

Public capital and institutions' quality

in the Italian regions

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Abstract

This paper investigates the role played by public capital on the production level of Italian regions by specifically accounting for the quality of institutions. Our analysis, carried out over the period 2000-2019, benefits from the use of a rich dataset on public expenditures which allows us to build the regional series of public capital stock by distinguishing among public institutions in charge of the investments and sectors of intervention. While controlling for several contextual variables (human capital, social capital, technological capital, population density), main results show that public capital has a positive and significant effect on production. Most interestingly, looking at the Mezzogiorno's regions, public capital carried out by local institutions turns out to have a lower impact than in the rest of the Italian regions. On the other hand, central bodies in the South exhibit an impact higher than the average. Moreover, institutions' quality exhibits a positive and significant effect on regional economic performance. These results cast serious doubts about the actual capacity of the local Southern administrations to effectively manage the enormous resources of the National Recovery and Resilience Plan and of the new European Union cohesion framework 2021-2027. Our results are also relevant for other European regions that, featuring structural traits similar to Southern Italian regions, are expected to face the same difficulties in managing public funding.

Keywords: Public capital stock; Productivity; Italian regions; Institutions' Quality

JEL: H54, D24, O47, R11

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1. Introduction

In the next years, Italy is expected to receive a vast amount of public funding (almost 280 billion euros) from the National Recovery and Resilience Plan (NRRP) for Italy and the new European Union (EU) Cohesion Framework 2021-2027. These plans aim to finance structural reforms to boost the economy by accelerating the green and digital transition and removing barriers to market competitiveness and access to essential services, primarily healthcare and education. It is important to remark that the regional and local administrations will manage a large share of the available financial resources. Moreover, almost half of the funding will be allocated to the eight regions of the Mezzogiorno. From a back-of-the-envelope calculation, the less developed Italian Southern regions are expected to allocate and spend almost 94 billion euros from the NRRP and 30 billion euros from the EU framework in the next five years. An amount of money they have never received before.

In this context, a relevant question raised by political analysts and policymakers is about the actual capacity of the Southern administrations to deal with such an extraordinary task. Some doubts about the capability of the local public bodies in the Mezzogiorno to manage and efficiently spend these financial resources have also been advanced by economists because of the low quality of the local institutions (Albanese et al. 2020, Di Caro and Fratesi 2022).

More generally, in the last decade, the economic literature has devoted increasing attention to the impact of the EU cohesion policies on the regional economic outcomes. Many studies have highlighted an overall positive role of the European structural funds. At the same time, some of them have emphasised the large degree of heterogeneity of the impact across territories depending on the quality of the regional institutions and the human and social capital endowments (Dall'Erba and Fang 2017, Crescenzi and Giua 2020, Rodríguez-Pose and Ganau 2022). Local institutions leverage the provision of public goods (education, innovation, infrastructures) in their regions, thus affecting their economic performance. Moreover, local administrations play a pervasive role in setting the normative and regulatory framework, and consequently, they influence firms' productivity (Lasagni et al. 2015).

The literature on the EU structural funds effectiveness is strictly related to the earlier debate on public capital's impact on economic performance originated from Aschauer (1989) and Munnell (1990) contributions. Over the last two decades, the literature on public capital has flourished through cross-countries and regional analyses. Results show a positive effect of public capital on economic outcomes, whose intensity varies depending on the development level and characteristics of the economies (see the meta-analyses by Bom and Ligthart 2014 and Núñez-Serrano and Velázquez 2017)

This paper aims to contribute to the current debate on public capital effectiveness by distinguishing among the government levels responsible for the expenditure (central and local bodies)

and explicitly considering local institutions' quality. Although institutional quality is getting more and more attention within the regional economic literature, accounting for the diversified role played by different government levels has been largely overlooked, especially for the limited availability of data.

The empirical analysis focuses on regional economic performance in Italy over the past two decades that, featuring a persistent divide between the northern and the southern regions of the country, represents a relevant case to analyse the relationship between public capital impact and the role played by different institutional levels. To this aim, we first set up a novel database on public capital at the regional level using the investment expenditures of the Extended Public Sector (Settore Pubblico Allargato, SPA) provided by Territorial Public Accounts (Conti Pubblici Territoriali, CPT). Following the methodology proposed in Marrocu and Paci (2010), we build the series on public capital stock for 21 NUTS2 Italian regions over the period 2000-2019, disaggregated by five levels of institutions responsible for the investments' implementation and by 29 economic sectors.

It is important to remark that this database provides a comprehensive measure of public capital, including all investment expenditures by national and local administrations and public companies. A noticeable share of these public investments is financed through EU structural funds, which are jointly deployed at the regional level along with other funding sources. Therefore, by estimating the overall effect of public capital, our analysis improves on previous literature that focused exclusively on the impact of EU structural funds but neglects the concurrent effects generated by the other important components of public capital funding.

As discussed above, this article devotes specific attention to the quality of the local institutions since they influence the public capital impact on regional economic outcomes. Indeed, almost half of the public capital expenditures in Italy are managed by local administrations or by local public companies. Moreover, this share is likely to increase due to the availability of the NRRP funds. Therefore, the issue of institutional quality is becoming even more crucial, especially in the less developed regions of Mezzogiorno.

Our econometric specification is based on a standard Cobb-Douglas production function augmented with a measure of the institutions' quality and other intangibles and territorial factors and considering different levels of disaggregation of the public capital. To deal with the issue of potential endogeneity of the main productive inputs, we adopt an instrumental variable approach, whereas the issue of spatial dependence is addressed by following a Spatial Lag of X (SLX) approach.

The main results highlight the positive impact of public capital on regional product levels with an elasticity higher than the private one. When we disaggregate public capital into *central* and *local* bodies, according to the institutional entities in charge of the expenditures, significant differences

between Centre-Northern and Southern regions emerge. Central bodies in the Southern regions exhibit an elasticity almost double with respect to the Northern ones. The opposite happens with the local bodies, which appear much less effective in the Southern regions. Another remarkable result is that the quality of institutions' variable exhibits the expected positive and significant elasticity, robust to all different specifications.

Although our analysis focuses on Italy, our results are also relevant for the rest of European regions, which feature varying levels of institutional quality. In some countries (e.g., Romania, Bulgaria, Hungary or Greece), institutions responsible for the management and allocation of public funding have a quality level very similar to the one exhibited by the Southern Italian regions.¹

The rest of the paper is organised as follows. In section 2 the literature on public capital impact is briefly reviewed. Section 3 deals with the construction and description of the public capital stock series. Section 4 presents the empirical model and a descriptive analysis of the main variables. The econometric results are discussed in section 5, and section 6 concludes.

2. Public capital and economic performance

The impact of public capital on the economic performance of states and regions is increasingly seizing the attention of academic researchers and policymakers alike. In addition to the traditional approach on the effects of public capital and infrastructures, a new stream of the literature has explicitly focused on the impact of public expenditures resulting from the EU structural funds.

The first approach on the impact of public capital on production has widely developed after the original contribution by Aschauer (1989). The initial studies (Aschauer 1989, Munnell 1990, Sturm and de Haan 1995) provided questionable estimates of the public capital elasticities because of unsolved econometric issues, such as reverse causality and spurious correlation (Romp and de Haan 2005, Holtz-Eakin 1994). In a meta-analysis based on 578 estimates from 68 studies for 1983–2008, Bom and Ligthart (2014) have found an average elasticity of 0.11, showing a major impact of infrastructures realised by the local and regional levels of government. More recently, Núñez-Serrano and Velázquez (2017), in a meta-analysis based on almost 2,000 elasticities from 145 studies, found an average elasticity of 0.13 and 0.16 for the short-term and long-term, respectively.

Over the last two decades, the literature on public capital impact has prospered through cross-countries and within-country analysis. The latter studies have proven the positive effect of public

¹ According to the European quality of Government index in 2021, the Italian Mezzogiorno has an index of -1.47, Bulgaria and Romania have very similar values (-1.47 and -1.48, respectively), Hungary and Greece a slightly higher one, -1.18 and -1.13. Note that the index ranges from -1.48 (Romania) to 1.68 (Finland).

capital on economic growth in developed (Kamps 2004, Fournier 2016, Han et al. 2017) and developing countries (Gupta et al. 2014, Agénor and Neandis 2015, Santiago et al. 2020).

Numerous analyses have studied the impact of public capital stock at the regional level, with specific attention to the case of Spain and Italy. In Spain, a positive effect of public capital has been estimated on economic growth by Moreno et al. (2015) and productivity levels by Gómez-Antonio and Fingleton (2012). Furthermore, Aray (2019) found a positive effect of decentralisation on the allocation of public infrastructures. In Italy, several contributions have estimated a positive impact of public capital on economic performance. Marrocu and Paci (2010) remarked a higher elasticity in the Northern regions, and Daniele (2009) showed similar results studying public expenditures. The role of public investments in Southern Italy has been analysed by Papagni et al. (2021), finding a positive impact only between 1951 and 1973. Moreover, Cosci and Mirra (2018) revealed that post-war public investments in road infrastructures had not reduced the economic divide between Northern and Southern Italy.

