

Public capital and the productivity of public spending across the Italian regions

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Abstract

Developing upon Golden and Picci (2005) cross-sectional measure of corruption, we produce a measure of the productivity of public capital spending, involving the construction of a comprehensive panel dataset for 20 Italian NUTS2 regions. The dataset provides an indicator of the productivity of sectoral public spending throughout 1989-2019 for six asset classes, as well as for core, noncore and total infrastructure aggregates. It also includes time-varying measures of monetary public capital stock for nine asset classes, and measures of infrastructure in physical terms for six classes of assets. We investigate the impact of the indicator of public spending productivity on the effectiveness of regional policies upon GDP per capita, comparing its performance with that of some contextual variables available from the literature. The new measure has a significant novel impact on the effectiveness of capital-account expenditures, shedding light on the relevance of this measure for the analysis of the Italian regional context.

JEL codes: O11, O43, R53, R58

Keywords: Golden-Picci corruption index, physical measures of infrastructure, perpetual inventory method, cohesion policies.

1. Introduction

The endowment of public capital¹ is considered among the most relevant factors impacting economic and social wellbeing. Aschauer (1989) is arguably the seminal reference in this field, while Aschauer (2000), Ezcurra et al. (2005), Nunez-Serrano and Velazquez (2017), among others, provide more recent analyses. This view has informed the EU's Cohesion Policy, which is largely involved in co-financing major infrastructure projects. Furthermore, it has been argued that the Cohesion Policy effectiveness is improved by a large regional infrastructural endowment (Crescenzi and Giua, 2016; Fratesi and Perucca, 2014; Di Caro and Fratesi, 2021).

A larger infrastructural endowment is in principle the product of higher public investments. Yet, the virtuous effects of public investments may be negated if their cumulative expenditure does not entail an equivalent physical infrastructure. In fact, Golden and Picci (2005) consider the relationship between two sets of objective data, the physical quantities of public infrastructure and the monetary values of public capital stocks and define the difference among the public capital in monetary terms and in physical terms as a measure of corruption, “indicating waste, fraud, and mismanagement in the public contracting process; Golden and Picci (2005, p. 5)”.

Developing upon Golden and Picci (2005), we define the relationship between public capital in physical terms (as an output) and in monetary terms (as an input) as the productivity of public capital expenditure. In the belief that the productivity of public capital expenditure is heterogenous both across space and time, we extend the approach of Golden and Picci (2005) by computing this productivity – for six classes of assets and various aggregates – for the Italian NUTS2 regions throughout 1989-2019. To do this, we fill two gaps in the available statistical information. We bring up to 2019 the series for regional public investment elaborated by Picci (2001) for 1890-1998, and we build a set of time-varying indicators for regional physical infrastructural endowment, disaggregated by asset classes, from 1987 to 2019. This allows computation of the regional monetary public capital for six asset classes throughout 1890-2019, by cumulating gross fixed capital formation year by year and deducting depreciation. We stop our analysis in 2019, because the treatment of the Covid-19 pandemic shock and of the subsequent huge inflow of investment expenditures requires careful consideration, needing further work in the future. Finally, we produce a 1989-2019 panel dataset for the productivity of public capital spending across Italian regions for six asset classes, as well as for core, noncore and total infrastructure aggregates.

We share with the corruption measure of Golden and Picci (2005) the focus on infrastructural endowment. There are however in the literature other measures of corruption and quality of government (well-known examples are provided by the European Quality Government Indexes from

¹ In this paper, we refer indistinctly to public capital or infrastructure.

Charron et al., 2014, 2015, 2019, 2022; the Institutional Quality Indexes from Nifo and Vecchione, 2014, 2015). To elucidate the difference between those indexes and our productivity measure, we develop an empirical analysis investigating the impact of all these indicators on the effectiveness of regional policies upon GDP per capita. Our findings unveil a novel and significant impact of our new measure of public spending productivity on the effectiveness of national capital-account expenditures (including national public investments).

The paper is organized as follows. Section 2 provides a review of the literature on the relationships between the performance of public institutions and the effectiveness of regional policies. This allows placing our measure of public capital expenditure within the broader concept of institutional capacity. Section 3 focuses on the construction of the new indicator of regional public spending productivity (PSP) in Italy for the last three decades. This requires the construction, also detailed in this section, of new time-varying indicators for regional monetary capital stock and for regional public infrastructure in physical terms. Section 4 pursues the comparison of the new PSP indicator with some well-known measures of corruption and quality of government (including the one from Golden and Picci, 2005), by analysing their influence on the effectiveness of various regional policies. Section 5 concludes.

2. Effectiveness of regional policies and performance of public institutions. The literature

There is a huge literature aimed at evaluating the effectiveness of regional policies. A key finding of this literature is that the institutional and structural context of the benefitting areas should carefully assessed and controlled to make sense of the analysis. Particular attention has been paid to the quality of public institutions and their administrative capacity. The influential studies of Becker et al. (2013), Rodriguez-Pose and Garcilazo (2015), Di Caro and Fratesi (2021), Bachtler et al. (2024), find that the better the quality of the local government, the more effective is the cohesion policy. Such findings have been recently reiterated by Papageorgiou and Vrettos (2026), particularly for technology-intensive sectors.

The role of institutional capacity in driving policy effectiveness has also been highlighted in Italy, a country notoriously characterized by deep structural and institutional differences, especially between the North and the South of the country. Controlling for a large set of contextual factors, D'Acunzio et al. (2004) provide evidence in favour of a particularly significant role of indicators of civic sense in constraining the growth of Mezzogiorno regions. The lack of effective governance is evoked in the literature as a crucial cause of the lacklustre outcome of the place-based regional policies gathered under the label of “Negotiated Programming” (1996-2006).²

² See Coppola et al. (2020) for a survey of this literature.

Some studies have highlighted the relevance of public institutions for explaining the different absorptive capability of funding in the Mezzogiorno and elsewhere. The findings in Milio (2007) vindicate a significant positive correlation between regional administrative capacity and expenditure capacity. Di Cataldo et al. (2026) show that local corruption distorts the allocation of EU funds in Italian regions. Municipalities with colluding politicians received significantly less funding compared to those with cleaner institutions.

The role of institutional capacity goes beyond its impact on funds' absorption. De Angelis et al. (2020) highlight that EU transfers often fail to boost economic growth, as they instead increase local crime and fund political corruption. Somehow differently, Coppola et al. (2020) find that quality of government has little relevance for European Union funds, while significantly enhancing the impact of some nationally financed policies. According to Arbolino and Boffardi (2024), organized crime and corruption significantly hamper the effectiveness of public investment across Italian regions through implementation delays, distortions in fund allocation, and inefficient management.

Summing up, as suggested by Domorenok et al. (2021), numerous studies have pointed out the centrality of the institutional domain for policy effectiveness, generally referring to the ability of governmental institutions to successfully perform given functions or deliver public policies. However, the definition of institutional capacity remains fragmented and somewhat indefinite, which possibly explains some differences in the results obtained in the Italian literature. For that reason, it is extremely useful to systematise the measurement of this capacity, as done with the Institutional Quality Indexes (Nifo and Vecchione, 2014 and 2015) and the European Quality Government Indexes (Charron et al., 2014, 2015, 2019, 2022).³ In this spirit, we offer in Section 3 a new index of public sector performance that is centred upon the productivity of public expenditure. Section 4 highlights the influence of the new index on the effectiveness of various regional policies, supporting the hypothesis that the focus on the productivity of public expenditure lends to a specific interest to this index.

3. Measuring public spending productivity

To measure regional PSP, we first construct two indexes (by main asset class) for monetary public capital (*m_index*) and for regional infrastructure index in physical terms (*f_index*). Subsequently, we derive PSP from the relationship between public capital in physical terms (as an output) and in monetary terms (as an input). As said in the Introduction, we stop our analysis in 2019. Once calculated the asset class indexes, we construct a total aggregate index as well as indexes for core infrastructure - primarily oriented toward the support of productive activities – and noncore

³ Recent examples of comparative analyses of the different dimensions of the European Quality Government Indexes include Coppola et al. (2026), Pinate et al. (2026).

infrastructure. The distinction between core and infrastructure is further detailed in §§ 3.1 and 3.2 and in Appendix 1 (Supplementary Material).

