regions the ratio between core and non-core components continuously declined after the late '70s. Such a relative decline of the most productive types of public capital, *ceteris paribus*, would suggest a declining output elasticity of public capital across Italy. The same Table and Figure also show that the infrastructure in the Mezzogiorno are composed by relatively little core public goods. Again *ceteris paribus*, this would hint at a lower public capital elasticity in the Mezzogiorno compared to the rest of Italy.

However, we also know that the growth rate of public capital decreased over time. This decrease was particularly marked in the Mezzogiorno. A greater scarcity of public capital goods would suggest an increasing impact on production of any given piece of infrastructure, the more so where public investments have decreased the most.

A priori, it is not possible to determine which one of this two countering effects would prevail. Dividing the data in the two dimensions relevant to these considerations – geographically, and temporally – seems to be the right way to separate and possibly identify the different effects. To this end, Table 4 also provides public capital estimates for the first and for the second half of the sample period. The first half, between 1970 to 1982, corresponds to the years when public investments where higher, when the core to non-core public capital ratio was also higher, and when growth rates were more uniform across Italy. The second part of the sample, from 1983 to 1996, corresponds to slowing investments, less core infrastructure, and diverging stocks between the North and the South.

The evidence presented in Table 4 is not amenable to any clear pattern, but it is instructive. In the whole of Italy, the public capital estimated elasticity is slightly lower in the second sample period[18], suggesting a prevailing negative influence of the decreased core to non-core infrastructure ratio. However, in all macro-regions, excluding the Center, the opposite is true. Looking at core and non-core public capital individually considered, the picture is also mixed. Core public capital is estimated to be more important in the later years of the sample in Italy as a whole and, significantly, in the Mezzogiorno.

To gain further insight into the problem, I compute, and show in Figure 4, marginal productivities of public capital for the geograpical disaggregation here considered. As public capital elasticities for such a computation, the estimates of Table 4 obtained with the whole sample period have been used. The Center is where public capital has the highest marginal productivity, with the Mezzogiorno following. However, had we used the estimates obtained for the 1983-1995 subperiod, the ranking would have been different, with the North-East showing the highest marginal productivity. Regardless of the choice of estimated coefficients used for computing public capital marginal productivity, we note an increase in public capital marginal productivity over time, the more so in Central Italy and in the Mezzogiorno, with the North-West as a possible exception.

The present analysis suggests that, after two decades of lagging public investments, a fairly clear case emerges in favor of added investments in infrastructure, especially the core ones, at the national level. However, the analysis of marginal productivities adds a cautioning words to

[18] La Ferrara - Marcellino (1999), using data from 1976 to 1991, similarly find a more important role for public capital after 1980.

any policy conclusions we may draw from the geographically disaggregated analysis. In the Mezzogiorno, public capital output elasticity is higher than the national average, and the more so in the second half of the sample period. This is true for public capital as a whole, and it is also true for both its core and non-core components. However, the ranking of marginal productivities of public capital is not uniquely determined by the present analysis. For this reason, it is not unambiguosly clear whether the Mezzogiorno should receive a bigger share of any national effort to bring infrastructure growth rates back to what they used to be.

Summary and conclusions.

Using a new data set on Italian regions, covering the years 1970 to 1995, I have assessed the importance of public capital in determining output. Compared to previous studies, the availability of regional data has permitted a more careful robustness check of the results and, also, has allowed for their geographic disaggregation. Different econometric techniques, entailing the consideration of both the time-series variation of the data, as in fixed effects estimation, and of its cross-sectional variation, as when long differences of the data are used, have all led to the same conclusion: infrastructure are important.

The evidence presented confirms and supplements past researches that have used cross sectional data (Bracalente - Di Palma (1982); Acconcia - Del Monte (1999)), aggregate data (Jappelli - Ripa di Meana (1990); Picci (1997); Acconcia - Del Monte (1999)) and, more recently, also regional panel data (La Ferrara - Marcellino (1999)). Unlike in other countries, there now seems to be an emerging consensus regarding the significance of the role of infrastructure in determining economic activity in Italy.