A second approach has focused on the impact of capital expenditure originated by the European structural funds. The EU has developed its cohesion policies to encourage and support the integration process among the country members by fostering economic growth and promoting development in the less developed regions. It is important to remark that the EU cohesion policies have gained relevance in the last years. The capital transfers from the EU and other international institutions to the Italian regions have increased by 23% between 2000 and 2019, and now they represent 28% of the regions' capital expenditure. Therefore, many researchers have analysed the impact of EU capital expenditure on economic growth and regional integration. While some contributions highlighted the overall positive influence of such policies, others have emphasised the heterogeneity of these effects across countries (see the meta-analysis by Dall'Erba and Fang 2017). Several authors report that the regional differences depend on national and regional contextual factors, such as the quality of local institutions and the endowment of human capital (Albanese et al. 2021, Di Caro and Fratesi 2022). Looking at the national intervention model, Crescenzi and Giua (2020) found that EU programs are more effective in enhancing economic growth in Germany, while their impact is weak in the Southern European regions. This result is coherent with Albanese et al. (2020), who estimated an average null effect of EU structural funds on Southern Italy total factor productivity. On the other hand, Coppola et al. (2020) indicated a positive impact of EU cohesion policies in Italy.

In general, the literature highlighted the relevant role of public infrastructures financed through EU cohesion policies. More importantly, sound evidence has been provided on the

fundamental role played by the quality of local institutions in favouring the impact of public capital expenditure on economic performance.

3. Public capital stock at the regional level

3.1 Construction of public capital stock series

The data on public capital stock is not available in Italy at the regional level. The Italian National Institute of Statistics (Istat) provides data only for total capital stock at the national level without distinguishing between private or public expenditure. Therefore, to obtain the series of regional public capital stock, we accomplish the following steps: (i) compute the series of total regional capital stock; (ii) compute the regional capital stock for the public component; (iii) decompose total capital in its public and private components.

The initial value of the capital stock in 1999, which represents the base for the series' reconstruction, is computed considering the annual mean value of the national total capital stock for 1996-1999. Then, we divide the national stock in the base year 1999 among the regions using the methodology in Gleed and Rees (1979), also used by Marrocu and Paci (2010). More specifically, the regional capital stock value is based on the regional share of investments (weight 0.75) and labour units (weight 0.25) in the preceding five years. Next, the total capital series for each region has been computed for the period 2000 to 2019 by applying the perpetual inventory method, which entails that the value of the capital stock at time t is equal to the value at time $t-1$, augmented by investment measured at time t and diminished by depreciation (we assume a 10% depreciation rate). Regional data on gross fixed investment, published by Istat, are in constant prices.

The second step entails constructing the public capital series using the investment expenditures of the Extended Public Sector (SPA). It is important to remark that the SPA includes public administrations and public companies, thus allowing for a more comprehensive assessment of the public investments' impact on the economy. The CPT database has been provided by Territorial Cohesion Agency, and it contains data for capital expenditure categories disaggregated into 29 activity sectors.

It is worth remarking that we consider a broad definition of public investments in this paper. In addition to the categories "real estate assets and works" and "movable property, machinery", we also include "capital transfers to households and social institutions" and "capital transfers to private undertakings". In such a way, our definition of public capital embraces the capital expenditures financed by the public sector, although the investment is realised by private entities.

The SPA dataset distinguishes five bodies responsible for the investments' implementation. The "central administration" includes the Italian State and government agencies such as the Revenue Agency, CDP (Cassa Depositi e Prestiti), and ANAS (the national Agency for roads). The "regional administration" encompasses the regional government and the local health units. The "local administration" embraces municipalities, provinces, and other territorial entities such as municipalities' unions, universities, port authorities and national parks. The "national public companies" include firms under the direct control of the government. Often, they are former public monopolies transformed today into private companies, listed on the stock exchange, but where the State still owns a relevant share.² Finally, the "local public companies" level comprises firms owned by the regional and local administrations, usually operating in local public services (water, transports, energy) and agrarian consortiums and cultural foundations.

This disaggregation is crucial for our analysis, which aims to investigate whether the impact of public capital depends on the level of government responsible for the expenditures. As before, the public capital stock series have been constructed using the perpetual inventory methodology with a 10% depreciation rate from 2000 to 2019. The initial value of regional public capital has been computed using the annual average share of regional public investments on regional total investments between 1996 and 1999. Following the same methodology, we have also obtained a series of public capital stock disaggregated into economic sectors and levels of government.

Finally, in the third step, we compute the private capital component as the difference between total and public capital.

To check whether our calculation of public capital based on CPT data sounds reliable, we compare our national series with the one computed by the International Monetary Fund (IMF) which is based on national accounts data. IMF (2017) shows that in Italy, over the years 1999-2014, the share of public capital stock over the total is equal to 22%. This estimate is very similar to the share (24%) we have computed using the broad definition of public investment, including physical works, machinery, and capital transfers to households and firms. Based on this result, we focus on the broad definition of public capital in the empirical analysis since it appears more coherent with the National Accounts.

3.2 Descriptive statistics of public capital series

Figure 1 displays Italy's total and public capital stock series over the years 2000-2019. The total capital stock decreased at a notable rate (-1.28% yearly) during the observed period. The decline

² Notable examples are ENI (the energy company), ENEL (the electrical company), Poste Italiane (the postal service), and Ferrovie dello Stato (the railway company).

in the capital accumulation process appears even more pronounced after the financial crisis of 2008. On the other hand, the level of public capital remains almost unchanged until 2009 and starts decreasing afterwards.

Table 1 reports the share of the public over total capital stock and some summary measures for the public stock of capital, namely index numbers for per capita and per unit of labour. In general, the share of public capital expenditure over the total is persistently increasing, and it reaches the value of 24.6 in 2019. The public component of the capital stock is more relevant in Southern Italy (36% in 2019). Public capital per labour unit is higher in Southern Italy even if they decrease over time, while they increase in the rest of the country. Figure 2 represents the regional shares of public capital (panel 1) and the regional public capital per labour unit (panel 2) in 2019. The maps show important differences between Northern and Southern Italy in both cases. Together with the small autonomous regions in the Alps, the Southern regions show a much higher presence of public investment.

Table 2 reports, for the years 2000 and 2019, the share of public capital stock for the five levels of government responsible for the capital expenditure. Interestingly, local administrations in the North show the highest share of public capital in 2000, while in Southern and Central Italy the highest shares are exhibited by the central administration and national public companies. It is worth remarking that the role of the national public companies has strongly increased over time, and in 2019 they manage 36% of national public capital expenditure. On the other hand, the role of local, regional and central administrations decreases over time (by -7, -3, and -5 percentage points, respectively). The considerable differences in the share of local public companies among the areas are also interesting: they play a relevant role in the North (15% in 2019) while they control a small share of public capital stock in the Southern regions (5% in 2019).

Table 3 reports the average shares over the years 2000-2019 of public capital stock for the five institutional levels for each region. As expected, the highest share for the regional administrations is shown by the six territories granted an autonomous status like Trento (47%), followed by Bolzano, Valle d'Aosta, Sardegna, Sicilia and Friuli-Venezia Giulia. Considering the whole period, central administrations play a key role in Southern regions, with Calabria showing the highest share, followed by Campania. National public companies exhibit a high capital expenditure in the Central regions (especially in Lazio and Toscana), whereas they play a limited role in Southern Italy. Finally, local public companies have an essential role in Northern regions like Emilia Romagna, Lombardia and Veneto, where companies owned by local administrations control a large part of local public services like transport, water, energy.

CPT data distinguishes between 29 sectors, which have been aggregated into 5 macro-sectors to allow for a more tractable and meaningful analysis (see Table A2 in the Appendix for the complete

list).³ Table 4 displays the percentage share of public capital stock for the different economic macro-sectors series in the starting (2000) and final (2019) years. Considering the whole period, the production sector is the main component of public capital stock in Italy (32%) and its share increases over time (+10 percentage points between 2000 and 2019). Northern and Central Italy display a similar composition of public capital with a prominent and increasing role played by the production sector (respectively 36.9% and 39.4% in 2019) and relevant percentages for infrastructures (respectively 27.3% and 25.6%). In contrast, the production sector is prominent (43.7%), and infrastructures account for a much lower proportion (22.7%) in the Southern regions.⁴

Overall, a highly differentiated picture among the regions emerges regarding the government levels responsible for capital expenditures and the sectoral distribution of the capital expenditures. We will consider this heterogeneity in the econometric analysis.

4. Production function model and data

4.1 The model

The role of public capital in the Italian regions over the period 2000-2019 is assessed by estimating a Cobb-Douglas production function considering different levels of disaggregation of the total capital stock and including a set of controls for the intangible factors and territorial characteristics of the regions.

The general formulation of the model is:

$$Y_{it} = A_i L_{it}^\alpha K_{it}^\beta QI_{it}^\delta \prod_{j=1}^J X_{j,it}^{\gamma_j} e^{\varepsilon_{it}} \quad (1)$$

where Y is regional value added in constant prices 2010, L are units of labour, K is total public capital stock, X is a set of $J=4$ control variables and A represents the total efficiency level. The subscript i indicates the region, while t refers to the time period. As an additional variable, in model (1) we also include the Quality of Institutions (QI), because, as argued in the previous sections, it exerts a pervasive role in driving economic outcomes, especially when public bodies are directly involved in investment decisions and indirectly by setting the normative and regulatory framework. Moreover, to control for regional heterogeneity, we include three immaterial factors: the endowments of human

³ The five macro-sectors are: "general" sector (includes general public services, public order, justice administration, health and social welfare); "intangibles" sector (education, R&D, culture and recreational services); "infrastructures" (transports and telecommunications); "environment" (waste disposal and integrated water service); "production" (sectoral economic activities).

⁴ The sectoral shares at the regional level are reported in Table A3 in the Appendix.

capital, social capital, and technological capital, which play a decisive role in enhancing the effectiveness of production inputs. Population density is also included to take into account demographic trends and possible agglomeration effects.

As discussed in section 3, the total capital stock can be disaggregated into private and public capital. The latter can also be considered at the level of bodies in charge of carrying out the investments and disaggregated according to the sectors of activity.

