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A Quantitative Evaluation of EU and National Cohesion Policies

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A Quantitative Evaluation of EU and National Cohesion Policies

Acronyms and Abbreviations

CAP	Common Agriculture Policy
CF	Cohesion Fund
CPT	Conti Pubblici Territoriali
CSF	Community Support Framework
EAFRD	European Agricultural Fund for Rural Development
EAGF	European agricultural guarantee fund
EAGGF	European Agricultural Guidance and Guarantee Fund
EFF	European Fisheries Fund
EMFF	European Maritime and Fisheries Fund
EQI	European Quality of Government Index
ERDF	European Regional Development Fund
ESF	European Social Fund
ESIF	European Structural and Investments funds
EU	European Union
FEAD	Fund for European Aid to the Most Deprived
FIFG	Financial Instrument for Fisheries Guidance
GDP	Gross Domestic Product
IQI	Institutional Quality Index
IVIE	Instituto Valenciano de Investigaciones Economicas
MIP	Mediterranean Integrated Programme
MISE	Economic Development Ministry, properly Ministero dello Sviluppo Economico
MIT	Infrastructure and Transport Ministry, properly Ministero delle infrastrutture e della mobilità sostenibile
MS	European Union Member State
NOP	National Operational Programme
PIM	Perpetual Inventory Method
RDD	Regression Discontinuity Design
ROP	Regional Operational Programme
TFP	Total Factor Productivity
YEI	Youth Employment Initiative

A Quantitative Evaluation of EU and National Cohesion Policies

Giulia Nunziante

Since the Treaty of Rome (1957) EU funds have been devoted to rebalancing regional economic and social disparities. Today more than ever, it does not seem feasible to advance towards a closer integration of the European Union, without favouring a greater economic and social cohesion between its countries. Yet, there are still very deep economic and social disparities both between countries and between regions that compose the Union, undermining its unity and cohesion. In order to rebalance these disparities, the EC Member States have developed a unitary strategy, namely the European Cohesion Policy, which has taken through different configurations according to the economic and political environment, the member states priorities, the financial resources, the past governance experience. In any case, the need to evaluate the appropriateness and effectiveness of development policies implemented through this powerful tool cannot be underestimated. For the new programming period (2021-2027), an amount of € 330.2 billion has been allocated in Europe for this policy, almost one third (30.7%) of the total budget of the European Union (€ 1,074.3 billion Euro net of Next Generation EU). See https://www.consilium.europa.eu/it/policies/the-eu-budget/long-term-eu-budget-2021-2027/.

The analysis of Cohesion Policy is very complex considering the different regional, multiregional and interregional programmes. There is an abundant and sophisticated literature on the effectiveness of EU Cohesion policy urged by the size of the budget and the critical role of the multilevel governance of development programmes. In most cases, this policy seems to have a positive impact on growth, but the significance of the results is far from uniform. A feature that emerges across various studies is that the policy impact depends on a series of conditioning factors (see Fratesi, 2016). Indeed, recent contributions pay attention to the relevance of some conditioning variables such as the quality of institutions – which positively affect Structural Funds effectiveness -, the expenditure typology – suggesting that investment in education and human capital are more viable for economic growth -, the territorial endowment in private, public, physical, and immaterial capital.

The endowment of public capital is considered among the most relevant factors impacting the growth process (Romp and De Haan, 2007). In that perspective, the Cohesion policy aiming to rebalance regional and social disparities, is largely involved in co-financing major infrastructure projects. Furthermore, the Cohesion policy effectiveness is improved by regional infrastructural endowment (Crescenzi and Giua (2016), Fratesi and Perucca (2014)). Therefore, investment flows in infrastructure should positively impact on social and economic wellness while the public capital stock should enhance EU action to development objectives, generating a virtuous circle. However, the efficiency of spending in public capital is not homogeneous, and the virtuous circle may be broken if the government cumulative investments – which is the basis of the Perpetual Inventory Method (PIM) used to measure the public capital in monetary terms – do not correspond to equivalent physical infrastructure due to waste, corruption, or other forms of inefficiency.

Inspired by Golden and Picci (2005a) who define the difference among the public capital in monetary terms and the public capital in physical terms (controlled for cost differences in infrastructure construction) a measure of corruption, "indicating waste, fraud, and mismanagement in the public contracting process", we investigate in Chapter 2 of the thesis the sectoral efficiency public spending across the Italian regions.

The approach adopts the following strategy. Firstly, we build a set of time-varying indicators to measure regional sectoral physical infrastructural endowment over the last 30 years, thanks to the collaboration with the research centre Studiare Sviluppo involved in the industrial PhD. In particular, in order to measuring regional public infrastructure in physical terms for the very long period 1987-2016, we detect 30 elementary indicators mostly mentioned by main approaches used to compute infrastructural endowments. The collection of the elementary indicators has been challenging because of the long period being considered and the different sources adopted (Istat, Eurostat, MIT, Terna, Unionpetrolifera, Autorità di regolazione per Energia, Reti e Ambiente (ARERA), Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA)).

Secondly, we update the regional sectoral public investment elaborated by Picci (2001) for 9 assets for 1890-1998 using the public expenditures from the database *Conti Pubblici Territoriali* (CPT). Some relevant assumptions must be taken since CPT data are organized in 30 Functions of Government classes (COFOG). Then, we tackle the public capital stock measurement for 7 assets by cumulating gross fixed capital formation year by year and deducting depreciation. The estimation approach for capital computation follows the methodology developed by EUKLEMS and used by the Fundacion BBVA-IVIE (The Valencian Institute of Economic Research), the foreign research centre involved in the industrial PhD.

Finally, we measure public spending efficiency throughout the long and updated period 1987-2016 adopting a novel methodological approach. We regress the infrastructure index in physical terms on the net public capital stock based on the PIM, allowing for a series of control variables. The regression is carried out over period 1987-2016 using regional (NUTS2) data. For all assets, we observe a high fit of the model and positive and significant coefficients for the net public capital stock. The new public spending efficiency index is then constructed using the area-related fixed effects and trends from these regressions, along with the mean values of the residual terms.

We assess the robustness of the new public spending efficiency index and conclude that our measure of public spending efficiency is broadly capable of bringing to a panel, time-varying, setup the cross-region institutional features highlighted by the Golden-Picci measure. We then reproduce the econometric approach used in Coppola et al. (2018) to analyze the impacts of European and national cohesion policies on the GDP per capita of the 20 Italian NUTS Regions over the period 1994-2016, introducing the new Public Spending Efficiency index as a conditioning factor for the effectiveness of these policies. Some interesting findings emerge from this analysis.

A traditional indicator of quality of government (Charron et al., 2014) is characterized by a positive influence on the effectiveness of current-account subsidies to firms and of national cohesion funds, and a negative (not easy to rationalize) influence on national public investments. The corruption index (Golden and Picci, 2005) only interacts positively with current-account subsidies to firms (it also some marginally insignificant negative interaction with national public investments). The new index of public spending efficiency for all assets has a more widespread positive interaction with all national policies (but, again, for national public investments), although this interaction is fully significant only for current-account subsidies to firms. The spending efficiency in Roads, Buildings and Health interacts strongly and positively with the effectiveness of both current-account subsidies to firms and national cohesion funds. However, in the first two cases, it also interacts negatively with the effectiveness of national public investments. The pattern for Rails, Water and Others is, by and large, close to that of the aggregate index. All in all, the new indexes of spending efficiency seem capable to bring about interesting information in the debate about the effectiveness of regional policies. There is, however, both for some of these indexes and for the former ones (from Charron et al., and, to a lesser extent, from Golden and Picci) a *negative* interaction between spending efficiency (or good governance) and the effectiveness of national public investments that is not easy to explain. A final important point is that the effectiveness of EU funds, like in Coppola et al. (2018) is impervious to the influence of the regional context. Arguably, this feature is linked to the effectiveness of the multilevel and multiannual programming governance of EU funds.

In the last decades, despite various impressive technological waves, Italy and Spain experienced a very disappointing evolution of Total Factor Productivity (TFP) – contrary to most advanced countries. However, the two countries differ from their capital dynamics. In fact, Spain reveals a strong capital accumulation while Italy experienced a relative delay in capital growth since the 1990s. Moreover, both countries presented relevant productive fragilities and regional dualisms, characterized by disparities in local production structure and specialization, ICT pervasiveness, human capital, infrastructure endowment.

In chapter 3, we explore similarities and differences of the Italian and Spanish economies at the regional (NUTS2) level. We rely on the Solow neo-classical growth model for closed economies, supposing that if regions in the two countries are similar with respect to preferences and technology, they converge to a long-run steady-state per capita capital per worker (and TFP level), poor regions tending to grow faster than rich ones. This comparative convergence analysis is carried out over period 1980-2016.

In order to carry out this analysis, we construct long times series for regional capital stock by asset and sector. In doing so, we fill an important gap in the statistical information available for Italian regions. These key statistics are indeed crucial for the study of several relevant issues relative to the effectiveness of structural policies, regional growth and convergence/divergence, the disparities in productivity in Italy with their economic and social implications. The methodology used to construct regional investment and capital series for Italy by assets and economic sectors, relative to the period 1970-2016. The approach is based on the EUKLEMS adaptation of the PIM, basically already used by BBVA-IVIE to compute regional series for the capital stock in Spain.

Moreover, we elaborate regional series throughout 1970-2016 for human capital by gender, level of education, 8 sectors (Agriculture, Energy, Manufacturing, Construction, Trade, Transport and Communication, Finance and Insurance, Others) using the methodology introduced in Destefanis et al. (2004). Specifically, the interpolating procedure adopted two sources of data, one with higher (annual) frequency, but less detailed - Annuario di statistiche del lavoro and the Bollettino mensile di statistica -, and another one (from census data) much more detailed, but only available at ten-years intervals.

We take advantage of these data to construct and discuss beta and sigma convergence statistics for regional productive capacities over the period 1980-2016 and propose a regional taxonomy from the convergence perspective for Italy and Spain. This descriptive analysis highlights that the process of convergence, both for capital per worker and TFP, has been stronger in Spain than in Italy. Hence, we proceed to analyze the impact of EU and national cohesion policies on the convergence process in Italy and Spain during 1980-2016 adopting two different approaches.

First, we update and extend the analysis by Destefanis and Sena (2005), who considered the empirical long-run relationship between public capital and TFP across Italian regions. We now examine a more recent sample, we extend the analysis to the Spanish regions, and we consider other potential determinants of TFP, such as human capital and direct indicators of EU structural funds. The main findings from this analysis validate the previous descriptive evidence. In fact, only in Spain core public capital and, to a lesser extent, human capital affect TFP in differences and in levels. This means that these regressors influence the steady state of TFP in Spain, thus achieving a stronger convergence. In Italy, core public capital only affects TFP in differences, which means that it cannot influence the steady-state level of TFP. On the other hand, EU funds are significant in Italy and not in Spain. Our interpretation, consistent with some literature (de la Fuente and Vives, 1995; de la Fuente, 2003), is that in Spain ESIFs work out their effect entirely through public capital and human capital, while in Italy they have an extra impact on TFP (because, for instance, of a better management of funds as explained in Coppola et al., 2018).

In order to acquire further knowledge upon the role of European structural funds and of national funds in the convergence process, we run a second econometric exercise, extending and updating the work of Coppola et al. (2018) of GDP per capita determination to both Italian and Spanish regions over 1993-2016. This exercise highlights again a strong independent role for ESIFs in Italy but not in Spain. On the other hand, the measures of public investment are basically insignificant in Italy and very significant in Spain. Human capital is somewhat significant in Spain but only shows up in Italy in terms of variations. Once more, one gets the impression that in Spain ESIFs work out their effect entirely through capital accumulation, while in Italy they have an extra impact on TFP, which can be rationalized in terms of a better management of EU funds vis-à-vis nationally funded policies.

1 The analysis of cohesion policies: the state of the art

Today more than ever, it does not seem feasible to advance towards a closer integration of the European Union, without favouring a greater economic and social cohesion between its countries. Yet, there are still very deep economic and social disparities both between countries and between regions that compose the Union, undermining its unity and cohesion. In order to rebalance these disparities, the EC Member States have developed a unitary strategy, namely the European Cohesion Policy[1], which has taken through different configurations according to the economic and political environment, the member states priorities, the financial resources, the past governance experience. In any case, the need to evaluate the appropriateness and effectiveness of development policies implemented through this powerful tool[2] cannot be underestimated. According to Felice (2017, p. 5), "Italy is arguably the only Western country where regional imbalances still play a major role nowadays: Italy's North-South divide in terms of GDP has no parallels in any other advanced country of a similar size, and Southern Italy is, after Eastern Europe, the biggest underdeveloped area inside the European Union." The evolution of the European Cohesion Policy in the last 60 years must be carefully appraised in order to provide a proper perspective to the analyses of the interactions of these policies with regional dualism in Italy that will be undertaken in the following chapters.

The chapter is organized as follows. Section 1 describes the evolution of the European Cohesion Policy in the last 60 years and Section 2 illustrates the empirical literature on the effectiveness of European regional policy with an in-depth analysis on contributions concerning Italy. Concluding remarks reported in Section 3 end the chapter.

1.1 The European Cohesion Policy: issues from the past and future perspectives

Although the first mention of regional differences dates to the Treaty of Rome (1957), the EU strategy adopted to reduce regional disparities in the Member States Regions has deeply evolved during four major periods. By and large this strategy has regarded the EU Structural and Investment Funds, that are:

- the European Regional Development Fund (ERDF), created in 1975 with the aim of reducing regional imbalances in the European Union;
- the European Social Fund (ESF), created in 1957 with the aim of promoting training and the educational attainment among the labour force, as well as other forms of active labour market policies;
- the European Agricultural Fund for Rural Development (EAFRD) and the European Agricultural Guarantee Fund (EAGF), aimed at facilitating the adjustment of agricultural structures and the development of rural areas. They substituted in 2007 the European Agricultural Guidance and Guarantee Fund (EAGGF) dating back to 1962;
- the European Fisheries Fund (EFF) supporting the national fishery programmes and substituting in 2007 the Financial Instrument for Fisheries Guidance (FIFG) created in 1994;
- the Cohesion Fund (CF), supporting transport and environment projects in countries where the gross national income per inhabitant is less than 90% of the EU average. It should be noted that, due to its relatively high GDP per capita, Italy does not qualify for the EU's Cohesion Fund.

We will now survey the evolution in the governance and other characteristics of these funds, with some emphasis on the developments that concern Italy more closely.

[1] In this chapter, we refer indistinctly to cohesion or regional policies.

[2] For the new programming period (2021-2027), an amount of € 330.2 billion has been allocated in Europe for this policy, almost one third (30.7%) of the total budget of the European Union (€ 1,074.3 billion Euro net of Next Generation EU). See https://www.consilium.europa.eu/it/policies/the-eu-budget/long-term-eu-budget-2021-2027/.

1.1.1 The early EU regional policy

The Paris Conference (1972) held with three new-coming EC members (Denmark, Ireland and United Kingdom) in addition to the six founding countries (Belgium, France, Germany, Italy, Luxembourg and the Netherlands), can be considered the first concrete step to face the harmonization of national regional policy in order to add new financial resources without substituting national funds for inter-regional rebalancing. In this period, despite the creation in 1975 of the European Regional Development Fund (ERDF) to adjust the most relevant regional disequilibrium in the Community in particular connected to the prevalence of agriculture activities, industrial transformation and structural unemployment, the Community regional policy remained exclusive competence of each Member State. In that perspective ERDF can be considered a mere complementary instrument to national Members financial resources – and in some case, a strictly repayment of public spending - in the supported areas detected by national governments, financing single projects rather than integrated and inter-regional programmes. During 1975-1977 the resources devolved to the nine Member States amount to nearly 4% of the Community budget[3].

The management of ERDF funds was initially attributed to each Member State that autonomously decided the supported areas until 1979 when a marginal 5% ERDF share was assigned to EU Commission dispositions for regional policy. In 1984, some multi-year Community initiatives proposed by the EU Commission to tackle Member States territorial problems were introduced. With the Community enlargement to Spain and Portugal (1986), some Mediterranean Integrated Programmes (MIPs) financed by ERDF and other EU Structural Funds were introduced to improve socio-economic infrastructures in the Mediterranean area, revealing the necessity to adopt inter-regional strategies.

1.1.2 The structural policy conducted through the structural funds

The structural policy, which took place in 1988 with the Single European Act (1986) and the successive two Regulations re-defining the tasks of the Funds[4], devolve existing EU Structural Funds to reduce economic and social disparities, defining the priorities, identifying the most disadvantaged regions, increasing the participation of local institutions, imposing common rules on policy management, control and evaluation, creating a system of multilevel governance centred on a multiannual programming period. In fact, this approach marked a radical turn point in comparison to the practice of reimbursing existing projects introduced by Member States on an annual basis which characterized previous EU programmes.

The reform of the EU Structural Funds introduced four key principles underpinning cohesion policy:

- *Concentration*: according to the *thematic concentration* the targeting investments are focused on key priorities; for the *geographic concentration* the greater part of structural fund resources is concentrated on the poorest regions and countries; for the *spending concentration*, at the beginning of each programming period, annual funding is allocated to each programme and these funds must be spent by the end of the second year after their allocation.
- *Partnership*: each programme involves in the different programming phases a collective process including European, regional, local level, social partners and organizations from civil society, in order to ensure the appropriate socio-economic impact and the effectiveness of the Community action.
- *Additionality*: financing from the European Structural funds may not replace national spending by Member States but add financial resources to public spending for the same target.
- *Programming*: cohesion policy funds multi-annual national programmes aligned on EU objectives and priorities. The programming process includes i) planning and selection of Member States needs revealed in multi-annual plans; ii) priority actions and strategy programming with the definition of the Community Support Framework (CSF); iii) implementation of the CSF through individual regional

[3] European Commission (2008).
[4] Regulation (EEC) No. 2052/88 and Regulation (EEC) No. 4253/88.

operational programmes (ROPs) and national operational programmes (NOPs); iv) monitoring and evaluation of the CSF.

The EU Structural Funds reform found its first application in the Community programming 1989-1993 which defined five priority objectives according to the concentration principle:

- Objective 1[5]: promoting the development and structural adjustment of regions whose development is lagging behind (financed by ERDF, ESF, EAGGF);
- Objective 2[6]: converting regions seriously affected by industrial decline (financed by ERDF, ESF);
- Objective 3: combating long-term unemployment (financed by ESF);
- Objective 4: facilitating the occupational integration of young people (financed by ESF);
- Objective 5: (a) speeding up the adjustment of agricultural structures (financed by ESF, EAGGF) and (b) promoting the development of rural areas (financed by ESF, EAGGF).

During 1989-1993, total EU Structural Funds budget (that in fact represent the most important instrument to implement regional development policy) was 69 billion ECU representing 25% of the EU budget and 0.3% of the total GDP of the EU. Nearly 64% of EU Regions and 54.8% funding were involved in Objective 1 funds. The main beneficiary countries were Spain (ECU 14.2 billion), Italy (ECU 11.4 billion), Portugal (ECU 9.2 billion), Greece (ECU 8.2 billion)[7].

At the end of this first programming period, the structural policy was revisited according to the fact that relevant allocated resources were not spent because of the inability of Member States and other local institutions involved in structural fund correct management.

1.1.3 The strengthening of the cohesion policy

In 1993 entered into force the Maastricht Treaty in the context of moves towards economic and monetary union and the establishment of a single currency, introducing the Cohesion Fund for countries with a Gross National Product of less than 90% of the Community average: Greece, Ireland, Portugal and Spain benefited from the fund between 1994 and 1999. According to the Treaty, the economic and social cohesion enforcement is included among the strategy to improve balanced and sustainable economic and social progress and the Commission pursued procedures simplification, and financial transparency and control and modified the list of the supported regions. Moreover, the Treaty established the consulting European Committee of the Regions composed of Regional and local representatives according to the subsidiarity principle which ensure that decisions are taken as closely as possible to the citizen. Finally, the Financial Instrument for Fisheries Guidance (FIFG) was launched in 1994 to support EU fisheries sector.

The financed objectives for 1994-1999 were:

- Objective 1[8]: promoting the development and structural adjustment of regions whose development is lagging behind. This Objective involved 26% of the Community population and two thirds of the EU Structural Funds;
- Objective 2: converting regions or parts of regions seriously affected by industrial decline. This Objective involved 16.4% of the Community population and was financed by 11% of EU Structural Funds;
- Objective 3: combating long-term unemployment and facilitating the integration into working life of young people and of persons exposed to exclusion from the labour market, promotion of equal

[5] The Southern Italian Regions included in Objective 1 for 1989-1993 are Abruzzo, Basilicata, Calabria, Campania, Molise, Apulia, Sardinia, Sicily.
[6] The Italian Provinces (NUTS3 areas) included in Objective 2 are in Abruzzo, Emilia Romagna, Friuli Venezia Giulia, Latium, Liguria, Lombardy, Marches, Piedmont, Tuscany, Trentino Alto Adige, Umbria, Aosta Valley e Veneto.
[7] European Commission (2008).
[8] At the end of 1996, Abruzzo left the Objective 1 status.

employment opportunities for men and women. 9.4% of EU Structural Funds was dedicated to this Objective, considering the share of young unemployed (1.3% of the population) and long term unemployed (2.4% of the population);
- Objective 4: facilitating adaptation of workers to industrial changes and to changes in production systems. This Objective was financed by 1.6% of EU resources;
- Objective 5: promoting rural development by (a) speeding up the adjustment of agricultural structures in the framework of reform of common agricultural policy and promoting the modernization and structural adjustment of the fisheries sector (financed by 4.4% of EU resources), (b) facilitating the development and structural adjustment of rural areas (financed by 5% of EU resources);
- Objective 6: development and structural adjustment of regions with an extremely low population density (as of 1 January 1995, financed by 0.5% of EU resources).

During 1994-1999, the total EU Structural Funds budget doubled (ECU 168 billion), representing about one third of the EU budget and 0.4% of the total GDP of the EU. The main beneficiary countries were Spain (ECU 42.4 billion), Germany (ECU 21.8 billion), Italy (ECU 21.7 billion), Portugal (ECU 18.2 billion), Greece (ECU 17.7 billion) and France (ECU 14.9 billion)[9].

1.1.4 The economic and social cohesion policy after the 2006 EU enlargement

Then, the EU Cohesion Policy moves towards simplification in parallel with the preparation for enlargement with 10 new Member States joining in May 2006 which brought a 20% increase in the EU's population, but only a 5% increase in the Union's GDP and the significant reduction of the average GDP per capita (in fact, EU25 GDP per capita is approximatively 12.5% lower than EU15 GDP per capita)[10]. With *Agenda 2000* more relevance was given to growth, employment and innovation. In particular, the following key goals were selected:

- Balanced long-term development of economic activities;
- Employment support;
- Environment protection;
- Reduction of economic Inequalities;
- Promotion of gender equality.

1.1.4.1 The 2000-2006 Programming cycle

The EU Structural Funds reform of 1999 for the programming period 2000-2006, implements a proper economic and social cohesion policy adopting a political perspective in order to reduce disparities, improving a parallel development of all Member States ensuring wellness and similar opportunities to EU citizens among the different EU regions. Specifically, the reform produced the simplification of EU Structural Funds programming and management. Moreover, the number of Structural Funds Objectives for the programming period 2000-2006 were reduced from six to three:

- Objective 1[11]: promoting the development and structural adjustment of regions whose development is lagging behind. The eligible Objective 1 Regions are characterized GDP per capita below 75% of the EU average. This Objective involved 22.2% of the Community population and was financed by 22.1 billion euro;
- Objective 2: supporting the economic and social conversion of areas facing structural difficulties, hereinafter. This Objective was financed by 11.5% of EU Structural Funds;
- Objective 3: supporting the adaptation and modernization of policies and systems of education, training and employment. All the EU Regions excluded the Objective 1 Regions are eligible for

[9] European Commission (2008).
[10] European Commission (2008).
[11] At the end of 2003, Molise left the Objective 1 status.

Objective 3 which can be considered the reference framework for human capital improvement strategy. 12% of the EU Structural Funds are devoted to this Objective exclusively financed through the ESF.

Total of EU Structural Funds available was 213 billion euro (195 billion euro for EU Structural Funds and 18 billion for the Cohesion Fund) for EU-15 between 2000 and 2006, and 21.7 billion euro for the 10 new Member States between 2004 and 2006, representing about one third of the EU budget and 0.4% of the total GDP of the EU. The main beneficiary countries were Spain (56.3 billion), Germany (29.8 billion), Italy (29.6 billion), Greece (24.9 billion), Portugal (22.8 billion), the United Kingdom (16.6 billion), and France (15.7 billion)[12].

In the same period the Community Initiatives were reduced from 13 to 4 (INTERREG III for trans-frontier, trans-national and inter-regional cooperation improving development and harmonious and balanced territorial framework, URBAN II for the economic and social recovery of degraded urban areas, LEADER + for rural development, EQUAL to improve transnational cooperation to reduce discrimination and inequality on the labour market) as well as the share of EU Structural Funds devolved to these programmes (5%).

According to the partnership principle, a clear assumption of functions and responsibilities was defined as:

- The quantification of the strategic Objectives, the priority axes and their relative funding, the measures description and the necessary guarantees for the implementation are Community level competences. The detailed programming is under the Member States responsibility that ascribe the operation measures, quantifying the specific Objectives and defining final beneficiaries and the selection criteria;
- In order to ensure a rigorous control and to strictly verify the results, EU Commission monitors that each Member State has appropriate systems for managing, evaluating and controlling.

After the French and Dutch referendum rejection in 2004 for the establishment of a Constitution for Europe, the Lisbon Treaty (2007) defining some institutional changes, introduced the concept of territorial cohesion beside economic and social components, improving the role of regions and local institutions in order to pursue a more balanced equilibrium of the EU territory.

1.1.4.2 The 2007-2013 Programming cycle

Due to the deepened economic and social disparities emerged after the enlargement, during the period 2007-2013 the EU Cohesion policy shifted to the highest concentration of resources on the poorest Member States and Regions and the inclusion of all Regions. This radical change imposed that a quarter of resources was earmarked for research and innovation and about 30% for environmental infrastructure and measures combating climate change.

The priority objectives were defined as follows:

- *Convergence*: aims at speeding up the convergence of the least-developed Member States and regions defined by GDP per capital of less than 75% of the EU average;
- *Regional Competitiveness and Employment:* covers all other EU regions with the aim of strengthening regions' competitiveness and attractiveness as well as employment;
- *European Territorial Cooperation*: based on the INTERREG initiative, support is available for cross-border, transnational and interregional cooperation as well as for networks.