3.1 The public capital in monetary terms

We proceed to construct the stock of public capital in monetary terms following the Perpetual Inventory Model (PIM) approach developed by EUKLEMS (<https://euklems.eu>) and used by the Fundacion BBVA-IVIE, the Valencian Institute of Economic Research (Mas et al., 2006). According to the PIM, the capital stock is calculated by cumulating gross fixed capital formation year by year and deducting depreciation. This capital stock provides the market value of the assets – and, therefore, a measure of wealth - under the assumption that it is equal to the present discounted value of the income expected to be generated by these assets.

To apply the PIM, we first need to update to 2019 the 1890-1998 series of public gross fixed capital formation developed by Picci (2001) using the expenditure data from the Conti Pubblici Territoriali (CPT) data. Relying on the CPT series (as in Di Giacinto et al., 2010b; Montanaro, 2010) allows matching of the asset classification used for the physical and monetary indexes. We proceed as follows:

1) We set up a table of correspondences among the Picci asset classes and the CPT sectoral functions (Table 1), for eight asset classes (Roads, Rails, Ports, Buildings, Health, Water, Land, Others). We exclude from the analysis the sectors with no readily available infrastructure index in physical terms (see Appendix 1 in Supplementary Material for further details). From these eight asset classes, we derive six main asset classes to be used in subsequent analysis. Note that the Picci asset class Roads includes expenditures for both roads and airports. On the other hand, the Picci asset classes Rails and Ports must be aggregated in a single main asset class (*m_Rails*) to ensure comparability with the CPT sectoral classification. Water and Land are aggregated in a single main asset class (*m_Water*) for reasons to be clarified in § 3.2. One main asset class (*m_Others*) includes sectoral functions relating to both core and noncore infrastructures.

Table 1. Table of correspondences among the Picci (2001) asset classes and CPT sectoral functions

		Public investment in infrastructure		
	Core/Noncore	Main asset classes	Picci asset classes	CPT sectoral functions
M_TOTAL	M_CORE	M_ROADS	ROADS ^a	00020 – Viabilità
		M_RAILS	RAILS	00019 - Altri trasporti
			PORTS ^b	
		M_WATER	WATER	00012 - Servizio Idrico Integrato
			LAND ^c	00022 – Agricoltura
	M_NONCORE	M_OTHERS	OTHERS	00027 – Energia
				00015 - Smaltimento dei Rifiuti
		M_BUILDINGS	BUILDINGS	00005 – Istruzione
				00008 - Cultura e servizi ricreativi
				00009 - Edilizia abitativa e urbanistica
				00010 – Sanità
		M_HEALTH	HEALTH	00016 - Altri interventi igienico sanitari

Sources: Own elaborations on data specified in (Picci, 2001) and the CPT database

(https://www.contipubbliciteritoriali.it/CPTDE/catalogo/CPTDE_CatalogoCPT.html)

Notes: a) Including roads and airports, b) Including ports, lake and river navigation, c) Including land reclamation and irrigation (Picci, 2001).

2) We define a matching year by visual inspection of the trends of the public investment series from Picci (2001) and of the CPT public investment series and apply the growth rate of CPT public investments from the chosen matching year onwards to the value for the previous year from the Picci series. The spliced series for nominal investments $I_{r,t}^a$ in asset a, region r, year t, is computed according to the following algorithm:

$$\left\{ \begin{array}{l} I_{r,t}^a = (I_{r,t}^a)_{Picci} \text{ for } 1890 < t < \bar{t}, \\ I_{r,t}^a = (I_{r,t-1}^a)_{Picci} * \left(1 + \left(\frac{I_{r,t}^a - I_{r,t-1}^a}{I_{r,t-1}^a} \right)_{CPT} \right), \text{ for } t = \bar{t}, \\ I_{r,t}^a = I_{r,t-1}^a * \left(1 + \left(\frac{I_{r,t}^a - I_{r,t-1}^a}{I_{r,t-1}^a} \right)_{CPT} \right), \text{ for } t > \bar{t}. \end{array} \right. \quad [1]$$

where $\bar{t}$ is the matching year.

3) Finally, we deflate the nominal investment series by the Istat Consumer Price Index (<https://www.istat.it/it/archivio/243273>), readily available from 1861 to 2019.

Further details about the above steps are provided in Appendix 1 (Supplementary Material). Once carried out the computation of public investment series, we tackle the measurement of the public capital stock.

We assume a geometrical pattern of depreciation following OECD (2009). In the absence of an initial net capital stock, we use the PIM to annual real fixed investment for period 1890-2019 to compute the net public stock capital, $PKN_R_{r,t}^a$, for each region and asset class, given the depreciation profile to calculate the net capital stock.

$$PKN_R_{r,t}^a = PKN_R_{r,t-1}^a + I_R_{r,t}^a - TD^a * \left[\frac{I_R_{r,t}^a}{2} + PKN_R_{r,t-1}^a \right] \quad [2]$$

Where $I_R_{r,t}^a$ is the real gross investment in asset a, region r, year t, and $PKN_R_{r,t}^a$ is the real net public capital in asset class a, region r, year t. Note that the computation of a *net* stock is appropriate also because our (physical) measures of infrastructural endowment cannot satisfactorily account for the substitution of obsolete physical stock. In § 3.3, $PKN_R_{r,t}^a$ is labelled as the monetary index (*m_index*) for various asset classes and aggregations.

Appendix 1 (in Supplementary Material) provides further details on data sources, methodology and descriptive evidence for the regional public capital in monetary terms.

3.2 The public capital in physical terms

To measure regional public infrastructure in physical terms we take 1987 as the initial year because this is the most remote year for which reliable information was available. In our analysis we rely on 30 elementary indicators, mainly used by Istituto Tagliacarne, that were available for most of the required years (Appendix 2 in Supplementary Material provides a detailed description of these elementary indicators). Given our aim to measure PSP for asset classes we develop indexes for physical infrastructural endowment comparable with the main classes of monetary capital stocks from Picci (2001): *f_Roads*, *f_Rails*, *f_Buildings*, *f_Health*, *f_Water*, *f_Others*. The information available for the elementary indicators did not allow the construction of separate physical indicators for Water and Land (hence the main class *f_Water*). The composite *f_Others* class includes categories from both core and noncore infrastructures, to ensure consistency with the classification adopted for monetary public capital stocks (see § 3.1).

The elementary index for the elementary indicator i, intermediate category j, main class k, for region r, and year t is defined as:

$$f_elementary_{k,j,i,t}^r = \frac{elementary\ indicator_{k,j,i,t}^r}{mean(elementary\ indicator_{k,j,i}^r)} \quad [3]$$

Table 2 details how we proceed further in the aggregation of these elementary indicators. The intermediate asset category is defined by the arithmetic mean of the relative elementary indexes, following the weighting procedure first suggested by Biehl et al. (1990). The main class index is the weighted arithmetic mean of the intermediate asset categories, unless otherwise specified. We

deemed as appropriate to use, whenever possible, the information from the CPT data to weigh the arithmetic means.⁴

More in detail:

- To provide a common unit of measurement for different elementary indicators, we divide them by their respective mean over period 1987-2019. This approach differs from traditional methodology that normalizes elementary indicators by either area or population and standardizes the results by the respective national normalized index. The advantage of our procedure is that we keep both the region-specific trend of the elementary index (which would be lost in dividing it by the national index) and the region-specific size of the physical endowment (which would be lost by normalizing in either population or surface).
- The index for the main asset class *f_Buildings* is the weighted arithmetic mean of the intermediate categories of Education, Cultural and Social infrastructure. Weights are given by the ratio of the respective investment expenditures taken from the CPT data for 1996-2019.⁵ The index for the main category *f_Others* is the weighted arithmetic mean of the intermediate categories of Energy (including Electricity, Gas and Petrol) and Waste infrastructure. Weights are given by the ratio of the respective investment expenditures taken from the CPT data for 1996-2019. The other indexes for the main asset classes (*f_Roads*, *f_Rails*, *f_Health*, *f_Water*) are unweighted arithmetic means of the relevant intermediate categories, due to lack of information from the CPT data.
- The aggregate indexes *f_Core* and *f_Noncore* are the weighted arithmetic mean of the relevant intermediate category indexes. Weights are given by the ratio of the respective investment expenditures taken from CPT data for 1996-2019.
- The aggregate index *f_Total* is the weighted arithmetic mean of the intermediate category indexes. Weights are given by the ratio of the respective investment expenditures taken from CPT data for 1996-2019.