Any debate on Italian regional data ends up by dealing with the problem of the North-South economic divide, and always indulges with the attempt of making useful policy recommendations. This paper is no exception. A first straightforward policy implication of the estimates at the national level is that, in the present context of budget cuts, policy makers should be careful not to penalize the capital account, since such a choice could carry a hefty ticket in terms of foregone future economic growth.

Looking at the evidence at the macro-regional level, the case of the Mezzogiorno stands out. The Mezzogiorno has experienced lower than average capital stock growth rates since 1980, has a below average, and diminishing, core-non core composition of its stock, and a high and possibly growing public capital output elasticity. An analysis of public capital marginal productivity, however, offers a less clear cut picture, since it does not indicate that the Mezzogiorno has the highest marginal productivity of public capital. Also, any suggestion of increased public expenditure should consider the often distortionary implications of its financing. In this respect, the present analysis helps to charactere the problem and offers some hints for its solution, but it is certainly not conclusive.

These considerations also indicate some directions for further research. Regional differences in the role of infrastructures deserve a more careful empirical evaluation and, obviously, one or more explanations of why different types of infrastructures have distinct roles in various economic contexts. The use of more flexible specifications of the production process, possibly to include time-varying characteristics of the local economies other than the quantities of the usual production inputs, could represent a fruitful line of research. More disaggregated data, at the provincial level, would provide the richness of information probably needed for such an analysis.

Appendix

In this appendix, derived form Bonaglia - Picci (2000)[19], the sources and methods of construction of the capital stocks are described. The reader can refer to the original paper for a more detailed description.

The public capital data

Rossi - Sorgato - Toniolo (1993, RST from now on), by integrating several statistical sources, obtain two long time series (covering the years from 1890 to 1992) of public investments at the national level. If one is not interested in the first decades of the sample period, the data allow for a computation of the stock by means of a permanent inventory technique even when an initial benchmark is not available. RST data on public investments have been extended to cover the years until 1996 using ISTAT (1998).

To obtain regional capital stocks, information contained in ISTAT (1954-1996) have been used. ISTAT collects those data by means of a form that is distributed every year to the relevant public officials, in order to record the amount of public investments divided by geographic area (down to the provincial level), type of good, and administration responsible for its realization and for its financing. The analysis is on «all public works related to new constructions, reconstructions, structural ameliorations, major repairing, extraordinary maintenance, and similar interventions, financed a) with total financing by the State or with its contribution, through Ministries and by means of the Cassa per il Mezzogiorno; b) with total or partial financing by national or territorial branches of the Public Administration (Inail, Inps, Regions, Provinces, Municipalities) or with the contribution of other administrations (the State excluded); c) with total financing by the Autonomous Administrations of the State and by other public corporations» (ISTAT (1954-1996)).

There are nine types of goods contemplated in the analysis. These are: roads and airports; railroads and subways; marine (ports, lake and river navigation); water (river planning, etc.) and electrical lines; public buildings and schools; sanitation (hospitals, water filtering, sewers); land reclamation and irrigation; telecommunications; other types of works (such as pipelines, infrastructures for tourism, etc.).

The time series of regional investments that are derived from these data have been made compatible to the aggregate data contained in RST. That is, the aggregate public investment time series in RST has been split into twenty regional time series, each one itself divided into the nine types of goods contemplated by the ISTAT data (for a total of 180 time series), so that the ratios between all the components of such subdivisions of the RST series are the same as the ones of the original ISTAT data.

Regional public capital stocks have then been computed using a permanent inventory technique, applied to each of the nine categories of public goods for each of the twenty regions. The permanent inventory technique used is the same one adopted by ISTAT. Capital goods are retired according to a normal distribution centered on the goods' mean life, and such that 90% of the goods are retired within ± 25% of the mean life. Moreover, the distribution is truncated at ± 40% of the mean life (ISTAT (1993)). Mean lives have been computed as the average of the mean lives adopted for comparable categories of goods by those OECD countries for which an indication exist (Italy not being among them), as recorded in OECD (1993). All vintages of goods before 1946 have been reduced by 8% to take into account the effects of World War 2, following indications in Rosa - Siesto (1985).