Because our data is considered at the regional level, we cannot use the control function approach, usually applied to firms' level data, to deal with the issue of potential endogeneity of the main productive inputs. For this reason, we adopt an instrumental variable approach and the Two Stage Least Squares (2SLS) estimation method. Labour and capital stock are instrumented by their own five-year lagged variables in all the estimated models. Although the choice of such a long lag comes at the cost of reducing the estimation sample size, it allows us to tackle more effectively endogeneity threats with respect to the case of shorter lags.⁵

Moreover, all the contextual variables are included with a five-year lag, which allows us to consider a period long enough for the contextual variables to exert their effects on the dependent variable and guard against the potential problem of reverse causality.

Due to the small time dimension of the panel and the number of regional contextual variables, which exhibit persistent cross-region variation, we do not include regional fixed effects. However, to take into account the time-invariant divide between the Centre-North and the Southern areas, we include a dummy variable *South* that takes the value of 1 for the eight Southern regions.⁶ Finally, time dummies (λ_t) are included to account for common shocks at the macroeconomic level.

The empirical specification is obtained by log-linearising model (1) and accounting for the lag structure discussed above:

$$y_{it} = a_i + \alpha l_{it} + \beta k_{it} + \delta q_{it-5} + \sum_{j=1}^{J=4} \gamma_j x_{jit} + South_i + \lambda_t + \varepsilon_{it} \quad (2)$$

Before presenting and discussing the main empirical results in the next sub-section we provide a detailed description of the most salient features of the variables used in our analysis other than the stock of capital, which has been already described in section 3.2.

⁵ We have also estimated the models with using as instruments for labour and capital stock variables their six-year lagged values. The results remain unchanged.

⁶ In a preliminary analysis we also included a dummy variable for the 9 Northern regions, however no significant differences were found with respect to the reference group of regions, i.e. the 4 Centre ones.

4.2 Data

We start by providing a statistical description for the dependent variable, regional value added, followed by institutional quality and the main contextual variables, namely human capital, social capital and technological capital. Table 5 and Figure 3 report the summary statistics of all the variables while the complete list of the variables and their sources is reported in Table A1 in the Appendix.

The Italian value added (VA) series shows a sharp decrease after the financial crisis of 2008 (-5.4% between 2008 and 2009) and after the Italian debt crisis of 2011 (-4.2% between 2011 and 2013). Looking at the per capita VA, the Southern regions are well below the national average (index 61 in 2019), while Northern Italy has an average value 13% higher than the national one, confirming the huge and even increasing economic differences between the two areas.

In the econometric analysis, as factors influencing the economic performance at the regional level, we consider the intangible assets whose effect on the production has been largely documented in the empirical literature on regional economic growth. Among them, we devote specific attention to the quality of the institutions in the region since a large share of public investment is implemented at the local level by administrations and public companies. Seminal contributions have emphasised the role of institutions in determining the performance of economic systems (among others, North 1990, Acemoglu et al. 2001, Glaeser et al. 2004). A high-quality government ensures the provision of more efficient public services, thus supporting local economic development. More recently, the growth-enhancing effect of institutions at the regional level has been remarked by Rodríguez-Pose (2013) and Rodríguez-Pose and Ganau (2022). In this paper, we use the Quality of Institutions (QI) index computed by Nifo and Vecchione (2014) as a composite index based on various measures of corruption, government effectiveness, regulatory quality, rule of law, and voice and accountability.⁷

Considering the other contextual variables, a large body of the literature has examined the positive influence of human capital on economic performance at the country level (Murphy et al. 1991, Benhabib and Spiegel 1994) and the local one (Moretti, 2004). The availability of well-educated labour forces favours the localisation of innovative firms, thus promoting regional productivity. As a proxy for high human capital, we use the percentage of people aged 25-64 with a tertiary education level (ISCED 5–6).

Social capital is a complex feature of social organisation which improves the efficiency of the local society and the transmission of knowledge by increasing the level of trust and thus, in turn, facilitating the cooperation among actors and reducing transaction costs for both firms and consumers

⁷ This index is similar to the Quality of Government Index computed by Gothenburg University for the European regions (Charron et al., 2015).

(Putnam 1993, Knack and Keefer 1997, La Porta et al. 1997; De Blasio and Nuzzo, 2009 for the Italian regions). In this paper, we proxy social capital by the number of people (per 100 inhabitants over 14 years old) that have taken part at least once in the last 12 months in social activities such as voluntary service (Dettori et al. 2012, Beugelsdijk and Van Schaik 2005).

The positive role played by technological capital in promoting productivity has been stressed in the literature following the original contribution by Griliches (1979). Firms may enjoy positive externalities deriving from the local availability of technology, enhancing the local economic performance (Rodriguez-Pose and Crescenzi 2008; see Audretsch and Feldman 2004 for a comprehensive survey). Technological capital is proxied by R&D expenditure over GDP.⁸

Table 5 and Figure 3 show a clear dualistic pattern between Northern and Southern Italy for all the exogenous factors considered. In the case of institutional quality, the Southern average is about half of the national one, while the Northern average is 2.4 times higher than the Southern one. As expected, institutional quality is particularly low in territories characterised by the presence of criminal organisations such as Sicilia (32), Calabria (32) and Campania (42). Social capital shows a less dramatic difference, but the gap between the South and the North is still remarkable, as the two areas are, on average, 65 percentage points apart. The regional differences are very high, with Trento showing in 2019 the highest value, which is 4.3 times higher than the lowest one in Sicilia. Human capital shows a minor difference between Northern and Southern Italy. At the same time, Central regions have the highest level of graduates with an average value of 19% higher than the national one. Differences between Northern and Southern Italy have decreased over time for social capital and institutional quality, whereas they have increased for human capital (6 percentage points in 2000 vs 25 percentage points in 2019). Technological capital is similarly distributed as human capital: Central regions display the highest mean value, even if, in this case, it decreases with time (129 in 2000 vs 110 in 2019). In this case, Southern and Northern Italy show significant and growing differences (32 percentage points in 2000 vs 45 percentage points in 2019).

5. Results

In this section we present the main results of the empirical analysis. We first discuss the evidence obtained by models in which the capital stock is included as an aggregate or by considering its private and public components. The analysis then proceeds by assessing whether the effects of public capital change significantly depending on the level of the administrations in charge of

⁸ We cannot use granted patent data since they are usually organised by year of applications and therefore the series is available only until 2012.

managing public investments (central vs local bodies) or the sector of policy interventions. Finally, we discuss the results of the most general model in which we allow the effect of public capital to change according to both levels of government and intervention sectors. Throughout the analysis we pay particular attention to the role of institutional quality and North-South differences.

5.1 *The basic model*

Table 6 reports the main results. In the first specification the capital stock is considered at the most aggregate level. The elasticity of labour is 0.6, while the total capital stock shows an elasticity of 0.38. With respect to previous studies on the Italian case covering the pre-crisis period (Marrocu and Paci, 2010) the estimated return appears higher for the capital input and lower for the labour input. The quality of institutions' variable exhibits the expected positive and significant elasticity. On the contrary, the other intangible assets are not statistically significant; this unexpected result is reasonably due to the high collinearity among the contextual variables. Among the territorial covariates, the population density shows a positive and significant impact signalling the relevance of agglomeration effects, while the dummy South has the expected negative sign, although it is not statistically significant.

In column 2 we include the capital stock according to its two components, private and public capital. They turn out to be both significant with the public stock displaying a higher elasticity (0.36) with respect to the private one (0.23). The public capital elasticity results three times higher than the one estimated by Marrocu and Paci (2010) for the years 1996-2003. Therefore, it seems that in recent years the role of public institutions in affecting production level has increased.

Interestingly, the human capital endowment turns out to be significant; the quality of institutions maintains its significance and shows a higher elasticity; this is also the case for population density. In this specification, the dummy South has a negative and significant coefficient signalling that, holding all other variables constant, the Mezzogiorno's regions are less productive with respect to the rest of the country.⁹

Before considering the specifications in which the public capital stock enters disaggregated according to the administrative level of the bodies responsible for the investments and the macro-sectors benefitting from such public interventions, we tackle the issue of possible spatial dependence among the territorial units. To test for global spatial dependence, we carried out the Moran's *I* test on the residuals of the second model in Table 6. To perform the test, we use both the first order contiguity

⁹ We have also computed a more restricted definition of public capital, excluding the transfers to families and firms. Estimation results using the narrower definition of public capital for the baseline model (model 2, Table 6) are very similar. However, the public capital elasticity using the narrow definition (0.29) is lower with respect to the wider one (0.36).

matrix and the inverse distance one¹⁰; both matrices are max-eigenvalue normalised (Kelejian and Prucha, 2010). In both cases the test was not significant: p-value=0.308 when the contiguity matrix was used and p-value=0.538 when the inverse distance matrix was employed. We also test for local spatial dependence by re-estimating model 2 of Table 6 according to a SLX (Spatial Lag of X) specification (Elhorst, 2014). Thus, we augment the model by including the spatial lags of the productive inputs. As shown by the results reported in the third model of Table 6, we find no evidence of local spatial dependence. Based on this finding, we proceed to investigate the effects of public capital by proposing more advanced specifications, whose baseline counterpart is represented by model 2 of Table 6.

5.2 Public capital by government bodies

In Table 7 we propose the results for models in which the public capital stock is included according to the institutional level of the administrative bodies in charge of carrying out public investments. We distinguish between *central* bodies (central administration and national public companies) and *local* bodies (regional and local administrations, local public companies). In model 1 of Table 7 we restrict the elasticities of public capital to be the same for the whole country and find that local bodies are slightly more effective (0.077) than central ones (0.061), as in Bom and Ligthart (2014). However, when we allow the elasticities to vary between Centre-Northern regions and Southern ones, sizeable and significant differences emerge.¹¹ Central bodies in the Southern regions exhibit almost twice the elasticity (0.094) of the Northern regions (0.054), whereas the opposite is the case for local bodies. Northern regions exhibit an elasticity (0.099) much higher with respect to Southern ones (0.066).