⁴ Using unweighted arithmetic means throughout the aggregation procedure yields similar indexes (available upon request). We believe however that the use of CPT weights, whenever possible, ensures more accurate measures. Worries that CPT weighting induces spurious correlation between the monetary and physical capital indexes are allayed by our empirical evidence. In § 3.3, we further comment on this issue.

⁵ These weights are 1996-2019 mean values taken for each region and asset class (or category).

Table 2. Main classes, intermediate categories, and elementary indexes for infrastructural endowment

	Core/ Noncore	Main classes	Intermediate categories	Aggregation method for elementary indicators	Elementary indicators	Available literature references ^a	
F_TOTAL	F_CORE	F_ROADS	ROADS	MEAN ($\frac{11}{7}$ ROAD1; ROAD2) ^e	ROAD1	B, CEa, CEb, T	
					ROAD2	--	
		F_AIRPORTS	AIRPORTS	MEAN (AIRP1; AIRP2)	AIRP1	B, CEa, CEb, T	
					AIRP2	CEa, T	
			F_RAILS	RAILS		RAIL1	T
				PORTS ^b	MEAN (PORT1; PORT2; PORT3; PORT4)	PORT1	CEa, Cab, Cab, T
		PORT2				CEa, Cab, T	
		PORT3				--	
		F_WATER	WATER ^c	MEAN (WATE1; WATE2; WATE3)	PORT4	--	
					WATE1	T	
					WATE2	T	
		F_OTHERS	ELECTRICITY	MEAN [MEAN (ELEC1; $\frac{38}{22}$ ELEC2); ELEC3] ^e	WATE3	--	
					ELEC1	CEb, T	
					ELEC2	CEb, T	
			F_HEALTH	GAS		ELEC3	T
		GAS1				B, CEa, CEb, T	
	PETR1	B, CEa, CEb, T					
	F_NONCORE	F_BUILDINGS	PETROL ^d	MEAN (PETR1; PETR2)	PETR2	--	
					WASTE	WAST1	B, T
			EDUCATION	MEAN (EDUC1; EDUC2; EDUC3; EDUC4; EDUC5)	EDUC1	CEa, T	
					EDUC2	CEa, T	
		EDUC3			CEa, T		
		EDUC4			CEa, T		
		EDUC5			CEa, T		
		CULTURE	MEAN (CULT1; CULT2)	CULT1	CEa, T		
				CULT2	CEa, T		
		SOCIAL	MEAN (SOCI1; SOCI2)	SOCI1	B, CEa		
				SOCI2	B		
F_HEALTH		HEALTH	MEAN (HEALT1; HEALT2)	HEALT1	B, CEa, T		
	HEALT2			T			

^a B (Biehl et al. (1990)), CEa (Confindustria-Ecoter, 2000a), CEb (Confindustria-Ecoter, 2000b), T (Istituto Tagliacarne); ^b For reasons of data availability, we use as indicator the freight loaded and unloaded (Istituto Tagliacarne uses n. of approaches for goods) and the passengers embarked and disembarked (Istituto Tagliacarne uses n. of approaches for passengers); ^c For reasons of data availability, we use as indicator the regional population served by complete wastewater treatment plants (not considered in the literature); ^d For reasons of data availability, we use as indicator the cumulative number of oil wells (not considered in the literature); ^e The weights are defined in Biehl et al (1990).

Appendix 2 (in Supplementary Material) provides further details on data sources, methodology and descriptive evidence for our indicator of public capital in physical terms.

3.3 Measuring public spending productivity (PSP)

PSP is estimated using a dynamic panel regression based on the quantitative analysis of production (Kumbhakar and Lovell, 2000, Ch. 3). We assume that, at any level of aggregation, the physical index of infrastructure, f_index , is the output of a production process where the net monetary public capital stock, m_index , is the key input. However, “several factors may affect the cost of a given public work” as suggested by Golden and Picci (2005, p. 12) such as population density - computed using the ratio of regional (time-varying) population living in cities with more than 30.000 inhabitants, the mean altitude of the municipalities of the region, the region surface, and the ratio of the coastline over surface. Furthermore, other structural or economic characteristics, not necessarily related with

corruption or mismanagement, could influence the physical accumulation of public capital. They include human capital (measured by the average years of school attainment), the technological capabilities (measured by patents per capita, that is the ratio of patents over population), sectoral structure (proxied by employment in agriculture and manufacturing). These variables, with the addition of year-specific effects, are our controls. In line with the quantitative analysis of production, regional-level factors intrinsically linked to public spending productivity are modelled through binary variables for all geographic areas (North-West, North-East, Centre, South, Isles),⁶ linear and quadratic region-specific trends, and further binary variables for some regions (d_r , to be detailed below). This specification allows separating region- and area-specific effects (to be ascribed to institutional factors, and, more generally, productivity) from geographical, demographic and economic factors that characterise the various regions. Had we used individual-specific dummies for all regions, we could not have separated these two sets of factors.

We estimate the following regional dynamic panel model over period 1989-2019 for each asset class and for the Core, Noncore and Total aggregates:

$$\ln f_{\text{index}}_{r,t} = \beta_1 \ln f_{\text{index}}_{r,t-1} + \beta_2 \ln f_{\text{index}}_{r,t-2} + \beta_3 \ln m_{\text{index}}_{r,t-1} + \beta_4 d_{\text{North West}} + \beta_5 d_{\text{North East}} + \beta_6 d_{\text{Centre}} + \beta_7 d_{\text{South}} + \beta_8 d_{\text{Isles}} + \beta_9 d_r + \beta_{10} \text{ctr_density}_{r,t-1} + \beta_{11} \text{ctr_altitude}_r + \beta_{12} \text{ctr_surface}_r + \beta_{13} \text{ctr_coast_surface}_r + \beta_{14} \ln hk_{r,t-1} + \beta_{15} \ln \text{pat_pc}_{r,t-1} + \beta_{16} \ln \text{emp_agr}_{r,t-1} + \beta_{17} \ln \text{emp_man}_{r,t-1} + \beta_{18} \text{trend}_{r,t} + \beta_{19} (\text{trend}_{r,t})^2 + \varepsilon_{r,t} \quad [4]$$

where subscripts r and t refer respectively to (NUTS2) region and year, *ctr_density*, *ctr_altitude*, *ctr_surface*, *ctr_coast_surface*, *hk*, *pat_pc*, *emp_agr* and *emp_man* are control variables: population density, mean altitude, total surface and coastline over surface, human capital, patents per capita, employment in agriculture and manufacturing.

We fully allow for the dynamic nature of the relationship between *f_index* and *m_index*. The dynamic specification of [4] stems from a general-to-specific search that started with once and twice lagged values for *f_index*, and current plus once and twice lagged values for *m_index* (this dynamic specification explains why the PSP index is only available from 1989 onwards). Inference for [4] is based on the consistent covariance matrix proposed by Driscoll and Kraay (1998). This matrix yields standard errors for the regression coefficients that are robust to very general forms of heteroskedasticity, serial correlation of residuals and cross-section dependence when the time dimension of the panel is large. Equation [4] implicitly assumes the existence of a long-run cointegrating relationship between the physical index of infrastructure and the net monetary public

⁶ North-West includes Piemonte (PIE), Valle d'Aosta (VDA), Liguria (LIG), Lombardia (LOM). North-East includes Trentino-Alto Adige (TAA), Veneto (VEN), Friuli-Venezia Giulia (FVG), Emilia-Romagna (EMR). Centre includes Toscana (TOS), Umbria (UMB), Marche (MAR), Lazio (LAZ). South includes Campania (CAM), Abruzzo (ABR), Molise (MOL), Puglia (PUG), Basilicata (BAS), Calabria (CAL). Isles include Sicilia (SIC), Sardegna (SAR).

capital stock. In our case, an appropriate test for cointegration is supplied by the bounds testing procedure proposed by Bertsatos et al. (2023), which generalizes to panel data the bounds testing procedure first developed by Pesaran et al. (2001).