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[19] I thank Federico Bonaglia for having allowed me to draw from joint work.

The private capital data

Regional capital stocks for the private sector are estimated using a perpetual inventory method. Three caregories of capital goods are considered: "Machinery and Installations", "Transport Equipment" and "Industrial buildings".

Average service lives are taken from ISTAT (1995): 35 years for buildings, 15 years for machinery and installations, and 10 years for transport equipments. Assets are assumed to be retired from the capital stock when they reach their average service life. This kind of survival function is usually known as "simultaneous exit" (more realistic and sophisticated assumptions about the distribution of retirements around the average service life have been introduced by national accounter. See ISTAT (1995) and OECD(1993)).

As a preliminary step to the permanent inventory method implementation, constant price fixed-investment series at the regional level are obtained combining data from ISTAT and FEEM. These sources provide information on fixed investment for the period 1980-1996 (ISTAT (1997)) and 1960-1991 (FEEM (1992)). Investment series are obtained for each region over the entire sample, and they are disaggregated for each kind of capital good. Due to lacking information on the relative weight of each capital good in aggregate regional investment, a simplifying assumption has to be made. In partcular, it is assumed that each region replicates the same pattern of investment observed at the nationale level.

Both gross and net estimates of capital stocks are provided in Bonaglia - Picci (2000). Net stocks, that are used in the empirical analyisis, are estimated by assuming straight-line depreciation: the same fraction (1/L) of the capital stock is consumed each year and the value of the asset is fully exhausted by the end of year L.

References

ACCONCIA A. - DEL MONTE A. (1999), "Regional Development and Public Spending. The Case of Italy", mimeo.

ASCHAUER, D. (1989), "Is Public Expenditure Productive?", *Journal of Monetary Economics*, vol. 23, pp. 177-200.

ATTANASIO O. - PICCI L. - SCORCU A.E. (2000), "Saving, Growth and Investment. A Macroeconomic Analysis using a Panel of Countries", *Review of Economics and Statistics*, forthcoming.

BALTAGI B. (1995), *Econometric Analysis of Panel Data*, New York, NY, Wiley.

BHARGAVA A. - FRANZINI L. - NARENDRANATHAN W. (1982), "Serial Correlation and the Fixed Effects Model", *Review of Economic Studies*, vol. 49, pp. 533-549.

BOARNET M.G. (1997), "Spillovers and Locational Effects of Public Infrastructure", mimeo.

BONAGLIA F. - PICCI L. (2000), "Lo stock di capitale nelle regioni italiane", mimeo.

BRACALENTE D. - DI PALMA M. (1982), "Infrastrutture e sviluppo regionale in Italia: un'analisi multidimensionale", *Note Economiche*, pp. 13-42.

CASELLI F. - ESQUIVEL G. - LEFORT F. (1996), "Reopening the Convergence Debate: A New Look At Cross-Country Growth Empirics", *Journal of Economic Growth*, Vol. 1, pp. 363-389.

FEEM (1994): *Banca dati regionale*, Milano.

FORNI M. - PABA S. (1999), "Industrial districts, social environment and local growth. Evidence from Italy", mimeo.

GARCIA-MILA T. - MCGUIRE T. - PORTER R. (1996), "The effect of public capital in state-level production functions reconsidered", *The Review of Economic and Statistics*, pp. 177-180.

GRAMLICH E. (1994), "Infrastructure Investment: A Review Essay", *Journal of Economic Literature*, Vol. 32, pp. 1176-1196.

GRILICHES Z. - HAUSMAN J.A. (1986), "Errors in variables in Panel Data", *Journal of Econometrics*, Vol. 31, pp. 93-118.