The EU Commission aim for this programming period is to improve EU Structural Funds efficacy by i) increasing co-financed programmes efficiency and quality thanks to strong partnerships and rigorous controlling mechanisms; ii) promoting a more strategic programming outlook; iii) introducing a major

[12] European Commission (2008).

responsibility devolution to Member States/Regions/Local institutions partnerships; iv) simplifying the management system.

Furthermore, the number of financial instruments for cohesion was reduced to two EU Structural Funds (ERDF, ESF) and the Cohesion Fund. The specific aid of the former EAGGF and FIFG came under the new European Agricultural Guarantee Fund (EAGF), the European Agricultural Fund for Rural Development (EAFRD) and the European Fisheries Fund (EFF). Moreover, according to the “unique fund” principle, the Operational Programmes will be financed by only one fund, except infrastructures financing that can draw on ERDF and Cohesion fund resources.

Besides, the zoning approach adopted for the EU Structural Funds is replaced by a thematic strategy to adopt comprehensive development schemes.

At last, in order to improve the coherence and the transparency of the EU Structural Funds management and control system, the Member States – through the activity of an independent audit agency – ensure and certify ex-ante, yearly ongoing, and ex-post the correctness of the expenditures.

During the period 2007-2013, the total of EU Structural Funds available was 347 billion euro representing 35.7% of the EU budget and 0.38% of the total GDP of the EU. Most interventions have focused on Convergence regions (57.5% of EU Structural Funds). The main beneficiary countries were Poland (67.3 billion), Spain (35.2 billion), Italy (28.8 billion), Czech Republic (26.7 billion), Germany (26.3 billion), Hungary (25.3 billion), Portugal (21.5 billion), and Greece (20.4 billion)[13].

1.1.4.3 The 2014-2020 Programming cycle

Finally, the new programming period 2014-2020 simplified common rules and a better focus on outcomes and results was given assessing clearer measurable targets for better accountability. Besides, EU Cohesion Policy was linked to economic reform for that the Commission may suspend funding for Member States which does not comply with EU economic rules. The EU’s maritime and fisheries policies for 2014-2020 are supported by the new European Maritime and Fisheries Fund (EMFF).

Three broad socio-economic goals define the Europe 2020 strategy:

- Smart growth, developing an economy based on knowledge and innovation;
- Sustainable growth, promoting a more resource efficient, greener and more competitive economy;
- Inclusive growth, fostering a high-employment economy which delivers on social and territorial cohesion.

These goals have been translated in 11 thematic goals such as:

- For smart growth: Research and innovation (1), Information and Communication Technologies (ICTs) and Digital Agenda (2), Competitiveness of Small and Medium-sized Enterprises (3),
- For sustainable growth: Shift towards a low-carbon economy (4), Climate change adaptation and natural risk prevention and management (5), Environment and cultural heritage safeguard and development (6), Sustainable transport and removing bottlenecks in key network infrastructures (7),
- For inclusive growth: Social inclusion (8), Education, skills and lifelong learning (9);
- For urban sustainability: Sustainable urban development (10);
- Technical assistance (11).

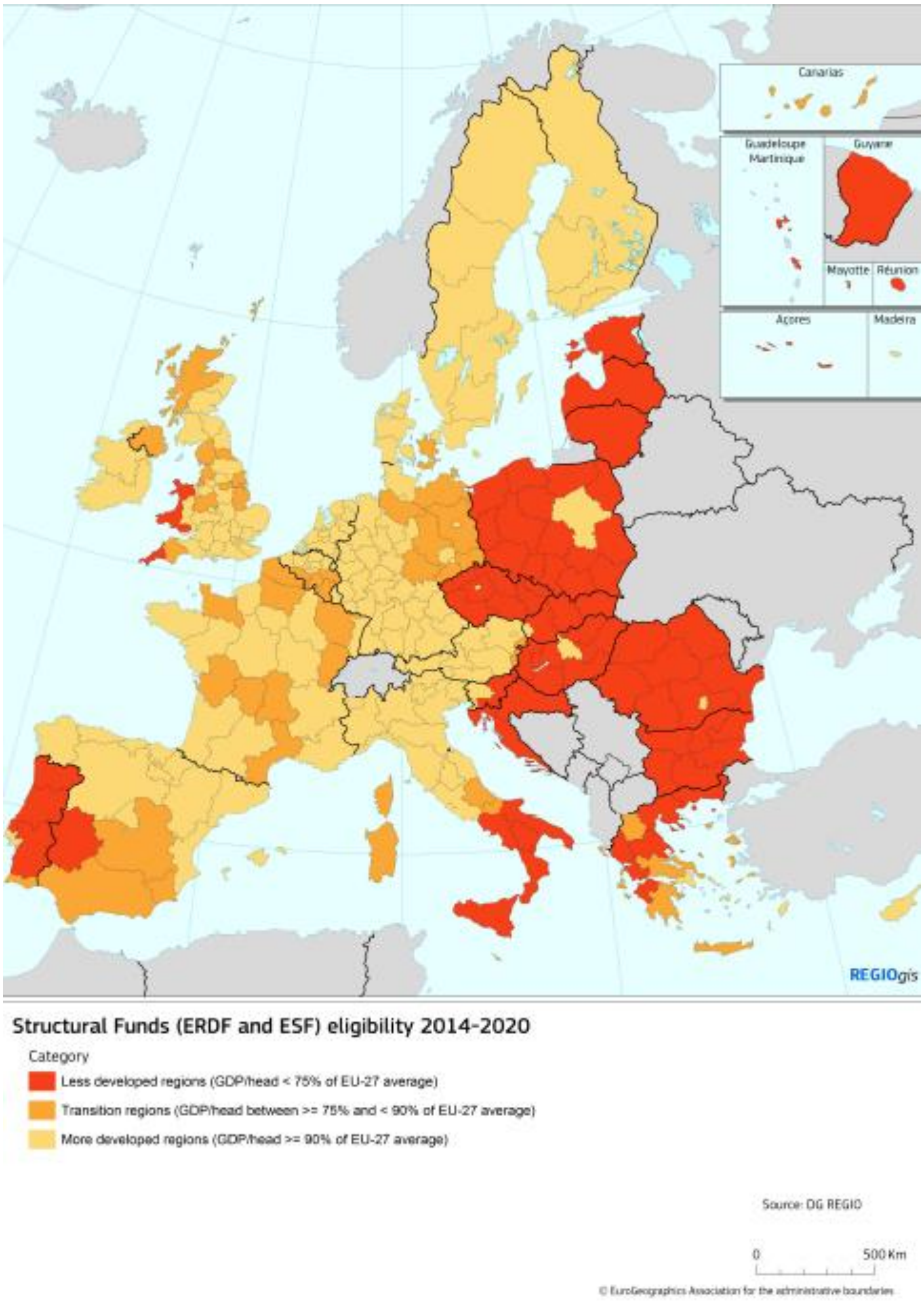
Investment from the ERDF will support all 11 objectives, with priority on 1-4 goals and ESF will provide resources to 8-11 objectives, though supporting also 1-4 priorities. The Cohesion Fund supports objectives 4-7 and 11.

[13] European Commission (2008).

Three Region categories were introduced (Map 1) instead of the previous two (Convergence and Regional competitiveness and employment in 2007-2013):

- '*Less developed' regions*, whose GDP per capita is below 75% of the EU average, will continue to be the top priority for the policy. The maximum co-financing rate is set at 75-85% in less developed and outermost regions;
- *'Transition' regions*, whose GDP per capita is between 75% and 90% of the EU average, will have a co-financing rate of 60%; and
- *'More developed' regions*, whose GDP per capita is above 90% of the average. The co-financing rate will be 50%.

Map 1. Member State eligibility for EU Structural Funds for the programming cycle 2014-2020



Source: https://ec.europa.eu/eurostat/documents/3217155/4387547/EU28-eligibility-1420.pdf

Other EU financial resources are devoted to specific purposes as the Youth Employment Initiative (YEI) to provide support to young people living in regions where youth unemployment was higher than 25% in 2012, and the Fund for European Aid to the Most Deprived (FEAD) to provide food and/or basic material assistance to the most deprived.

Actually, approximately a third of the EU budget 2014-2020, that is nearly 355.1 billion euro over seven years, of which 44.7 billion euro earmarked for Italy, is allocated to reduce disparities in the level of development between EU regions[14].

Lastly, the Regional Development and Cohesion Policy for the programming cycle 2021-2027 is pending final approval of the legal texts by the European Parliament and the Council. Regional development investments will be strongly focused on Objectives 1[15] and 2[16]. In particular, 65% to 85% of ERDF and Cohesion Fund resources will be allocated to these priorities, depending on Member State' relative wealth.

Table 1 and Graph 1 resume the key elements and the financial payments by programming cycle.

[14] https://ec.europa.eu/regional_policy/fr/policy/what/investment-policy/.

[15] For the 2021-2027 programming period, Italian NUTS2 regions considered "less developed" are Molise, Campania, Apulia, Basilicata, Calabria, Sicily and Sardinia.

[16] For the 2021-2027 programming period, Italian NUTS2 regions considered "in transition" are Abruzzo, Umbria, Marches.

Table 1. Key elements of EU Cohesion Policy, European Structural and Investments Funds (ESIF) and Common Agriculture Policy (CAP) by programming cycle

<table>
<tr><th rowspan="2">Programming cycle</th><th rowspan="2">Member States</th><th rowspan="2">Priority objectives (n.)</th><th colspan="3">Financial instruments</th><th rowspan="2">Structural funds (ESIF) and Cohesion Fund (CF) budget</th></tr>
<tr><th>Cohesion Policy</th><th>European Structural and Investments funds (ESIF)</th><th>Common Agriculture Policy (CAP)</th></tr>
<tr><td>1989-1993</td><td>12 MSs: from 1958, Belgium, France, Germany, Italy, Luxembourg, Netherlands; from 1973, Denmark, Ireland, UK; from 1981, Greece; from 1986, Portugal, Spain</td><td>5 priority objectives</td><td>European Regional Development Fund (ERDF)

European Social Fund (ESF)</td><td>European Regional Development Fund (ERDF)

European Social Fund (ESF)

European Agricultural Guidance and Guarantee Fund (EAGGF)</td><td rowspan="3">European Agricultural Guidance and Guarantee Fund (EAGGF)</td><td>69 bln ECU representing 25% of the EU budget and 0.3% of EU GDP</td></tr>
<tr><td>1994-1999</td><td>15 MSs: from 1995, Austria, Finland, Sweden</td><td>6 priority objectives and 13 Community Initiatives</td><td rowspan="3">European Regional Development Fund (ERDF),

European Social Fund (ESF),

Cohesion Fund (CF)</td><td rowspan="2">European Regional Development Fund (ERDF)

European Social Fund (ESF)

Cohesion Fund (CF)

European Agricultural Guidance and Guarantee Fund (EAGGF)

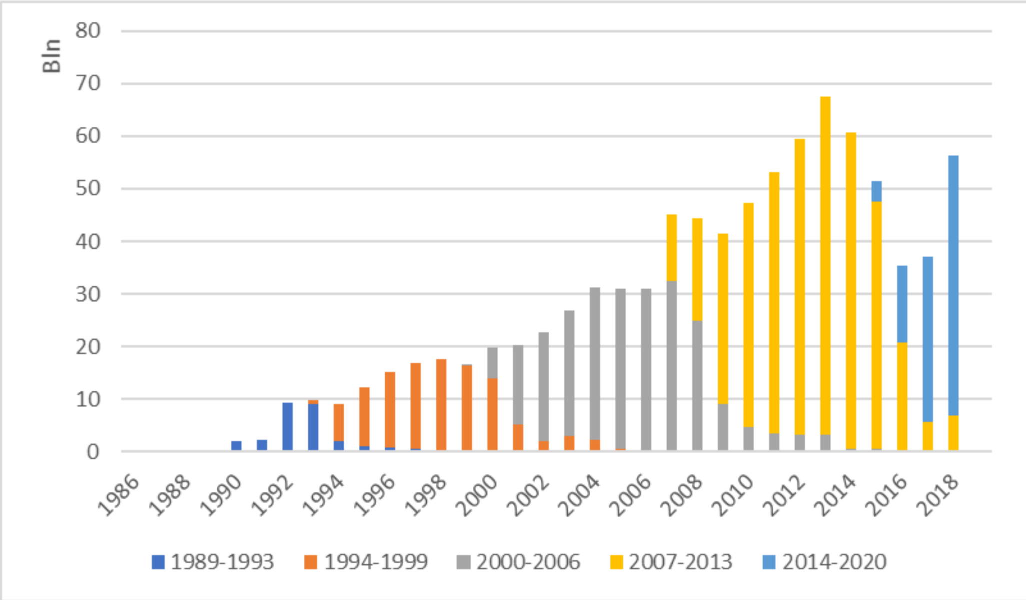
Financial Instrument for Fisheries Guidance (FIFG)</td><td>168 bln ECU representing about one third of the EU budget and 0.4% of EU GDP</td></tr>
<tr><td>2000-2006</td><td>25 MSs: from 2004, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia</td><td>3 priority objectives and 4 Community Initiatives</td><td>213 bln euro for EU15 between 2000 and 2006, and 21.7 billion euro for the 10 new Member States between 2004 and 2006, representing about one third of the EU budget and 0.4% of EU GDP</td></tr>
<tr><td>2007-2013</td><td>28 MSs: from 2007, Bulgaria, Romania, from 2013, Croatia</td><td>3 priority objectives</td><td>European Regional Development Fund (ERDF)

European Social Fund (ESF)

Cohesion Fund (CF)</td><td>European Agricultural Fund for Rural Development (EAFRD)</td><td>347 bln euro representing 35.7% of the EU budget and 0.38% of the total GDP of the EU</td></tr>
</table>

				European Agricultural Fund for Rural Development (EAFRD) European Fisheries Fund (EFF)	European agricultural guarantee fund (EAGF)	
2014-2020		3 goals translated into 11 thematic goals		European Regional Development Fund (ERDF) European Social Fund (ESF) Cohesion Fund (CF) European Agricultural Fund for Rural Development (EAFRD) European Maritime and Fisheries Fund (EMFF)		355 bln euro representing 32.5% of the EU budget

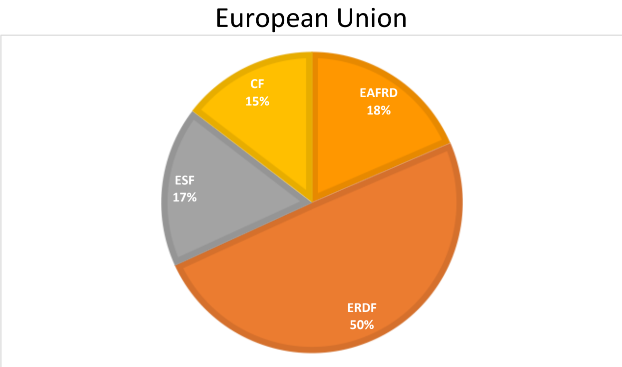
Graph 1. EU Annual Budget Structural and Investment Funds Payments[17] by programming cycle (Bln euro). 1986-2018

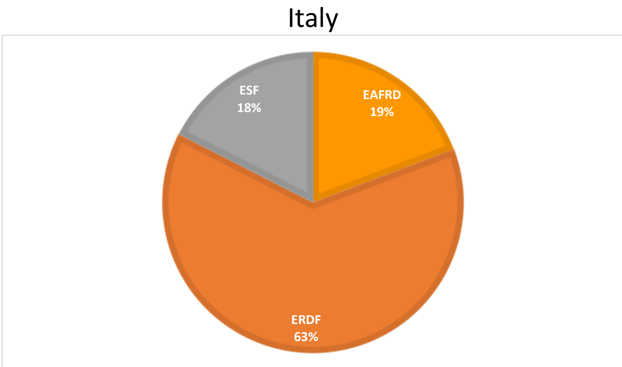


Source: Own elaboration on Cohesion data statistics (https://cohesiondata.ec.europa.eu/Other/Historic-EU-payments-regionalised-and-modelled)

Focusing on the funds providing financial resources, Graphs 2 reveals the prevalence of ERDF payments with 50% of ESIF for Europe and 63% for Italy over 1989-2020, while ESF cover 17 and 18% of respective ESIF payments.

Graph 2. Budget Structural and Investment Funds (ESIF) Payments by funds (1989-2020, % of total)



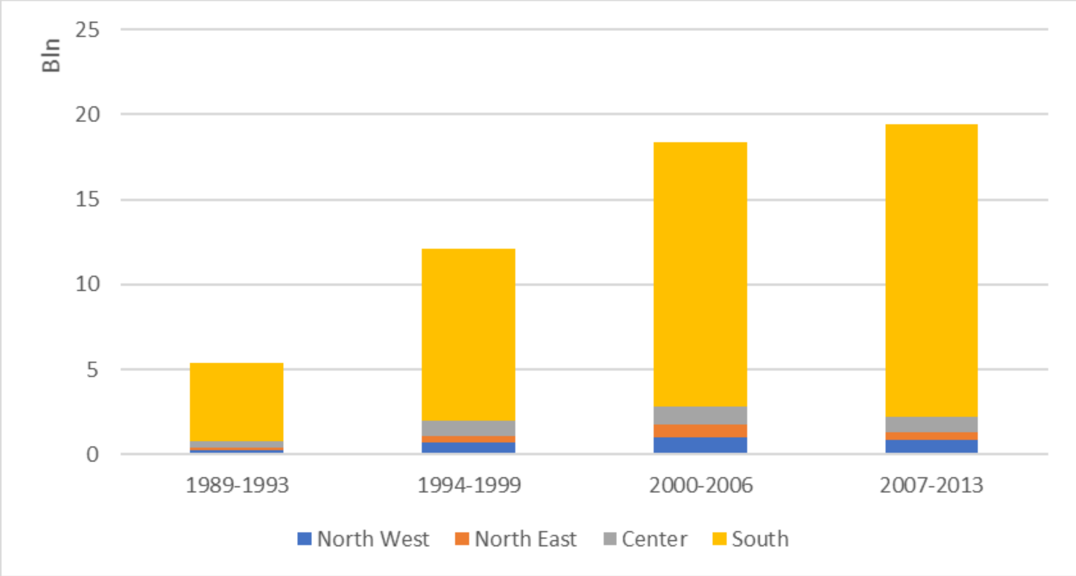


Source: Own elaboration on Cohesion data statistics (https://cohesiondata.ec.europa.eu/Other/Historic-EU-payments-regionalised-and-modelled)

Finally, Graph 3 reproduces the ERDF payments by geographic area in Italy, revealing that Southern regions (most of which still included in Objective 1) benefit from nearly 86% of ERDF payments.

[17]European regional development fund (ERDF), European social fund (ESF, data available from 2000), European agriculture for rural development (EAFRD), European Maritime and Fisheries Fund (EMFF), Cohesion fund (CF), Fund for European Aid to the Most Deprived (FEAD), Youth Employment Initiative (YEI).

Graph 3. ERDF payments in Italy, by geographic area and programming cycle (Bln euro)



Source: Own elaboration on Cohesion data statistics (https://cohesiondata.ec.europa.eu/Other/Historic-EU-payments-regionalised-and-modelled)

1.2 A survey of the empirical literature on the effectiveness of EU regional policy

There is an abundant and sophisticated literature on the effectiveness of EU Cohesion policy urged by the size of the budget and the critical role of the multilevel governance of development programmes. In most cases, this policy seems to have a positive impact on growth, but the significance of the results is far from uniform. A feature that emerges across various studies is that the policy impact depends on a series of conditioning factors (see Fratesi, 2016). In order to report the relevant empirical literature, we will focus on such features of the analysis as the different periods, the level of territorial disaggregation and the EU Structural Funds considered, the estimation methodologies, the variables included in the model. An in-depth survey of Cohesion policy effectiveness in Italy concludes the Section.

1.2.1 Empirical analysis for EU regional policy. A broad overview

1.2.1.1 Period and geographical scale

Period and level of territorial disaggregation widely differ across the papers. For instance, Rodriguez-Pose and Garcilazo (2015) consider the EU Structural Funds for 169 NUTS2 Regions in 1996-2007, Fratesi and Perucca (2014) assess the efficient implementation of cohesion policies in 108 CEE NUTS3 regions for the period 2004-2006, while Tomova et al (2013) studied the effectiveness of ESIF for 28 Member States for the very long period 1980-2013.

Less recent analysis such as Esposti and Bussoletti (2008) tested the effectiveness of Objective 1 financing for eleven years (1989-2000) and 206 EU15 regions, Ederveen et al. (2006) studied ERDF payments for thirty-five years (1960–1995) of 13 Member States (NUTS1), Rodriguez-Pose and Fratesi (2004) take into account ten years (1989–1999) for 162 EU15 NUTS2 Regions. Finally, Boldrin and Canova (2001) investigate the impact of EU Structural Funds on the process of economic growth for 185 European regions of 15 member countries over 1980-1996.

In conclusion, according to Fratesi (2016), the issue of the scale should be related to the context and the type of policy. For instance, Italy and Spain are characterized by NUTS2 regions endowed with administrative powers, validating NUTS2 territorial disaggregation approaches for the evaluation on Cohesion Policy.

1.2.1.2 Estimation methods

Many papers estimate a regression *à la Barro*, augmented by EU Structural Funds (e.g., Garcia Solanes and Maria-Dolores (2002), Rodriguez-Pose and Fratesi (2004); Puigcerver-Peñalver (2007), Esposti and Bussoletti (2008), Rodriguez-Pose and Novak (2013), De Dominicis (2014); Crescenzi and Giua (2016)). This particular "growth" approach is appropriate to assess the accumulation production factors that affect the growth rate of the recipient economies. To that perspective, regional policies finance greater level of physical capital which may correspond, according to neoclassical Solow growth model, to a higher steady state.. Most of these empirical contributions concentrate on studying the issue of convergence and the interaction of EU Structural Funds to regional structural variables.

Spatial spillovers effects are detected by Barrios and Strobl (2005) - adopting a growth model à la Lucas (2000) where spillovers are the main vehicle of long-term economic growth -, Lesage and Fischer (2008) – using a Bayesian model averaging in a panel European growth context -, Dall'Erba and Le Gallo (2008), Mohl and Hagen (2010) – applying a spatial panel econometric estimator -, Le Gallo et al (2011) - analyzing a Bayesian locally linear spatial estimation method on a conditional beta-convergence model -, Maynou et al. (2014) - with a Bayesian approach -, Fratesi and Perucca (2014), and Antunes et al. (2020) - adopting a Durbin model with panel data.

Ederveen et al. (2006) adopted pooled OLS to estimate the dynamic panel data model assessing what conditions affect EU Structural Funds effectiveness.

The macroeconomic impact evaluation through macro-econometric or other economic-wide models usually contains detailed specification of sectors or consumption expenditure categories (Tomova et al (2013)). Generally, macroeconomic simulations find that regional policy has a positive impact in both the short and long term, on GDP and employment.

Finally, counterfactual analysis brought the comparison of economic performance among different hypothesis and situations. Boldrin and Canova (2001) test Convergence versus Divergence hypothesis considering the disrupt of the technological adoption process related to socio-political conditions, while Becker et al (2012) assumed a non-parametric method to estimate treatment effects conditional on observable determinants of treatment intensity, and Becker et al. (2013) and Pellegrini et al. (2013) adopted regression discontinuity approaches to the impact of Cohesion policy.

1.2.1.3 Model specification (structure and variables)

The variables included in the models are specific of the different approaches in the empirical literature and the impact of cohesion policy has been mediated by a large number of aspects, such as the type of expenditure (Rodrìguez-Pose and Fratesi, 2004), the perception of corruption (Beugelsdijk and Eijffinger (2005), the degree of economic openness (Barrios and Strobl 2005; Ederveen et al., 2006), the human capital (Ederveen et al., 2006; Lesage and Fischer, 2008; Becker et al., 2013; Rodrìguez-Pose and Novak, 2013), the formal institutions and administrative capacity (Ederveen et al., 2006; Becker et al., 2013; Rodrìguez-Pose and Novak, 2013; Rodrìguez-Pose and Garcilazo, 2015), the territorial capital and regional characteristics (Lesage and Fischer, 2008; Fratesi and Perucca, 2014; Crescenzi and Giua, 2016), the sound fiscal policy (Tomova et al, 2013), the presence of urban areas (De Dominicis, 2014), the socio-economic structure (Crescenzi and Giua, 2016).

1.2.1.4 The results

The period and level of territorial disaggregation, the different methods applied, the dataset and variables used in the literature obviously imply heterogeneous results. Usually, the EU Structural Funds seem to have a positive impact on GDP growth, but different results have been achieved.

Among the papers assessing a negative, or nearly insignificant impact of the EU Structural Funds, Boldrin and Canova (2001, p.4) detect the effect of EU Structural Funds on the distribution of labour productivity. The authors pointed out that the combination of differences in total factor productivity, differences in employment level and differences in the share of agriculture in regional income affected inequality in regional income and that the Structural Fund investments do not impact on these three factors. Their conclusion is then that "regional and structural policies serve mostly a re-distributional purpose, motivated by the nature of the political equilibria upon which the European Union is built. They have little relationship with fostering economic growth." Dall'Erba and Le Gallo (2008) investigated the presence of spatial spill overs in order to test the impact of the EU Structural Funds on the targeted region and its neighbours for 145 EU regions between 1989 and 1999. The authors find that the funds have no impact on the convergence process. The same conclusion is confirmed by Autunes et al. (2020) for 96 NUTS2 regions over 1995-2009.

On the other hand, Garcia-Solanes and Maria-Dolores (2002) are more optimistic assessing that the inclusion of Funds in the regression increases the estimated speed of convergence between 1989-1996 and has a significant impact on the steady-state growth rate (both in total and their elementary components), but these effects are stronger in the NUTS1 regression than in the NUTS2 regression. For Puigcerver-Peñalver (2007) the impact of EU Structural Funds has been stronger during the 1989-93 programming cycle than in 1994-99. Using a spatial econometric perspective, Ramajo and Marquez (2008) estimate the convergence speed of 163 EU Regions in 1981-1996. According to the authors, the Regions belonging to Cohesion countries reveal a faster conditional convergence in relative income levels. Moreover, Becker et al (2012) find evidence of a maximum desirable treatment intensity. At a transfer intensity beyond this level, the Null hypothesis of zero (or even negative) growth effects induced by additional transfers can no longer be rejected. At treatment intensities below this maximum desirable treatment intensity, per-capita income growth in the recipient regions could be raised significantly by providing higher transfers (at given GDP) up to the maximum desirable treatment intensity. Pellegrini et al (2013) using a causal model based on a non-experimental comparison group method, evaluate policy effects on the basis of both non-parametric and parametric approaches for the two Programming cycles 1994-99 and 2000-06. Their findings show positive impact of Regional Policy on economic growth. Along the same line, Maynou et al. (2014, p. 10) illustrate that Structural and Cohesion "have positively contributed to the gross domestic product per inhabitant growth of receiving regions, thus allowing them to reach (conditional) convergence". The positive impact of Regional Policy on economic growth is also shown by Pellegrini et al (2013) for 213 NUTS2 regions in the EU15 area during the two programming cycles 1994-99 and 2000-06.