Since our models include the current quality of institutions and a number of other factors which are expected to account for North-South differences, varying administrative level elasticities could be due to such variables not being adequate enough to control for latent traits related to institutional quality and social capital (Durlauf, 2002), as they are inherently difficult to measure. Another possible explanation could be related to an almost "intrinsic" way of functioning of Italian public administrations, rooted in the country's historical development, so strongly influenced by its geography. As argued by Daniele et al. (2018), the process of modern growth that started in Italy in the late XIX century brought about structural changes, differentiated access to markets agglomeration dynamics that set the two macro-areas of the country on quite diverging paths, with the Northern one more densely interconnected with the wider and competitive European continental markets resulting

¹⁰ Distance between any two regions is computed with reference to their centroids.

¹¹ Note that for multicollinearity issues the dummy South is not included in model 2.

in a more open and vibrant socio-economic environment. Such development process reasonably had important effects also on the administrative practices and ruling approaches of local government bodies, although the legislation and the normative setting have been the same across the whole country.

Notwithstanding such effects, the arguments advanced in Bigoni et al. (2016) could provide a more profound and convincing explanation of local administrations' varying effectiveness, which emerges from our results. Bigoni et al. (2016), using a lab-in the field experiment, show that the persisting North-South divide can be explained in terms of a behavioural gap in cooperation, implying differences in the way people react to incentives in the two macro-areas of the country, which in turn reveal differences in preferences, expectations and social norms. Such lack of cooperative behaviour has apparently prevented Southern territories from taking advantage of the regional autonomy, enhanced by the 2001 devolution reform of Title V of the Italian constitution. For the Southern regions, the devolution resulted in a more fragmented political environment, higher pressure from specific stakeholders, and narrow administrative-decision capabilities to deal with the challenges the Mezzogiorno has to confront. These include persistent issues, such as demographic trends, brain drain, low attractiveness for external investment, and the new ones brought about by the pandemic crises and the severe instability of the international scenario. These considerations help in explaining the estimated lower elasticities of Mezzogiorno's public capital once controlling for the positive role of institutional quality.

5.3 Public capital by macro-sectors

Table 8 reports the main results of the analysis carried out to assess the role of public capital according to the macro-sectors of policy interventions. As discussed in section 3 (see also Table TA2), we distinguish among public investments related to *general* administration, *infrastructures* in the *intangibles'* assets, *infrastructures*, *environment* and *production* activities. Model 1 results indicate that the highest elasticity is exhibited by the public capital endowment in the intangibles (0.14), followed by the infrastructures (0.09) and the production sector (0.04). The high heterogeneity of the public expenditures' impact across sectors in the Mezzogiorno has been found by Albanese et al. (2020), who remarked the positive role of the investment in infrastructures. Similar results have been found by Crescenzi et al. (2016) for the impact of transport infrastructures in the European regions, which turns out to be positively associated with the quality of regional government.

Elasticities for the general and environment macro-sectors are not significant. This result might be due to a more indirect role of such kind of public capital on the level of production, but also to multicollinearity issues as the variables are highly correlated. It is worth noting that results for all

the other variables included in the model and previously discussed are confirmed. In models 2-4 we test whether the significant elasticities for intangible capital stock, infrastructures and production macro-sectors are the same across the Northern and Southern macro-areas of the country. Because of multicollinearity issues, we add the interactive term with respect to the South dummy one at a time while keeping all the variables already included in model 1. All interactive terms are significant and exhibit a negative sign, indicating that macro-sectors elasticities are lower for Southern regions. Differences, however, are not sizeable: 0.142 vs 0.134 for intangible capital stock, 0.087 vs 0.081 for infrastructures and 0.039 vs 0.035 for the production macro-sector; in all cases they are higher than 90% of the Northern elasticities.

5.4 Public capital by bodies and sectors

This section considers whether significant differences in elasticities across sectors could be related to the government level in charge of public investments. Column 1 in Table 9 reports a specification where public capital for each of the five sectors is included according to the central or local body carrying out the expenditure. Interestingly, it emerges that the impact of central and local levels in each sector is highly differentiated.

As expected, the central government is more effective in general public investment, which comprises the typical centralised activities like public order, justice, defence and health. The impact of public expenditure carried out by the central bodies is positive and significant also in the production sector. This is a predictable result since most of the transfers to the firms, which are a relevant share of public investment in the production sector, are managed by the central bodies. Finally, public capital in the environment sector performed by the central bodies turns out to be negative and significant, which may signal a sort of displacement effect for capital expenditure in other sectors more directly related to value added. Although crucial to enhancing long-run economic performance, the interventions to protect the environment are less likely to produce economic effects at shorter horizons.

A highly differentiated picture appears when we look at the sectoral effects of public capital managed by local bodies. In this case the coefficients are not significant for the general, environment and production sectors. Contrary to what was found for the central levels, local bodies are significantly effective in the provision of public capital related intangibles (education, culture, training) and infrastructures sectors. This result has relevant policy implications because the increase in the endowment of capital in such sectors is crucial for driving regional performance along sustainable, innovative, high-value growth trajectories. Hence, the quality of local institutions is

pivotal for territories, such as the Italian Mezzogiorno, in need to bridge persistent gaps in their socio-economic development process.

To investigate more on these positive impacts, we allow for the public capital coefficient in intangibles (model 2) and infrastructures (model 3) managed by local bodies to be different for the Southern regions. For both sectors, the public capital performed by the Mezzogiorno local administrations exerts an impact that is lower than the Centre-North one.

These results generally highlight that local and central bodies have a specialised objective that appears highly differentiated across sectors. Their heterogeneous sectoral impact on the regional production levels calls for great attention in the definition of both general and place-based policy measures and in the allocation of financial resources.

6. Conclusions

This study aims to evaluate the impact of public capital stock and institutions' quality on regional economic performance. Such an assessment is crucial to evaluate the European and national economic growth policies and to assess the ability of the local institutions in Italy to efficiently invest the vast NRRP resources they are about to receive to boost the economy after the pandemic crisis.

The regional series of public capital stock - and their disaggregation into different macro-sectors or according to various government levels managing the funds – have been reconstructed using the data on investment expenditures of the Extended Public Sector made available through the CPT database. Our novel database comprises all investment expenditures by national and local administrations and public companies. Therefore, it includes the capital expenditures financed by the EU structural funds, whose effects are thus implicitly considered in our analysis. We estimate Cobb-Douglas production functions relationships, including the standard production inputs such as labour units, private and public capital stock, together with the institutions' quality, intangible assets and territorial features. Production functions have been estimated using the 2SLS methodology to deal with endogeneity issues.

The first result is that public capital stock plays a positive role in driving the level of production, with a higher elasticity with respect to the private one. A second important finding is the role played by the quality of institutions; a variable often neglected in previous studies on production function estimation because of a lack of reliable data. The positive and significant elasticity exhibited in all specifications remarks the importance of public institutions for fostering development processes and enhancing economic growth.

The disaggregation of public capital into macro-sectors has shown a high degree of heterogeneity in its impact on production levels. A crucial role is exerted by the intangibles, remarking the productivity-enhancing effect of capital accumulation in culture, human capital, training and research. Positive and significant elasticities have also been estimated for the infrastructures like transports and telecommunications. A positive effect is found for the public capital directly devoted to the production sectors, including capital transfers to private companies to support their investments.

A central result of our analysis is the considerable difference across territorial areas and sectors in the impact of capital expenditure realised by central and local institutions. Considering the disaggregation into government levels, it turns out that in Southern Italy, central bodies display almost twice the elasticity of Centre-North. The opposite result is found for the local bodies, which prove much less effective in the Southern regions. After having accounted for institutions' quality and other territorial factors, the different elasticities estimated for local institutions across the country might be rooted in the country's historical development and, more specifically, in the persisting North-South behavioural gap in cooperation which entails a different way of reacting to incentives. This, in turn, could also have shaped the different ways of public administrations functioning across macro-areas of the country.

The low elasticity estimated for the public capital stock realised by Southern local administrations cast shadows on the success of NRRP and other cohesion policies. More than 120 billion euros should be invested by the local institutions in the Southern regions respecting the EU rigorous rules in the next years. The inefficiency and inadequacies that characterised Southern local administrations might determine the policy's failure, losing a unique opportunity to narrow the economic gap between North and South of Italy.

To avoid these negative consequences, it is necessary to act urgently at least in two directions. In the short run, since the programs must be in place immediately and the expenditures completed in a few years, the central government must help the local administrations by making available in each Southern region a task force of experts to follow the implementation phases of the programs.

As our results have shown, the low quality of institutions is one of the most relevant factors that continue to slow down Mezzogiorno's development. Adopting long-run policies to address such profound and structural issues is imperative. Obviously, increasing the quality of the local institutions is not an easy task, as demonstrated by decades of failures of the North-South territorial rebalancing policies in Italy. If local institutions' quality is rooted in the country's historical development, it cannot be simply changed or improved by central government law. What is essential is a profound change in people's social norms in the Southern regions, which can be attained only through a long-term

education policy. Investing, for a long period of time, considerable human and financial resources in the schooling and university system in the Southern regions seems the only policy able to remove the persistent territorial divide in Italy and activate a virtuous and self-reinforcing mechanism by which increasing levels of human capital create a more favourable local environment for families and firms and contribute to further enhance the quality of institutions.