HOLTZ-EAKIN D. (1994), "Public-sector Capital and the Productivity Puzzle", *The Review of Economic and Statistics*, Vol. 76, pp. 12-21.

HOLTZ-EAKIN D. - SCHWARTZ A. (1994) "Infrastructure in a Structural Model of Economic Growth", N.B.E.R. Working Paper No. 4824.

JAPPELLI T. - RIPA DI MEANA A. (1990), "Investimenti pubblici, onere del debito e accumulazione del capitale", *Rivista di Politica Economica*, Vol. 12, pp. 89-115.

ISTAT (1954-1996), *Opere Pubbliche*, Roma.

ISTAT (1995), *Investimenti, stock di capitale e produttività dei fattori. Anni 1980-1994*, Note e Relazioni N. 2, Roma

ISTAT (1997), *Contabilità Nazionale. Tomo 1 - Conti Economici Nazionali Anni 1970-95*, Roma.

ISTAT (1997), *Contabilità Nazionale. Tomo 2 - Conti Economici Regionali Anni 1980-95*, Roma.

ISTAT (1998), *Contabilità Nazionale*, Roma.

LA FERRARA E. - MARCELLINO M. (1999), "TFP, Costs, and Public Infrastructure: An Equivocal Relationship", mimeo.

MUNNELL A. (1990a), "Why Has Productivity Growth Declined? Productivity and Public Investment", *New England Economic Review*, pp. 3-22.

MUNNELL A. (1990b), "How Does Public Infrastructure Affect Regional Economic Performance?" in *Is There a Shortfall in Public Capital Investement?* ed. by A. Munnell, Boston, MA, Federal Reserve Bank of Boston.

OECD (1993), *Methods Used by OECD Countries to Measure Stocks of Fixed Capital, National Accounts: Sources and Methods*, No. 2, Paris, OECD.

PACI R. - PIGLIARU F. (1995), "Differenziali di crescita nelle regioni italiane: un'analisi cross section", *Rivista di Politica Economica*, Vol. 85, pp. 3-34.

PEREIRA A.M. - FLORES DE FRUTOS R. (1999), "Public Capital Accumulation and Private Sector Performance", *Journal of Urban Economics*, Vol. 46, p. 300-322.

PICCI L. (1995b), "Il "capitale mancante" nel Mezzogiorno italiano", Quaderni del Dipartimento di Scienze Economiche n. 212, Università. di Bologna.

PICCI L. (1995a), "Lo stock di capitale nelle regioni italiane", Quaderni del Dipartimento di Scienze Economiche n. 229, Università di Bologna.

PICCI L. (1997), "Infrastrutture e produttività: il caso italiano", *Rivista di Politica Economica*, Vol. 1, pp. 67-88.

ROSA G. (1979), *Lo stock di capitale nell'industria italiana. Nuove stime settoriali e territoriali*. Roma, Sipi.

ROSA G. - SIESTO V. (1985), *Il capitale fisso industriale. Stime settoriali e verifiche dirette*. Bologna, Il Mulino.

ROSSI N. - SORGATO A. - TONIOLO G. (1993) "I conti economici italiani: una ricostruzione statistica, 1890-1990", *Rivista di Storia Economica*, Vol. 10, pp. 1-47.

Table 1.