The effect of EU Cohesion Policy is ambiguous according to Esposti and Bussoletti (2008) who test Objective 1 funds on regional growth convergence in the EU using an augmented conditional convergence econometric model. The authors find a limited but positive impact on growth which turns negative is some cases (i.e. German, Greek and Spanish Objective 1 regions). More recently, Mohl et al. (2010) show that Objective 1 payments in particular do, in fact, promote regional economic growth, whereas the total amount of Objectives 1, 2, and 3 do not have a positive and significant impact on the EU regions' growth rates. Moreover, Becker et al. (2010) find positive per capita GDP growth effects (roughly +1.6%) of Objective 1 transfers, but no employment growth effects. The analysis is conducted using a regression-discontinuity approach for 285 NUTS2 and 1213 NUTS3 Regions in Europe for three programming cycles (1989-93, 1994-99, 2000-06). Ambiguous outcomes are also found by Le Gallo et al (2011) for 145 regions over the period 1980-2004. In particular, the authors show that EU Structural Funds have a weak global impact on the convergence process between European regions but that their local impacts are very diverse, with a positive influence on the growth of British, Greek and southern Italian regions.

Considering the initial conditions of the Regions where funds are allocated, Barrios and Strobl (2005) argued that some degree of regional inequality is hardly avoidable, at least at the initial stages of development. Suggesting that regional policy and public investment should aim at boosting national growth in order to guarantee greater national prosperity levels at the expense of temporarily rising inequality, especially for the least developed countries such as the new EU member states. Ederveen et al. (2006) using a single equation, panel dataset approach, reveal that EU Structural Funds by themselves do not explain growth differentials among the member states but the "quality" of institutions (measured by high institution quality) matters - more than low inflation, low budget deficit, and a cohesive social policy - because the set of rules of institutions in a country determines the allocation of the funds to productive activities or to "rent-seeking" activities. Becker et al (2013) using a regression discontinuity design with systematically varying heterogeneous treatment effects show that only about 30 percent and 21 percent of the regions—those with sufficient human capital and good-enough institutions—are able to turn transfers into faster per capita income growth and per capita investment, respectively. Tomova et al (2013) show that EU Structural Funds are effective in helping Member States to enhance socio-economic development and this effectiveness is higher when combined with sound national fiscal and macroeconomic policies. Rodrìguez-Pose and Novak (2013) find that the level of economic growth is much more related to the initial wealth of a given region, its wealth relative to the rest of the country, its infrastructural endowment, its level of human capital, and the quality of its institutions. In that perspective, there has been a marked improvement in the returns of investment in EU Structural Funds between the second and third programming cycles. The constant scrutiny and feedback which are at the heart of the policy making process since the 1989 reform of the EU Structural Funds has created a learning process which has contributed to an improvement in the effectiveness of intervention. Generally, recent programming cycles seem to be more effective as revealed by Rodriguez-Pose and Novak (2013), despite Puigcerver-Penalver (2007) conclusion. Rodriguez-Pose and Garcilazo (2015, p.2) examine the impact of the quality of local and regional governments on the returns of investment from EU Structural Funds showing its relevance both as a direct determinant of economic growth, and as a moderator of the efficiency of EU Structural Funds expenditure. Moreover, the authors assess that "above a significant threshold level of expenditure, the quality of government is the key factor determining the returns of public investment."

The spatial growth approach of Lesage and Fischer (2008, p.278) reveals how "long-run steady-state regional income will depend on: own region and neighbouring region characteristics, the spatial connectivity", the strength of spatial dependence. In particular, the authors argued that indirect effects or spatial spillovers can be more relevant than the direct effects of regional characteristics that have been the focus of non-spatial growth regressions. The endogenous local asset is also considered in the approach adopted by Fratesi and Perucca (2014) who analyze the mechanisms through which endowment of the so-called "territorial capital" - defined by the system of territorial assets of economic, cultural, social and environmental nature characterizing the territorial development potential - affects the outcomes of EU Cohesion Policies in Central and Eastern European (CEE) NUTS3 Regions. The Cohesion policy investment are classified among interventions aimed at reaching social and political outcomes (such as measures for the reduction of inequalities and for the support of cohesion and sustainability) and programmes designed to promote economic growth and competitiveness (such as the provision of new infrastructures, R&D incentives, supports to SMEs). The authors conclude that the combination of a large number of specific types of territorial assets positively affect the gains from investments and Cohesion policy expenditure. Moreover, according to Crescenzi and Giuia (2016), the positive influence of the EU Regional Policy is stronger in the regions with the most favourable socio-economic environment. This reveals a potential paradox of the EU Cohesion policy that works better in the relatively stronger (and better performing) regions with comparatively smaller (although still positive) gains for the most disadvantaged areas of the Union.

On the contrary in Beugelsdijk and Eijffinger (2005) the empirical evidence does not indicate that more corrupt countries use their funds in a more inefficient way, and also for this reason the hypothesis that EU Structural Funds reduced interregional disparities within the current 15 European countries cannot be rejected.

Finally, according to a number of authors, the axes of expenditure of Cohesion Policy may affect EU Structural Funds effectiveness on economic growth. Rodriguez-Pose and Fratesi (2004) detect an interesting distinction between development axes in Objective 1 regions over 1989-1999. The returns to commitments on infrastructure and, to a lesser extent, on business support are not significant (despite the concentration of development funds on these axes). Support to agriculture has just short-term (positive) effects on growth. Only investment in education and human capital – which represents about 1/8 of total commitments - has medium-term positive and significant returns in the period 1989-1999. De Dominicis (2014) shows that there isn't an overall significant relationship in Europe between agglomeration and growth. However, distinguishing between Objective 1 and Non-objective 1 regions the author finds that in the less developed regions, agglomeration positively impacts subsequent growth.

Tab. 2 reports the main features of the papers considered in the empirical literature in this sub-section.

Table 2. Overview of the empirical literature on the effectiveness of European region policy for EU

Author	Cohesion Policy data used in analysis	Time period	Territorial units	Empirical approach	Model specification (variables)	The results
Autunes et al. (2020)	No EU Structural Funds data used in the regressions	1995-2009	96 NUTS2	Dynamic and spatial models		Existence of conditional convergence and the importance of neighborhood and spillover effects but no existence of positive impacts from EU Structural Funds
Crescenzi, Giua (2016)	EU Structural Funds (SF) Objective 1 eligibility	1988-1989	LAU-2 (municipalities) in 4 MS: DE, ES, IT, UK	Regression à la Barro, augmented by the EU Structural Funds	Structural socio-economic conditions, innovative capacity, infrastructure endowment	EU Regional Policy has a positive influence on economic growth in all regions. However, its impact is stronger in the most socio-economically advanced areas and is maximized when its expenditure is complemented by Rural Development and Common Agriculture Policy (CAP) funds.
Rodrigues-Pose, Garcilazo (2015)	EU Structural funds payments	1996-2007	169 NUTS2	Two-way fixed effect panel regression mod	Quality of local and regional governments	Greater levels of cohesion expenditure would, in the best- case scenario, only lead to a marginal improvement in economic growth, unless the quality of government is significantly enhanced.
De Dominicis (2014)	EU Structural Funds Objective 1 eligibility	1991-2004	188 NUTS2	Regression à la Barro, augmented by the EU Structural Funds		Agglomeration positively impacts on growth only in the less developed regions of Objective 1.
Fratesi, Perucca (2014)	ERDF and Cohesion Fund (CF)	2004-2006	108 NUTS3 in CEE	Dynamic and spatial models	Territorial capital	Regional policy is not so much effective per se but its impact depends on the type and amount of territorial capital possessed by the region.
Maynou et al. (2014)	ERDF, CF, EAGGF, FIFG transfers, as % of GDP, at country level	1995-2006	17 MS (Euro area)	Convergence analysis		EU Structural funds have positively contributed to the gross domestic product per inhabitant growth of receiving regions.
Pellegrini et al. (2013)	SF Objective 1 eligibility	1995-2006	190 NUTS2	Regression discontinuity approach		Positive impact of EU Regional Policy on economic growth
Rodriguez-Pose, Novak (2013)	SF payments to Objectives 1,2,5b and 6	1994-2006	133 NUTS2	Regression à la Barro, augmented by the EU Structural Funds	Infrastructure endowment, human capital, innovative capacity, quality of institutions	The constant scrutiny and feedback since the 1989 reform of the EU Structural Funds has created a learning process which has contributed to an improvement in the

						effectiveness of intervention.
Tomova et al. (2013)	ESIF payments (ERDF, CF, EAGGF, FIFG, Cohesion Fund), at country level	1980-2013	28 MS	Macroeconomic simulation models	Soundness of fiscal policy	Linking ESIF to macro-economic imbalances also contributes to improving the effectiveness of ESIF.
Becker et al (2013)	EU Structural Funds and CF commitments	1989-2006	251 NUTS2	Regression discontinuity approach	Human capital, institution quality	Only regions with sufficient human capital and good-enough institutions are able to turn transfers into faster per capita income growth and per capita investment.
Becker et al (2012)	EU Structural Funds and CF commitments	1994-2006	1091 NUTS3 in 1994-99 and 1213 NUTS3 in 2000-06	Propensity score estimation		Some reallocation of the funds across target regions would lead to higher aggregate growth in the EU and could generate even faster convergence than the current scheme does.
Le Gallo et al (2011)	EU Structural Funds payments	1989-1999	145 NUTS2	Dynamic and spatial models		EU Structural Funds have a weak global impact on the convergence process between European regions.
Becker et al (2010)	Eligibility for Objective 1 transfers	1989-2006	285 NUTS2 and 1213 NUTS3	Regression discontinuity design (RDD)		EU Structural Funds have positive per capita GDP growth effects of Objective 1 transfers, but no employment growth effect
Mohl, Hagen (2010)	EU Structural Funds and CF commitments	2000-2006	126 NUTS2	Spatial panel econometric model		Objective 1 payments do promote regional economic growth, whereas the total amount of Objectives 1, 2, and 3 do not have a positive and significant impact on the EU regions' growth rates.
Dall'Erba, Le Gallo (2008)	EU Structural Funds transfers	1989-1999	145 NUTS2	Spatial econometric model		Significant convergence takes place, but the structural funds have no impact on it.
Esposti, Bussoletti (2008)	Objective 1, payments (ERDF, ESF, EAGGF and FIFG) per capita	1989-2000	206 NUTS2	Regression à la Barro, augmented by the Structural Funds		A positive impact of SF is confirmed over the whole EU space, although its statistical significance and magnitude may vary across alternative estimators. The impact of the Objective 1 policy on growth, is generally quite limited and may become negligible and even negative in some regional cases.
Lesage, Fischer (2008)	No EU Structural Funds data used in the regressions	1995-2003	255 NUTS2	Spatial growth model	Human capital, output of innovation activities, specialization measure, diversity measure, HT invention activities, patent activities, regional industry composition	Indirect effects or spatial spillovers can be more relevant than the direct effects of regional characteristics that have been the focus of non-spatial growth regressions
Ramajo et al. (2008)	No EU Structural Funds data used in the regressions	1981-1996	163 NUTS2	Convergence analysis		There was a faster conditional convergence in relative income levels of the regions

						belonging to Cohesion countries than in the rest of the regions of the EU
Puigcerver-Penalver (2007)	ERDF, ESF and EAGGF transfers	1989-1999	41 NUTS2 (Obj.1 regions)	Regression à la Barro, augmented by the EU Structural Funds		EU Structural Funds have positively influenced the growth process of Objective 1 region during 1989-2000, although their impact has been stronger during the first programming period than the second
Ederveen et al. (2006)	ERDF payments	1960-1995	13 MS	Pooled OLS for dynamic data model	Human capital accumulation, institutional conditioning variable (inflation, trust, openness, corruption)	EU Structural Funds do not explain growth differentials among the member states. However, EU Structural Funds allocated to economies with 'good' institutions are effective.
Beugelsdijk and Eijffinger (2005)	EU Structural funds as part of GDP	1995-2001	15 MS	Convergence analysis	Perception of corruption	The less clean countries (or as we measure it, more 'corrupt' countries) of the current EU-15 do not gain less economic growth from the EU Structural Funds.
Barrios, Strobl (2005)	No EU Structural Funds data used in the regressions	1975-2000	312 NUTS2 (including 132 for EU25)	Growth model *à la* Lucas (2000)	International trade openness, regional industrial specialization, fiscal decentralization, level of EU Structural Funds as percentage of national GDP	The allocation of EU Structural Funds can provide greater welfare through more concentration on the most dynamic regions in order to favour nation-wide growth
Rodriguez-Pose, Fratesi (2004)	EU Structural Funds commitments (also broken down by 4 main categories)	1989-1999	162 EU15 NUTS2	Regression à la Barro, augmented by the EU Structural Funds		Only investment in education and human capital has medium-term positive and significant returns
Garcia Solanes and Maria-Dolores (2002)	ESF, ERDF and EAGGF funds	1989-1996	EU12 NUTS1 and NUTS2	Convergence analysis		The EU Structural Funds foster the speed of convergence.
Boldrin, Canova (2001)	No EU Structural Funds data used in the regressions	1980-1996	185 NUTS2	Convergence versus Divergence		Regional policies serve mostly a re-distributional purpose, with little impact on the process of economic growth

1.2.2 Empirical analyses for Italy

The findings in Becker et al. (2012) suggest the existence of high regional heterogeneity in the effectiveness of EU Structural Funds, partly due to the lack of administrative capacity. This section sums up the empirical literature on the effectiveness of EU funds in Italy.

Firstly, we start with Percoco (2005), who adopts a simple supply-side model estimated for EU Structural Funds expenditure for six Regions (Molise, Campania, Apulia, Basilicata, Calabria, Sardinia), using data collected through an ad hoc survey among Managing Authorities, and grouped in five main categories (investment in social infrastructure, public expenditure in training and education, investment in economic infrastructure, subsidies to private investments, and technical assistance) and from the CRENOS panel of regional data over the period 1970-1994. A GMM-IV estimator is applied to a Cobb-Douglas function in which the dependent variable chosen is GDP and the regressors are private capital, social and economic infrastructures, employment and human capital. The effects of EU Structural Funds on GDP are attributed to the weight that their spending has upon these regressors. There are therefore highly variable, but substantially positive, effects across regions.

More optimistic are the findings of Loddo (2006), revealing positive and significant impact of the EU Structural Funds on regional convergence in Italy over the period 1994-2004. In particular, considering EU Structural Funds as a conditioning variable in the convergence equation over 1994-2004, the author shows that the expenditure allocated by ERDF has medium term positive and significant returns but support to agriculture has short-term positive effects on growth which wane quickly.

Coppola and Destefanis adopt a different framework to study the impact of Funds accredited (Coppola and Destefanis, 2007) and payments (Coppola and Destefanis, 2015) on convergence across the 20 Italian regions in 1989-2006 by analyzing the sectoral impact of the different types of EU Structural Funds. The components of total factor productivity (TFP) change are measured through a non-parametric FDH approach and then regressed on Funds and other variables considering separately four sectors (agriculture, energy and manufacturing, construction, services) in order to calculate some Malmquist index numbers of productivity. The authors use data of the *Spesa Statale Regionalizzata* (SSR) for EU Structural Funds disbursements. They find a weak but significant impact of actually spent funds on total factor productivity change but virtually no effect on capital accumulation and employment. Moreover, different kinds of EU Structural Funds have widely different influences, with the ESF wielding the strongest impact.

Aiello and Pupo (2009) analyze the effects of EU spending from 1996 to 2007 to the 20 Italian administrative regions. The data on actually spent, include EU, national and private funds. In particular, the authors use data from the *Ragioneria Generale dello Stato* (RGS) and the half-early report of the Minister of Economics and Finance for Cohesion Policy programmes. Their empirical analysis is based on panel estimates of an augmented neoclassical growth model where the EU Structural Funds are an explanatory variable of the conditioned convergence equation. They find that the funds, although having a stronger impact in the South than in the Centre-North, have only weakly contributed to regional convergence in Italy, mostly showing a redistributive effect.

Ciani and de Blasio (2015) find limited effects of EU Structural Funds in relation to employment, population and house price in the Southern Italy between 2007 and 2013. Focusing on 325 Local Labour Markets (LLM) during the years of the economic crisis, the authors estimate the effect of these geo-referenced payments on the growth rates of the outcomes, controlling specific LLM time-invariant features and LLM time trends. The analysis suggests a limited impact on employment associated with the acceleration/re-targeting of payment after 2011, and hardly any effect on population growth and house prices.

Del Bo and Sirtori (2016) analyze the EU Structural Funds allocated to the 20 Italian regions between 1996 and 2010 through time-series techniques, focusing on three broad typologies of effects that can distort the national choices of the beneficiaries such as the substitution effect, the displacement effect and the effect on taxation. The authors assess the presence of substitution effects between EU and national funds and, to a lesser extent, of biases in fund allocation toward regions endowed with more bargaining power or high-growth sectors such as health, education, R&D, and transport and telecommunications infrastructure.

Optimistic assessments on EU Regional Policy effectiveness are exposed by Giua (2017, p. 129). Using both border strategy framework and traditional Regression Discontinuity Design (RDD) to test the effect on the Italian Objective 1 regions' employment, the author finds a positive impact for the earlier programming period (1988-1993 and 1994-1999). In particular, "the EU Regional Policy has supported the development of the Italian Mezzogiorno, persistently underdeveloped scenario par excellence in Europe, by leveraging on strategic sectors closely linked to territorial advantages and without implying any displacement of the economic activities from the richest areas (in this case, northern Italy)".

In Coppola et al. (2018) the effectiveness - in terms of productivity and employment - of EU and National Funds is tested on the 20 Italian Regions for 1994-2013, considering four sectors (agriculture, energy and manufacturing, construction, services). Complementary as well as substitution mechanisms between EU Structural and national Funds are also analyzed using a fixed-effect dynamic model of the allocation mechanisms across Italian Regions. EU Structural and national Funds are taken into account in terms of disbursements to the regions from the database *Spesa Statale Regionalizzata* (SSR). The authors find that funds have a significant impact on GDP per capita and the sectoral evidence reveals that the EU Structural Funds favour services and the nationally financed subsidies seem to affect equally all sectors of the economy, the first are more effective than nationally based policies thanks to strong institutions and structural heterogeneities.

Finally, Albanese et al. (2021) present new evidence on the effectiveness of EU Structural Funds over some regional well-being indicators including economic, educational, health, and demographic outcomes for 2007-2013. Using a fuzzy Regression Discontinuity Design (RDD), the authors find a modest impact of the policy on young employment, female activity rate and tertiary education. Moreover, they assert that the quality of institutions, human capital and urban density affect the capacity of the policy to determine significant effects on GDP and employment, but the effect of these characteristics on health and education remains not significant. Furthermore, according to the authors a low quality of institutions seems to be associated with lower effect of the policy on GDP and employment, revealing that "giving money to less developed EU regions might be quite ineffective where their institutional settings do not guarantee the best utilization of the received funds. Albanese et al. (2021, p. 12)"

Tab. 3 reports the main features of the papers characterizing the empirical literature for Italy.

Table 3. Overview of the empirical literature on the effectiveness of European region policy for Italy

Author	Cohesion Policy data used in analysis	Time period	Territorial units	Empirical approach	Model specification (Structure and variables)	The results
Albanese et al. (2021)	EU transfers	2007-2013	20 NUTS2 regions	Regression Discontinuity Design (RDD)		The authors are pessimistic about the effectiveness of EU cohesion policy to close the gap in well-being
Coppola et al. (2018)	EU Structural Funds payments	1994-2013	20 NUTS2 regions	Panel: fixed-effect dynamic model	Structure: the impact of the funds is assessed on four sectors (agriculture, energy and manufacturing, construction, services)	EU SF are more effective on GDP per capita than nationally based policies, the first favouring services and the second affecting equally all sectors of the economy
Giua (2017)	Eligibility for Objective 1 transfers	1988-1999	Municipalities (NUTS3) belonging to Objective 1 regions (Abruzzo, Molise, Campania) and non-Objective 1 contiguous regions (Marches and Latium)	Dynamic and spatial models		The EU Regional Policy positively impacts on the employment of Objective 1 Italian regions

Del Bo and Sirtori (2016)	EU Structural funds committed	1996-2010	20 NUTS2 regions	Time-series techniques		There is a substitution effects between SFs and national funds
Ciani and de Blasio (2015)	EU Structural Funds payments	2007-2013	325 Southern Local Labor Markets (LLM)	Diff-in-diffs estimates	A long set of fixed LLM characteristics is included in the model specification	EU funding had limited impact on employment and any effect on both population and house prices.
Aiello and Pupo (2009)	EU Structural Funds payments	1996-2007	20 NUTS2 regions	Conditional convergence analysis		SFs have only weakly contributed to regional convergence in Italy, mostly showing a redistributive effect.
Coppola and Destefanis (2007, 2015)	EU Structural Funds accredited (2007) and payments (2015) by SF (ERDF, ESF, EAGGF)	1989-2006	20 NUTS2 regions	Non-parametric FDH-VP approach	Structure: the impact of the funds is assessed on four sectors (agriculture, energy and manufacturing, construction, services)	The authors find a weak but significant, impact of actually spent funds on total factor productivity change but virtually no effect on capital accumulation and employment
Loddo 2006	Payments by EU Structural Funds	1994-2004	20 NUTS2 regions	Convergence analysis		The expenditure allocated by ERDF has medium term positive and significant returns while support to agriculture has short-term positive effects on growth which wane quickly
Percoco (2005)	EU Structural Funds expenditures	1994-1999	6 NUTS2 regions	Supply-side approach	Variables: Private capital, social and economic infrastructures, human capital	EU Structural Funds induce a high level of volatility in the growth rates

1.3 Summing up

From 1988, the EU strategy to reduce social, economic and territorial disparities has greatly evolved. The implementation of the Maastricht Treaty and the launch of the Cohesion Fund, the rise of the resources devolved to EU Structural Funds, the gradual involvement of the multilevel-governance institutions, the enlargement to new Member States, the global and pervasive financial and economic crisis occurred from 2007-2008 brought about a new set of fewer and clearer priorities, the definition of privileged areas and a proper auditing in order to improve the effectiveness of EU Regional policy.

Despite the abundant and sophisticated empirical literature measuring the effect of the Cohesion policy on growth, employment, productivity, and, more generally, regional disparities, the significance of the results is far from uniform. The majority of the authors finds a positive impact, but the complexity of the policy involving regional, national, multiregional, interregional and European programmes, different periods and levels of territorial disaggregation, the adoption of several estimation methods, and the inclusion of many different sets of variables included in the model, all make for a high heterogeneity of results. According to Coppola and Destefanis (2020), the heterogeneity of results, at least for Italy, also depends on such factors as the proper modelling of expenditure dynamics, the complexity of the dynamic link between GDP and employment, and the heterogeneity of macro and micro-databanks.

However, an important point highlighted in some recent contributions, is the relevance for the results of some conditioning variables such as the quality of institutions – which positively affect EU Structural Funds effectiveness -, the expenditure typology – suggesting that investment in education and human capital are more viable for economic growth -, the territorial endowment in private, public, physical, and immaterial capital.

In fact, the analysis of the literature reveals some additional extensions to investigate for a correct assessment of the Cohesion policy impact in particular, exploring the role of different infrastructure endowment and the related conditionality of the effects of the Cohesion policy in the long-run convergence process. In that perspective, a deep and comprehensive empirical analysis on the impacts of Cohesion policy in Italian NUTS2 Regions - which are still characterized by relevant social, economic and territorial differences despite a long run EU and national cohesion policy -, became pressing and strategic in order to focus successful practices and prior sectors of interventions.

2 Public capital efficiency. A regional and sectoral analysis of the last 30 years in Italy.

The endowment of public capital[1] is considered among the most relevant factors impacting the growth process. Aschauer (1989) is arguably the seminal reference in this literature, which is analyzed in Romp and De Haan (2007), Albanese and Sorge (2010). This view has informed the European Cohesion policy, which is largely involved in co-financing major infrastructure projects. Furthermore, it has been argued that the Cohesion policy[2] effectiveness is improved by a large regional infrastructural endowment (Crescenzi and Giua (2016), Fratesi and Perucca (2014)). Therefore, investment flows in infrastructure should positively impact on social and economic wellbeing while the public capital stock should enhance the performance of development policy, generating a virtuous circle.

However, the efficiency of public capital expenditure is not homogeneous across time and space, and this virtuous circle may be broken if public cumulative investments do not entail an equivalent physical infrastructure. In fact, Golden and Picci (2005a, p. 5) define the difference among the public capital in monetary terms and the public capital in physical terms (controlling for cost differences in infrastructure construction) as a measure of corruption, "indicating waste, fraud, and mismanagement in the public contracting process."

The aim of this chapter is to extend the approach of Golden and Picci (2005a) to investigate aggregate and sectoral[3] efficiency of regional public capital expenditure in Italy over the period 1987-2016 and to test the impact of this efficiency on the long-run determination of GDP per capita. In order to do this, we must fill two gaps in the available statistical information, i) building a set of time-varying indicators to measure regional sectoral physical infrastructural endowment over the last 30 years, and ii) updating the regional sectoral public investment elaborated by Picci (2001) for 1890-1997 and computing the net regional public capital for seven assets - by cumulating gross fixed capital formation year by year and deducting depreciation.

The chapter is organized as follows. Section 1 introduces the main approaches used to measure public capital. Section 2 describes in some detail the sources and the methodology adopted in Italy to construct indexes for regional public endowment in physical terms for the last three decades. Section 3 explains how the regional sectoral public investment elaborated by Picci for 1890-1997 was updated and used to compute a measure of net capital stock. Section 4 focused on the construction of an indicator of public spending efficiency and its comparison with corruption index elaborated by Golden and Picci (2005a) and other available government quality indexes. Section 5 extends the approach adopted in Coppola et al. (2018) to analyze the role of the regional quality of government on the impact of European and national cohesion policies. Some concluding remarks complete the chapter.