As said above, some regional dummies were included in the regressions. This was needed, in some case, to obtain residuals that were not serially correlated. Indeed, the Reset misspecification test is unreliable in the presence of serially correlated residuals (Godfrey, 1988). Besides, white noise residuals imply that there is no weak endogeneity problem for the monetary capital, if only lagged values of the latter enter the estimates. Appendix 3 (in Supplementary Material) provides further details on the model specification and the bounds testing procedure.

Once we are satisfied about the specification of [4], the PSP index of region r at year t is defined, for each asset class and aggregation, as:

$$\text{PSP index}_{r,t} = \beta_4 d_{\text{North West}} + \beta_5 d_{\text{North East}} + \beta_6 d_{\text{Center}} + \beta_7 d_{\text{South}} + \beta_8 d_{\text{Isles}} + \beta_9 d_r + \beta_{18} \text{trend}_{r,t} + \beta_{19} (\text{trend}_{r,t})^2 \quad [5]$$

The PSP index takes the value of the coefficients for the territorial dummies and the regional trends. Controls are, by definition, not related to productivity. PSP can be perceived as the upside-down revisitation of the corruption index constructed by Golden and Picci (2005, p.4) “namely, the difference between a measure of the physical quantities of public infrastructure and a measure of the value of public capital stocks” depending on waste, fraud, and mismanagement of public capital expenditures. From [5] we derive three aggregate PSP indexes: Total, Core, and Noncore, as well as PSP indexes for the six asset classes: Roads, Rails, Buildings, Health, Water, Others. Obviously, each one of the regressions listed in Table 3 produces a different productivity index.

Our approach fully allows for the time-varying nature of productivity. Yet, it cannot separate changes in the state of technology (technical progress) from changes in technical or scale efficiency. Attempts at distinguishing these sources of productivity dynamics (e.g., through calculation of Malmquist productivity indexes) must be left to future research. Hence, changes in the index computed in [5] can occur across time (and space) because of changes in technology as well as in efficiency and cannot simply be ascribed to the latter.

The results of the dynamic panel regressions are presented in Table 3 for each of the six main asset categories Roads, Rails, Buildings, Health, Water, Others, and for the aggregate indexes Total, Core, and Noncore.

Table 3. Regression output of Equations [5] (1989-2019). Dependent variable: ln of regional index for infrastructure in physical terms defined in § 3.1. Two-way fixed effect panel LS model with robust standard errors (Driscoll-Kraay consistent covariance matrix).

Regressors	Total	Core	Noncore	Roads	Rails	Buildings	Health	Water	Others
Ln f_index (t-1)	0.817***	0.782***	0.780***	0.835***	0.884***	0.726***	0.645***	1.650***	0.790***
Ln f_index (t-2)	0.058						0.203***	-0.743***	
Ln m_index (t-1)	0.044**	0.129***	0.075***	0.127***	0.045***	0.081**	0.118***	0.017**	0.028***
ctr_density (t-1)	0.001***	0.001***	0.001***	0.001***	0.000***	0.001***	0.000	0.001***	0.002***
ctr_altitude	0.000	-0.000*	0.000**	-0.000***	-0.000***	0.000***	-0.000**	-0.000**	0.000***
ctr_surface	0.003**	0.005***	0.005***	0.007***	0.005*	0.007***	-0.003	0.000	0.003***
ctr_coast_surface	0.308*	0.733***	1.076***	0.652***	1.536**	0.948***	-0.329	-0.911**	1.385***
ln hk (t-1)	-0.124**	-0.709***	-0.146	-0.610***	-0.288**	-0.028	1.118***	-0.113***	0.034
ln pat_pc (t-1)	-0.001*	-0.003**	0.006***	-0.003***	-0.004***	0.008***	0.005***	0.001***	-0.004
ln emp_agr (t-1)	0.008	-0.006	0.054***	-0.001	-0.010**	0.076***	0.024**	0.001	0.017*
ln emp_man (t-1)	0.027***	-0.001	0.059***	-0.003	0.02	0.080***	0.052**	-0.005	0.107***
d_North_West	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
d_North_East	-0.012	-0.012	0.046***	-0.002	0.035*	-0.054***	-0.043***	-0.041***	0.139***
d_Centre	-0.051***	-0.096***	-0.024***	-0.071***	0.017**	0.015	-0.057***	-0.104***	0.075**
d_South	-0.051**	-0.120***	-0.083***	-0.073***	-0.003	-0.039	-0.001	0.064**	0.153***
d_Isles	-0.060**	-0.197***	-0.204***	-0.171***	-0.027	-0.177**	0.139***	0.000	0.116***
d_Piemonte		0.082***							0.159**
d_Valle d'Aosta			-0.258***			-0.324***			
d_Lombardia									0.240**
d_Veneto									0.221**
d_Toscana								0.032***	
d_Abruzzo		0.037**							
d_Basilicata		-0.177***		-0.147***				-0.056***	0.061**
d_Sicilia			0.123***			0.158***		-0.043***	
N	580	600	600	600	600	600	580	580	600
Rss	0.216	0.375	0.506	0.733	0.802	0.753	0.655	0.035	0.479
Aic	-2769	-2554	-2376	-2156	-2104	-2138	-2126	-3819	-2405
Bic	-2411	-2180	-2006	-1791	-1744	-1768	-1768	-3448	-2026
A-B test	0.1265	0.1198	0.1477	0.8563	0.4129	0.6447	0.0000	0.9772	0.1434
Reset test	0.7136	0.1596	0.4831	0.4356	0.9037	0.0691	0.9159	0.2144	0.3072
BTP F _{yx}	107.83***	463.88***	785.03***	391.04***	508.88***	546.39***	719.40***	967.24***	841.56***
BTP t _y	23.98***	18.14***	29.73***	13.03***	15.93***	50.02***	33.86***	35.08***	24.48***
BTP F _x	11.90***	34.00***	48.85***	17.24***	9.92***	70.81***	117.99***	22.58***	14.60***

Note: *** stands for $p < 0.01$; ** for $p < 0.05$; * for $p < 0.1$. N is the number of observations, rss is the residual sum of squares, Aic is the Akaike information criterion, Bic is the Bayesian Schwarz information criterion. A-B is the Arellano-Bond test for serial correlation present at lag one, Reset is Ramsey's test for functional form and omitted variables (carried out including quadratic terms of fitted values). values reported for the A-B test and the Reset test. See Appendix 3 (Supplementary Material) for information about BTP F_{yx}, BTP t_y, BTP F_x.

For all regressions, we observe a high predictive fit of the model with an adjusted R-squared (not reported here) always above 0.99. The diagnostics are good. The Reset test always yields satisfactory results. There generally is no significant first-order serial correlation in the residuals. As estimates never include current values of monetary capital, the latter is subsequently (weakly) exogenous. This dynamic feature also allays doubts about any spurious relationship arising between monetary and physical capital indexes because of the CPT weighting procedures adopted for the physical stocks of infrastructure. The bounds testing procedure always rejects the null hypothesis of no cointegration, vouching for the existence of a cointegrating relationship running from the monetary public capital stock to the physical index of infrastructure.

Table 4 and Map 1 depict the regional distribution of the PSP indexes, and their evolution over time comparing 1989 and 2019. The Northern regions report higher levels of the aggregate PSP indexes.