Finally, it is worth noting that our results also have external validity. Several European regions, or even countries, share with the Italian Mezzogiorno similar structural gaps – in terms of human capital, quality of institutions, innovative capacity and per capita income – and have to confront the challenge of effectively managing the EU Next-generation funds to recover from the pandemic crisis and to counterbalance the international scenario instability.

References

- Acemoglu D., Johnson S., Robinson J.A. (2001) The colonial origin of comparative development: an empirical investigation, *American Economic Review*, 91, 1369–1401.
- Agénor P.R., Neandis K.C. (2015) Innovation, public capital and growth, *Journal of Macroeconomics*, 44, 252–275.
- Albanese G., Carrieri V., Speziali M.M. (2021), Looking for a Star: Evaluating the Effect of the Cohesion Policy on Regional Well-Being, *IZA DP No. 14521*.
- Albanese G., De Blasio G., Locatelli A. (2020) Does EU regional policy promote local TFP growth? Evidence from the Italian Mezzogiorno, *Papers in Regional Science*, 100: 327-348.
- Aray H. (2019) A new approach to test the effects of decentralisation on public infrastructure investment, *Regional Studies*, 53:7, 1042-1057.
- Aschauer D.A. (1989) Is public expenditure productive? *Journal of Monetary Economics*, 23, 177-200.
- Audretsch, D.B., Feldman. M. (2004) Knowledge Spillovers and the Geography of Innovation, in J.V. Henderson and J.F. Thisse (eds.), *Handbook of Regional and Urban Economics: Cities and Geography*. Amsterdam: Elsevier, 2713–2740.
- Benhabib, Jess and Mark M. Spiegel. (1994) The Role of Human Capital in Economic Development: Evidence from Aggregate Cross-country Data, *Journal of Monetary Economics*, 34, 143–173.
- Beugelsdijk S. and Van Schaik T. (2005) Social capital and growth in European regions: an empirical test, *European Journal of Political Economy* 39, 301–324.
- Bigoni M., Bortolotti S., Casari M., Gambetta D., Cambotto F. (2016) Amoral Familism, Social Capital, or Trust? The Behavioural Foundations of the Italian North-South Divide, *Economic Journal*, 126, 1318-1341.
- Bom P.R.D., Ligthart J.E. (2014) What have we learned from three decades of research on the productivity of public capital?, *Journal of Economy Surveys* 28:5, 889–916.
- Charron N., Dijkstra L., Lapuente V. (2015) Mapping the regional divide in Europe: a measure for assessing quality of government in 206 European regions. *Social Indicators Research*, 122: 315–346.
- Coppola G., Destefanis S., Marinuzzi G., Tortorella W. (2020) European Union and nationally based cohesion policies in the Italian regions, *Regional Studies*, 54:1, 83-94.
- Cosci S., Mirra L. (2018) A spatial analysis of growth and convergence in Italian provinces: the role of road infrastructure, *Regional Studies*, 52:4, 516-527.
- Crescenzi R., Di Cataldo M., Rodriguez-Pose A. (2016) Government quality and the economic returns of transport infrastructure investment in European regions. *Journal of Regional Science*, 56: 555–582.
- Crescenzi R., Giua M. (2020) One or many Cohesion Policies of the European Union? On the differential economic impacts of Cohesion Policy across member states, *Regional Studies*, 54:1, 10-20.
- Dall'Erba S., Fang F. (2017) Meta-analysis of the impact of European Union Structural Funds on regional growth, *Regional Studies*, 51:6, 822-832.
- Daniele V. (2009) Regional convergence and public spending in Italy. Is there a correlation?, *MPRA Paper No. 14334*.

- Daniele V., Malanima P., Ostuni N. (2018) Geography, Market Potential and Industrialization in Italy 1871-2001, *Papers in Regional Science*, 97, 639-662.
- De Blasio G., Nuzzo G. (2009) Historical traditions of civiness and local economic development, *Journal of Regional Science*, 50: 4, 833–857.
- Dettori B., Marrocu E., Paci R. (2012) TFP, intangible assets and spatial dependence in the European regions, *Regional Studies*, 46(10) 1401-1416.
- Di Caro P., Fratesi U. (2022) One policy, different effects: Estimating the region-specific impacts of EU cohesion policy, *Journal of Regional Studies*, 62, 307-330.
- Durlauf S.N. (2002) On the Empirics of Social Capital, *Economic Journal*, 112, 459-479.
- Elhorst J.P. (2014) *Spatial econometrics. From cross-sectional data to spatial panels*. Heidelberg: Springer.
- Fournier J. (2016) The positive effect of public investment on potential growth, *OECD economics department working papers*, 1347.
- Glaeser E.L., La Porta R., Lopez-de-Silanes F., Shleifer A. (2004) Do institutions cause growth? *Journal of Economic Growth*, 9: 271–303.
- Gleed R. H., Rees R. D. (1979) The Derivation of Regional Capital Stock Estimates for UK Manufacturing Industries. 1951-1973, *Journal of the Royal Statistical Society. Series A (General)*, Vol. 142, No.3, 330-346.
- Gómez-Antonio M., Fingleton B. (2012) Regional productivity variation and the impact of public capital stock: an analysis with spatial interaction, with reference to Spain, *Applied Economics*, 44:28, 3665-3677.
- Griliches Z. (1979) Issues in Assessing the Contribution of Research and Development to Productivity Growth, *The Bell Journal of Economics*, 10, 92–116.
- Gupta S., Kangur A., Papageorgiou C., Wane A. (2014) Efficiency-adjusted public capital and growth, *World Development* 57, 164–178.
- Han J., Ryu D., Sickles R. (2017) How to Measure Spillover Effects of Public Capital Stock: A Spatial Autoregressive Stochastic Frontier Model, *Advances in Econometrics*, 37, 259-294.
- Holtz-Eakin D. (1994) Public-sector capital and the productivity puzzle, *Review of Economics and Statistics*, 76, 12-21.
- International Monetary Fund/IMF (2017) IMF investment and capital Stock dataset, 2017, *IMF*, Washington, DC.
- Kamps C. (2004) New estimates of government net capital stocks for 22 OECD countries 1960-2001, *IMF working paper*, W.P./04/67
- Kelejian H.H., Prucha I.R. (2010) Specification and estimation of spatial autoregressive models with autoregressive and heteroskedastic disturbances, *Journal of Econometrics*, 157, 53-67.
- Knack S., Keefer P. (1997) Does Social Capital Have an Economic Payoff? A Cross-country Investigation, *Quarterly Journal of Economics*, 112, 4, 1251-1288.
- La Porta R., Lopez-de-Silanes F., Shleifer A. and Vishny RW (1997) Trust in large organisations, *American Economic Review Papers and Proceedings* 87, 333–338.
- Lasagni A., Nifo A., Vecchione G. (2015) Firm productivity and institutional quality: Evidence from Italian industry, *Journal of Regional Science*, 55(5), 774–800.

- Marrocu E., Paci R. (2010) The effects of public capital on the productivity of the Italian regions, *Applied Economics*, 42: 8, 989—1002.
- Moreno J.D.J., Romero J.M., Zorzona C.C., Castillo L.L. (2015) Effects of public capital on economic growth and productivity in Spain during the period 1980-2007, *Journal of Economic Development*, 40:4.
- Moretti, E. (2004) Workers' Education, Spillovers, and Productivity: Evidence from Plant-Level Production Functions, *American Economic Review*, 94, 656–690
- Munnell A.H. (1990) How does public infrastructure affect regional economic performance?, *New England Economic Review*, (September/October), 11-32.
- Murphy K.M., Shleifer A., Vishny RW (1991) The Allocation of Talent: Implication for Growth, *Quarterly Journal of Economics*, 106, 2, 503-530.
- Nifo A., Vecchione G. (2014) Do Institutions Play a Role in Skilled Migration? The Case of Italy, *Regional Studies*, 48(10), 1628- 1649.
- North DC (1990) *Institutions, Institutional Change and Economic Performance*. Cambridge: Cambridge University Press.
- Núñez Serrano J.-A., Velázquez F.J. (2017) Is public capital productive? Evidence from a meta-analysis, *Applied Economic Perspectives and Policy*, 39:2, 313-345.
- Papagni E., Lepore A., Felice E., Baraldi A.L., Alfano M.R. (2021) Public investment and growth: lessons learned from 60-years experience in Southern Italy, *Journal of Policy Modeling*, 43, 376-393.
- Putnam R. (1993) *Making Democracy Work: Civic Traditions in Modern Italy*. Princeton University Press, Princeton, NJ.
- Rodríguez-Pose A, Ganau R (2022) Institutions and the productivity challenge for European regions, *Journal of Economic Geography*, 22(1), 1-25.
- Rodriguez-Pose A. (2013) Do institutions matter for regional development? *Regional Studies*, 47: 1034–1047.
- Rodriguez-Pose A., Crescenzi R. (2008) Research and Development, Spillovers, Innovation Systems, and the Genesis of Regional Growth in Europe, *Regional Studies*, 42, 51–67.
- Romp W., De Haan J. (2005) Public capital and economic growth: A critical survey, *European Investment Bank (EIB)*, 10:1, 41-70.
- Santiago R., Koengkan M., Fuinhas J. A., Marques A. C. (2020) The relationship between public capital stock, private capital stock and economic growth in the Latin American and Caribbean countries, *International Review of Economics*, 67, 293–317.
- Sturm J.E., de Haan J. (1995) Is public expenditure really productive? New evidence for the US and the Netherlands, *Economic Modelling*, 12, 60-72.