2.1 The measurement of infrastructure: a short survey

Infrastructure is a huge umbrella term for many factors facilitating the production of goods or services. In fact, a number of infrastructure classifications have been introduced by different authors. Moreover, several approaches have been adopted to measure infrastructural endowment, either in physical terms – constructing a measure of physical public infrastructure using appropriate elementary indicators -, or in monetary terms – using the Perpetual Inventory Model to cumulate fixed capital formation. This section

[1] In this chapter, we refer indistinctly to public capital or infrastructure.
[2] In this chapter, we refer indistinctly to cohesion or regional policies.
[3] In this chapter, we refer indistinctly to public sector or public asset.

describes the different infrastructure classifications and estimating methodologies and broadly reviews the empirical analyses conducted in Italy within both the physical and the monetary approach.

2.1.1 Infrastructure: a classification

Hansen (1965, pp. 150-151) distinguished the *economic* from the *social infrastructure* according to the direct or indirect influence of infrastructure on the economy: "the division of local public overhead capital (OC) into two components, "social" overhead capital (SOC) and "economic" overhead capital (EOC). (…) Those items classified as EOC are primarily oriented toward the support of directly productive activities or toward the movement of economic goods. SOC items (…) may also increase productivity, the way in which they do so is much less direct than in the case for EOC items". According to this classification economic infrastructure includes roads, highways, airports, naval transport, sewer networks, aqueducts, networks for water distribution, gas networks, electricity networks, irrigation plant and structures dedicated to the commodities transfer. On the other hand, social infrastructure involves schools, structures for public safety, public accommodation, plant of waste disposal, hospitals, sport structures, green areas, and so on. The same classification has been adopted by The World Development Report (1994) including transport, energy (power, oil, gas, coal), telecommunications, water (irrigation projects, etc.), waste disposal, among economic infrastructure, and education, health, family welfare, housing, drinking water, sanitation, all the services available to the people for self-development and professional proficiency, among social infrastructure.

The distinction among *core* and *not-core infrastructure* is introduced by Aschauer (1989) in his pioneering analysis on the contribution of public capital to productivity and growth. According to Aschauer, core infrastructure (roads and highways, airports, public transport, electric and gas networks, network for water distribution and sewer networks) is of paramount importance in the economic growth of a country.

Biehl (1991) refers to *network infrastructure* considering roads, railroads, "water's highway", networks of communication, systems for energy and water provisioning, to *nucleus/punctual infrastructure* for schools, hospitals and museums, relatively characterized by an elevated degree of immobility, indivisibility, "not-interchangeability" and multi-purpose features, and the basin of use coincides with the territorial unity in which the infrastructure is located, and to *territory infrastructure* including services that, even if object of private investments and activities, have effects on the territory attractiveness, on its quality of the life and on the dynamics of development.

Sturm et al. (1995) use a distinction among *basic* and *complementary infrastructure* referring for the first category to main railways, roads, canals, harbours and docks, the electromagnetic telegraph, drainage, dikes, and land reclamation, while including in the complementary infrastructure light railways, tramways, gas, electricity, water supply, and local telephone networks.

Jochimsen (1996, p. 133) distinguishes between *material*, *personal* and *institutional infrastructure*. Personal infrastructure refers to "the number and the qualities of people in the market economy characterized by the division of labour with reference to their capabilities to contribute to the increase of the level and the degree of integration of economic activities" usually represented by human capital; institutional infrastructure "comprises the grown and set norms, institutions and procedures in their reality of constitution, insofar as it refers to the degree of actual equal treatment of equal economic data, excluding meta-economic influences. It determines the framework within which economic agents may formulate their own economic plans and carry them out in co-operation with others" in the function of social integration; material infrastructure is then characterized both by fulfilment of social needs and mass production, including goods and services able to satisfy those wants of economic agents originating from physical and social requirements of human being.

Buhr (2003, p.22) defines as *material infrastructure* those immobile, non-circulating capital goods that essentially contribute to the production of infrastructure goods and services needed to satisfy basic physical and social requirements of economic agents and unavailable to the individual economic agents (households, firms etc.) for production and cost reasons so that mass production is economically cogent. In contrast, *immaterial infrastructure* includes some kind of infrastructure – primarily innovation and education infrastructure – linked to the development of the material one.

Finally, ISTAT (2006) includes Transport and Energy network in *Economic infrastructure*; Health, Education, Cultural and Environment endowment in *Social infrastructure*; Tourist and Trade infrastructure and Monetary intermediation among the *Territory infrastructure*.

2.1.2 The different approaches to measure infrastructure

There are two main approaches to measuring public capital stock. Public capital in physical terms measures the existing physical infrastructure by collecting data considering the physical endowments or assessing infrastructure needs in terms of population or territorial area. On the other hand, public capital in monetary terms measures the public capital stock as the cumulative sum of past gross investment, adjusted for depreciation, typically adopting the Perpetual Inventory Method (PIM) suggested by Goldsmith (1951). Both approaches are characterized by significant advantages and disadvantages which are briefly described in Table 1.

Tab. 1 Advantages and disadvantages of different computation approaches to estimating public capital stocks

	Advantages	**Disadvantages**
Physical estimation	- Compute the actual effective quantity of infrastructure and not the resources used to build the stock; - Available for many types of infrastructure; - Useful to analyze the effects of infrastructure in terms of competitiveness and development of a territory	- Data accessibility and collection; - Subjectivity in index choice; - Difficulty in comparison and aggregation of elementary indicators; - Sensitive to the criteria of normalization and aggregation
Monetary estimation	- Simplicity and directness of the PIM; - Comparability of the value among regions/countries; - Easy to insert the value of the public capital stock into the national statistical system; - Availability for a large number of public infrastructures	- Distortion of the territorial competitiveness determined by infrastructure endowment (not considering differences in territorial morphology, construction costs of the public works, efficiency/corruption of the spending process); - Related to very long time series and sensitive to theoretical assumptions

Recently, a third approach is available considering the performance of the public capital stock in terms of accessibility and interconnection and its impact to the economic activity, but the availability of data is still very limited (Isfort (2006), Messina (2007), Alampi and Messina (2011)).

The different methodologies used to compute infrastructure cannot be simply considered as “two faces of the same coin”. In fact, the index of infrastructure in physical terms should disclose the *actual* effective public endowment while the public capital measured by accumulating investment flows using the Perpetual Inventory Method reveals the *expected* public endowment. The difference between the two methodologies is not purely semantic but reveals the efficiencies (viz. inefficiencies) of public spending in infrastructure. Keeping this in mind, we develop in this chapter new updated and comprehensive public capital series in both physical and monetary terms over the 1987-2016 period. We review the main approaches used in the Italian literature, first for the physical and then for the monetary indicators.

2.1.3 Overview of the indicators for infrastructure in physical terms

2.1.3.1 Indexes constructed by Biehl, Bracalente, Di Palma and Mazziotta[4]

The regional (NUTS2) index of physical infrastructure has been initially measured by Bracalente and Di Palma (1982). Later, Biehl et al. (1986) developed an infrastructural index based on 47 indicators including roads (kilometres of highways, as well as national, provincial, and municipal roads), railroads (kilometres of double and single track, electrified and non-electric), airports (square meters of runways and of parking areas), schools (numbers of school rooms in elementary, middle and high schools, as well as university personnel), health (numbers of hospital beds), child care facilities (numbers of cots), stadiums, theatres, and other public utilities and buildings. These indicators are calculated for Italian regions, and then, using the methodology described in Biehl (1986) are normalized either by area or by population. "Space serving" public capital refers to roads, railroads, airports, ports, other transportation infrastructure, telecommunication, energy, oil and natural gas pipelines, and water supply. "Population serving" public capital refers to schools and universities, hospitals, kindergartens, sports facilities, theatres, museums, and libraries. The general index for infrastructural endowment has been computed for 1970 (Biehl, 1986), 1977 (Bracalente and Di Palma, 1982), 1987 (Biehl et al., 1990), 1997 (Di Palma and Mazziotta, 2002). Data sources are described in Biehl et al. (1986, p. 81-83).

In 2000 the index of public capital stock was extended by Confindustria and Ecoter (2000a) to Italian regions (NUTS2) and provinces (NUTS3) for four economic (transport, communication, energy, water infrastructure) and 5 social categories (education, health, childcare, sport, culture), grouping some 50 elementary categories, for 1995 and 1997. This index was used by Golden and Picci (2005a) in the construction of their corruption index.

Finally, between 1998 and 2000, Confindustria and Ecoter (2000b) updated the Biehl et al. (1990) series using Eurostat data, computing infrastructural indexes for the NUTS2 regions (132 regions) of the five major European countries (France, Germany, Italy, Spain, United Kingdom), for economic infrastructure - such as transport (railway and roads, ports and airports), energy (oil and gas pipeline, electricity) and communications -, and some social infrastructure such as education endowment, grouping 20 elementary categories, for 1985 and 1995.

2.1.3.2 Indexes constructed by Istituto Guglielmo Tagliacarne[5]

The Istituto Guglielmo Tagliacarne produced two different general indexes for physical public capital:

i) Regional (NUTS2) and provincial (NUTS3) infrastructural indexes measuring Italian infrastructure endowment normalized to the potential demand according to the population, the size and the effective demand for 1987, 1991, 1995-1996, 1997-2000, 2001-2004, 2005-2007, 2009, 2011, 2012.

This index can be classified in 10 categories: Roads (10 elementary categories); Railways (9 elementary categories); Ports (18 elementary categories); Airports (14 elementary categories); Energy and environment equipment (17 elementary categories); Communication structures and networks (11 elementary categories); Banking and business service (16 elementary categories); Cultural and leisure structures (35 elementary categories); Education structures (25 elementary categories); Health and welfare infrastructure (44 elementary categories). Approximatively 200 elementary indicators have been built.

[4] Biehl (1986), Bracalente and Di Palma (1982), Biehl et al. (1990), Mazziotta (1998), Di Palma and Mazziotta (2002), Confindustria and Ecoter (2000a, 2000b)

[5] Istituto Gugliemo Tagliacarne (2001, 2006)

ii) Regional (NUTS2) infrastructural indexes measuring infrastructure endowment normalized to the potential demand according to the population, the size and the effective demand for the major EU members (Germany, Italy, Spain, France, UK), for 1985 and 1995, using Eurostat data.

These indexes elaborated by Istituto Tagliacarne introduce some methodological innovations in order to broaden the observations on social infrastructure and isolate the mere endowment from the quality or appropriateness of the resources.

2.1.3.3 Indexes constructed by ISTAT[6]

The *Atlante statistico territoriale delle infrastrutture* produced by ISTAT offers exclusively elementary indicators describing the Italian infrastructure endowment from 1996 (Table 2). More than 600 provincial (NUTS3) and regional (NUTS2) indicators are displayed, describing economic, social and territorial infrastructure (Table 2), but no sectoral and general indexes is produced.

Tab. 2 Istat infrastructure classification according to macro-categories and sub-categories

Economic infrastructure	
Transport network	Road transport Railway transport Air transport Sea transport Other aspects
Energy network	Electricity network Gas network Other aspects
Social infrastructure	
Health infrastructure	Free hospital treatment Health service Social security
Educational Infrastructure	Nursery Primary school for pupils aged 11 – 14 Secondary school Compulsory education University Other aspects
Culture infrastructure	Cultural, artistic and historic heritage Theatre, music, cinema and entertainment
Environmental infrastructure	Water purification plant Waste disposal Green areas Other aspects
Territorial infrastructure	
Tourist infrastructure	Tourist receptiveness other aspects
Trade Infrastructure	Retail trade Wholesale trade Other aspects
Monetary intermediation infrastructure	Monetary intermediation

Source: Istat (2006)

Table 3 sums up the main infrastructure indexes in physical terms still currently extant for Italian regions and provinces.

Tab. 3 The main infrastructure indexes in physical terms for Italian regions and provinces. A summing-up

Authors	**n. of elementary indicators**	**Territorial reference**	**Years**

[6] Istat (2015a, 2015b)

Biehl, Bracalente, Di Palma and Mazziotta	47	Italian regions (NUTS2)	1970, 1977, 1987, 1997
Confindustria-Ecoter (2000a)	48	Italian provinces (NUTS3)	1995, 1997
Confindustria- Ecoter (2000b)	20	Regions of France, Germany, Italy, Spain, United Kingdom (NUTS2)	1985, 1995
Istituto Tagliacarne	200	Italian regions (NUTS2) and provinces (NUTS3)	1987, 1991, 1995-1996, 1997-2000, 2001-2004, 2005-2007, 2009, 2011, 2012
Istituto Tagliacarne		Regions of Germany, Italy, Spain, France, UK (NUTS2)	1985, 1995
ISTAT	600	Italian provinces (NUTS3) and regions (NUTS2)	from 1996

2.1.3.4 Other non-specific infrastructural indicators and a summing-up

Finally, other databases not properly focused on infrastructure offer some interesting indicators for physical capital endowment. For instance, the *Istat Territorial indicators database for development policies* (https://www.istat.it/it/archivio/16777) covers 316 indicators available at regional (NUTS2) and sub-regional level (NUTS3), in most cases from 1995, for macro areas such as Water resources, Waste, Energy, Labour, Competitiveness, Business Demographics, Capital market and corporate finance, Information, Legality and security, Care services, Transport and mobility, Air pollution, Environment, Cultural goods, Education and training, Sectoral dynamics, Internationalization, Research and innovation, Social exclusion, Social capital, Towns, Tourism, Public administration. On the other hand, *Eurostat* (https://ec.europa.eu/eurostat/web/regions/data/database) provides *Regional statistics* for social, economic and environmental issues from 1990, for Agriculture, Demographic, Education, Science and technology, Structural business, Health, Tourism, Transport, Labour market, Labour costs, Digital economy and society, Environment and energy, Poverty and social exclusion, Crime statistics.

To sum up, the elementary indicators and the methodology adopted to construct synthetic indexes are pivotal to measure territorial public capital in physical terms (Mazziotta et al., 2010). Firstly, the elementary indicators which quantify different assets are used to compute sectoral synthetic indexes which are themselves adopted to elaborate a general index. The selection of them necessarily impacts on the statistical results. Moreover, the normalization approach (to population, area, GDP), the standardization of elementary indicators (to provide them a common unit of measurement), and the aggregation weighting procedures to compute synthetic indicators are critical steps to build a robust infrastructural index.

In Section 2 we proceed to construct time-varying aggregate and sectoral indexes in physical terms for Italian NUTS2 regions over 1987-2016, relying on the methodology developed by the Istituto Tagliacarne. We do so (unlike for instance Golden and Picci (2005a), who adopt the 1997 general index for infrastructure produced by Ecoter), because Istituto Tagliacarne provides both sectoral and synthetic indexes (unlike Istat) which are available for different years (unlike Biehl et al. and Confindustria and Ecoter), using a relevant number of elementary indicators (unlike Biehl et al. and Confindustria and Ecoter). Relying on these indexes allows us to construct time-varying indicators, and to test the validity of the new indicators, comparing them to the indexes of Istituto Tagliacarne over the available years.

2.1.4 Overview of the series developed to measure public capital in monetary terms

2.1.4.1 Series created by Picci[7]

The annual regional (NUTS2) and provincial (NUTS3) public capital stock series for nine categories of goods built by Picci and successively updated are available for 1890-1998. They rely on the PIM and their data sources are:

- National public investments and national public capital stock (Rossi et al. (1992)) 1890-1992;
- At the regional level:
  - ✓ Regional data on "lavori eseguiti[8]" (Opere pubbliche, Istat, 1954-2002) for nine types of goods: Roads and airports ; Railways and other transport lines; Ports, lake and river navigation; River planning, electric grid, power plants; Public buildings, school and social facilities, residential buildings; Sanitation infrastructure; Land reclamation and transformation; Communications; Others.
  - ✓ Conti Pubblici Territoriali (from 1996) and Conto Economico AAPP (from 2000)

2.1.4.2 Series created by Montanaro (2003)

In 2003, Montanaro built the regional (NUTS2) investment series for 1928-1999 and the regional (NUTS2) gross stock of public capital for 1979-1999 for five categories of capital goods, using the PIM on:

- For national statistics: Ercolani (1928-1951), Brandolini and Muzzicato (1951-1995), ISTAT-SEC95 (1995-1999);
- For regional and sectoral computation: ISTAT (1928-1999) and specific hypothesis for 1973-1979.

Few years later, Montanaro (2010), developed regional investment series of the enlarged public sector for 1996-2007 using Istat national accounts and Conti Pubblici Territoriali. Data are available for economic (Civil Engineering) and social assets.

2.1.4.3 Series created by Di Giacinto et al.[9]

Di Giacinto et al. updated the investments computed by Montanaro using national account statistics (1996-2007) and for territorial and sectoral computation, data from ISTAT (Indagine sui lavori iniziati/eseguiti until 2002) and Conti Pubblici Territoriali (2002-2007) in order to calculate the regional productive stock for four categories of capital goods for 1970-2007.

Table 4 resumes the different series of public capital in monetary terms for Italian regions (NUTS2) and provinces (NUTS3), all based on the PIM.

[7] Picci (1995a), Picci (2001), Bonaglia and Picci (2000).

[8] In particular, "tutti i lavori in opere pubbliche relativi a nuove costruzioni, ricostruzioni, miglioramenti strutturali, grandi riparazioni, manutenzioni straordinarie ed assimilate [...] realizzati:
a) con il finanziamento totale dello Stato o con il contributo di esso, tramite i Ministeri e la Cassa per il Mezzogiorno;
b) con il finanziamento totale o parziale di Enti nazionali e territoriali della Pubblica Amministrazione (Inail, Inps, Enti Regione, Amministrazioni provinciali, Comuni) o con il contributo di altri Enti (escluso lo Stato);
c) con il finanziamento totale delle Aziende autonome dello Stato e di altre Aziende pubbliche." (Bonaglia and Picci, 2000, p. 7)

[9] Di Giacinto et al. (2010a, 2010b, 2012).

Tab. 4. Scheme for the monetary value of the public capital stock for Italy

SERIES	LITERATURE REFERENCES	TERRITORIAL DETAIL FOR ITALY	YEARS	N. OF CATEGORIES FOR CAPITAL GOODS	SOURCE FOR NATIONAL DATA	SOURCE FOR REGIONAL AND SECTORAL COMPUTATION
PUBLIC INVESTMENT AND GROSS PUBLIC CAPITAL STOCK	Picci (1995a), Picci (2001), Bonaglia and Picci (2000)	NUTS2 and NUTS3	1890-1998 (investment), 1890-1998 (public capital stock)	9	Rossi et al. (1993)	Opere pubbliche (Istat), 1954-2002; Conti Pubblici Territoriali (from 1996); Conto Economico AAPP (from 2000)
PUBLIC INVESTMENT AND GROSS STOCK OF PUBLIC CAPITAL	Montanaro (2003)	NUTS2	1928-1999 (investment), 1979-1999 (public capital stock)	5	Ercolani (for 1928-1951), Brandolini and Muzzicato (for 1951-1995), ISTAT-SEC95 to update (1995-1999)	ISTAT (1928-1999) and specific hypothesis for 1973-1979
	Montanaro (2010)	NUTS2	1996-2007 (enlarged public sector investments)	2	Istat national account	Conti Pubblici Territoriali (1996-2007)
PUBLIC INVESTMENT AND PUBLIC PRODUCTIVE STOCK	Di Giacinto et al. (2010b, 2010c, 2012)	NUTS2	1928-2007 (investment), 1970-2007 (productive capital of the enlarged public sector capital)	4	National account statistics (1996-2007)	ISTAT (Indagine sui lavori iniziati/eseguiti, until 2002) and Conti Pubblici Territoriali (2002-2007)

These different regional public investment series and sectoral public capital stocks reveal that, even always using the PIM, outcomes may differ, mainly because of the source of data (national, as well as regional and sectoral).

In line with our empirical analysis aiming to extend the approach of Golden and Picci (2005a) in order to investigate public capital efficiency of the Italian regions over the period 1987-2016, in Section 3 we update the sectoral investment series produced by Picci (2001) for 1890-1997. However, following some methodological updates (Mas et al., 2006 and Perez et al. 2019), we construct the net regional public capital for seven assets - by cumulating gross fixed capital formation year by year and deducting depreciation, while Golden and Picci considered gross capital formation.

2.2 The public capital in physical terms

In this section we describe the approach used to compute a new infrastructure index in physical terms over the period 1987-2016. Considering our aim to measure the sectoral public spending efficiency we developed indexes for physical infrastructural endowment comparable with the sectoral public capital stocks of Picci (2001) that we will consider and further develop in Section 2.3. As we already said, we base our measure for physical infrastructural endowment on the methodology developed by Istituto Tagliacarne. The new indicator is then validated comparing it to the index elaborated by Istituto Tagliacarne for the available years.

2.2.1 The methodological approach to construct the infrastructure index

In order to measuring regional public infrastructure in physical terms for the very long period 1987-2016, we detected 30 elementary indicators frequently mentioned by main approaches used to compute infrastructural endowments (Table 5) and available for most of the required years. In particular, we consider:

- 18 elementary indicators for economic infrastructure, grouped in 8 intermediate categories (Roads, Airports, Railways, Ports, Water, Electricity, Gas and Petrol) and in 4 main classes (Roads (including Roads and Airports), Rails (including Rails and Ports[10]), Water disposal, Others (including Energy infrastructure));
- 12 elementary indicators for social infrastructure, grouped in 5 intermediate categories (Waste, Education, Culture, Social, Health) and in 3 main classes (Buildings (including Education, Cultural and Social infrastructure), Health, Others (Waste)).

The main category of Communication infrastructure was not considered because of the particular evolution of the sector during the long period 1987-2016 for which Biehl (1991) used elementary categories as Telephone, Telex, Fax network that, according to our own opinion, do not actually represent the current endowment of communication coverage increasingly related to internet networking system.

Thanks to the research centre Studiare Sviluppo involved in the industrial PhD and its collaboration with the Infrastructure and Transport Ministry (MIT), various data sources could be reached, yielding long and consistent time series for our indicators (Table 6). The main sources were Eurostat – Regional statistics, which provides relevant regional and sectoral data for 1990-2017, and Istat – Atlante Statistico Territoriale delle infrastrutture for specific data on infrastructure for 1996-2015. Other Istat statistics have been used from I.Stat and Istat – Indicatori territoriali delle Politiche di sviluppo. For less recent statistics the data have been sourced from Istat – Annuario statistico italiano, and MIT – Conto nazionale delle infrastrutture e dei trasporti. For some specific intermediate categories, more particular sources have been adopted: Terna for electricity network system, Unionpetrolifera and Economic Development Ministry (MISE) for statistics on Petroleum infrastructure, Autorità di regolazione per Energia, Reti e Ambiente (ARERA) for natural gas pipelines, Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA) for waste infrastructure.

In order to complete the time series, we have carried out linear interpolations by the arithmetic mean of adjacent known elementary values have been done. Furthermore, in order to provide a common unit of measurement to different elementary indicators, they were all divided by their respective mean over period 1987-2016. This approach differs from traditional methodology that normalizes elementary indicators respectively by either area and 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 the area or surface normalization).

Once carried out the above-described operation, an intermediate index is defined by arithmetic average of the relative elementary indexes (see Table 5, last column), according to the procedure applied by Biehl et al (1990).

Finally, an additional novelty has been introduced in the aggregation approach adopted for the sectoral and the aggregate indexes. While usually the synthetic indexes are obtained as simple averages of the intermediate indexes, in our case the index of the main class and the synthetic regional index are the weighted arithmetic average of the respective. Weights are given by the ratio of the respective investment expenditures taken from Conti Pubblici Territoriali data for 1996.

[10] Roads include Roads and Airports, and Rails include Rails and Ports, in order to achieve comparability with the monetary indicators considered in Section 2.3.

Tab. 5. Main, intermediate and elementary categories for infrastructural endowment index

		Main class[11]	Intermediate category	Elementary index[12]	Elementary indicator description	Literature references[13]	Elementary aggregation methodology for intermediate category
F_INDEX[14]	CORE	F_ROADS	ROADS	ROAD1	Motorway (km)	B, CEa, CEb, T	MEAN ($\frac{11}{7}$ ROAD1; ROAD2)[15]
				ROAD2	Other roads (km)	Detailed other roads (B, CEa, CEb, T)	
			AIRPORTS	AIRP1	Runways surface (m2)	B, CEa, CEb, T	MEAN (AIRP1; AIRP2)
				AIRP2	Parking area (m2)	CEa, T	
		F_RAILS	RAILWAYS	RAIL1	Total railway lines (km)	T	
			PORTS[16]	PORT1	Lenght of docks (m)	CEa, Cab, Cab, T	MEAN (PORT1; PORT2; PORT3; PORT4)
				PORT2	Total quays surface (sqm)	CEa, Cab, T	
				PORT3	Freight loaded and unloaded (thousand tonnes)		
				PORT4	Passengers embarked and disembarked (thousand)		
		F_WATER	WATER[17]	WATE1	Water delivered (thousand m3)	T	MEAN (WATE1; WATE2; WATE3)
				WATE2	Sewage treatment plants (thousand)	T	
				WATE3	Regional population served by complete wastewater treatment plants (%)		
		F_OTHERS[18]	ELECTRICITY	ELEC1	Lenght of electricity network system 220Kv (Km)	CEb, T	MEAN (MEAN (ELEC1; $\frac{38}{22}$ ELEC2); ELEC3)
				ELEC2	Lenght of electricity network system 380 Kv (Km)	CEb, T	
				ELEC3	Net production of electrical energy (GWh)	T	
			GAS	GAS1	Total lenght natural gas pipelines (km)	B, CEa, CEb, T	
			PETROL[19]	PETR1	Total lenght petroleum pipelines (km)	B, CEa, CEb, T	MEAN (PETR1; PETR2)
				PETR2	Cumulative n. of oil wells		
	NON- CORE		WASTE	WAST1	Production of urban waste (thousand tonnes)	B, T	
		F_BUILDINGS[20]	EDUCATION	EDUC1	n. of maternal classrooms	CEa, T	MEAN (EDUC1; EDUC2; EDUC3; EDUC4; EDUC5)
				EDUC2	n. of primary classrooms	CEa, T	
				EDUC3	n. of secondary first cycle classrooms	CEa, T	
				EDUC4	n. of secondary upper cycle classrooms	CEa, T	
				EDUC5	n. of university professors and researchers	CEa, T	
			CULTURE	CULT1	n. of visitors of public art institutes	CEa, T	MEAN (CULT1; CULT2)
				CULT2	n. of tickets for theatres and concerts	CEa, T	
			SOCIAL	SOCI1	n. of available beds in nursing and residential care facilities	B, CEa	MEAN (SOCI1; SOCI2)
				SOCI2	Kindergartens (number of users)	B	
		F_HEALTH	HEALTH	HEALT1	n. of beds in hospitals	B, CEa, T	MEAN (HEALT1; HEALT2)
				HEALT2	n. doctors	T	

Note: 30 elementary indicators frequently mentioned by main approaches have been used to compute infrastructural endowments.