Output: Average Growth Rates.						
	N.West	N.East	Center	South	Islands	Italy
'71-'78	2.91%	4.11%	3.13%	3.89%	3.12%	3.29%
'79-'87	1.97%	2.22%	2.85%	2.81%	3.04%	2.90%
'88-'95	1.62%	2.47%	1.69%	1.74%	1.50%	1.32%
'71-'95	2.16%	2.90%	2.57%	2.81%	2.57%	2.42%
Output per Labor Unit: Average Growth Rates						
'71-'78	2.04%	3.50%	2.30%	2.71%	2.13%	2.46%
'79-'87	1.66%	1.50%	1.58%	1.93%	1.67%	1.69%
'88-'95	1.85%	2.53%	2.04%	2.76%	1.94%	2.15%
'71-'95	1.84%	2.47%	2.00%	2.55%	1.90%	2.08%
Labor Units: Average Growth Rates.						
'71-'78	0.87%	0.60%	0.83%	0.84%	0.99%	0.83%
'79-'87	0.30%	0.72%	1.27%	0.88%	1.37%	0.79%
'88-'95	-0.23%	-0.05%	-0.36%	-1.02%	-0.44%	-0.36%
'71-'95	0.31%	0.43%	0.61%	0.26%	0.67%	0.43%
Private Capital: Average Growth Rates.						
'71-'78	3.51%	4.86%	5.02%	8.34%	7.27%	5.11%
'79-'87	2.32%	2.86%	4.29%	1.97%	-0.09%	2.44%
'88-'95	1.60%	2.15%	1.34%	1.27%	1.04%	1.57%
'71-'95	2.47%	3.27%	3.58%	3.78%	2.62%	3.01%
Public Capital: Average Growth Rates.						
'71-'78	2.82%	2.82%	2.67%	3.38%	3.58%	3.06%
'79-'87	2.74%	2.77%	2.17%	2.26%	2.30%	2.44%
'88-'95	2.66%	2.60%	1.91%	1.35%	1.55%	1.99%
'71-'95	2.74%	2.73%	2.24%	2.33%	2.50%	2.49%
Public Capital: Ratio between "core" and residual component.						
'70-'78	2.21	1.74	2.16	1.29	1.24	1.65
'79-'87	2.09	1.64	2.01	1.16	1.17	1.53
'88-'95	1.74	1.49	1.70	1.10	1.11	1.39
'70-'95	2.03	1.63	1.96	1.19	1.18	1.53
Public Capital: Average Coefficients of Variation.						
'70-'78	89.50%	95.70%	35.92%	35.70%	35.29%	41.47%
'79-'87	113.17%	105.22%	31.20%	29.18%	21.99%	51.56%
'88-'95	107.07%	101.89%	32.10%	35.23%	25.69%	56.16%
'70-'95	103.10%	100.90%	33.11%	33.29%	27.74%	49.48%

Output is regional gross product; labor is regional units of labor (source: Prometeia's data base); private and public capital stocks are from Bonaglia and Picci (2000).
Definitions of "core" and "non core" public capital are in note n. 9 in the text.

Table 2.
Dependent variable: regional product (logs)

Constraints:	None	None	None	CRS (private inputs)	CRS (all inputs)
Estimation method:	OLS (A)	FE (B)	RE (C)	FE (D)	FE (E)
Variable:					
Constant	4.144	-	-	-	-
	(44.4)				
Labour	1.080	0.836	0.859	-	0.462
	(63.4)	(15.7)	(41.6)		(21.3)
Private capital	0.133	0.171	0.112	0.171	-
	(10.3)	(17.2)	(13.5)	(17.2)	
Public capital	-0.248	0.358	0.072	0.359	0.358
	(-16.9)	(16.3)	(3.60)	(18.0)	(15.4)
R^2	0.992	0.965	0.982	0.942	0.939
BFN		0.765	-	0.761	0.947
Test 1		0.00		0.00	0.00
Test 2		0.00		0.00	0.00
Test 3				0.89	0.00
n. of obs.	520	520	520	520	520

Output is regional gross product; labor is regional units of labor (source: Prometeia's data base); private and public capital stocks are from Bonaglia and Picci (2000). All variables are in logs.
OLS: OLS pooled; FE: Fixed Effects; RE: Random Effects. t statistics are between parentheses.
All tests results report P-values.
BFN: Bhargava-Franzini-Narendranathan test;
Test 1: H_0: no FE.
Test 2: Hausman Test: FE vs. RE.;
Test 3: H_0: Constant Returns to Scale

Table 3.
Dependent variable: first differences of regional product (logs) (columns 1. and 2.); long differences of regional product (logs) (column 3.); regional product (logs) (column 4.)