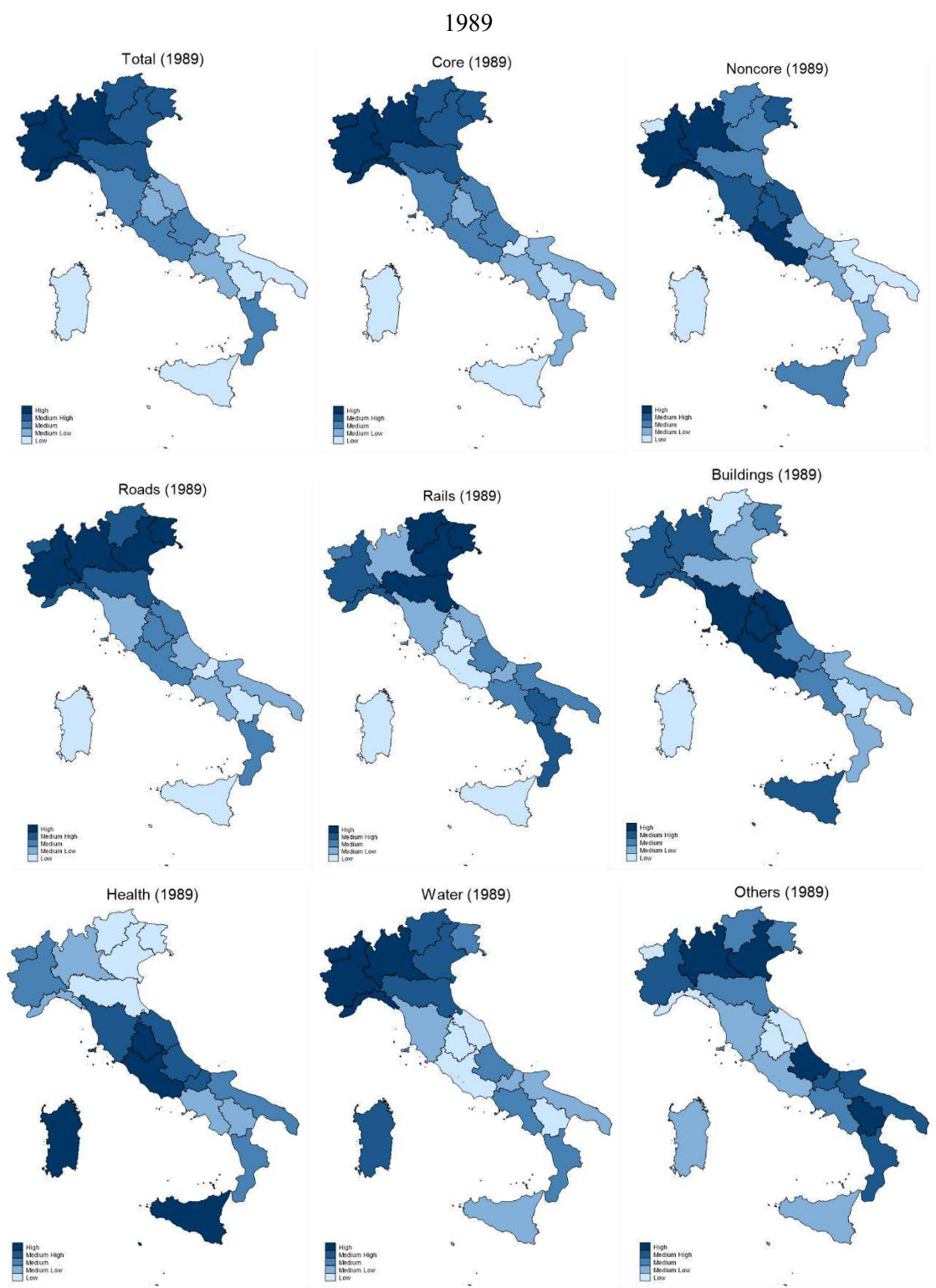
There is a however a fall in the ranking of Trentino Alto-Adige for Core (and Total) assets. The PSP index is high also in Lazio, Abruzzo and Calabria for Roads, in Toscana and Calabria for Rails, in Toscana and Lazio for Buildings, in Puglia for Health, in Abruzzo and Sardegna for Water, in Molise, Basilicata and Calabria for Others.

Table 4. The public spending productivity (PSP) index. Regional rankings (1989, 2019)

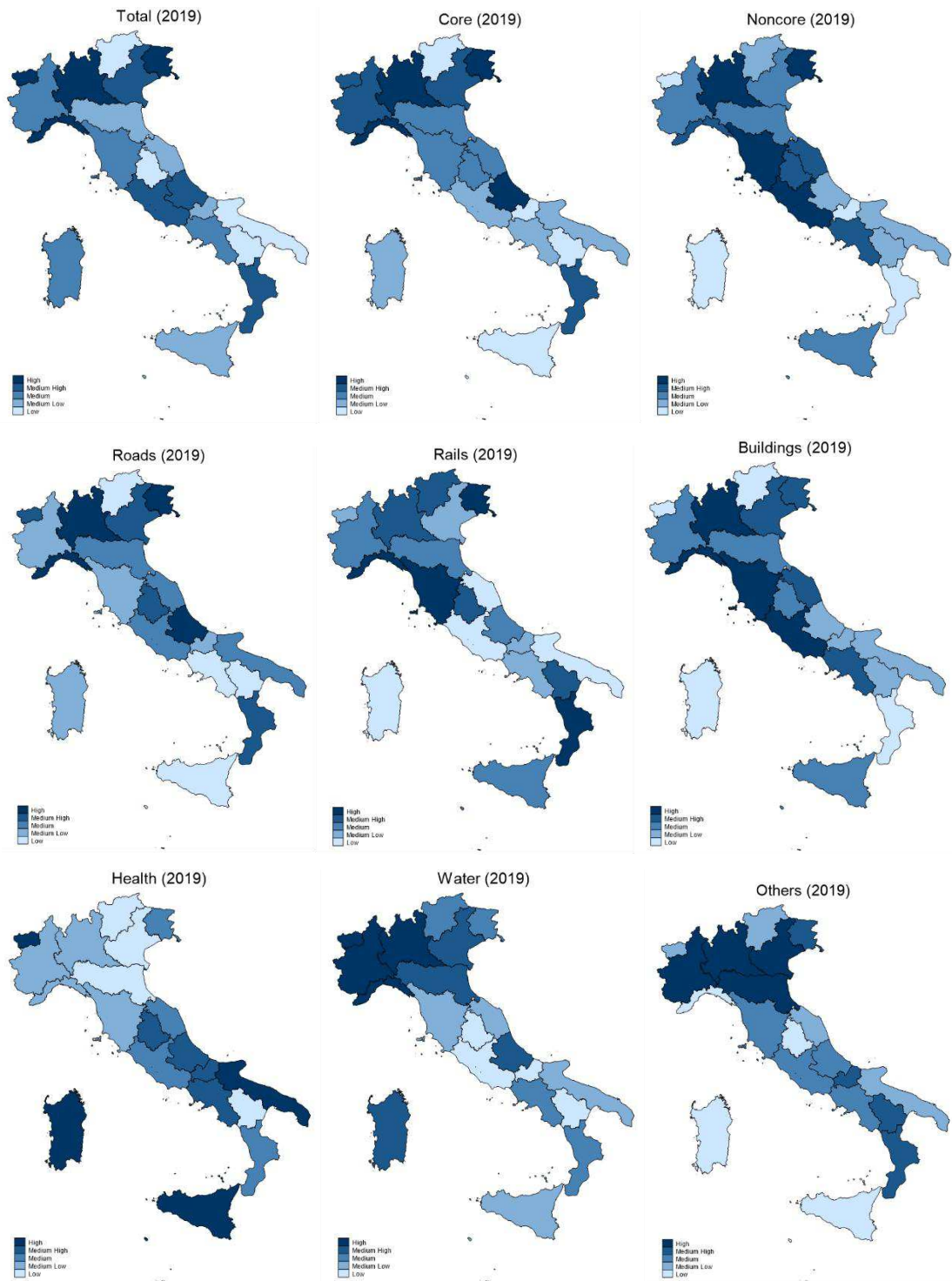
	Total		Core		Noncore		Roads		Rails		Buildings		Health		Water		Others	
	1989	2019	1989	2019	1989	2019	1989	2019	1989	2019	1989	2019	1989	2019	1989	2019	1989	2019
PIE	4	9	1	7	3	10	3	15	7	12	7	10	12	14	1	1	5	4
VDA	2	1	4	5	20	20	6	7	9	14	20	20	9	4	4	2	20	14
LIG	3	2	3	1	2	8	5	3	6	3	6	4	14	13	3	4	19	20
LOM	1	3	2	2	1	2	1	4	13	6	5	3	13	16	2	3	2	2
TAA	8	18	8	19	11	16	8	19	4	5	18	18	19	20	7	9	12	15
VEN	5	5	5	6	9	9	2	8	1	13	14	8	17	17	6	7	1	1
FVG	6	4	7	4	8	4	4	1	2	1	9	6	18	9	9	12	11	8
EMR	7	13	6	9	10	11	7	10	3	9	16	11	20	19	8	8	10	3
TOS	12	10	10	10	6	3	14	13	15	4	3	2	6	15	16	13	16	11
UMB	16	19	13	11	5	7	12	6	17	8	2	9	3	8	19	20	18	18
MAR	13	14	11	12	7	6	11	11	16	17	4	7	5	12	18	14	17	16
LAZ	10	6	12	15	4	1	9	9	18	19	1	1	4	11	17	19	15	12
CAM	15	12	16	16	14	5	16	18	10	16	10	5	15	7	11	10	9	10
ABR	11	7	9	3	13	13	13	2	12	10	11	15	8	6	10	6	4	9
MOL	14	15	17	18	15	17	17	16	14	15	12	16	7	5	14	17	6	7
PUG	17	17	15	13	17	14	15	12	11	20	15	13	10	2	13	16	8	13
BAS	18	20	20	20	18	15	20	20	8	7	17	14	16	18	20	18	3	6
CAL	9	8	14	8	16	18	10	5	5	2	13	19	11	10	12	11	7	5
SIC	20	16	19	17	12	12	19	17	19	11	8	12	1	1	15	15	13	17
SAR	19	11	18	14	19	19	18	14	20	18	19	17	2	3	5	5	14	19