[11] The main class index is the simple average of the relative intermediate indexes, unless otherwise specified.

[13] B (Biehl et al. (1990)), CEa (Confindustria-Ecoter, 2000a), CEb (Confindustria-Ecoter, 2000b), T (Istituto Tagliacarne)

Tab. 6. Primary and secondary sources by elementary index over the period 1987-2016

Elementary index	Primary data source (green)	Secondary data source (yellow)	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
ROAD1	Eurostat	Istat																														
ROAD2	Eurostat	Istat																														
AIRP1	Istat	MIT																														
AIRP2	Istat	MIT																														
RAIL1	Eurostat																															
PORT1	Istat	MIT																														
PORT2	Istat	MIT																														
PORT3	Eurostat	Istat																														
PORT4	Eurostat																															
WATE1	Istat																															
WATE2	Istat																															
WATE3	Istat																															
ELEC1	Istat	MIT																														
ELEC2	Istat	MIT																														
ELEC3	Istat	MIT																														
GAS1	ARERA	Istat																														
PETR1	MIT																															
PETR2	MISE																															

[13] B (Biehl et al. (1990)), CEa (Confindustria-Ecoter, 2000a), CEb (Confindustria-Ecoter, 2000b), T (Istituto Tagliacarne)

[14] The general index F_INDEX for infrastructure in physical terms is the weighted arithmetic mean of the intermediate infrastructure indexes. Weights are given by the ratio of the respective investment expenditures taken from Conti Pubblici Territoriali data for 1996.

[15] The weighted are defined in Biehl et al (1990).

[16] For reasons of data availability, we use as output indicators freight loaded and unloaded (Istituto Tagliacarne uses n. of approaches for goods) and passengers embarked and disembarked (Istituto Tagliacarne uses n. of approaches for passengers).

[17] For reasons of data availability, we use an indicator (regional population served by complete wastewater treatment plants) not considered by literature references.

[18] The index for the main category F_Others is the weighted average of the intermediate categories of Energy and Waste infrastructure. Weights are given by the ratio of the respective investment expenditures taken from Conti Pubblici Territoriali data for 1996.

[19] For reasons of data availability, we use an indicator (cumulative number of oil wells) not considered by literature references.

[20] The index for the main category F_Buildings is the weighted average of the intermediate categories of Education, Cultural and Social infrastructure. Weights are given by the ratio of the respective investment expenditures taken from Conti Pubblici Territoriali data for 1996.

WAST1	Istat	
EDUC1	Istat	
EDUC2	Istat	
EDUC3	Istat	
EDUC4	Istat	
EDUC5	Istat	
CULT1	Istat	
CULT2	Istat	
SOCI1	Istat	
SOCI2	Istat	
HEALT1	Eurostat	Istat
HEALT2	Eurostat	Istat

Note: Different data sources have been used for the 30 elementary indicators (primary data source (2nd column) has been used for green cells and secondary data source (3rd column) has been used to fill yellow cells). Linear interpolations among adjacent known elementary values have been carried out to fulfil white cells.

2.2.2 *Validating the new physical index for infrastructure*

In order to validate the selection of the elementary indicators and the resulting new infrastructure index in physical terms, we compare our measure to our benchmark for infrastructural endowment, namely the indexes elaborated by Istituto Tagliacarne. Therefore, we apply the standard procedure for constructing composite indicators of public infrastructural endowment (Mazziotta, 2006) to the 30 regional elementary indicators over 1987-2016, actually removing the methodological novelties introduced in the construction of the new index.

Generally, the elementary indicators are normalized by land area for "network" or space serving infrastructure and by population for "punctual" indicators or population serving infrastructure. To that purpose the Economic elementary categories of Transport, Energy and Water infrastructure have been related to regional area and the Social elementary categories of Education, Cultural, Social, Health and Waste infrastructure to regional population.

The normalized indicators are not yet comparable, as they are expressed in different units of measurement (km of roads per square km of land area, or number of doctors per inhabitant). One common method for this purpose is to relate, within the same infrastructural category, the yearly normalized indices of each territorial unit to the national value of the series, thus obtaining the immediate comparability between the indicators considered.

Finally, in order to aggregate elementary standardized indicators in intermediate and main category, an averaging procedure is used. Usually, the arithmetic mean is adopted to aggregate elementary indicators within a category (hypothesis of greater fungibility) and the geometric mean to combine different main categories (hypothesis of smaller substitutability).

Tables 7a and 7b report the new aggregated index for the six main classes (Roads, Rails, Buildings, Health, Water, Others), the Economic and Social infrastructures, as well as the synthetic aggregate index for the first and the last year of the period in order to compare the infrastructural endowment between regions and the trend of each regional index throughout 1987-2016.

As expected, the Southern regions are generally less equipped in terms of public infrastructure, with some outliers in the North (Aosta Valley, Trentino Alto Adige) and Centre (Umbria). Relevant differences emerge for economic assets - for which Liguria and Lombardy are highly equipped, while social facilities are relatively more widespread in all Northern and Central Italy.

Tab. 7a. Regional infrastructure index for Main classes, Economic, Social and total assets (1987)

	ROADS	RAILS	WATER	BUILDINGS	HEALTH	OTHERS	TOTAL ECONOMIC	TOTAL SOCIAL	TOTAL
Piedmont	98.61	64.65	150.07	96.47	78.23	102.66	102.47	91.91	97.05
Aosta Valley	48.60	22.36	109.74	99.60	86.29	62.00	68.23	96.28	81.05
Liguria	314.47	439.18	177.57	88.11	101.03	239.41	268.18	91.34	156.51
Lombardy	167.83	58.21	147.30	91.12	91.56	213.42	152.58	91.23	117.99
Trentino Alto Adige	42.15	28.06	78.42	112.42	98.87	57.60	53.56	109.04	76.42
Veneto	108.10	123.77	114.95	80.82	113.03	123.54	120.02	88.87	103.28
Friuli Venezia Giulia	107.29	189.98	130.00	101.79	115.22	108.83	122.30	105.14	113.40
Emilia Romagna	105.38	63.16	107.83	126.52	107.14	141.92	120.67	121.67	121.17
Tuscany	76.37	114.27	68.26	134.82	108.09	87.07	84.26	128.14	103.91
Umbria	55.64	41.37	77.99	94.17	101.26	60.84	57.88	95.94	74.52
Marches	91.67	61.83	71.60	95.50	100.51	77.40	80.00	96.75	87.98
Latium	226.62	89.52	97.78	116.84	95.74	127.82	133.16	111.57	121.89
Campania	121.72	169.79	105.38	78.13	60.13	71.66	107.11	73.63	88.81

Abruzzo	117.01	62.18	117.55	73.63	113.45	85.09	94.33	83.59	88.80
Molise	41.60	66.84	83.36	59.61	77.64	70.41	66.85	64.12	65.47
Apulia	108.13	103.60	89.95	54.42	97.71	76.46	91.26	65.24	77.17
Basilicata	26.45	31.91	47.28	59.12	92.91	60.44	47.65	67.57	56.74
Calabria	106.69	106.78	60.36	50.54	77.74	53.46	72.95	57.34	64.68
Sicily	129.66	137.85	54.13	84.57	64.80	72.50	95.59	79.63	87.24
Sardinia	56.17	77.22	69.22	64.85	68.47	41.83	53.93	65.75	59.55

Tab. 7b. Regional infrastructure index for Main classes, Economic, Social and total assets (2016)

	ROADS	RAILS	BUILDINGS	HEALTH	WATER	OTHERS	TOTAL ECONOMIC	TOTAL SOCIAL	TOTAL
Piedmont	97.55	64.16	94.25	91.58	159.30	104.16	104.59	93.58	98.93
Aosta Valley	76.45	21.33	90.91	94.13	119.55	63.35	86.53	91.71	89.08
Liguria	237.47	465.82	91.75	101.29	157.83	175.44	221.88	94.13	144.52
Lombardy	201.98	60.34	87.42	92.38	160.99	193.11	149.18	88.66	115.00
Trentino Alto Adige	41.88	31.24	96.42	87.57	85.90	54.39	48.55	94.21	67.63
Veneto	140.73	105.72	83.28	87.04	106.75	127.89	111.71	84.22	97.00
Friuli Venezia Giulia	93.97	177.23	119.21	94.72	104.39	94.20	96.87	113.08	104.66
Emilia Romagna	100.54	85.50	103.69	99.60	116.82	159.20	121.15	102.67	111.53
Tuscany	89.22	119.99	121.86	90.98	69.07	82.84	94.04	114.14	103.60
Umbria	48.76	38.14	81.49	93.74	71.25	53.00	76.35	84.55	80.34
Marches	78.09	68.02	90.50	87.30	96.01	78.86	96.52	89.70	93.04
Latium	229.31	101.67	142.34	98.90	83.82	108.09	115.24	131.48	123.09
Campania	112.27	167.00	71.00	80.68	131.35	83.02	98.39	73.42	84.99
Abruzzo	114.30	48.98	65.61	91.98	126.97	97.55	101.10	72.20	85.44
Molise	37.30	61.18	68.43	96.38	74.91	74.74	97.26	75.42	85.65
Apulia	90.21	85.66	54.31	82.39	66.73	92.86	99.92	61.33	78.28
Basilicata	25.41	32.93	67.58	82.74	48.32	72.63	55.89	71.37	63.16
Calabria	97.49	134.04	51.07	73.77	60.42	61.92	96.90	56.75	74.15
Sicily	115.30	116.99	75.30	87.42	48.50	81.54	119.33	78.33	96.68
Sardinia	58.19	77.51	72.94	99.79	67.44	33.82	57.23	79.65	67.51

Note: The new composite regional infrastructure index has been computed for 1987-2016 using 30 elementary indicators from different sources (Autorità di regolazione per Energia, Reti e Ambiente (ARERA), Economic Development Ministry (MISE), Eurostat, Infrastructure Ministry (MIT), Istat, Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA), Terna, Unionpetrolifera). Value equal to/greater than/less than 100 shows region with infrastructural endowment equal to/greater than/less than the national average.

More to the point, Table 8 reproduces the correlation between the new indexes of some intermediate categories, Total economic, Total social and General and the relative indexes of Istituto Tagliacarne. The generally high correlation between the indicators of the two series indicates the appropriateness of the 30 elementary indicators chosen to measure public capital in physical terms.

Tab. 8. Correlation between the new regional infrastructure indexes and relative indexes of Istituto Tagliacarne (years 1991, 1995-1996, 1997-2000, 2001-2004, 2005-2007, 2009, 2011, 2012)

	1991	1995-1996	1997-2000	2001-2004	2005-2007	2009	2011	2012
Energy			0.82	0.82	1.00	0.75	0.76	0.76
Education	0.78		0.84	0.84	0.99	0.87	0.85	0.88
Health	0.88		0.88	0.89	1.00	0.92	0.92	0.92
Social	0.48		0.57	0.62	0.99	0.59	0.60	0.59
Total economic				0.91	0.99	0.89	0.92	0.90
Total social				0.92	1.00	0.92	0.92	0.93
General index	0.87	0.83	0.91	0.90	0.90	0.91	0.91	0.92

Note: The table reports the Pearson correlation index for some intermediate categories (Energy, Education, Health and Social), Total economic and social assets, General index for infrastructure in physical terms. The high correlation with our benchmark for infrastructural endowment, namely the indexes elaborated by Istituto Tagliacarne (https://www.ucer.camcom.it/studi-ricerche/dati/bd/infrastr/numeri-indici-delle-dotazioni-infrastrutturali-n-r-p), validates the robustness of the new regional infrastructure index.

2.3 The public capital in monetary terms

Once computed the infrastructure index in physical terms, we proceed by constructing the net public capital in monetary terms over 1890-2016. In fact, inspired by Golden and Picci (2005a) approach estimating the regional corruption through comparison of the two measures of public capital, we assess the efficiency of the public capital by poising the physical endowment index of Section 2.2 on a monetary stock elaborated adopting the PIM.

In order to adopt the PIM, we first update the regional public investment flows developed by Picci (2001) for nine assets, using the public expenditures from the *Conti Pubblici Territoriali* (CPT) data. Some assumptions must be made in doing this, since CPT data are organized in 30 Functions of Government classes (COFOG) and must be allocated to our nine assets. Then, we compute the net regional public capital using the methodology of Mas et al. (2006) and Perez et al. (2019).

2.3.1 Picci's approach to measure sectoral territorial public investment flows and capital stock

Public investments and capital data elaborated by Picci (2001) adopted the series created by Rossi et al. (1993) public investments at national level[21] for 1890-1992. The series have been successively updated to 1998 using Istat (1999a, 1999b, 2000) public investments[22].

Provincial data on public investment flows by asset are calculated by Picci using Istat series (Istat, Opere Pubbliche, 1954-1998). The Istat publication considers all the conducted public works (properly *lavori eseguiti*) relative to new constructions, reconstructions, structural improvements, major repairs, extraordinary maintenance entirely financed by the State (and Ministers), completely or partially financed by public and local agencies (Inail, Inps, Regions, Provinces, Municipalities), totally financed by public non-financial companies.

In particular, Picci public investments series are available for NUTS3 provinces and nine types of assets: Roads and airports (STRAD), railways (FER), maritime and waterway infrastructure (MAR), water and electrical systems (IDR[23]), public, social and school buildings (EDPUB[24]), hygiene and health infrastructure (IGIEN[25]), land reclamation (BONIF), communications equipment (COMUN), others (ALTR).

In line with Aschauer (1989), Picci defines assets STRAD, FER, MAR, IDR, BONIF, COMUN and half of ALTR as core infrastructure with relevant impact on the productive process, whereas EDPUB, IGIEN, and the other half of ALTR (further details are provided below) are expected to wield a social impact and are therefore, considered as non-core infrastructure.

The PIM is then applied to the investment series, considering a normal distribution for retirement, centred on the average service life of the asset. Picci postulates that 90% of goods are retired within 25% of the mean life, in line with Istat methodology (1995) and OECD suggestions (2001a). The normal distribution is truncated

[21] Until 1952, the data include only investments by the central administration (Golden and Picci, 2005a).
[22] Istat adopted a new classification for public institutions in 1999 and updated the classification of infrastructure in line with Eurostat standard. Therefore, the series for public investments are not completely consistent with the series for the previous years (Istat, 2001). For that reason, we update Picci public investment flows using the database CPT (see Section 2.3.2)
[23] Including hydraulic infrastructure, waterways, use of public water and similar
[24] Including monumental buildings, excavation sites, public buildings, schools and similar.
[25] Including aqueducts, sewage, hospitals, slaughterhouses, markets and similar.

at 40% of the average life. A specific cut of 8% for the wartime destruction has been considered for the period before 1946. Moreover, Picci assumes the average service life of OECD (1993) countries: 45 years for STRAD, 55 for FER, 46 for MAR, 43 for IDR, 65 for EDPUB, 58 for IGIEN, 43 for BONIF, 50 for COMUN, 50 for ALTR.

2.3.2 Updating Picci public investment flows

We use the public expenditures from the database *Conti Pubblici Territoriali* (CPT) to update the regional investments series elaborated by Picci, since the Istat publication used by Picci is no longer available. Processing the same source adopted to update other infrastructure series (Di Giacinto et al.(2010b)[26]; Montanaro (2010)[27]), we i) cover a more recent period (until 2016), ii) for more infrastructure assets, iii) in line with the classification used for the construction of the infrastructure index in physical terms (Section 2.2), in order to measure regional sectoral public spending efficiency.

Notice that CPT database includes the investments carried out by the so-called enlarged public sector (*settore pubblico allargato*)[28] while Picci series focus on investments of the public administration, public works and public utility works. In addition, other differences between Picci and CPT series must be tackled. In particular, regional data of central and local administrations expenditures are classified by CPT in 30 Functions of Government classes (COFOG) for the period 1996-2016. We consider only outflows for building works (properly *Beni e opere immobiliari*) in the specific sectors of interest. These outflows include the costs supported for buildings, extraordinary maintenance (to fix, complete, readjust the infrastructure) and purchases of real estate assets including civil engineering infrastructure (such as roads, ports, airports, land reclamation, consolidation works, etc.). The sectoral functions are not univocally related to one or more assets of Picci investments series, and some assumptions, to be made explicit below, must be taken. Other differences between the Istat-based series used by Picci and the CPT series, not relevant for present purposes, are listed in CPT (2019).

In order to updating Picci series, we proceed as suggested by Di Giacinto et al. (2010b) and Montanaro (2010). Basically, we link Picci series to the public investments derived by CPT, exploiting their similar dynamics across a given matching year. To that end, we adopt the following steps.

1) We assume a table of correspondences among Picci assets and CPT sectoral functions (Table 9), in line with the classification used for the infrastructure index in physical terms, for 8 asset classes (ROADS, RAILS, BUILDINGS, HEALTH, WATER, LAND, TLC, OTHERS).

[26] The public regional investments series updated by Di Giacinto et al. for the enlarged public sector concern transport, electric, water and gas pipelines, complex constructions on industrial sites infrastructure, estimated for 1928-2007.
[27] Montanaro uses CPT investments dynamics to update the series of Civil engineering works (Transport infrastructure, Pipelines, communication and electricity lines, Complex constructions on industrial sites, Other civil engineering works) constructed in Montanaro (2003) for the Public sector (1970-2007) and the enlarged public sector (1996-2007)
[28] Including Public company (Azienda dei Monopoli di Stato; Cassa depositi e prestiti (from 2004); Ente Tabacchi Italiano (since 2003); Enel; Società Poste Italiane; Ferrovie dello Stato spa; ENI; ACI; Aziende ex IRI (Aeroporti di Roma, Alitalia, Finmeccanica, Fintecna, RAI); ENAV (from 2001); GSE (Gestore Servizi Elettrici, ex GRTN); Terna Rete Elettrica Nazionale, Infrastrutture Spa (since 2005); Italia Lavoro; Simest (Società Italiana per le Imprese all'Estero); Sogesid (Società gestione impianti idrici); Sogin (Società gestione impianti nucleari); Invitalia (ex Sviluppo Italia)) and Local public company (Consorzi e forme associative di enti locali; Aziende e istituzioni locali; Società e fondazioni partecipate).

Tab. 9. Table of correspondences among the intermediate categories of the infrastructure index in physical terms, Picci assets and CPT sectoral functions[29]

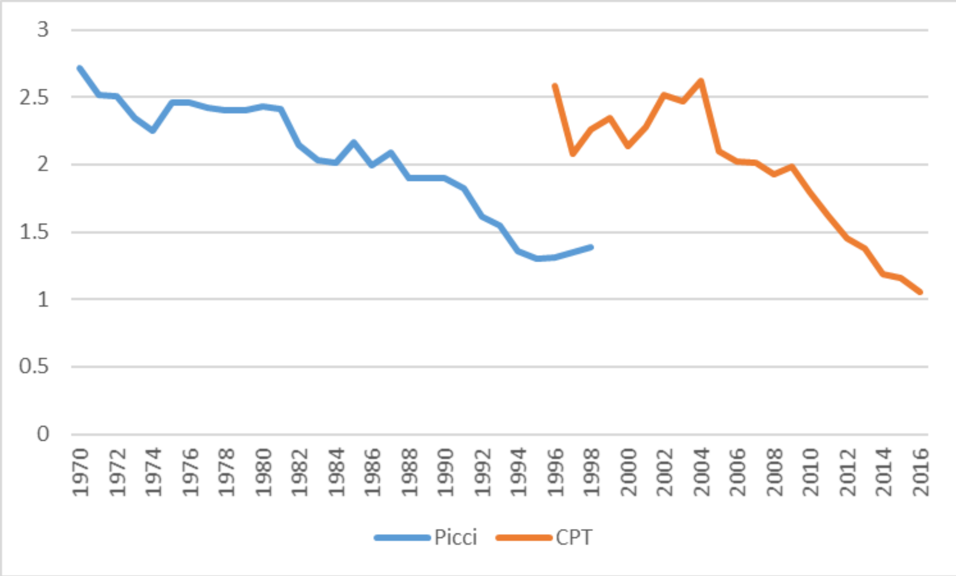
	Public investment in infrastructure			**Index in physical terms**
Main category	**Asset**	**Picci assets**	**CPT sectoral functions**	**Intermediate category (Column 4 of Table 5)**
TRANSPORT	ROADS	STRAD	00020 – Viabilita’	ROADS
				AIRPORTS
	RAILS	FER	00019 - Altri trasporti	RAILWAYS
		MAR		PORTS
EDUCATION, CULTURAL AND SOCIAL BUILDINGS	BUILDINGS	EDPUB	00005 – Istruzione	EDUCATION
			00008 - Cultura e servizi ricreativi	CULTURE
			00009 - Edilizia abitativa e urbanistica	SOCIAL
HEALTH INFRASTRUCTURE	HEALTH	IGIEN	00010 - Sanita'	HEALTH
			00016 - Altri interventi igienico sanitari	
ENVIRONMENTAL INFRASTRUCTURE	WATER	IDR	00012 - Servizio Idrico Integrato	WATER
	LAND	BONIF	00022 - Agricoltura	
COMMUNICATION INFRASTRUCTURE	TLC	COMUN	00021 - Telecomunicazioni	
OTHERS INFRASTRUCTURE	OTHERS	ALTR	00015 - Smaltimento dei Rifiuti	WASTE
			00027 - Energia	ELECTRICITY
				GAS
				PETROL

Note: in order to compare the infrastructure index in physical terms constructed in Section 2.2 (last column of the Table) with the public capital series updating Picci investment series (Picci, 2001) using CPT database (https://www.contipubbliciterritoriali.it/CPTDE/catalogo/CPTDE_CatalogoCPT.html) a correspondence table among the assets of the two series has been adopted.

For most assets, CPT investments (including real estate disposals) have higher values than the series computed by Picci (Graphs 1 and 2), with the exception of health infrastructure (HEALTH), communication equipment (TLC) after the privatization of the public company *Telecom Spa* (TLC, for 1997 and 1998) and marginally, water disposals (WATER). These exceptions mostly originate from some non-univocally sectoral attributions related to these asset classes.

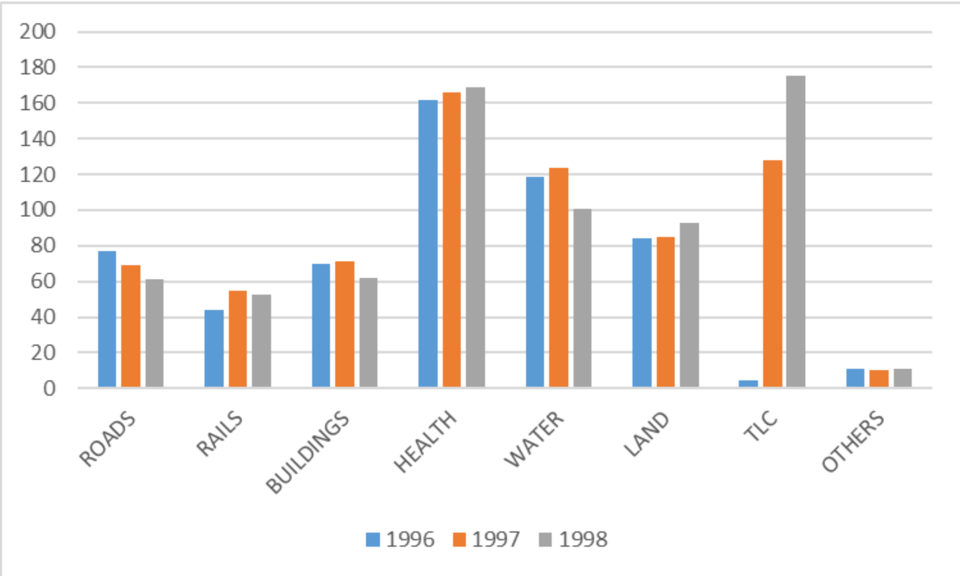
[29] In particular, we excluded the sectors not covered by the infrastructure index in physical terms: Amministrazione Generale; Difesa; Sicurezza pubblica; Giustizia; Formazione; Ricerca e Sviluppo (R. & S.); Interventi in campo sociale (assist. e benef.); Ambiente; Lavoro; Previdenza e Integrazioni Salariali; Pesca marittima e Acquicoltura; Turismo; Commercio; Industria e Artigianato; Altre opere pubbliche; Altre in campo economico; Oneri non ripartibili.

Graph 1. Public investment by data source (% of GDP). 1970-2016



Note: The public investment series elaborated by Picci for 1890-1998 (Picci, 2001) are updated using CPT database (https://www.contipubbliciterritoriali.it/CPTDE/catalogo/CPTDE_CatalogoCPT.html) carried out by the so-called enlarged public sector.

Graph 2. Public investment by asset (Picci/CPT index, in %). 1996, 1997, 1998



Note: CPT investments (https://www.contipubbliciterritoriali.it/CPTDE/catalogo/CPTDE_CatalogoCPT.html) have higher values than the series computed by Picci (2001), with few exceptions, mostly originated from some non-univocally sectoral attributions.

In particular, for the updating of HEALTH, the Picci series referring to "Aqueducts, sewage, hospitals, slaughterhouses, markets and similar", we use two CPT sectors - *Sanità* and *Altri interventi igienico-sanitari* - which do not include some relevant outflows regarding Sewage and purification expenditures, Research & Development, hygiene infrastructure related outflows incurred by General administration, Defence, Public safety, Assistance and charity.

At any rate, in spite of occasionally wide differences of investment flows between Picci and CPT series (in particular for assets TLC and OTHERS), most of the investment flows by asset are highly correlated during the overlap years 1996-1998 (Table 10).

Tab. 10. Correlation between regional investments flows by Picci assets and the correspondent CPT sectoral functions, 1996-1998

	Pearson			**Spearman**		
	1996	**1997**	**1998**	**1996**	**1997**	**1998**
ROADS	0.89	0.87	0.88	0.91	0.89	0.91
RAILS	0.93	0.89	0.87	0.58	0.70	0.72
BUILDINGS	0.77	0.79	0.83	0.80	0.89	0.88
HEALTH	0.89	0.94	0.88	0.84	0.89	0.91
WATER	0.79	0.65	0.68	0.75	0.75	0.87
LAND	0.74	0.23	0.54	0.58	0.47	0.61
TLC	0.04	-0.04	0.28	0.52	0.57	0.61
OTHERS	0.48	0.52	0.53	0.52	0.57	0.61

Note: Despite the sectoral differences between the series for regional public investments by Picci (2001) and the correspondent CPT investments (https://www.contipubbliciterritoriali.it/CPTDE/catalogo/CPTDE_CatalogoCPT.html), Pearson and Spearman correlations are robust.