Transf:	Levels, "core" vs. "non-core" kp	First differences	First differences, 2nd. order translog	Long differences
Estimation method:	FE (A)	OLS (B)	OLS (C)	OLS (D)
Variable:				
Constant	-	0.016	0.013	0.357
		(2.91)	(1.74)	(4.79)
Labour	0.976	0.462	0.442	0.404
	(19.2)	(8.12)	(7.61)	(1.95)
Private	0.140	0.072	0.085	0.125
capital	(14.1)	(2.77)	(1.68)	(3.29)
Public	-	0.184	0.342	0.260
capital		(2.69)	(1.49)	(2.39)
Core Public	0.501	-	-	-
capital	(15.7)			
Non-core	-0.052	-	-	-
Pub. Capital	(2.78)			
l^2	-	-	3.73	-
			(2.39)	
k^2	-	-	-0.084	-
			(0.37)	
kp^2	-	-	-2.00	-
			(0.68)	
$l \cdot k$	-	-	0.002	-
			(0.53)	
$l \cdot kp$	-	-	-0.001	-
			(0.20)	
$k \cdot kp$	-	-	-0.001	-
			(0.24)	
R^2	0.970	0.528	0.535	0.629
BNF	0.786			
Test 1	0.00	0.45	0.52	
Test 2			0.071	
Test 3			0.117	
Test 4			0.938	
n. of obs.	520	500	520	20

Output is regional gross product; labor is regional units of labor (source: Prometeia's data base); private and public capital stocks are from Bonaglia and Picci (2000). k: private capital; l: labour units; kp: public capital; .kp-core: "core" public capital; kp-nocore: public capital residual component. All variables are in logs. OLS: OLS pooled; FE: Fixed Effects. t statistics are between parentheses. All tests results report P-values.
Test 1: H_0: no FE. P-values.
Test 2: H_0: coefficients of terms involving kp are jointly zero;
Test 3: H_0: coefficients of squared terms are jointly zero;

Table 4.
Dependent variable: regional product (logs)
Estimated public capital elasticities in the Italian macro-regions.

Variable: Estimation method:	Public capital FE	Public capital average estimates	Core Pub. Capital FE	Non-core Pub. Capital -FE
North-West ('70-'95)	0.147	0.496	0.114	0.055
	(2.35)		(1.04)	(1.07)
'70-'82	-0.100		-0.137	0.130
	(0.576)		(0.85)	(0.756)
'83-'95	0.396		0.147	0.182
	(8.10)		(0.34)	(0.87)
North-East ('70-'95)	0.210	0.278	0.720	-0.358
	(4.01)		(7.58)	(5.26)
'70-'82	0.452		0.906	-0.185
	(3.45)		(5.28)	(2.00)
'83-'95	0.623		0.556	0.052
	(4.55)		(3.41)	(0.32)
Center ('70-'95)	0.893	0.755	0.507	0.332
	(13.2)		(5.85)	(4.53)
'70-'82	0.826		0.618	0.184
	(5.46)		(2.91)	(0.99)
'83-'95	0.556		0.368	0.238
	(8.15)		(4.13)	(4.70)
Mezzogiorno ('70-'95)	0.588	0.878	0.537	0.114
	(19.2)		(16.2)	(4.52)
'70-'82	0.541		0.490	0.079
	(10.1)		(8.49)	(1.53)
'83-'95	1.078		0.799	0.308
	(16.9)		(8.56)	(4.04)
Italy ('70-'95)	0.358	0.657	0.501	-0.052
	(16.3)		(15.7)	(2.78)
'70-'82	0.484		0.366	0.175
	(9.66)		(6.43)	(3.61)
'83-'95	0.417		0.651	-0.060
	(14.4)		(9.85)	(1.74)

Output is regional gross product; labor is regional units of labor (source: Prometeia's data base); private and public capital stocks are from Bonaglia and Picci (2000). All variables are in logs.
FE: Fixed Effects. "Average estimates": average of the OLS estimates obtained considering each region separately. t statistics are between parentheses.
Observations for F.E. estimates for the full samples: North-West, North-East and Centre: 104; Mezzogiorno: 208. For the subsamples: one half of the full sample.
Observations for individual OLS estimates (full sample only): 26 for each region.