Notes: A lower figure corresponds to a higher productivity.

Map 1. The public spending productivity (PSP) index (1989, 2019)



2019



Note: Higher value corresponds to darker blue regions and to higher public spending productivity.

In Appendix 3 (Supplementary Material), we provide further descriptive information about the PSP index and its relationships with the Golden-Picci (2005) corruption index and other well-known indexes of corruption, government effectiveness and quality of government, such as the Institutional Quality Indexes (Nifo and Vecchione, 2014 and 2015) and the European Quality Government Indexes (Charron et al., 2014, 2015, 2019, 2022). It turns out that the correlation among the other indexes is higher than the correlation between the PSP index and any of them (note that the Institutional Quality

Index of corruption is based, by construction, on the Golden-Picci index as well as on other indicators).

The relative lack of correlation between the new PSP index and the other indexes could either mean that the new index conveys little information, or, on the other hand, that it brings about interesting new information vis-à-vis the other indicators. In the following section, we endeavour to show evidence in favour of the latter alternative.⁷

4. An econometric analysis using the public spending productivity index

In this section we build upon Coppola et al. (2020) to analyse the impacts of European and national cohesion policies on the GDP per capita of the 20 Italian NUTS2 Regions, assessing the role of the PSP indexes for Total, Core, and Noncore assets as conditioning factors for the effectiveness of these policies.

We estimate the following dynamic panel specifications for the GDP per capita equation over period 1994-2019 (data for European and national cohesion policies are only available from 1994 onwards):

$$y_{rt} = a_1 y_{rt-1} + a_2 gfi_{rt-1} + a_3 D.pop_{rt} + a_4 SF_{rt} + a_5 Nat_{jrt} + a_6 PERIOD_2 * SOUTH + a_7 PERIOD_3 * SOUTH + a_8 PERIOD_4 * SOUTH + a_w W_{rt-1} + a_r + a_t + \varepsilon_{rt} \quad [6]$$

$$y_{rt} = a_1 y_{rt-1} + a_2 gfi_{rt-1} + a_3 D.pop_{rt} + a_4 SF_{rt} + a_{4,j} q_r SF_{rt} + a_5 Nat_{jrt} + a_{5,j} q_r Nat_{jrt} + a_6 PERIOD_2 * SOUTH + a_7 PERIOD_3 * SOUTH + a_8 PERIOD_4 * SOUTH + a_w W_{rt-1} + a_r + a_t + \varepsilon_{rt} \quad [7]$$

where $r = 1, \dots, 20$ refers to regions; $t = 1, \dots, n$ refers to years; and $j = 1, \dots, m$ refers to the type of fund being considered. The dependent variable y_{rt} is the (ln) GDP per capita; the lagged dependent variable y_{rt-1} allows for the dynamic structure inherent in the data. Variables gfi_{rt} and $D.pop_{rt}$, are the (ln) ratio of gross fixed investment over GDP and the (ln) variation of population respectively. SF_{rt} refers to the EU funds, inclusive of national co-financing, and Nat_{jrt} stands for an array of national funds related to regional policies (indexed by j), including current account subsidies to firms, nationally financed cohesion funds, capital account subsidies,⁸ nationally financed public investments. Both SF_{jrt} and Nat_{jrt} are taken as natural logs of ratios over GDP, in accordance with common practice in the literature. Variables a_r and a_t are region and year fixed effects respectively. Unobserved sources of time-varying unobserved heterogeneity are controlled through the interaction terms $PERIOD_n * SOUTH$, where $SOUTH$ is a binary variable equal to 1 for the Mezzogiorno regions; $PERIOD_2$, $PERIOD_3$ and $PERIOD_4$ are binary variables equal to 1 respectively in the

⁷ By saying that our indicator brings about novel information we do not imply that it is more comprehensive than previous indexes. For instance, our indicator does not rely on measures of the sources of corruption or inefficiency, such as the crimes against public administrations, or the presence of organized crime (see, e.g., Nifo and Vecchione, 2014, 2015).

⁸ Before year 2000 capital account subsidies to public administrations, to firms, and to households were gathered in a single account. Therefore, we aggregated all capital account subsidies into a single variable also after 2000.

second (2000–06), third (2007–13), fourth (2014–2019) SFs’ programming period. ε_{rt} is the customary independent and identically distributed (i.i.d.) error term.

Regions receiving more support from public policies are likely to be specific types of regions (the most disadvantaged ones or those experiencing difficult economic situations). We deal with this selection bias within the control function approach (Heckman and Hotz, 1989; Wooldridge, 2004). This approach posits that SF_{rt} and Nat_{jrt} , conditionally on observable covariates, are randomly allocated. This hypothesis of unconfoundedness underlies the estimation of the average treatment effect of policies through a ‘kitchen sink’ regression (with GDP per capita as a dependent variable) that includes SF_{rt} and Nat_{jrt} along with other determinants of the dependent variable, and some variables determining the regional allocation of the funds.⁹ The latter are gathered in the W_{rt-1} vector. This approach, readily lending itself to the modelling of multiple policy variables (SF_{rt} and Nat_{jrt}), is particularly convenient in the present case. Wooldridge (2004) shows that [6] and [7] yield consistent estimates of the average treatment effect of SF_{rt} and Nat_{jrt} , provided that these policy funds are continuous variables, and are a linear function of W_{rt-1} and of the other regressors. This function can be either homoscedastic or characterized by heteroskedastic residuals orthogonal to the coefficient estimates. We can take continuity for granted, and test for the other conditions (functional form, homoscedasticity or heteroskedasticity orthogonal to the coefficient estimates).