2) We define the matching year and apply the growth rate of CPT public investments *for that year* to the value *for the previous year* from Picci series, comparing the correlation between the trends of the two series (Table 11).

As excepted, the correlation between the regional trends by asset is lower. However, the analysis of Pearson and Spearman indexes are relevant to determine the matching year of the overlap period.

Tab. 11. Correlation between regional investments growth rates by Picci assets and the correspondent CPT sectoral functions, 1996-1998

	Pearson		**Spearman**	
	1996-1997	**1997-1998**	**1996-1997**	**1997-1998**
ROADS	0.04	**0.27**	0.19	**0.23**
RAILS	0.03	**0.12**	0.03	**0.13**
BUILDINGS	0.10	**0.47**	0.12	**0.29**
HEALTH	**0.31**	0.09	**0.36**	0.40
WATER	-0.16	**0.35**	-0.13	**0.23**
LAND	**0.42**	-0.15	**0.27**	-0.25
TLC	-0.04	**-0.14**	-0.36	**-0.22**
OTHERS	**0.23**	0.27	**0.13**	0.12

Note: The matching year for applying the trend of public investments by CPT (https://www.contipubbliciterritoriali.it/CPTDE/catalogo/CPTDE_CatalogoCPT.html) to regional investment flows by Picci (2001) within the overlapping period 1996-1998 is detected according to the higher correlation of the relative sectoral growth rates.

Hence, we update Picci series by asset and region with CPT dynamics using the higher correlated growth rates by asset, according to both Pearson and Spearman indexes. In particular, we take 1997 as matching year, $\bar{\mathbf{t}}$, for HEALTH[30], LAND and OTHERS[31] and 1998 as matching year for assets ROADS, RAILS, BUILDINGS, WATER, TLC.

More formally, we obtain the spliced series for nominal investments $I\_N_{r,t}^{a}$ in asset a, region r, year t, according to the following algorithm:

[30] For HEALTH, we reject the option 1997-1998 growth rate because of the low Pearson correlation.

[31] For OTHERS, we reject the option 1997-1998 growth rate because of the lower Spearman correlation.

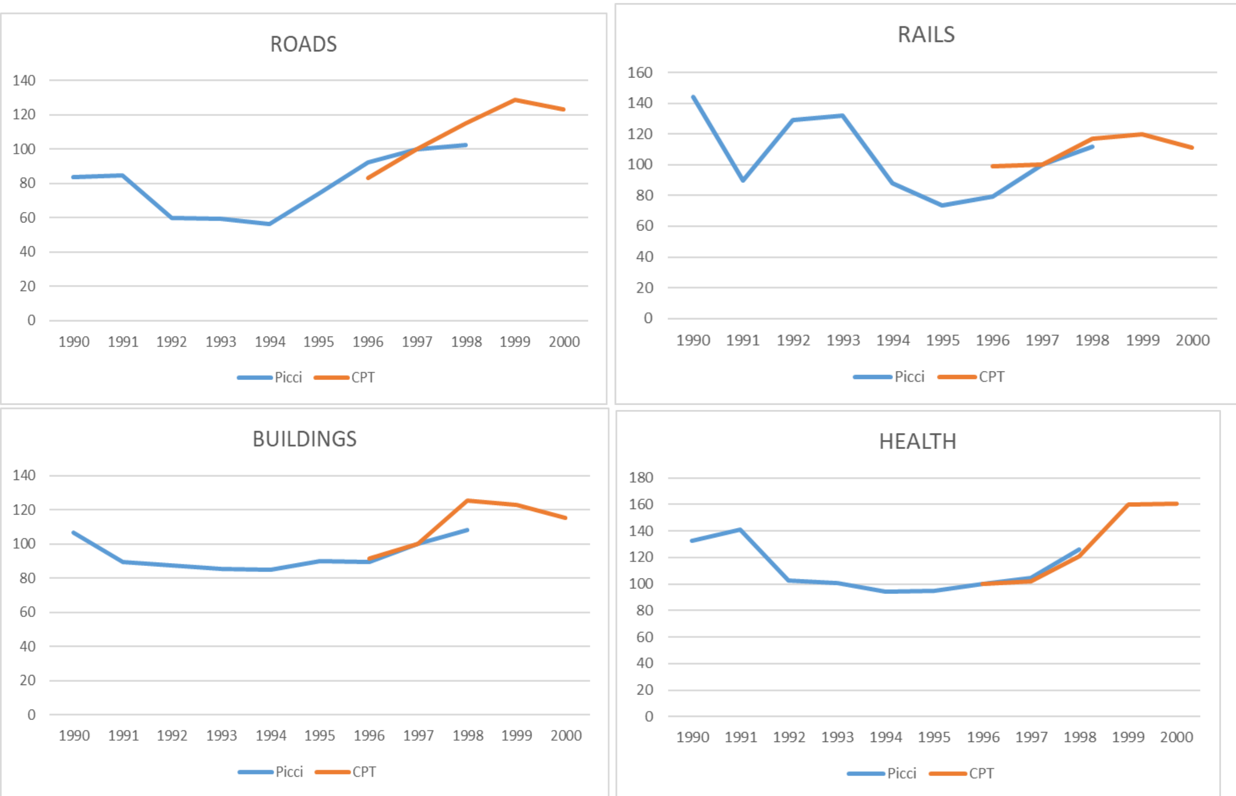
$$
\begin{cases}
I\_N^{a}_{r,t} = \left(I\_N^{a}_{r,t}\right)_{Picci} \text{ for } 1890 < t < \bar{\mathbf{t}}, \\
I\_N^{a}_{r,t} = \left(I\_N^{a}_{r,t-1}\right)_{Picci} * \left(1 + \left(\frac{I\_N^{a}_{r,t} - I\_N^{a}_{r,t-1}}{I\_N^{a}_{r,t-1}}\right)_{CPT}\right) \text{, for } t = \bar{\mathbf{t}}, \\
I\_N^{a}_{r,t} = I\_N^{a}_{r,t-1} * \left(1 + \left(\frac{I\_N^{a}_{r,t} - I\_N^{a}_{r,t-1}}{I\_N^{a}_{r,t-1}}\right)_{CPT}\right) \text{, for } t > \bar{\mathbf{t}}.
\end{cases}
\qquad [1]
$$

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

3) Finally, we deflate the nominal investments using Istat Consumer Price Index[32].

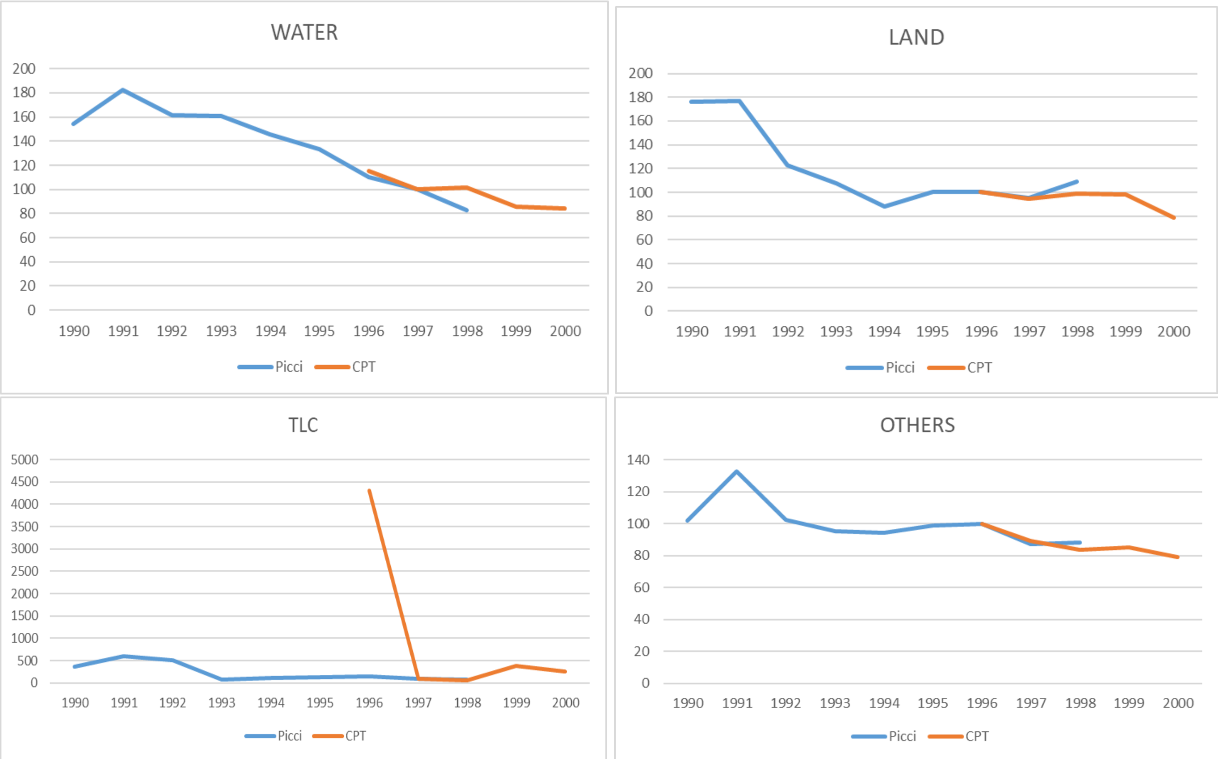
Graph 3 plots both public investment series from Picci and CPT in the neighbourhood of the matching years for each asset class, highlighting their similar trends in this ambit.

Graph 3. Real public investment index (1996=100 for HEALTH, LAND and OTHERS, 1997=100 for ROADS, RAILS, BUILDINGS, WATER, TLC[33]), 1990-2000



[32] https://www.istat.it/it/archivio/230127

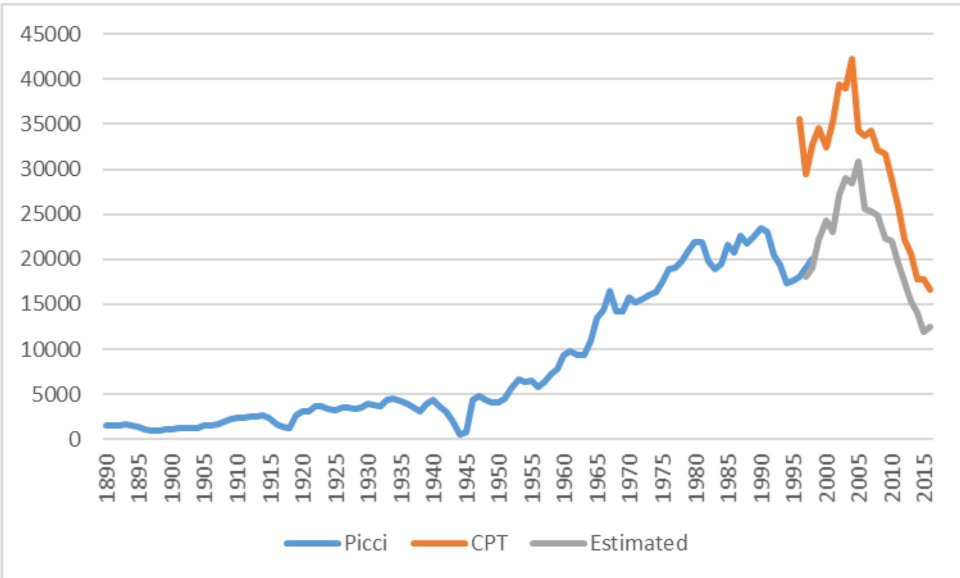
[33] Until 1996 CPT investments in *Telecomunicazioni* includes the public company *Telecom Spa* which was privatized in 1997.



Note: The public investment series elaborated by Picci for 1890-1998 (Picci, 2001) are updated applying the trend of the public investment series of CPT (https://www.contipubbliciterritoriali.it/CPTDE/catalogo/CPTDE_CatalogoCPT.html).

Graph 4 reproduces the aggregate spliced real public investment series constructed from Picci and CPT data, displaying the sharp drop since 2005.

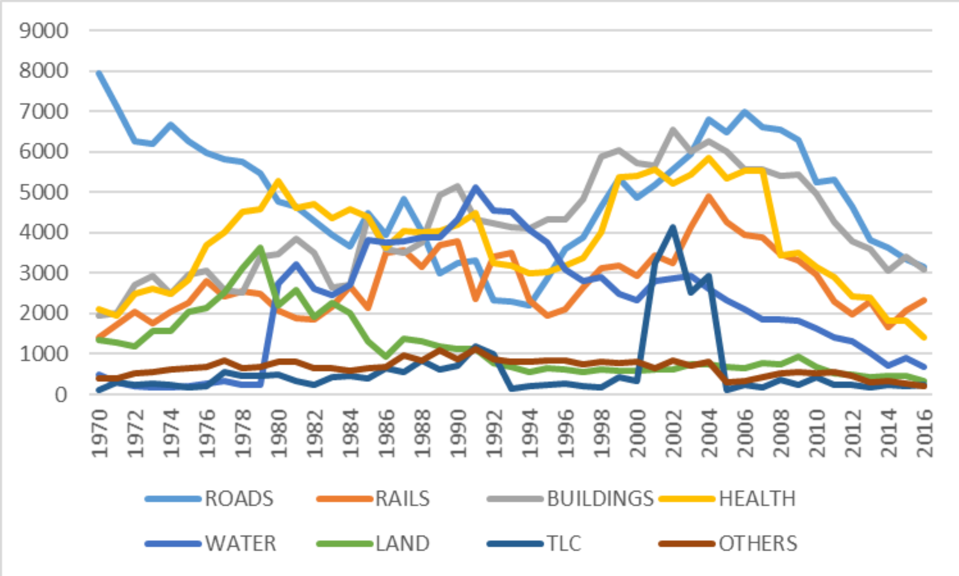
Graph 4. Real public investments (Mln euro 2010), 1890-2016



Note: The new regional public investments series constructed using Picci data (Picci, 2001) follow the dynamics of investment flows elaborated by CPT (https://www.contipubbliciterritoriali.it/CPTDE/catalogo/CPTDE_CatalogoCPT.html) for 1996-2016.

Graph 5 shows the dynamics of real public investment flows by asset during 1970-2016. We observe how relevant have been roads investments until the 1980s, absorbing almost half of infrastructure spending at the beginning of the 1970s.

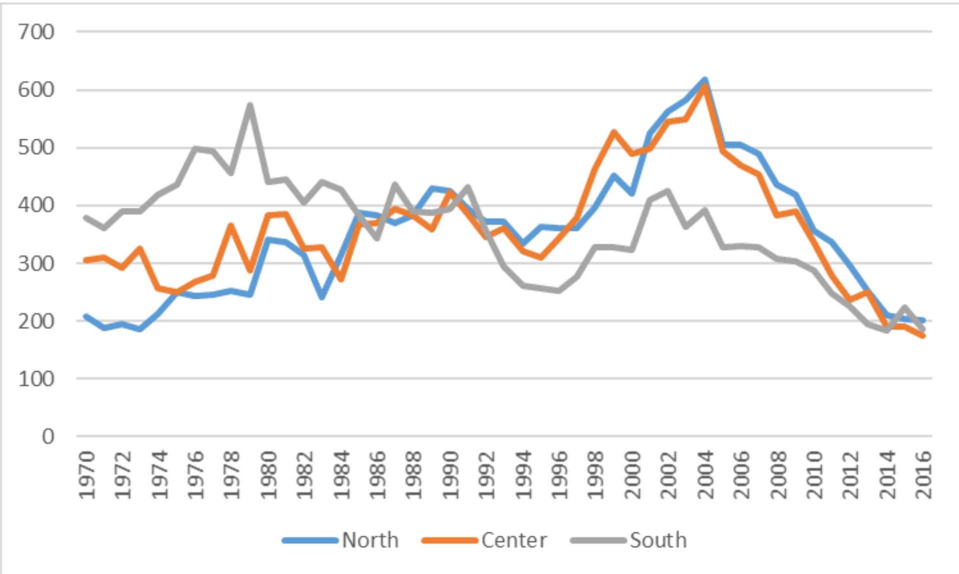
Graph 5. Real public investments by asset (Mln euro 2010), 1970-2016



Note: The trends of public investments by asset reveal the volatility in Telecommunications and the decreasing flows of public investments in Roads, according to our computation using data of Picci (2001) and CPT (https://www.contipubbliciterritoriali.it/CPTDE/catalogo/CPTDE_CatalogoCPT.html)

Finally, Graph 6 reveals the Southern priority destination of public investments until the mid-1980s within the so-called "extraordinary intervention" in the *Mezzogiorno*, later replaced by a bias in favour of the Northern and Central areas.

Graph 6. Real per capita public investments by area (euro 2010), 1970-2016



Note: According to the series public investments computed using different data sources (Picci (2001), CPT (https://www.contipubbliciterritoriali.it/CPTDE/catalogo/CPTDE_CatalogoCPT.html)), Northern and Central regions benefited from higher per capita flows in the last 25 years.

2.3.3 Applying IVIE methodology to construct net public capital stock

Once carried out the computation of public investment series, we tackle the public capital stock measurement. The computation of the capital stock follows the methodology developed by EUKLEMS[34] and used by the Fundacion BBVA-IVIE (The Valencian Institute of Economic Research). According to the PIM, the net capital stock is calculated by cumulating gross fixed capital formation year by year and deducting depreciation.

We assume a geometrical pattern of depreciation following OECD (2009):

$$\mathrm{TD} = \frac{\text{Declining balance rate}}{\text{Average service rate}} \qquad [2]$$

Under a "geometric" profile, the decline in efficiency is more pronounced during the first years of the service life. Therefore, the price-age profiles are also convex to the origin due to this hypothesis on the depreciation model. The geometric efficiency profile is in fact used for practical reasons to approximate a combined age-price/retirement pattern (Hulten and Wyckoff, 1996). For the combined average service life/depreciation rate and retirement function, we adopt the time-invariant EUKLEMS implicit depreciation rates by asset for Non-residential buildings, in Transport for assets ROADS and RAILS, in Public administration and Education for asset BUILDINGS, in Health and social work for asset HEALTH, in Electricity, gas and water supply for asset WATER, in Agriculture for LAND, in Telecommunications for asset TLC, in Public administration for asset OTHERS. Moreover, we assume the declining balance rates proposed by IVIE for Roads and airports (ROADS), Railways and maritime infrastructure (RAILS), Public water infrastructure (WATER), Telecommunication (TLC), Other constructions (BUILDINGS, HEALTH, LAND, OTHERS). The hypotheses on the depreciation pattern are summed up in Table 12.

Tab. 12. Hypotheses on the combined average service life/depreciation rate and retirement function

	Declining balance rate (IVIE) [35]	**Depreciation rate (EUKLEMS)**[36]	**Average service life**	**Picci's hypothesis on average service life (Picci, 2001)**
ROADS	1.251	0.028	45	45
RAILS	1.251	0.028	45	46-55
BUILDINGS	1.390	0.025	56	65
HEALTH	1.390	0.027	51	58
WATER	1.112	0.023	48	43
LAND	1.390	0.024	58	43
TLC	1.725	0.027	64	50
OTHERS	1.390	0.025	56	50

In the absence of the initial net capital stock, we use the PIM to annual real fixed investment for the period 1890-2016 to compute the net stock capital, $\mathrm{SKN\_R}^{a}_{r,t}$, for each region and asset, given the depreciation profile to calculate the net capital stock.

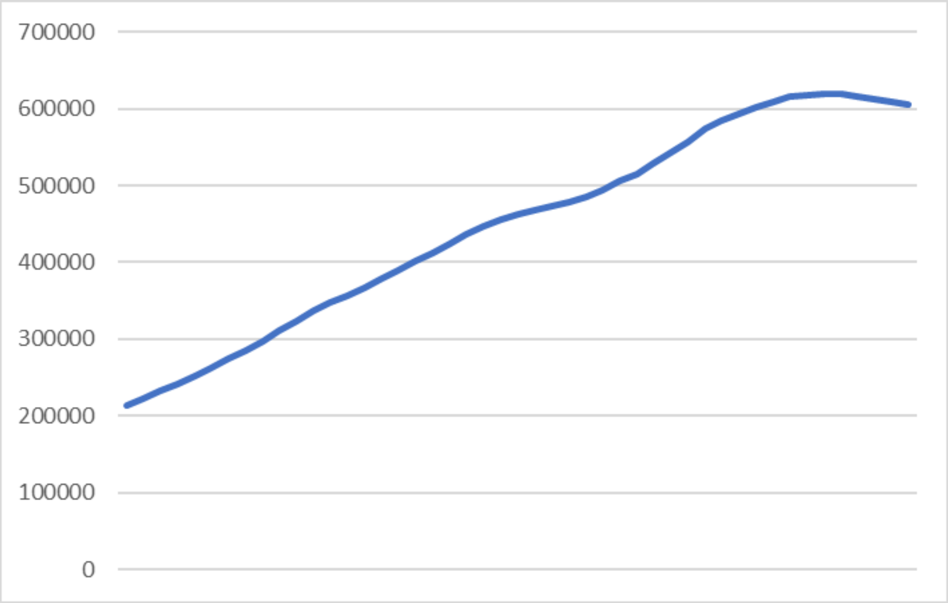
$$\mathrm{SKN\_R}^{a}_{r,t} = \mathrm{SKN\_R}^{a}_{r,t-1} + \mathrm{I\_R}^{a}_{r,t} - \mathrm{TD}^{a} * \left[\frac{\mathrm{I\_R}^{a}_{r,t}}{2} + \mathrm{SKN\_R}^{a}_{r,t-1}\right] \qquad [3]$$

Where $\mathrm{I\_R}^{a}_{\mathrm{r,t}}$ is real gross investment in asset a, region r, year t and $\mathrm{SKN\_R}^{a}_{\mathrm{r,t}}$ is real net capital in asset a, region r, year t.

Graph 7 plots the estimated real net capital for all eight assets. The slope of the curve is gradually declining since 2011 as a result of the decreasing investment from 2005 (Graph 4).

[34] EUKLEMS provides economic growth, productivity, employment creation, capital formation and technological change at the industry level for all European Union member states from 1970 (www.euklems.net).
[35] Perez et al. (2019).
[36] https://euklems.eu/

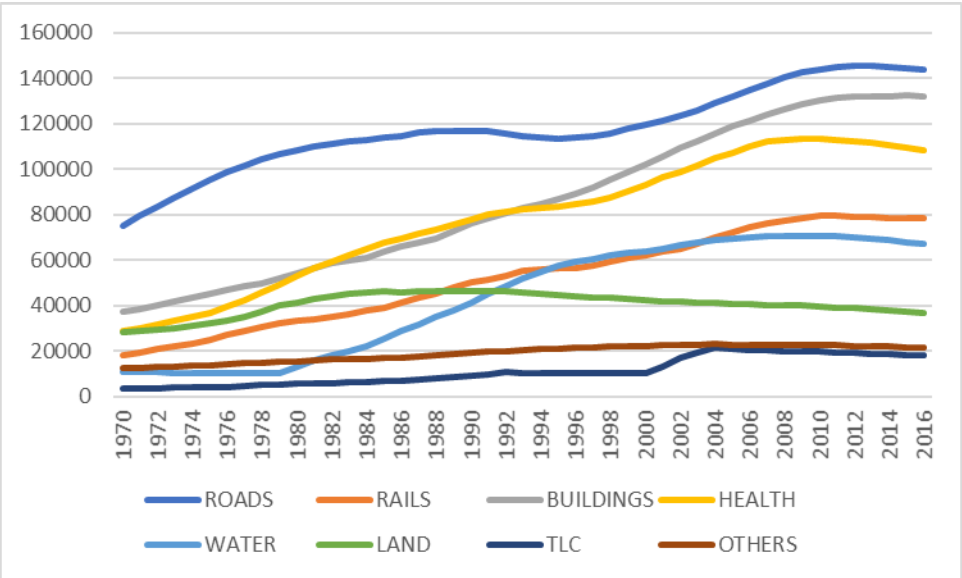
Graph 7. Real net public capital SKN_R (Mln euro 2010), 1970-2016



Note: the public capital stock has been computed applying the PIM to the series of public investment elaborated using data by Picci (2001) and CPT ([https://www.contipubbliciterritoriali.it/CPTDE/catalogo/CPTDE_CatalogoCPT.html)](https://www.contipubbliciterritoriali.it/CPTDE/catalogo/CPTDE_CatalogoCPT.html) and assuming the declining balance rate by IVIE (Perez et al., 2019) and the depreciation rate by EUKLEMS (https://euklems.eu/) for the geometric pattern of depreciation.

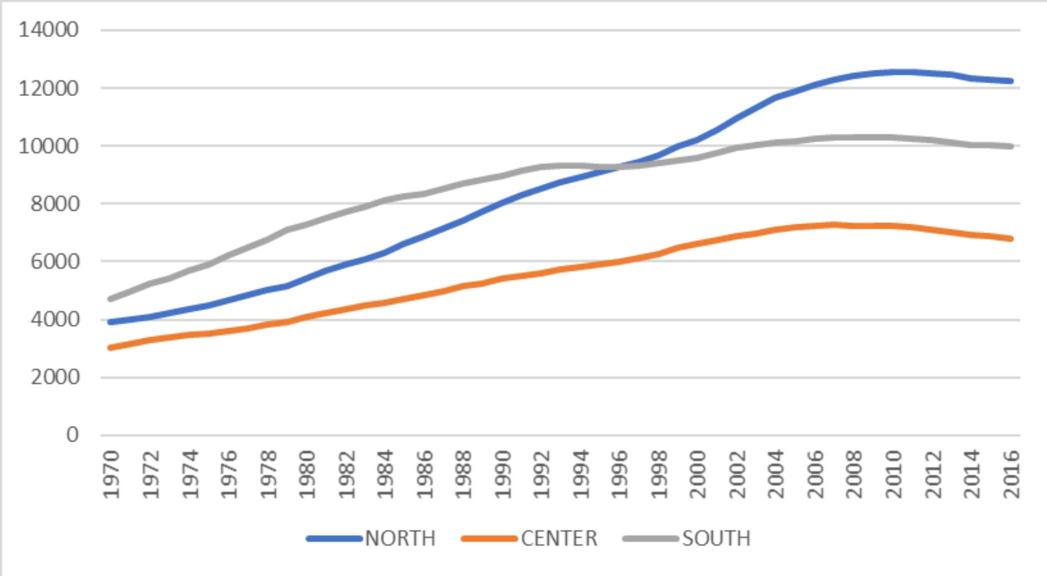
According to Graph 8, Roads, Buildings and Health infrastructure are the main public assets in terms of real net public capital, while Graph 9 reveals the North is the most public equipped area since 1995 (attracting 47% of total real net public capital in 2016), replacing Southern primacy.