Figure 1.

Public Capital: Average Growth Rates in North (North-West and North-East), Centre, "Mezzogiorno" (South and Islands) and Italy. Public capital stocks are from Bonaglia and Picci (2000).

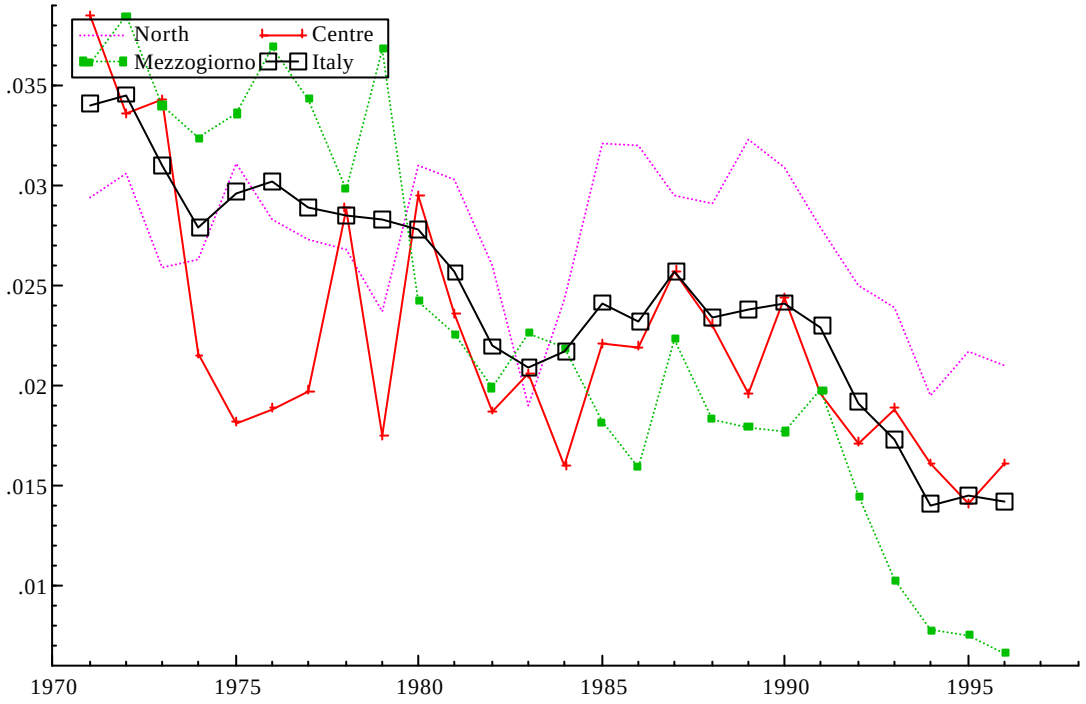

Figure 2.

Public Capital: Ratio between "Core" Public Capital and non-core Public Capital. Public capital stocks are from Bonaglia and Picci (2000).