Figure 1. Total and public capital stock in Italy, 2000-2019

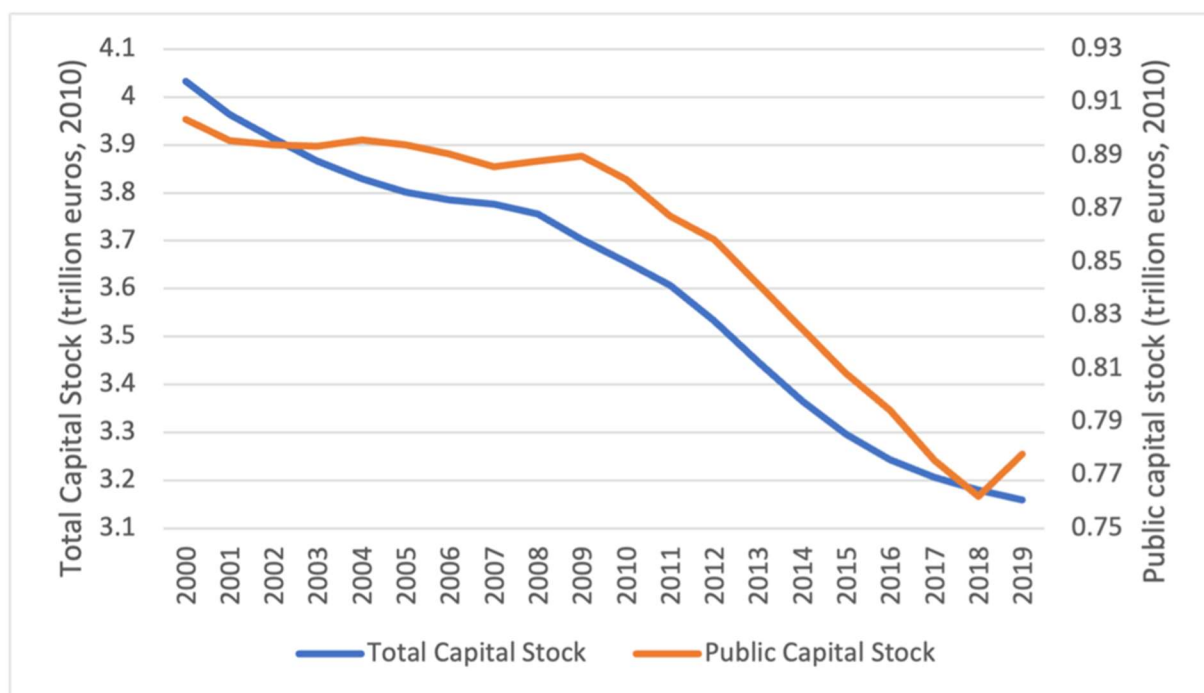


Figure 2: Regional distribution of public capital, 2019

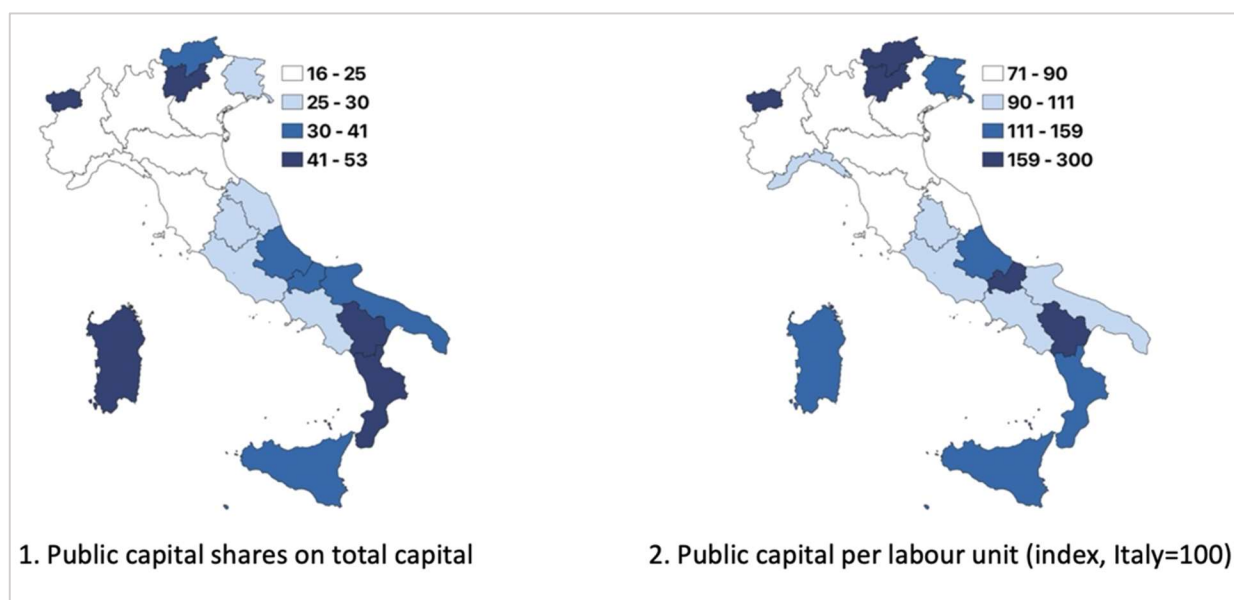


Figure 3: Regional distribution of main variables, 2019 (Indices, Italy = 100)

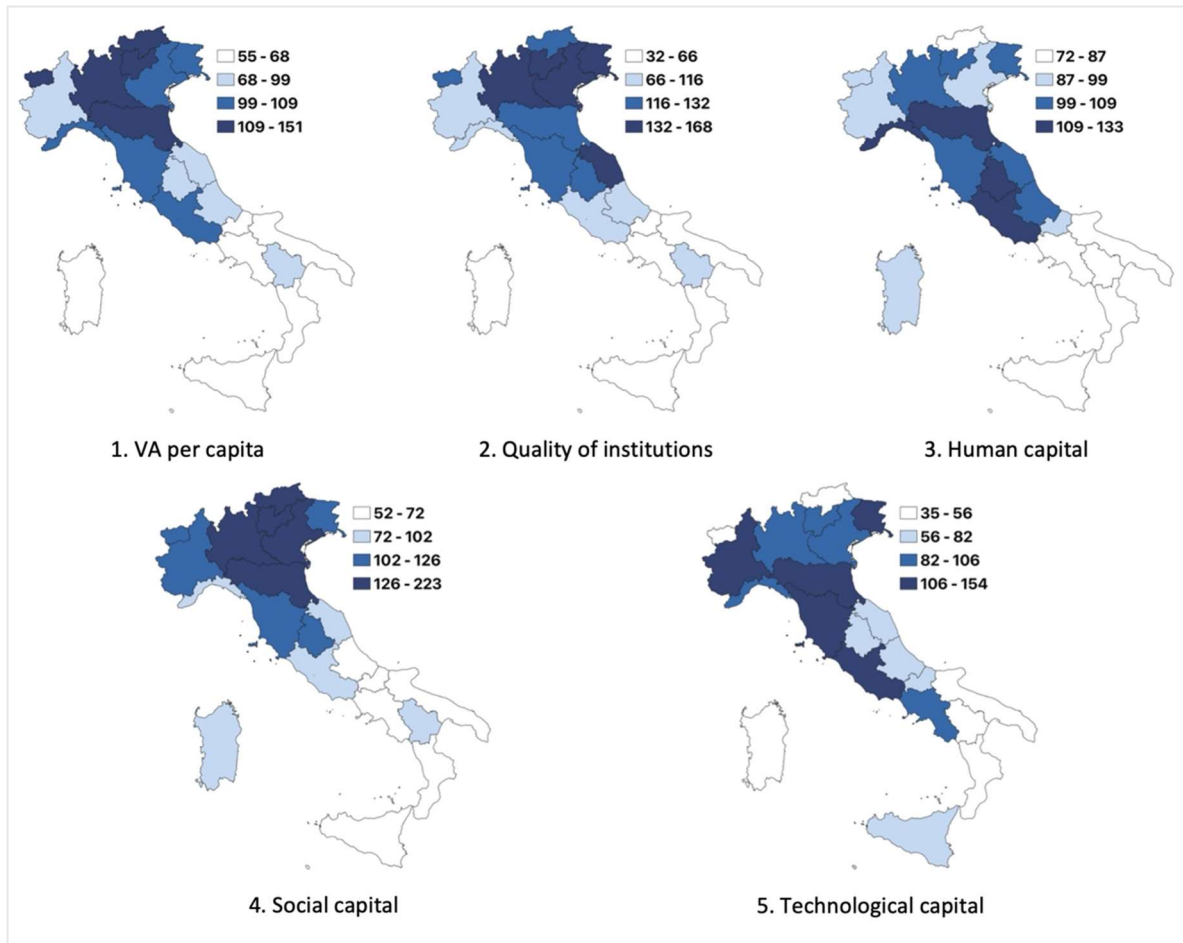


Table 1. Public capital stock by macro-areas

| | North | | Centre | | South | | Italy | |
|--------------------------|--------------|------|---------------|------|--------------|------|--------------|------|
| | 2000 | 2019 | 2000 | 2019 | 2000 | 2019 | 2000 | 2019 |
| Share on total stock (%) | 17.0 | 19.5 | 22.2 | 26.1 | 33.9 | 36.1 | 22.4 | 24.6 |
| Per capita (index) | 92 | 98 | 103 | 107 | 108 | 99 | 100 | 100 |
| Per labour unit (index) | 82 | 88 | 97 | 99 | 133 | 124 | 100 | 100 |