Graph 8. Real net public capital SKN_R by asset (Mln euro 2010), 1970-2016



Source data: Own elaboration on *Picci (2001) and CPT ([https://www.contipubbliciterritoriali.it/CPTDE/catalogo/CPTDE_CatalogoCPT.html)](https://www.contipubbliciterritoriali.it/CPTDE/catalogo/CPTDE_CatalogoCPT.html); for the declining balance rate IVIE (Perez et al., 2019) and for the depreciation rate EUKLEMS (https://euklems.eu/).*

Graph 9. Real net public capital SKN_R per capita by area (euro 2010), 1970-2016



Source data: Own elaboration on *Picci (2001) and CPT (https://www.contipubbliciterritoriali.it/CPTDE/catalogo/CPTDE_CatalogoCPT.html); for the declining balance rate IVIE (Perez et al., 2019) and for the depreciation rate EUKLEMS (https://euklems.eu/).*

Table 13 reproduces the range (minimum and maximum) of the annual correlations between Picci regional real gross capital series and the estimated real net capital stock by asset for the period 1890-1998. The two series are very highly correlated considering the very long period (more than a century) and the different methodologies adopted to compute the stocks. In particular, the relatively low minimum correlation for public buildings and water equipment may be partially due to the different assumptions on the service life of the asset (Table 12). Yet, this correlation increases in the last decades.

Tab. 13. Annual correlation between Picci regional real gross capital series (Picci, 2001) and the estimated real net capital stock by asset (1890-1998)

	ROADS	RAILS	BUILDINGS	HEALTH	WATER	LAND	TLC	OTHERS	TOTAL
				Pearson					
MIN	0.95	0.87	0.58	0.97	0.57	0.94	0.98	0.82	0.93
MAX	1.00	0.97	0.96	1.00	0.96	1.00	1.00	0.92	1.00
1970-79 (mean)	0.99	0.90	0.76	1.00	0.73	1.00	0.99	0.83	1.00
1980-89 (mean)	1.00	0.91	0.92	1.00	0.93	0.99	0.99	0.84	1.00
1990-98 (mean)	0.99	0.96	0.92	0.99	0.90	1.00	0.98	0.83	1.00
				Spearman					
MIN	0.97	0.84	0.56	0.94	0.59	0.96	0.98	0.77	0.93
MAX	1.00	0.98	0.94	1.00	0.96	1.00	1.00	0.90	1.00
1970-79 (mean)	0.98	0.86	0.71	0.99	0.73	1.00	0.99	0.84	0.99
1980-89 (mean)	0.99	0.88	0.91	0.99	0.91	0.99	0.99	0.82	0.99
1990-98 (mean)	0.99	0.97	0.92	0.99	0.91	1.00	0.99	0.78	0.98

Note: The high correlation between the gross public stock elaborated by Picci (Picci, 2001) and the new net stock series (using data from Picci (2001) and CPT (https://www.contipubbliciterritoriali.it/CPTDE/catalogo/CPTDE_CatalogoCPT.html) increases for most of the assets in the last years of the overlapping period.

Table 14 reports the regional public capital per capita estimated.

Tab. 14. Regional public capital per capita (euro 2010). 1970, 1980, 1990, 2000, 2010, 2016

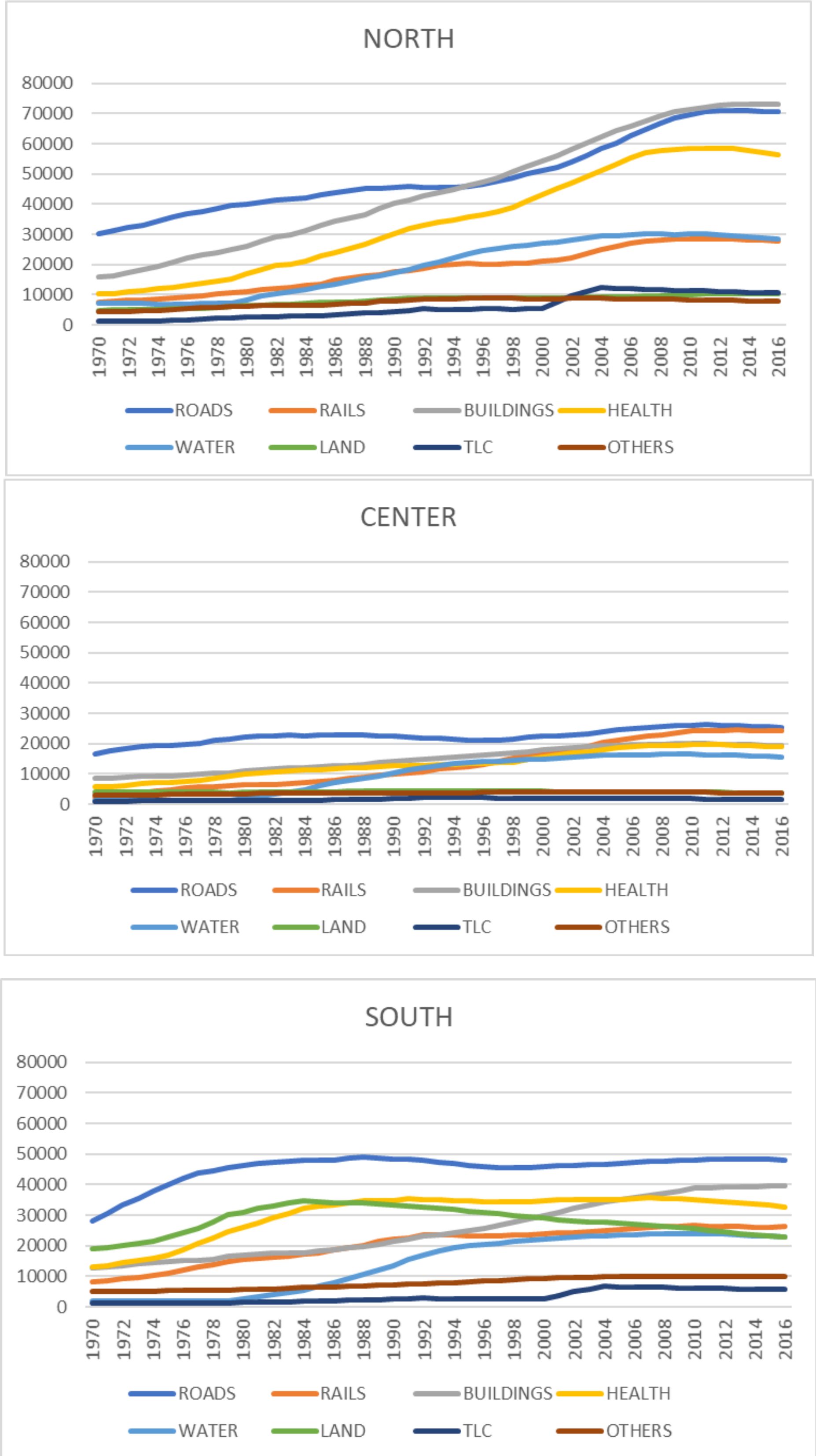
	1970	1980	1990	2000	2010	2016
Piedmont	2428	3778	5929	7975	10108	9844
Aosta Valley	11107	13637	29042	40541	40270	39099
Liguria	5621	7270	9169	10912	11195	10735
Lombardy	2475	3368	5104	6485	7633	7361
Trentino Alto Adige	5323	9362	14634	21194	27603	27462
Veneto	2963	3924	5679	7212	10488	10530
Friuli Venezia Giulia	4149	6162	11296	12252	11941	11295
Emilia Romagna	4398	5965	8006	9888	12024	11554
Tuscany	4240	5339	7360	8530	9319	8924
Umbria	4470	6708	7918	8492	8077	7588
Marches	4314	6711	7735	9001	10205	9887
Latium	4018	5262	7140	9385	10567	9696
Campania	3596	4742	6436	6930	7670	7450
Abruzzo	5810	9507	10946	11309	11404	10837
Molise	10519	19805	20809	21603	23889	23376
Apulia	3027	5523	6670	7248	8175	8163
Basilicata	10709	19495	22397	24185	25649	25242
Calabria	8009	10273	12003	12859	14674	14873
Sicily	3643	6505	8307	8931	9137	8612
Sardinia	6970	9967	12522	13661	14248	13427

Source data: Own elaboration on *Picci (2001) and CPT (https://www.contipubbliciterritoriali.it/CPTDE/catalogo/CPTDE_CatalogoCPT.html); for the declining balance rate IVIE (Perez et al., 2019) and for the depreciation rate EUKLEMS (https://euklems.eu/).*

Note: Smallest regions (such as Aosta Valley, Basilicata, Molise) figure with higher net public capital per capita.

Graph 10 shows the dynamics of the detailed real public capital stocks during 1970-2016 by geographic area, and the growth of most of the stock for all assets in the North.

Graph 10. Real net capital stock SKN_R by asset and area (Mln euro 2010), 1970-2016



Source data: Own elaboration on *Picci (2001) and CPT (https://www.contipubbliciterritoriali.it/CPTDE/catalogo/CPTDE_CatalogoCPT.html); for the declining balance rate IVIE (Perez et al., 2019) and for the depreciation rate EUKLEMS (https://euklems.eu/).*

Before going to the analysis of public spending efficiency that uses the indicators of physical infrastructure endowment and of public capital stock built respectively in Sections 2.2 and 2.3, we believe it useful to summing up the main steps of the analysis of these two sections:

- We compute an infrastructure index in physical terms for six main assets (ROADS, RAILS, BUILDINGS, HEALTH, WATER, OTHERS), using eighteen elementary indicators for economic infrastructure and twelve elementary indicators for social infrastructure, most of which used by Biehl et al. (1990), Confindustria and Ecoter (2000a, 2000b), and Istituto Tagliacarne (1995, 1998, 2001, 2002, 2006). We base ourselves on the methodology used by Istituto Tagliacarne but follow different normalization and aggregation procedures for the elementary indexes. In order to provide a common unit of measurement to different elementary indicators, we divide them by their respective mean over period 1987-2016, and we aggregate them to construct the sectoral and aggregate indexes.
- In order to validate our elementary indicators, we construct a composite sectoral public endowment index following the standard normalization, standardization and aggregation procedures described in Mazziotta (2006). This measure is highly correlated (0.83 – 0.92) to the benchmark – i.e. the regional index of Istituto Tagliacarne - over the period 1991-2012.
- Regional public investment flows elaborated by Picci (2001) for eight assets (ROADS, RAILS, BUILDINGS, HEALTH, WATER, LAND, TLC, OTHERS) have been updated using CPT investment dynamics, the same data source and methodology adopted by Di Giacinto et al. (2010b, 2010c, 2012) - for public investments in transport, electric, water and gas pipelines, complex constructions on industrial sites infrastructure -, and Montanaro (2010) - for Civil engineering works (Transport infrastructure, Pipelines, communication and electricity lines, Complex constructions on industrial sites, Other civil engineering works).
- The monetary approach for net capital stock is based on applying the PIM to the public investment flows obtained at the previous step, taking into account OCDE (2009) methodological recommendations. We use a geometric efficiency profile to approximate a combined age price/retirement pattern to compute the net public capital stock. In the absence of information on the shape of the geometric pattern, we overcome the double-declining balance rate applying new assumptions on asset lives. In particular, we adopt the time-invariant geometric depreciation rate by asset provided by EUKLEMS and we assume IVIE declining balance rate assessing different convexity profile of the depreciation function: higher declining balance rate (specifically for Telecommunication equipment) are characterized by higher convexity depreciation pattern, revealing a relevant decline in efficiency in the first asset service years; lower declining balance rate (for Land infrastructure) denoted a lower convexity depreciation model, showing a slight efficiency reduction in the first asset service years.

2.4 Measuring public spending efficiency and corruption

In this section, we regress the regional sectoral infrastructure index in physical terms on the net public capital in order to measure public spending efficiency for the panel 1987-2016. We consider other control variables in these equations, including region-idiosyncratic trends in order to capture various factors influencing this relationship. We argue that the residuals of these equations are a measure of public spending efficiency that we can compare to the corruption index elaborated by Golden and Picci (2005a) or to the government quality index elaborated by the QOG Institute (Charron et al., 2014) and the Institutional Quality Index (Nifo and Vecchione, 2015).

We proceed as follows: firstly, we describe our empirical model, then we apply the model using the index of infrastructural endowment described in Section 2.2 and the net public capital of Section 2.3, finally we compute the new regional sectoral public spending efficiency index and check the robustness of our results.

2.4.1 The model

The public spending efficiency is estimated using a dynamic panel function approach. We basically assume that infrastructure in physical terms is the dependant variable of a function where the main regressor is the net public capital stock. However, "several factors may affect the cost of a given public work" as suggested by Golden and Picci (2005a, 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 (NUTS4) of the region, the region surface, and the ratio of the coastline over surface. We add as further control variables five geographic area dummies (North-West, North-East, Centre, South, Islands), linear as well as quadratic region-specific trends, year dummies and some dummies for specific regions (to be detailed below). This specification was preferred to a standard regional fixed effects model that wholly suppressed the between variation in our infrastructure indexes. Note that these region-specific trends and dummies are always jointly significant, and the gist of our evidence is left untouched by their exclusion from the equation (these estimates are available upon request).

Hence, we estimate the following function over period 1987-2016 using regional (NUTS2) data:

$$\ln \mathrm{f\_index}_{r,t} = \beta_1 \ln \mathrm{f\_index}_{r,t-1} + \beta_2 \ln \mathrm{f\_index}_{r,t-2} + \beta_3 \ln \mathrm{SKN\_R}_{r,t-1} + \beta_4\, d_{\mathrm{North\ West}} + \beta_5\, d_{\mathrm{North\ East}} + \beta_6\, d_{\mathrm{Center}} + \beta_7\, d_{\mathrm{South}} + \beta_8\, d_{\mathrm{Islands}} + \beta_9\, d_{\bar{r}} + \beta_{10}\, \mathrm{ctr\_density}_{r,t} + \beta_{11}\, \mathrm{ctr\_altitude}_{r} + \beta_{12}\, \mathrm{ctr\_surface}_{r} + \beta_{13}\, \mathrm{ctr\_coast\_surface}_{r} + \beta_{14}\, \mathrm{trend}_{r,t} + \beta_{15}\, (\mathrm{trend}_{r,t})^2 + \beta_{16}\, d_t + \varepsilon_{r,t} \quad [4]$$

Where subscripts r and t refer respectively to region and year, *f_index* is the regional index for infrastructure in physical terms defined in Section 2.2; SKN_R is the regional public net capital computed using the PIM described in Section 2.3 and hence incorporates all past flows of public investment; *ctr_density*, *ctr_altitude, ctr_surface* and *ctr_coast_surface* are the control variables for density, altitude, total surface and coastline ratio respectively. The dynamic structure of [4] was found using a general-to-specific search.

2.4.2 The results from the dynamic regressions

The results of the OLS regressions applied to the aggregate index of infrastructure and to each of the six main asset categories ROADS, RAILS, BUILDINGS, HEALTH, WATER, OTHERS are presented in Table 15. For all regressions, we observe a high predictive fit of the model with R-squared close to 1.

All the functions figured with positive and significant coefficient for lagged dependent variable *f_index* and for *SKN_R*. Only Water reveals a negative coefficient for the double-lagged f_index. Most of the assets displays $\beta_1 + \beta_2 + \beta_3 \leq 1$, except Health and Others.

Focusing on the elasticity of the public capital, we observe higher value for Health infrastructure so that the outcomes of public investments are more "tangible" in physical terms. Other performing assets in terms of infrastructure are Roads, Rails and Buildings. On the opposite, the public capital contribution to Water and Others infrastructure endowment is significant and positive but very low.

The dummies for areas generally reveal a lower performance for public capital spending in the Southern regions, Sicily and Sardinia. Specifically, North-western regions display higher coefficients for Roads, Rails, Water and Others assets, while the North East is more performing for Roads and Buildings. In contrast, the Central regions show lower coefficients for Rails and Water, the Southern regions for Water and Other infrastructure, Sicily and Sardinia for Roads, Buildings, Health and Others.

As said above, inclusion in the regressions of a few regional dummies was needed mainly in order to improve the significance of public capital spending. This was true for Rails (Molise which is characterized by an outdated railway network with single non-electrified tracks), Water (Abruzzo and Apulia for Apulian Aqueduct, and Molise for Central Molise aqueduct) and Others (Veneto, benefiting from its strategic proximity to Austria for energy infrastructure).

Tab. 15. Regression output of public capital efficiency (1987-2016)

Variable	Aggregate	Roads	Rails	Buildings	Health	Water	Others
ln f_index							
L1.	0.8213***	0.8847***	0.8509***	0.8963***	0.7148***	0.9696***	0.9582***
L2.	0.0997***				0.1629***	-0.1139**	
ln SKN_R							
L1.	0.0639***	0.0636**	0.0629**	0.0549**	0.1151***	0.0235***	0.0251**
d_area_north west	-0.2731**	-0.2579	0.0679	-0.1672	-0.4292**	0.5674***	0.03868
d_area_north east	-0.2965**	-0.2559	0.0574	-0.1455	-0.4179**	0.5167***	0.0016
d_area_center	-0.3127**	-0.2943*	0.0144	-0.1793	-0.4130**	0.4497***	-0.0079
d_area_south	-0.3288**	-0.2881*	0.0390	-0.1726	-0.5066**	0.4523***	-0.0045
d_area_islands	-0.3217**	-0.3371*	0.0219	-0.2448*	-0.5661**	0.5004***	-0.0003
d_veneto							0.1411***
d_molise			-0.1064**				
d_abruzzo_molise_puglia						0.0831***	
ctr_density	0.0003	0.0011**	0.0006	0.0010**	0.0008	0.0005	0.0002
ctr_altitude	-0.0000	0.0000	-0.0001*	-0.0001**	-0.0001	-0.0001**	-0.0000
ctr_surface	1.3863	5.9073**	4.4693	6.8344**	3.4603	0.5885	1.9239
ctr_coast_surface	-0.1800	0.4033	0.6990	0.0237	0.3369	-0.6548**	-0.1618
Arellano-Bond test for serial correlation	0.3838	0.3158	0.3371	0.3955	0.4525	0.5662	0.2203

Note: The regional index for infrastructure in physical terms defined in Section 2.2, dependent variable.
****p<0.01; ** p<0.05; * p<0.1*

2.4.3 The new public spending efficiency index

The public spending efficiency can be perceived as the opposite side of the so-called corruption index constructed by Golden and Picci (2005a, p.4) on objective data, "namely, the difference between a measure of the physical quantities of public infrastructure and a measure of the value of public capital stocks".

Let us define for each asset, the new public spending efficiency index of region r at year t as:

$$New\ public\ spending\ efficiency\ index_{r,t} = \overline{\varepsilon_{r,t}} + \beta_4\, d_{North\,West} + \beta_5\, d_{North\,East} + \beta_6\, d_{Center} + \beta_7\, d_{South} + \beta_8\, \mathrm{d_{Islands}} + \beta_9\, \mathrm{d_{\bar{r}}} + \beta_{14}\, \mathrm{trend_{r,t}} + \beta_{15}\, (\mathrm{trend_{r,t}})^2 \quad [5]$$

Hence the index takes the mean value of the residuals of the regression plus the coefficients for the area and trend dummies. Controls are by definition not related to efficiency. An aggregate index of efficiency straightforwardly comes from the regression for the Aggregate variables. Yet, we can compute another aggregate index (Total_w) defined by the weighted average of the relative asset indexes, using as weights the relative public investments from CPT data for 1996.

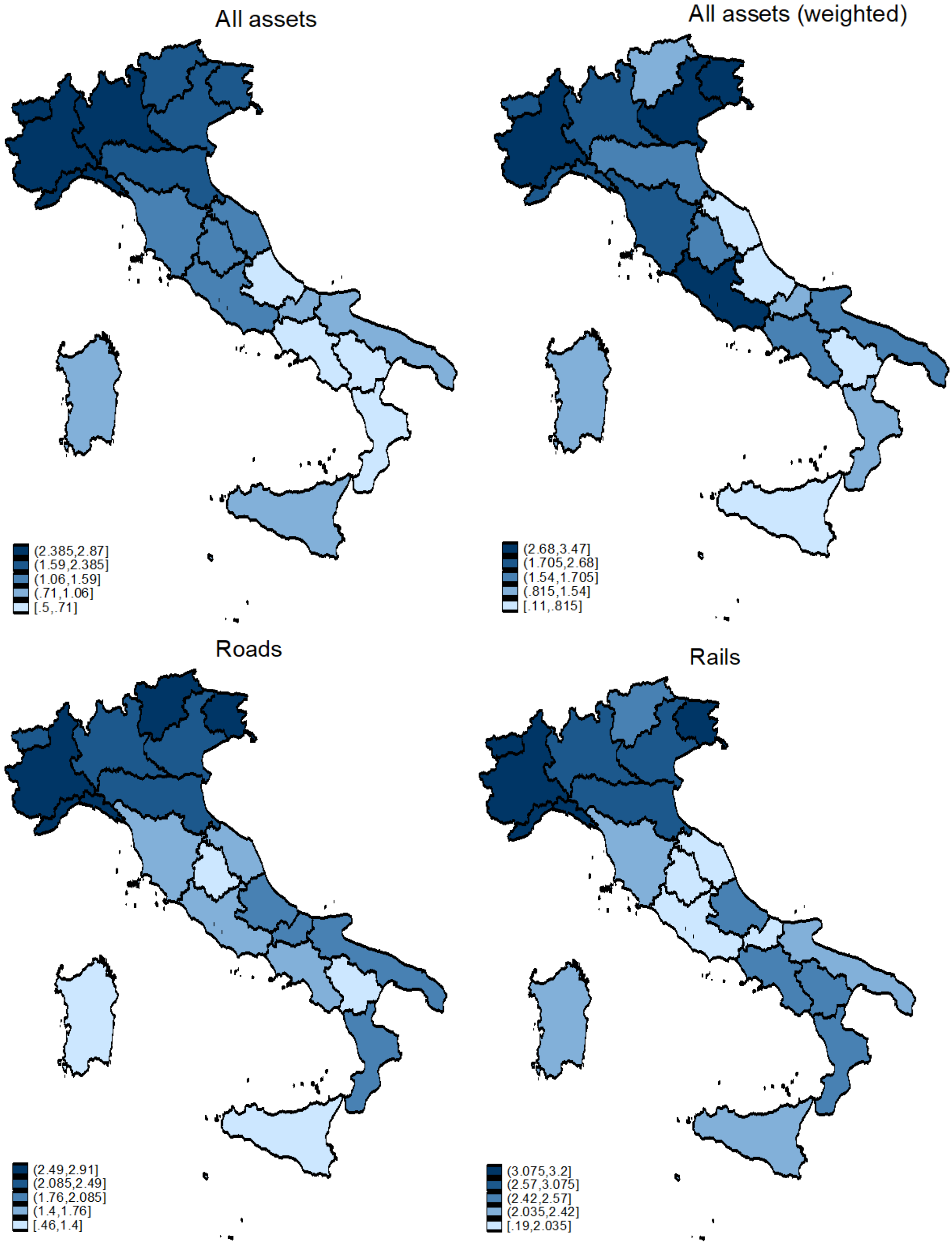
Tables 16 and Map 1 reproduce the new normalized regional public spending efficiency indexes for all asset. Considering that higher values are associated to higher efficiency, they reveal the best performing regions for each asset.

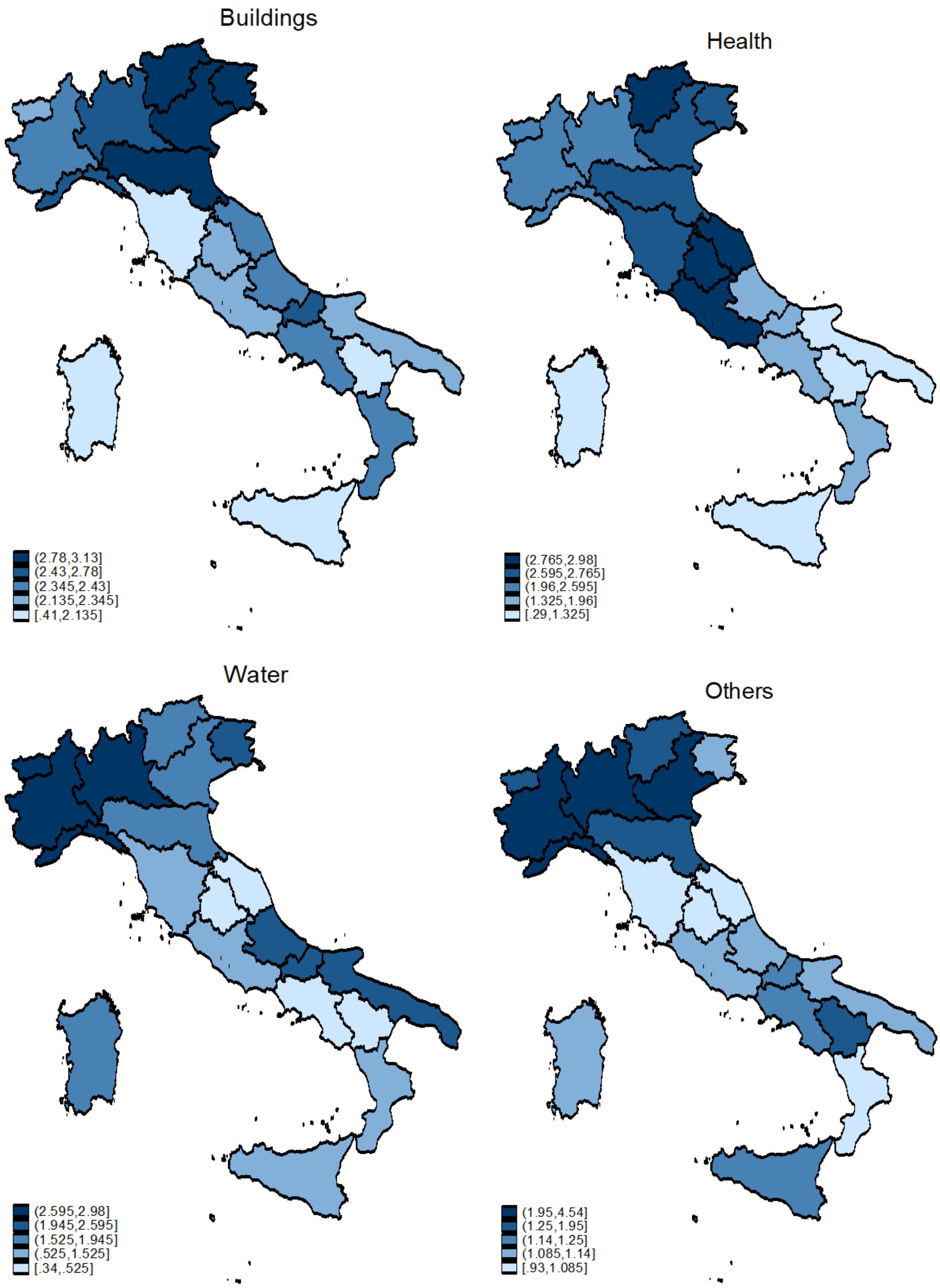
Tab. 16. New normalized regional public spending efficiency index over 1987-2016.