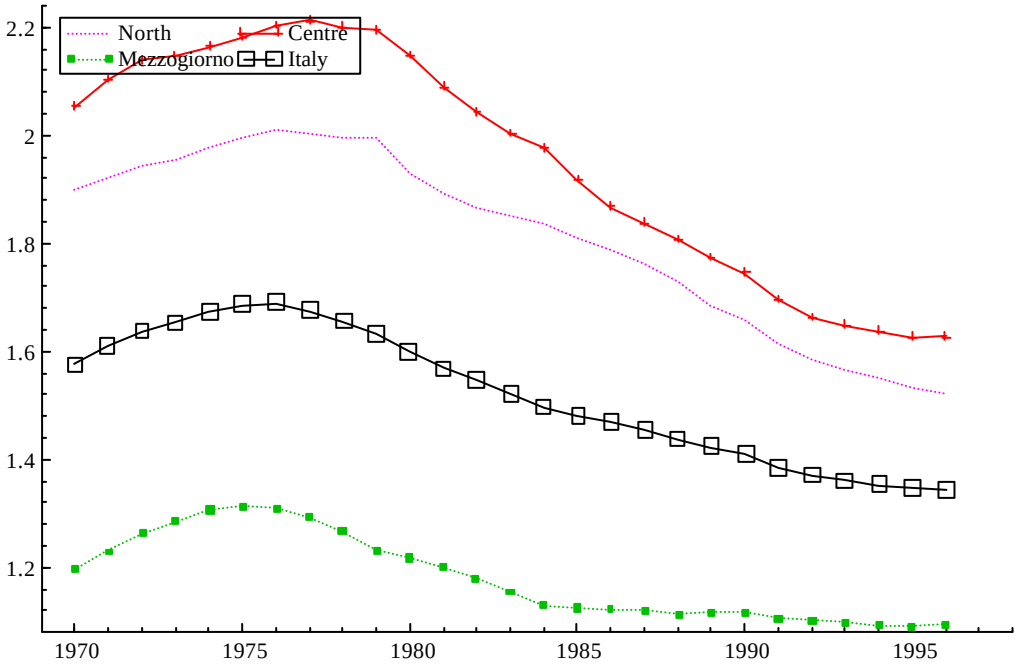

Figure 3.

Public Capital: Coefficient of Variation of Growth Rates. Public capital stocks are from Bonaglia and Picci (2000).

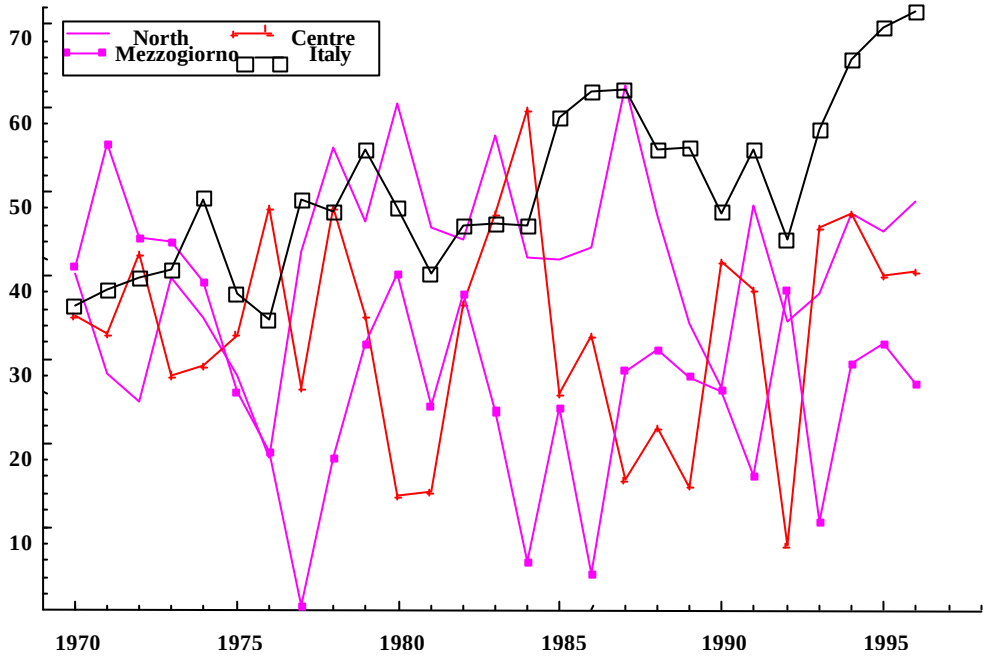

Figure 4.

Marginal prductivity of public capital.