The role of the new PSP index and of the other institutional indexes emerges from the comparison between [6] and [7]. The latter includes interaction terms between indicators of the regional context (q_r) and the policy funds. Positive a_4 or a_5 coefficients mean that a higher contextual quality brings about higher policy effectiveness. Here we proxy the quality of the regional context through the index of corruption from Golden and Picci (2005), the Institutional Quality Indexes (IQI General index, IQI corruption index, IQI government effectiveness index), the European Quality Government Indexes (EQI general index, EQI corruption index, EQI quality of government index),¹⁰ and the PSP indexes for Total, Core, and Noncore assets. Since the index from Golden and Picci refers to a single year (1997), we take regional mean values also for the other indexes (that, in principle, vary through time) to provide a more meaningful comparison. More information about equations [6] and [7] and the econometric setup of the present section is given in Appendix 4 (supplementary material).

Table 5 shows the main results for equations [6] and [7], focusing upon the role of the quality of the regional context on the effectiveness of funds.

⁹ In [6] and [7] policy funds can react only with delay to changes in the economic or political environment. Indeed, we tested for the presence of contemporaneous policy effects, which turned out to be insignificant. These tests are available upon request.

¹⁰ These EQI and IQI indexes are all defined by Pinate et al. (2026) as representative of economic institutions.

Table 5a. Equation [6]

Regressors	(1)	(2)	(3)	(4)	(5)
EU Funds plus national co-financing	0.003**	0.003**	0.003**	0.003**	0.003**
Current account subsidies to firms		0.002			
Nationally financed cohesion funds			-0.002***		
Capital account subsidies				-0.001	
Nationally financed public investments					-0.001*
N	500	500	500	500	500
Rss	0.077	0.077	0.076	0.077	0.077
r2_a	0.998	0.998	0.998	0.998	0.998
Aic	-2864	-2862	-2864	-2861	-2861
Bic	-2641	-2631	-2632	-2629	-2629
A-B test	0.8498	0.8053	0.5493	0.748	0.8114
Reset test	0.2998	0.3394	0.1571	0.3256	0.3137

Note: *EU Funds plus national co-financing*, *Current account subsidies to firms*, *Nationally financed cohesion funds*, *Capital account subsidies*, *Nationally financed public investments* are all taken as the natural log of their ratio over GDP. *** stands for $p < 0.01$; ** for $p < 0.05$; * for $p < 0.1$. N is the number of observations, rss is the residual sum of squares, r2_a is the coefficient of determination adjusted for degrees of freedom, Aic is the Akaike information criterion, Bic is the Bayesian Schwarz information criterion. A-B is the Arellano-Bond test for serial correlation present at lag one, Reset is Ramsey's test for functional form and omitted variables (carried out including quadratic terms of fitted values). *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$; P-values reported for the A-B test and the Reset test.

Table 5b. Equation [7]: EU Funds plus national co-financing

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EU Funds plus national co-financing	0.003***	0.004***	0.006***	0.005***	0.003	0.003*	0.003	0.006	0.012	0.007**
Current account subsidies to firms										
Nationally financed cohesion funds										
Capital account subsidies										
Nationally financed public investments										
EU Funds plus national co-financing $\times q^1$	0.000	-0.002	-0.005*	-0.007***	0.000	0.000	0.000	-0.009	-0.004	-0.008*
Current account subsidies to firms $\times q^1$										
Nationally financed cohesion funds $\times q^1$										
Capital account subsidies $\times q^1$										
Nationally financed public investments $\times q^1$										
N	500	500	500	500	500	500	500	500	500	500
Rss	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077
r2_a	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998
Aic	-2862	-2862	-2863	-2864	-2862	-2862	-2862	-2862	-2862	-2863
Bic	-2634	-2635	-2635	-2636	-2634	-2634	-2634	-2635	-2635	-2635
A-B test	0.8552	0.8329	0.829	0.84	0.8676	0.8678	0.8528	0.8178	0.8188	0.8509
Reset test	0.295	0.319	0.3066	0.2529	0.271	0.2788	0.2836	0.3200	0.3123	0.2209

Note: ¹ Eq(1) q = Corruption index, Golden and Picci (2005); Eq(2) q = General index, IQI; Eq(3) q = Corruption index, IQI; Eq(4) q = Government effectiveness index, IQI; Eq(5) q = General index, EQI; Eq(6) q = Corruption index, EQI; Eq(7) q = Quality of government, EQI; Eq(8) q = New index of public spending efficiency – All assets; Eq(9) q = New index of public spending efficiency – Core assets; Eq(10) q = New index of public spending efficiency – Noncore assets. See note to Table 5a for further information.

Table 5c. Equation [7]: EU Funds plus national co-financing and current account subsidies to firms

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EU Funds plus national co-financing	0.002***	0.003***	0.005***	0.005***	0.003**	0.003*	0.003**	0.007	0.015	0.007**
Current account subsidies to firms	-0.005**	-0.009***	-0.015***	-0.002	0.004***	0.004***	0.004***	-0.009	-0.047***	0.007***
Nationally financed cohesion funds										
Capital account subsidies										
Nationally financed public investments										
EU Funds plus national co-financing $\times q^1$	0.000	-0.001	-0.003	-0.008***	0.001	0.000	0.000	-0.01	-0.006	-0.008*
Current account subsidies to firms $\times q^1$	0.005***	0.017***	0.022***	0.014***	0.005***	0.004***	0.005***	0.028**	0.023***	-0.010***
Nationally financed cohesion funds $\times q^1$										
Capital account subsidies $\times q^1$										
Nationally financed public investments $\times q^1$										
N	500	500	500	500	500	500	500	500	500	500
Rss	0.075	0.074	0.075	0.076	0.075	0.075	0.074	0.076	0.076	0.076
r2_a	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998
Aic	-2867	-2875	-2872	-2865	-2873	-2869	-2875	-2860	-2864	-2860
Bic	-2627	-2635	-2632	-2625	-2632	-2628	-2635	-2620	-2624	-2620
A-B test	0.8822	0.6014	0.6628	0.6981	0.869	0.9306	0.7691	0.7659	0.7054	0.874
Reset test	0.4234	0.6181	0.3799	0.2919	0.4593	0.3759	0.5453	0.3767	0.3002	0.247

Note: see notes to Tables 5a and 5b.

Table 5d. Equation [7]: EU Funds plus national co-financing and nationally financed cohesion funds

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EU Funds plus national co-financing	0.002**	0.003***	0.006***	0.004***	0.003*	0.003*	0.003	0.006	0.004	0.007**
Current account subsidies to firms										
Nationally financed cohesion funds	-0.003***	-0.005**	-0.004	-0.002***	-0.001**	-0.001**	-0.001*	-0.005	-0.019*	-0.001
Capital account subsidies										
Nationally financed public investments										
EU Funds plus national co-financing $\times q^1$	0.001	-0.001	-0.004	-0.006**	0.001	0.001	0.000	-0.008	-0.001	-0.008*
Current account subsidies to firms $\times q^1$										
Nationally financed cohesion funds $\times q^1$	0.001*	0.005*	0.003	0.003*	0.002**	0.001**	0.002***	0.008	0.008*	-0.001
Capital account subsidies $\times q^1$										
Nationally financed public investments $\times q^1$										
N	500	500	500	500	500	500	500	500	500	500
Rss	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076
r2_a	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998
Aic	-2861	-2863	-2861	-2862	-2862	-2862	-2864	-2860	-2861	-2860
Bic	-2621	-2622	-2621	-2621	-2622	-2621	-2624	-2620	-2621	-2620
A-B test	0.6493	0.5201	0.573	0.5253	0.6807	0.6912	0.6167	0.5326	0.5572	0.5819
Reset test	0.1574	0.2258	0.1798	0.1408	0.1568	0.148	0.2067	0.1760	0.1670	0.099

Note: see notes to Tables 5a and 5b.