Table 2. Public capital stock by institutions and macro-areas (% share)

| Bodies | Macro-bodies | North | | Centre | | South | | Italy | |
|--------------------------|---------------------|--------------|------|---------------|------|--------------|------|--------------|------|
| | | 2000 | 2019 | 2000 | 2019 | 2000 | 2019 | 2000 | 2019 |
| Central administrations | Central | 16.2 | 15.7 | 25.3 | 23.6 | 34.4 | 24.0 | 25.1 | 20.1 |
| Regional administrations | Local | 16.8 | 12.8 | 7.6 | 5.4 | 15.8 | 12.6 | 14.6 | 11.2 |
| Local administrations | Local | 31.6 | 23.2 | 27.8 | 19.2 | 27.4 | 22.4 | 29.2 | 22.1 |
| National pub. companies | Central | 22.0 | 33.0 | 28.2 | 41.7 | 16.4 | 35.5 | 21.0 | 35.7 |
| Local pub. companies | Local | 13.4 | 15.3 | 11.2 | 10.1 | 6.0 | 5.4 | 10.1 | 10.9 |

Table 3. Public capital stock by institutions and regions

(% share, average 2000-2019)

| Region | Central adm. | Regional adm. | Local adm. | National public companies | Local public companies |
|-----------------------|-------------------------|--------------------------|-----------------------|--|---------------------------------------|
| Piemonte | 18.8 | 13.7 | 28.2 | 30.5 | 8.9 |
| Valle d'Aosta | 6.9 | 37.7 | 20.0 | 13.4 | 22.0 |
| Liguria | 22.8 | 6.8 | 31.3 | 28.5 | 10.6 |
| Lombardia | 17.1 | 9.4 | 30.1 | 26.4 | 17.0 |
| Prov. Bolzano | 3.7 | 43.9 | 27.9 | 9.8 | 14.7 |
| Prov. Trento | 5.7 | 46.6 | 26.0 | 8.5 | 13.3 |
| Veneto | 16.6 | 12.2 | 30.1 | 25.3 | 15.8 |
| Friuli Venezia Giulia | 10.7 | 22.6 | 31.2 | 20.9 | 14.5 |
| Emilia Romagna | 14.8 | 11.5 | 26.3 | 28.9 | 18.6 |
| Toscana | 16.1 | 10.7 | 29.3 | 32.4 | 11.5 |
| Umbria | 21.1 | 8.1 | 39.5 | 21.9 | 9.4 |
| Marche | 16.0 | 11.8 | 34.8 | 27.7 | 9.7 |
| Lazio | 30.8 | 3.3 | 18.9 | 35.5 | 11.5 |
| Abruzzo | 31.1 | 13.8 | 28.8 | 19.6 | 6.7 |
| Molise | 28.9 | 14.1 | 26.8 | 25.1 | 5.2 |
| Campania | 32.0 | 11.0 | 32.2 | 17.0 | 7.8 |
| Puglia | 31.0 | 9.0 | 25.6 | 29.9 | 4.6 |
| Basilicata | 29.7 | 14.8 | 24.2 | 27.1 | 4.2 |
| Calabria | 44.3 | 7.3 | 24.5 | 21.3 | 2.6 |
| Sicilia | 26.5 | 23.6 | 21.1 | 22.5 | 6.3 |
| Sardegna | 23.2 | 25.9 | 25.2 | 18.2 | 7.5 |

Table 4. Public capital stock by macro-sectors (% share)

| | North | | Centre | | South | | Italy | |
|-----------------|--------------|------|---------------|------|--------------|------|--------------|------|
| | 2000 | 2019 | 2000 | 2019 | 2000 | 2019 | 2000 | 2019 |
| General | 23.4 | 18.3 | 25.6 | 19.8 | 22.3 | 18.4 | 23.4 | 18.7 |
| Intangibles | 11.4 | 9.9 | 11.8 | 9.1 | 9.7 | 8.5 | 10.8 | 9.2 |
| Infrastructures | 29.4 | 27.3 | 31.2 | 25.6 | 23.0 | 22.7 | 27.3 | 25.4 |
| Environment | 9.2 | 7.6 | 7.9 | 6.2 | 8.2 | 6.7 | 8.6 | 7.0 |
| Production | 26.5 | 36.9 | 23.6 | 39.4 | 36.8 | 43.7 | 29.9 | 39.7 |

Table 5. Descriptive statistics, indices (Italy = 100)

| | North | | Centre | | South | |
|-----------------------------|--------------|------|---------------|------|--------------|------|
| | 2000 | 2019 | 2000 | 2019 | 2000 | 2019 |
| Value Added (per capita) | 113 | 113 | 105 | 102 | 63 | 61 |
| Quality of Institutions (a) | 135 | 132 | 112 | 118 | 54 | 55 |
| Human capital | 98 | 106 | 116 | 121 | 92 | 81 |
| Social capital (b) | 131 | 127 | 96 | 97 | 61 | 66 |
| Technological capital | 102 | 110 | 129 | 110 | 70 | 65 |

(a) initial year, 2004

(b) final year, 2018

Table 6. The effect of public capital on value added, 2000-2019

Dependent variable: value added

| | Model 1 | Model 2 | Model 3 |
|-----------------------------|----------------------|-----------------------|----------------------|
| Labour | 0.602 *** (0.090) | 0.463 *** (0.069) | 0.438 *** (0.064) |
| Total capital stock | 0.383 *** (0.094) | | |
| Private capital | | 0.233 *** (0.042) | 0.381 *** (0.042) |
| Public capital | | 0.362 *** (0.049) | 0.249 *** (0.041) |
| Spatial lag Labour | | | -0.141 (0.180) |
| Spatial lag Private capital | | | 0.275 (0.238) |
| Spatial lag Public capital | | | -0.202 (0.181) |
| Quality of Institutions | 0.039 ** (0.018) | 0.096 *** (0.018) | 0.096 *** (0.016) |
| <i>Contextual factors</i> | | | |
| Human Capital | 0.054 (0.087) | 0.098 * (0.052) | 0.052 (0.057) |
| Social capital | 0.066 (0.047) | 0.005 (0.025) | -0.019 (0.027) |
| Technological capital | 0.013 (0.028) | -0.023 (0.023) | -0.033 * (0.019) |
| Population density | 0.068 ** (0.032) | 0.094 *** (0.023) | 0.093 *** (0.023) |
| South | -0.060 (0.049) | -0.082 *** (0.032) | -0.065 (0.042) |
| Spatial matrix | NO | NO | Inverse distance |

Estimation method: Two Stage Least Squares (labour and capital variables are instrumented with their own 5-year lag)

All variables are log-transformed

Quality of Institutions and contextual variables are 5-year lagged

South, dummy variable = 1 for the eight Southern regions and 0 for the remaining regions

All models include time dummies

Spatial lags are computed by using the inverse distance matrix (max-eigenvalue normalized)

Robust Standard Error, in parentheses, are clustered at region level

Significance levels: *** (1%), ** (5%), * (10%).

Cross-section observations (regions): 21

Number of panel observations: 315

Table 7. The effect of public capital by government bodies, 2000-2019

Dependent variable: value added

| | Model 1 | Model 2 |
|-------------------------|----------------------|----------------------|
| Labour | 0.618 *** (0.078) | 0.581 *** (0.055) |
| Private capital | 0.093 ** (0.042) | 0.108 *** (0.030) |
| Public capital: | | |
| central bodies | 0.061 *** (0.020) | 0.054 *** (0.017) |
| local bodies | 0.077 *** (0.012) | 0.099 *** (0.009) |
| central bodies * South | | 0.040 ** (0.021) |
| local bodies * South | | -0.033 ** (0.015) |
| Quality of Institutions | 0.076 *** (0.014) | 0.080 *** (0.017) |
| Contextual factors | yes | yes |
| South | yes | no |

Estimation method: Two Stage Least Squares (labour and capital variables are instrumented with their own 5-year lag)

All variables are log-transformed

Quality of Institutions and contextual variables are 5-year lagged

Contextual factors: human capital, social capital, technological capital, population density

South, dummy variable = 1 for the eight Southern regions and 0 for the remaining regions

All models include time dummies

Robust Standard Error, in parentheses, are clustered at region level

Significance levels: *** (1%), ** (5%), * (10%).

Cross-section observations (regions): 21

Number of panel observations: 315

See Table 2 for the list of bodies

Table 8. The effect of public capital by economic sectors, 2000-2019

Dependent variable: value added

| | Model 1 | Model 2 | Model 3 | Model 4 |
|-------------------------|----------------------|----------------------|----------------------|----------------------|
| Labour | 0.500 *** (0.058) | 0.507 *** (0.060) | 0.507 *** (0.059) | 0.509 *** (0.060) |
| Private K | 0.226 *** (0.044) | 0.222 *** (0.044) | 0.222 *** (0.044) | 0.220 *** (0.044) |
| Public capital: | | | | |
| general | 0.024 (0.023) | 0.034 (0.024) | 0.031 (0.023) | 0.032 (0.024) |
| intangibles | 0.143 *** (0.032) | 0.142 *** (0.033) | 0.140 *** (0.032) | 0.139 *** (0.033) |
| infrastructures | 0.087 ** (0.042) | 0.087 ** (0.043) | 0.087 ** (0.042) | 0.086 ** (0.043) |
| environment | -0.016 (0.022) | -0.019 (0.022) | -0.017 (0.022) | -0.018 (0.022) |
| production | 0.039 *** (0.015) | 0.036 *** (0.014) | 0.038 *** (0.015) | 0.039 *** (0.015) |
| intangibles * South | | -0.008 ** (0.003) | | |
| infrastructures * South | | | -0.006 ** (0.003) | |
| production * South | | | | -0.004 ** (0.002) |
| Quality of Institutions | 0.100 *** (0.025) | 0.098 *** (0.026) | 0.098 *** (0.026) | 0.098 *** (0.026) |
| Contextual factors | yes | yes | yes | yes |
| South | yes | no | no | no |

Estimation method: Two Stage Least Squares (labour and capital variables are instrumented with their own 5-year lag)

All variables are log-transformed

Quality of Institutions and contextual variables are 5-year lagged

Contextual factors: human capital, social capital, technological capital, population density

South, dummy variable = 1 for the eight Southern regions and 0 for the remaining regions

All models include time dummies

Robust Standard Error, in parentheses, are clustered at region level

Significance levels: *** (1%), ** (5%), * (10%).