Table 5e. Equation [7]: EU Funds plus national co-financing and capital account subsidies

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EU Funds plus national co-financing	0.003***	0.004***	0.007***	0.005***	0.003	0.003*	0.003	0.007	0.018	0.007**
Current account subsidies to firms										
Nationally financed cohesion funds										
Capital account subsidies	-0.008***	-0.004	-0.014*	-0.001	0.000	0.001	0.000	-0.033***	-0.093***	-0.010**
Nationally financed public investments										
EU Funds plus national co-financing $\times q^1$	0.000	-0.003	-0.006**	-0.009***	0.000	0.001	0.000	-0.013	-0.007	-0.010*
Current account subsidies to firms $\times q^1$										
Nationally financed cohesion funds $\times q^1$										
Capital account subsidies $\times q^1$	0.005**	0.004	0.016	-0.002	0.002	0.003**	0.002	0.081***	0.042***	0.019**
Nationally financed public investments $\times q^1$										
N	500	500	500	500	500	500	500	500	500	500
Rss	0.076	0.077	0.076	0.077	0.077	0.077	0.077	0.076	0.076	0.077
r2_a	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998
Aic	-2861	-2858	-2861	-2859	-2858	-2860	-2858	-2862	-2863	-2859
Bic	-2620	-2617	-2621	-2619	-2618	-2619	-2618	-2622	-2623	-2619
A-B test	0.8203	0.7229	0.658	0.7313	0.8216	0.8201	0.7972	0.7496	0.6848	0.5808
Reset test	0.3102	0.3431	0.3302	0.2687	0.2389	0.2259	0.2653	0.3028	0.3735	0.2650

Note: see notes to Tables 5a and 5b.

Table 5f. Equation [7]: EU Funds plus national co-financing and nationally financed public investments

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EU Funds plus national co-financing	0.003***	0.004***	0.005***	0.005***	0.003	0.003	0.003	0.007	0.012	0.007**
Current account subsidies to firms										
Nationally financed cohesion funds										
Capital account subsidies										
Nationally financed public investments	0.004*	0.010***	0.012***	0.000	-0.008***	-0.008***	-0.008***	-0.019*	-0.042	-0.021***
EU Funds plus national co-financing $\times q^1$	0.000	-0.002	-0.004	-0.007***	0.000	0.000	0.000	-0.011	-0.005	-0.009*
Current account subsidies to firms $\times q^1$										
Nationally financed cohesion funds $\times q^1$										
Capital account subsidies $\times q^1$										
Nationally financed public investments $\times q^1$	-0.006**	-0.021***	-0.018***	-0.003	-0.007***	-0.006***	-0.007***	0.046*	0.019*	0.041***
N	500	500	500	500	500	500	500	500	500	500
Rss	0.076	0.076	0.076	0.077	0.075	0.076	0.075	0.077	0.077	0.076
r2_a	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998
Aic	-2860	-2866	-2861	-2859	-2867	-2864	-2868	-2858	-2858	-2863
Bic	-2620	-2626	-2621	-2619	-2627	-2624	-2627	-2618	-2618	-2623
A-B test	0.9963	0.6982	0.8322	0.8162	0.7924	0.8157	0.7565	0.6522	0.6646	0.8562
Reset test	0.4232	0.4965	0.3329	0.232	0.4785	0.3723	0.502	0.3423	0.3774	0.3326

Note: see notes to Tables 5a and 5b.

Estimation of [6] unveils a positive impact of EU funds, while national funds are not significant at all or, like the national cohesion funds, have a negative sign. We are aware that it has been often argued that EU funds are mismanaged in Italy. Our results indicate that national funds could be much more decisively mismanaged than EU funds. Indeed, estimation of [7] shows that the effectiveness of national funds is more sensitive to the influence of the regional context than that of EU funds.¹¹ The multilevel and multiannual programming governance of EU funds possibly shields these funds from detrimental contextual influences. We come back to this point in the concluding remarks.

“Traditional” indicators of the quality of regional context (the index of corruption from Golden and Picci, 2005; the Institutional Quality Indexes; the European Quality Government Indexes) have a pervasively positive influence on the effectiveness of current-account subsidies to firms, but so do the PSP indexes. However, all the “traditional” indicators have a negative influence on the effectiveness of national public investments, an effect that is significant in six cases out of seven and that is not easy to rationalize. The PSP indexes have, on the other hand, a significantly positive interaction with national public investments, which is very much in line with a priori expectations. Our new indexes also positively interact with capital-account subsidies. Except for the pervasively influenced current-account subsidies to firms, the latter is the only commonality of the PSP indicators with the Golden-Picci index. All in all, it appears that the new indexes bring about interesting new information vis-à-vis the other indicators in the field of capital-account expenditures. This is what one would have expected from their construction, especially for national public investments, and it is an important result, given the policy relevance of this kind of expenditure (Aschauer, 1989; Romp and De Haan, 2007; Rodríguez-Pose et al. 2012; Crescenzi and Giua, 2016; Di Caro and Fratesi, 2021). We wish to stress that the series for national public investments used in [6] and [7] (sourced from *Spesa statale regionalizzata*, *Ragioneria Generale dello Stato*) differs the public investment series (sourced from CPT) used for the reconstruction of the monetary indicator of public capital. Accordingly, our results cannot be readily ascribed to a spurious correlation arising from the construction of the PSP index. Summing up, our evidence suggests that the PSP index adds useful new information. Moreover, being available for six asset classes, as well as for core, noncore and total infrastructure aggregates, the PSP index could be of particular interest in applications focusing on selected areas of public spending.

¹¹ EU funds are only sporadically influenced by the quality of the regional context (more often than not with a negative sign that is difficult to rationalise).

5. Concluding remarks

More infrastructure likely brings about higher GDP per capita and effectiveness of regional policies, supporting economic and social wellbeing and helping to remove economic and social disparities. However, public investments may be ineffective. Developing upon Golden and Picci (2005) measure of corruption, we construct a time-varying index of sectoral public spending productivity (PSP) throughout 1989-2019. This measure, although deeply inspired by the Golden-Picci approach, differs from it in terms of data on physical and monetary public capital and structure of the econometric approach. Throughout our econometric analysis, we pay attention to the cross-section dependence and dynamic properties of the data and look for the existence of long-run relationships among the variables under scrutiny. Our PSP measure is a time-varying annual indicator, computed over a wide time range, unlike Golden-Picci cross sectional indicator. A further novelty of the new measure is its availability for six asset classes, as well as for core, noncore and total infrastructure aggregates.

Our findings reiterate the strong and critical differences existing across Italian regions in terms of public spending productivity. Yet, relative to the existing indexes of corruption, government effectiveness and quality of government, the new PSP index conveys interesting new information. We provide a first assessment of the novel information brought about by our new indicator, investigating the impact of PSP on the effectiveness of regional policies upon GDP per capita. All the “traditional” indicators have a negative influence on the effectiveness of national public investments, which is not easy to rationalize. The PSP (core, noncore and total) indexes have, on the other hand, a significantly positive impact on the effectiveness of national public investments, very much in line with a priori expectations. The PSP indexes also positively impact the effectiveness of capital-account subsidies. It has been often argued in the literature that EU funds are mismanaged in Italy. Our results suggest that EU funds are less sensitive than national funds to the influence of the regional context. We can surmise that this finding is linked to the presence of gross fixed investment in [6] and [7] (a specification not very common in the literature), and to the control function approach that allows for the selection bias in fund allocation. At any rate, future work on this issue can take full advantage of the informational content of the new regional dataset, which spans a lengthy period and provides information for six asset classes, as well as for core, noncore and total infrastructure aggregates.

Another obvious task for further research is the careful consideration within our setup of the Covid-19 pandemic shock and of the subsequent huge inflow of investment expenditures, which is propaedeutic to the extension of our dataset beyond 2019. Other future work could address the separation of changes in the state of technology from changes in technical or scale efficiency as

sources of PSP dynamics through, e.g., the calculation of Malmquist productivity indexes. Yet another potentially interesting field of research relates to the spatial analysis of the PSP indicators. A relevant limit of the new indicators is that they cannot be readily computed at finer levels of territorial disaggregation than NUTS2 regions. This is due to the lack of information for public investments in smaller areas, e.g., at NUTS3 level, at least since 2002 (see on this Roncaccia and Iannaccone, 2009). A further limit relates to the discrepancies in asset classification for physical and monetary measures that have been highlighted in §§ 3.1 and 3.2. Future work on the CPT and other datasets could be addressed to overcome these limitations, allowing the creation of more accurate and detailed indexes for public spending productivity.

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