Cross-section observations (regions): 21

Number of panel observations: 315

See Table TA2 for the list of sectors

Table 9. The effect of public capital by bodies and sectors, 2000-2019

Dependent variable: value added

| | Model 1 | Model 2 | Model 3 |
|-------------------------|-----------------------|-----------------------|-----------------------|
| Labour | 0.543 *** (0.137) | 0.557 *** (0.140) | 0.608 *** (0.133) |
| Private K | 0.258 *** (0.085) | 0.245 *** (0.088) | 0.214 *** (0.084) |
| Public capital central: | | | |
| general | 0.069 * (0.035) | 0.065 * (0.035) | 0.056 (0.034) |
| intangibles | -0.063 (0.055) | -0.066 (0.054) | -0.049 (0.052) |
| infrastructures | -0.009 (0.024) | -0.005 (0.023) | -0.015 (0.024) |
| environment | -0.026 *** (0.010) | -0.025 *** (0.010) | -0.024 *** (0.009) |
| production | 0.106 ** (0.050) | 0.105 ** (0.050) | 0.089 * (0.049) |
| Public capital local: | | | |
| general | -0.054 (0.045) | -0.038 (0.041) | -0.052 (0.040) |
| intangibles | 0.108 ** (0.052) | 0.104 ** (0.052) | 0.094 * (0.050) |
| infrastructures | 0.195 *** (0.063) | 0.193 *** (0.062) | 0.197 *** (0.061) |
| environment | -0.018 (0.034) | -0.021 (0.035) | -0.026 (0.032) |
| production | -0.081 (0.080) | -0.078 (0.081) | -0.060 (0.077) |
| intangibles * South | | -0.011 *** (0.004) | |
| infrastructures * South | | | -0.013 *** (0.004) |
| Quality of Institutions | 0.095 *** (0.026) | 0.093 *** (0.027) | 0.083 *** (0.025) |
| Contextual factors | yes | yes | yes |
| South | yes | no | no |

Estimation method: Two Stage Least Squares (labour and capital variables are instrumented with their own 5-year lag)

All variables are log-transformed

Quality of Institutions and contextual variables are 5-year lagged

Contextual factors: human capital, social capital, technological capital, population density

South, dummy variable = 1 for the eight Southern regions and 0 for the remaining regions

All models include time dummies

Robust Standard Error, in parentheses, are clustered at region level

Significance levels: *** (1%), ** (5%), * (10%).

Cross-section observations (regions): 21

Number of panel observations: 315

See Table 2 for the list of bodies and Table TA2 for the list of sectors

Appendix. Table A1. Data sources and definition

| Variable | Primary Source | Years | Definition |
|-------------------------------|-----------------------------|--------------|---|
| Value Added | Eurostat | 2000-2019 | Millions euros, constant price 2010 |
| Labour | Eurostat | 2000-2019 | Units of labour, thousands |
| Gross fixed capital formation | Istat | 2000-2019 | Millions euros, constant price 2010 |
| Public investment | Territorial Public Accounts | 2000-2019 | Millions euros, constant price 2010 |
| Total capital stock | Own calculation | 2000-2019 | Millions euros, constant price 2010 |
| Public capital stock | Own calculation | 2000-2019 | Millions euros, constant price 2010 |
| Private capital stock | Own calculation | 2000-2019 | Millions euros, constant price 2010 |
| Quality of Institutions | Nifo & Vecchione (2014) | 2000-2019 ** | Composite index based on Corruption, Government effectiveness, Regulatory quality, Rule of law, Voice |
| Human Capital | Eurostat | 2000-2019 | Population aged 25-64 with tertiary education (Isced 5-8) over total population 25-64, % |
| Technological capital | Eurostat | 2000-2019 | R&D expenditure over GDP (% , variables in 2010 prices). R&D computed as 3-yeras moving average |
| Social capital | Istat, Multiscopo | 2000-2018 * | People aged 14 and over who volunteered on the total population aged 14 and over (percentage) |
| Population density | Eurostat | 2000-2019 | Persons per square kilometre |

* Year 2019 has been assumed equal to 2018

** Years 2000-2003 have been computed using the time dynamics over the years 2000-2004 for the available simple indicators

Appendix. Table A2. Public capital stock in Italy by sectors (% share)

| Sector | Macro sectors | 2000 | 2010 | 2019 |
|-----------------------------------|----------------------|-------------|-------------|-------------|
| General administration | General | 8.2 | 7.9 | 5.8 |
| Public order | General | 1.6 | 2.0 | 2.1 |
| Justice | General | 0.6 | 0.6 | 0.4 |
| Defence | General | 0.0 | 0.0 | 0.0 |
| Non-recoverable charges | General | 0.2 | 0.2 | 0.2 |
| Social affairs | General | 1.0 | 1.0 | 0.8 |
| Health | General | 3.3 | 3.5 | 3.0 |
| Other hygiene and health measures | General | 0.7 | 0.7 | 0.5 |
| Labour | General | 0.4 | 0.3 | 0.2 |
| Pensions, wage supplementations | General | 1.3 | 1.3 | 1.2 |
| Housing, urban development | General | 6.1 | 5.6 | 4.4 |
| Culture, recreational services | Intangibles | 3.8 | 3.6 | 2.9 |
| Education | Intangibles | 4.5 | 4.1 | 3.4 |
| Training | Intangibles | 0.4 | 0.5 | 0.4 |
| Research and development | Intangibles | 2.1 | 2.2 | 2.6 |
| Other public works | Infrastructures | 0.5 | 0.4 | 0.2 |
| Other transport | Infrastructures | 14.2 | 14.3 | 12.8 |
| Roads | Infrastructures | 10.4 | 10.8 | 9.1 |
| Telecommunications | Infrastructures | 2.1 | 2.2 | 3.2 |
| Environment | Environment | 3.8 | 3.4 | 2.6 |
| Waste disposal | Environment | 1.2 | 1.2 | 1.2 |
| Integrated water service | Environment | 3.6 | 3.7 | 3.2 |
| Agriculture | Production | 3.6 | 3.0 | 2.0 |
| Marine fishing and aquaculture | Production | 0.0 | 0.1 | 0.1 |
| Energy | Production | 10.6 | 12.7 | 19.5 |
| Industry and artisan | Production | 11.8 | 10.3 | 9.7 |
| Wholesale and retail distribution | Production | 0.5 | 0.5 | 0.5 |
| Tourism | Production | 0.8 | 0.7 | 0.5 |
| Other economic sectors | Production | 2.7 | 3.4 | 7.5 |

Appendix. Table A3. Public capital stock by macro-sectors (% shares, average 2000-2019)

| Region | Macro areas | General | Intangibles | Infrastructures | Environment | Production |
|-----------------------|--------------------|----------------|--------------------|------------------------|--------------------|-------------------|
| Piemonte | north | 20.6 | 10.5 | 29.7 | 7.9 | 31.3 |
| Valle d'Aosta | north | 32.2 | 10.2 | 30.1 | 4.7 | 22.7 |
| Liguria | north | 21.6 | 7.7 | 35.8 | 7.5 | 27.4 |
| Lombardia | north | 18.8 | 11.0 | 28.9 | 8.4 | 33.0 |
| Prov. Bolzano | north | 30.0 | 13.1 | 27.8 | 6.6 | 22.5 |
| Prov. Trento | north | 29.7 | 13.3 | 24.2 | 11.4 | 21.4 |
| Veneto | north | 22.9 | 9.7 | 31.7 | 11.3 | 24.5 |
| Friuli Venezia Giulia | north | 29.2 | 11.3 | 22.7 | 8.0 | 28.8 |
| Emilia Romagna | north | 20.3 | 9.9 | 29.2 | 8.4 | 32.3 |
| Toscana | centre | 21.7 | 11.1 | 34.3 | 9.0 | 23.8 |
| Umbria | centre | 32.7 | 7.6 | 28.0 | 9.9 | 21.9 |
| Marche | centre | 26.4 | 9.6 | 23.6 | 9.8 | 30.5 |
| Lazio | centre | 23.8 | 10.7 | 28.7 | 5.4 | 31.4 |
| Abruzzo | south | 27.5 | 11.3 | 24.3 | 6.3 | 30.5 |
| Molise | south | 17.1 | 7.9 | 28.8 | 10.6 | 35.6 |
| Campania | south | 22.6 | 10.7 | 25.8 | 7.8 | 33.1 |
| Puglia | south | 19.4 | 8.3 | 18.5 | 6.4 | 47.5 |
| Basilicata | south | 21.0 | 8.1 | 16.4 | 8.4 | 46.1 |
| Calabria | south | 17.4 | 9.0 | 33.2 | 5.7 | 34.6 |
| Sicilia | south | 21.8 | 11.5 | 20.7 | 8.5 | 37.5 |
| Sardegna | south | 20.4 | 7.0 | 20.4 | 11.5 | 40.7 |
| North | | 22.2 | 10.5 | 29.3 | 8.7 | 29.3 |
| Centre | | 24.2 | 10.4 | 29.6 | 7.3 | 28.5 |
| South | | 21.2 | 9.6 | 23.2 | 7.9 | 38.0 |
| Italy | | 22.2 | 10.2 | 27.2 | 8.1 | 32.2 |