	Total	Total_w	Roads	Rails	Buildings	Health	Water	Others
PIE	2.79	3.19	2.61	3.17	2.38	2.57	2.98	2.02
VDA	2.73	2.05	2.35	3.08	2.26	2.46	2.89	1.88
LOM	2.87	2.65	2.28	3.07	2.59	2.57	2.80	2.15
TAA	1.86	1.26	2.85	2.57	3.13	2.82	1.86	1.27
VEN	1.83	2.71	2.42	2.83	3.01	2.70	1.89	4.54
FVG	2.04	2.80	2.91	3.20	3.08	2.74	2.00	1.14
LIG	2.85	1.77	2.56	3.11	2.71	2.54	2.85	2.05
EMR	1.94	1.57	2.42	2.67	2.85	2.62	1.88	1.30
TOS	1.35	2.58	1.42	2.18	2.13	2.75	0.54	1.08
UMB	1.22	1.64	1.38	1.69	2.32	2.98	0.52	0.93
MAR	1.33	0.75	1.75	1.95	2.37	2.84	0.42	1.04
LAZ	1.16	3.47	1.73	1.83	2.19	2.78	0.53	1.09
ABR	0.67	0.63	1.77	2.57	2.43	1.40	2.39	1.14
MOL	0.75	0.98	1.84	0.19	2.45	1.40	2.21	1.23
CAM	0.57	1.58	1.60	2.54	2.43	1.40	0.34	1.19
PUG	0.75	1.62	1.77	2.41	2.14	1.25	2.15	1.13
BAS	0.50	0.11	1.38	2.43	2.13	1.25	0.44	1.27
CAL	0.65	1.51	1.89	2.50	2.43	1.46	0.56	1.05
SIC	0.96	0.69	0.47	2.30	0.78	0.41	1.45	1.21
SAR	0.81	0.88	0.46	2.12	0.41	0.29	1.60	1.11

Note: the new regional public spending efficiency index is defined by the residual of the dynamic regression using the infrastructural endowment index described in Section 2.2 and the net public capital of Section 2.3. Higher value corresponds to higher efficiency in public spending.

Map 1. New normalized regional public spending efficiency index over 1987-2016.





Note: The elaboration of the new regional public spending efficiency index is described in Section 2.4. Higher value corresponds to darker blue regions and to higher efficiency in public spending.

Table 17 reports the evolution of the regional ranking in terms of public spending efficiency in 1987 and 2016.

Tab. 17. Public spending efficiency ranking (1987, 2016)

	Total		Total_w		Roads		Rails		Buildings		Health		Water		Others	
	1987	2016	1987	2016	1987	2016	1987	2016	1987	2016	1987	2016	1987	2016	1987	2016
PIE	3	4	2	3	4	2	4	6	8	13	9	6	1	2	4	5
VDA	4	7	7	10	7	6	5	5	12	14	12	13	2	3	5	20
LOM	2	1	5	5	6	3	2	10	6	10	10	8	4	1	2	3
TAA	7	9	14	15	2	5	8	16	1	8	3	2	10	11	7	13
VEN	8	5	4	4	8	1	7	2	3	3	7	7	11	6	1	1
FVG	5	2	3	2	1	4	3	1	2	1	6	11	8	8	14	4
LIG	1	3	8	7	3	7	1	9	5	4	11	9	3	4	3	2
EMR	6	6	10	12	5	8	6	3	4	11	8	10	9	10	6	7
TOS	9	10	6	6	16	17	16	13	18	17	4	5	14	15	18	9
UMB	11	8	9	8	17	14	19	19	14	6	1	1	19	16	20	14
MAR	10	11	16	16	14	11	17	14	13	12	2	4	18	20	19	17
LAZ	12	14	1	1	12	10	18	18	15	16	5	3	16	14	16	10
ABR	18	19	18	19	13	16	11	12	10	9	16	15	5	9	15	8
MOL	16	15	15	14	10	12	20	20	7	7	14	14	6	7	9	11
CAM	19	13	13	11	15	15	12	11	9	2	15	16	20	17	8	16
PUG	15	17	11	13	11	13	10	7	17	15	17	17	7	5	12	19
BAS	20	20	20	20	18	18	13	15	16	18	18	18	17	18	10	6
CAL	17	16	12	9	9	9	9	8	11	5	13	12	15	19	17	18
SIC	13	12	19	17	20	19	14	4	19	19	19	19	13	13	11	12
SAR	14	18	17	18	19	20	15	17	20	20	20	20	12	12	13	15
Correlation	0.92		0.97		0.89		0.72		0.77		0.95		0.92		0.47	

Note: The elaboration of the new regional public spending efficiency index is described in Section 2.4. Higher ranking value corresponds to lower efficiency in public spending.

The methodology adopted in Section 2.4 differs from the Golden-Picci approach along various lines.

- *The data*: we constructed a new updated index for infrastructure in physical terms which is highly correlated to the index of Istituto Tagliacarne (Table 8), rather than using the Ecoter index of Golden and Picci (as already said, our choice was justified by the greater amenability of the Istituto Tagliacarne index to a panel setup). Moreover, we constructed a net public capital stock, instead of the gross capital used by Golden and Picci. The net public capital stock, however, is highly correlated to Picci's series (Table 13);
- *The period*: with the construction of long series for infrastructure index and net public capital, we are able to capture the trend of public capital efficiency/inefficiency for 1987-2016;
- *The econometric method*: we estimate a dynamic equation where the physical index is a dependent variable and the net capital a regressor. This econometric approach provides a dynamic analysis of the nexus between the index of infrastructure index and the real net public capital stock that cannot be appraised adopting the methodology of Golden and Picci (2001) based on the regional ratio between the physical index and the cost-corrected infrastructure index in monetary terms (see Section 2.4.4);
- *The in-depth asset analysis*: the construction of efficiency index for six assets, excluding Telecommunication infrastructure, has given rise to an in-depth sectoral analysis.

The Pearson correlation coefficient of the new public spending efficiency index with Golden-Picci elaboration is 0.57 and the Spearman correlation measures 0.64 while the correlations are lower for the new weighted index (0.28 and 0.31 respectively).

We can proceed further and report the correlation of our proposed measure (averaged over 1987-2016) and of the Golden-Picci index with other well-known indexes of corruption, government effectiveness and quality of government as the Institutional Quality Index (https://sites.google.com/site/institutionalqualityindex/home) and the European Quality Government Index (https://www.gu.se/en/quality-government/qog-data/data-downloads/european-quality-of-government-index) in Table 18. Notice that Golden and Picci are mentioned among the main sources used for the IQI corruption index and therefore the correlation between the two indexes is high by construction. Our new indexes are highly correlated to most of IQI and EQI indexes.

Tab. 18. Correlation of the new public spending efficiency indexes with other indexes

		Institutional Quality Index (2004-2012)[37]			**European Quality of Government Index (2010, 2013)**[38]		
		General	**Corruption**	**Government effectiveness**	**General**	**Corruption**	**Quality of public sector**
Public spending efficiency index	Pearson	0.59	0.41	0.69	0.70	0.65	0.71
	Spearman	0.71	0.46	0.79	0.73	0.72	0.75
Weighted public spending efficiency index	Pearson	0.46	0.21	0.57	0.29	0.25	0.28
	Spearman	0.48	0.26	0.66	0.34	0.34	0.38
Golden-Picci corruption index (1997)[39]	Pearson	0.81	0.76	0.60	0.82	0.81	0.81
	Spearman	0.76	0.85	0.61	0.83	0.82	0.81

[37] https://sites.google.com/site/institutionalqualityindex/home
[38] https://www.gu.se/en/quality-government/qog-data/data-downloads/european-quality-of-government-index
[39] Golden and Picci (2001)

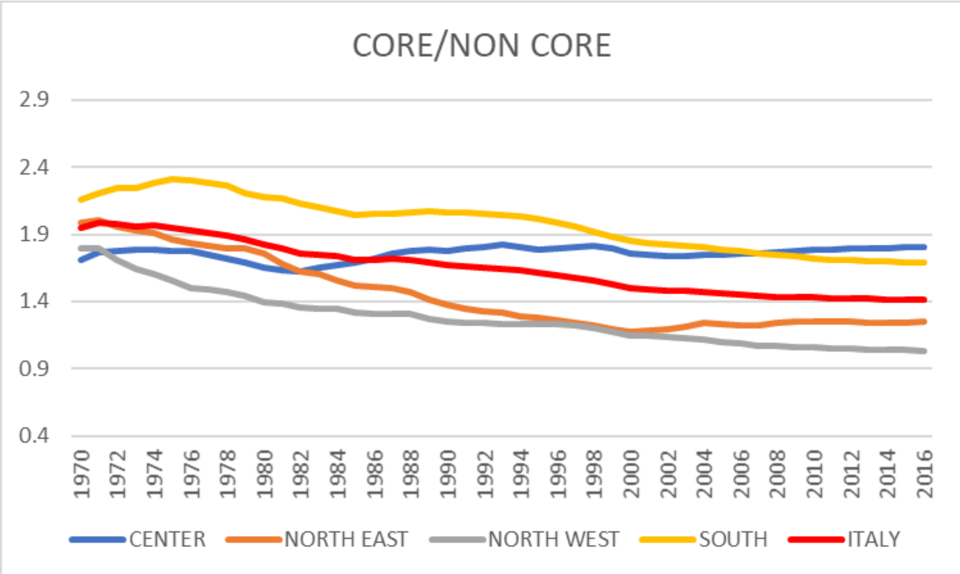
2.4.4 A further comparison with the Golden-Picci results

In order to gain further knowledge about the new indexes, and to test how their different methodology affects the results, we apply the Golden-Picci strategy to our data, proceeding with the following steps:

1) *Construction of the public NET capital index in monetary terms*: In line with Golden and Picci (2005), we assume that core assets include Transport network (ROADS[40], RAILS[41]), Energy network[42], Water systems (WATER), land reclamation (LAND), and non-core assets refer to Health infrastructure (HEALTH), Public buildings (BUILDINGS[43]), and Waste disposal. We excluded Telecommunication equipment not computed in the capital index in physical terms. Graph 11 displays the estimated core/non-core net capital series with a relevant prevalence of the infrastructure affecting the productive process.

   To compute the monetary index, the core net stock is normalized using the regional surface while the non-core net capital is normalized by population. Both normalized capital stocks are standardized by the respective yearly national average. Finally, the index of the net public capital stock in monetary terms is constructed as a geometric average of the standardized core and non-core indexes;

Graph 11. Net public capital. Core/non-core ratio by geographical area (1970-2016).



Source data: Own elaboration on *Picci (2001) and CPT (https://www.contipubbliciterritoriali.it/CPTDE/catalogo/CPTDE_CatalogoCPT.html); for the declining balance rate IVIE (Perez et al., 2019) and for the depreciation rate EUKLEMS (https://euklems.eu/). The sectoral classification among Core and Non-core assets is described in Golden and Picci (2005a)*

1) *Cost correction of the public capital index in monetary terms*: Following Golden and Picci (2005a, p.13), "we constructed an aggregate regional cost index (…) as a geometric average of the labour, sand and cement indices. (…) Such a cost measure was used to scale the perpetual inventory capital stock data";

2) *Construction of the infrastructure index in physical terms.* The physical infrastructural index has been measured adopting the same normalization and standardization methodologies of the monetary index

[40] Including Airports.

[41] Including Ports.

[42] Golden and Picci (2005a) considered that half of Others infrastructure are Core assets and half are Non-Core assets.

[43] Including Education, Cultural and Social infrastructure.

applied to our 30 elementary indicators. However, in line with our aggregation procedure, the core and non-core indexes are the weighted average of the relative main indexes, according to the relative public investments estimated using CPT data for 1996, and the synthetic index is the geometric average of the weighted core and non-core indexes;

3) *Computation of the index for corruption*. Then, we regress the regional ratio between the physical index and the cost-corrected infrastructure index in monetary terms for 1997. For the controlling variables, we elaborate the altitude control variable suggested by Golden and Picci computing for each municipality (NUTS4) "the difference between the lowest and highest altitude, excluding altitudes above 1000 meters in order to limit the influence of (relatively unpopulated) mountains, and we aggregated the data at the regional level by weighting the municipal data by their population." In addition, the population density control variable is measured by the ratio of regional population living in cities with more than 30.000 inhabitants. The proposed index for public spending efficiency is equal to the residual of the previous regression plus 1.

Relative to the measure of public inefficiency of the previous sub-section, this last corruption index using our net public capital stock and elementary indicators to measure infrastructure in physical terms, but applying Golden and Picci approach, is more highly correlated to the Golden-Picci 1997 corruption index (Pearson correlation is 0.65 and Spearman correlation is 0.74). To repeat, this happens despite the differences in data (infrastructure in monetary terms is defined by the net capital and infrastructure in physical terms is determined by a new index using original elementary indicators), aggregation (the general physical index is a weighted average of the main indexes of infrastructure), and sectors (we do not consider Telecommunication assets). We take these findings as indication that our measure of public spending efficiency is broadly capable of bringing to a panel, time-varying, setup the cross-region institutional features highlighted by the Golden-Picci measure.

Table 19 displays the corruption ranking for 1997 according to Golden and Picci (2005a) and to our data applying the Golden-Picci approach, with higher ranking for the more corrupt (less efficient, in our parlance) regions.

Tab. 19. Regional corruption ranking according to Golden and Picci (2005a) and our data applying Golden and Picci methodology (1997)

Region	Corruption index using GP approach	Golden and Picci (2005a)
PIE	1	3
VDA	9	5
LOM	2	11
TAA	4	2
VEN	3	9
FVG	8	12
LIG	10	10
EMR	6	6
TOS	7	4
UMB	11	1
MAR	14	8
LAZ	15	14
ABR	13	13
MOL	19	16
CAM	17	19
PUG	12	15
BAS	20	17
CAL	18	20
SIC	16	18

SAR	5	7

Source data: For the physical infrastructure index: Autorità di regolazione per Energia, Reti e Ambiente (ARERA), Economic Development Ministry (MISE), Eurostat, Infrastructure Ministry (MIT), Istat, Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA), Terna, Unionpetrolifera. For the net public capital: own elaboration on Picci (2001) and CPT (https://www.contipubbliciterritoriali.it/CPTDE/catalogo/CPTDE_CatalogoCPT.html); for the declining balance rate IVIE (Perez et al., 2019) and for the depreciation rate EUKLEMS (https://euklems.eu/). For the methodology: Golden and Picci (2005a).

Note: Higher ranking value corresponds to lower efficiency in public spending (2nd column) and higher corruption (3rd column).

2.5 An econometric exercise using the new Public Spending Efficiency index

In this section we extend the econometric approach used in Coppola et al. (2018) to analyse the impacts of European and national cohesion policies on the GDP per capita of the 20 Italian NUTS2 Regions over the period 1994-2016, introducing the new Public Spending Efficiency index described in section 2.4.3 as a conditioning factor for the effectiveness of these policies.

2.5.1 The impact of EU and national cohesion policies on regional GDP per capita

As in Coppola et al. (2018) we estimate the average partial effects of policy funds using a control-function approach, assuming that funds are randomly allocated, *conditional on a set of observable covariates W*.

The panel specification for GDP per capita equation is:

$$\mathrm{D.y_{rt}} = \mathrm{a_1 y_{rt-1}} + \mathrm{a_2 iflpriv_{rt}} + \mathrm{a_3 D.pop_{rt}} + \mathrm{a_{4j} SF_{jrt}} + \mathrm{a_{5j} Nat_{jrt}} + \mathrm{a_6 PERIOD_2 * SOUTH} + \mathrm{a_7 PERIOD_3 * SOUTH} + \mathrm{a_{8}}_{j}\mathrm{W_{rt-1}} + \mathrm{a_i} + \mathrm{a_t} + \varepsilon_{\mathrm{rt}} \qquad [6]$$

Where r = 1,…, 20 refers to regions; t = 1,…, n refers to years; and j = 1,…, m refers to the type of fund being considered. Variables $\mathrm{a_r}$ and $\mathrm{a_t}$ are region and year fixed effects respectively; and $\varepsilon_{\mathrm{rt}}$ is the customary independent and identically distributed (i.i.d.) error term. The dependent variable $\mathrm{D.y_{rt}}$ is the (log) variation of GDP per capita; the lagged dependent variable $\mathrm{y_{rt-1}}$ allows for the dynamic structure inherent in the data. Variables $\mathrm{gfipriv_{rt}}$ and $\mathrm{D.pop_{rt}}$, are the (log) ratio of gross fixed private investment[44] over GDP and the (log) variation of population respectively. $\mathrm{SF_{jrt}}$ refers to the European SFs (whose types are indexed by j: in the exercises below we will take all the EU funds, inclusive of national cofinancing, aggregated together, as well as the ERDF taken in isolation[45]); and $\mathrm{Nat_{jrt}}$ stands for an array of national funds related to regional policies (also indexed by j). Both $\mathrm{SF_{jrt}}$ and $\mathrm{Nat_{jrt}}$ are taken as log ratios over GDP, in accordance with common practice in the literature. The author control for territorial differences in total factor productivity (as well for other sources of time-varying unobserved heterogeneity, such as the rate of human capital accumulation) through the interaction terms PERIOD_n*SOUTH, where SOUTH is a binary variable equal to 1 for the Mezzogiorno regions; PERIOD_2 and PERIOD_3 are binary variables equal to 1 respectively in the second (2000–06) and third (2007– 13) SFs' programming period. Finally, as In Coppola et al. (2018), we include a vector of $\mathrm{W_{rt-1}}$ variables presiding over the regional allocation of funds[46], with a view to control for the role of fund assignment. This control function approach (Wooldridge, 2004) is particularly convenient in our

[44] Following Marrocu and Paci (2008, p.4) "the private component has been obtained as the difference between total and public investments". The elaboration of total investment series is described in Section 3.1 and the elaboration of public investment series is described in Section 2.3.2.

[45] Estimation of a similar equation in Coppola et al. (2021) reveals that the European Regional Development Fund (ERDF) is by far the most effective of all EU funds.

[46] As in Coppola et al. (2018), W_{it-1} includes lags of policy funds, GDP per capita and gross fixed investment; measures of regional female rates of unemployment and sectoral shares of employment and value added; and politically based indicators (political orientation of each regional government and alignment of the political orientation of each regional government with the national government). We assume that funds can react only with delay to changes in the economic or political environment.

application for the following reasons. First, although there have been in time some explicit rules presiding to the allocation of funds between regions (especially as far as the Convergence objective was concerned), these rules have never fully presided to the allocation of funds, even in the case of EU funds. An important consequence of this situation is that in our sample there are no regions which do not receive any kind of funding. This is true for SFs, and even more for nationally financed funds. Hence a counterfactual strategy based on the creation of a control group (for instance, receiving no funding) cannot be enacted in our case. Besides, this approach is very convenient in our case because it is readily adapted to the modelling of multiple continuous treatments (the various policy funds, some of which we may want to jointly include in a regression).
All variables are briefly described in Table 20. We estimate equation [6] through a dynamic panel (fixed-effects) method. Similarly, to what has been done in Coppola et al. (2018), the endogeneity of all current regressors was tested and not found to be significant (these diagnostics are available upon request). On the other hand, the adoption of a GMM Arellano-Bond set-up was not deemed as appropriate given the relatively low number of our cross-section units and the relatively high number of time periods in our sample (see Attanasio et al., 2000).

Tab. 20. Summary statistics of variables used for the update and extension of Coppola et al (2018) and legend of the equations

Variable	Description	Source	Mean	Std. Dev.	Min	Max
y	(log) GDP per capita	Own elaboration on Prometeia	3.21	0.27	2.66	3.62
iflpriv	(log) ratio of private gross fixed investment over GDP	Own elaboration	-1.66	0.19	-2.15	-1.14
pop	(log) population	Prometeia	7.56	1.06	4.76	9.21
fdr	(log) ratio of EU funding plus national co-financing over GDP	Spesa statale regionalizzata	-5.19	0.92	-7.66	-2.50
erdf	(log) ratio of ERDF funds over GDP	Spesa statale regionalizzata	-6.79	1.23	-9.21	-3.52
trasf_c_y	(log) ratio of Current account subsidies over GDP	Spesa statale regionalizzata				
trasf_ci_y	(log) ratio of Current account subsidies to firms over GDP	Spesa statale regionalizzata	-5.60	0.83	-9.88	-3.62
trasf_cf_y	(log) ratio of Current account subsidies to households over GDP	Spesa statale regionalizzata	-5.37	0.78	-7.07	-3.39
ncf_y	(log) ratio of National cohesion funds over GDP	Spesa statale regionalizzata	-6.32	1.60	-15.14	-2.72
trasf_k_y	(log) ratio of Capital subsidies over GDP	Spesa statale regionalizzata	-3.75	0.68	-5.77	-1.96
trasf_ki_y	(log) ratio of Capital subsidies to companies over GDP	Spesa statale regionalizzata	-4.14	0.82	-6.92	-2.02
iflpubb_y	(log) ratio of public gross fixed investment over GDP	Own elaboration (Section 2.3)	-4.19	0.47	-5.61	-2.68
esf	(Log) ratio ofEU Social Fund (ESF) over GDP	Spesa statale regionalizzata	-7.21	0.81	-9.21	-4.33
al	(log) ratio of EU Agricultural Fund over GDP	Spesa statale regionalizzata	-7.29	1.42	-9.21	-2.93
cofin	(log) ratio of National co-financing over GDP	Spesa statale regionalizzata	0.64	0.31	-0.06	1.59
tdis_f	Rate of female unemployment	Spesa statale regionalizzata	12.67	6.75	2.59	34.21
oquota_iss	Industry(employment) share	Own elaboration on Prometeia data	0.18	0.07	0.06	0.32

oquota_ser	Services (employment) share	Own elaboration on Prometeia data	0.68	0.06	0.54	0.85
vquota_agr	Agriculture (value added) share	Own elaboration on Prometeia data	0.03	0.01	0.01	0.05
vquota_iss	Industry (value added) share	Own elaboration on Prometeia data	0.19	0.06	0.07	0.33
vquota_cos	Construction (value added) share	Own elaboration on Prometeia data	0.06	0.01	0.04	0.13
vquota_ser	Services (value added) share	Own elaboration on Prometeia data	0.72	0.06	0.58	0.86
vquota_pub	Public sector (value added) share	Own elaboration on Prometeia data	0.20	0.05	0.11	0.33
alignement	Political alignment	Own elaboration on Prometeia data	0.60	0.49	0.00	1.00
lpul_ser	(Log) Services productivity (value added/employment)	Own elaboration on Prometeia data	4.09	0.10	3.84	4.27
eqi	The Quality of Government index	Own elaboration (Section 2.4.3)	-0.55	0.79	-2.10	0.88
index_picci	Golden and Picci corruption index	Own elaboration (Section 2.4.3)	1.00	0.49	0.18	1.77
total	New public efficiency index (all assets)	Own elaboration (Section 2.4.3)	-0.31	0.03	-0.37	-0.18
roads	New public efficiency index (roads)	Own elaboration (Section 2.4.3)	-0.26	0.05	-0.47	0.03
rails	New public efficiency index (rails)	Own elaboration (Section 2.4.3)	0.02	0.06	-0.23	0.30
buildings	New public efficiency index (buildings)	Own elaboration (Section 2.4.3)	-0.20	0.05	-0.40	-0.03
health	New public efficiency index (health)	Own elaboration (Section 2.4.3)	-0.46	0.07	-0.74	-0.31
water	New public efficiency index (water)	Own elaboration (Section 2.4.3)	0.61	0.09	0.18	0.85
others	New public efficiency index (others)	Own elaboration (Section 2.4.3)	0.04	0.05	-0.13	0.28

LEGEND OF THE EQUATIONS: Region and year fixed effects, or region-idiosyncratic trends, are always included in the estimates, and not shown in the interest of parsimony. The D. symbol stands for a first difference. R^2 is the coefficient of determination adjusted for degrees of freedom not inclusive of the effect of region and year fixed effects, Rss is the residual sum of squares. A-B is the Arellano-Bond test for serial correlation present at lags one and two C-W is the Cook-Weisberg test for heteroskedasticity, R is the Reset test for functional form and omitted variables (carried out including quadratic terms of fitted values).

Table 21 shows the results for the auxiliary regressions selecting the relevant W_{rt-1}variables. Specifications in Table 21 only include regressors that have a t-ratio above one, or that are instrumental in getting good diagnostics, as required by the application of this control function approach (Wooldridge, 2004). According to this approach, one can assume that funds are randomly allocated, conditional on observable covariates (Coppola et al., p.4). Indeed, we find satisfactory diagnostics for most auxiliary regressions (the Reset test for national cohesion policies being the main exception to this rule, as was already the case in Coppola et al., 2018). We do not find much of a relationship between EU and national funds, while there are some complementarities among the latter. The ERDF is strongly countercyclical, while aggregate EU funds only react countercyclically to private investment. Among the other potential determinants of fund allocation, we find a role for sectoral shares. Political variables have a significant effect only for aggregate EU funds.

Tab. 21. European Union (EU) and national cohesion funds, nationally funded current account subsidies, nationally funded capital account expenditures and auxiliary regressions for the fund-allocation mechanism.

		Dependent variables					
		D.(EU funding + national cofinancing)	D. (ERDF)	D.(Current-Account Subsidies to Firms)	D.(Nationally funded Cohesion Funds)	D.(Capital-Account Subsidies)	D.(Public Investment Expenditure)
Regressors	fdr (t-1)	0.1680 (0.01)					
	fdr (t-2)	0.1440 (0.01)					
	erdf (t-1)		0.0732 (0.33)			-0.0636 (0.04)	-0.0081 (0.76)
	esf (t-1)		-0.0294 (0.65)				-0.0206 (0.52)
	al (t-1)		0.0738 (0.10)		0.0594 (0.17)	0.0485 (0.03)	0.0472 (0.04)
	cofin (t-1)			-0.1530 (0.18)			-0.1010 (0.33)
	trasf_c_y (t-1)	0.1976 (0.00)					
	trasf_cf_y (t-1)					-0.2758 (0.00)	
	trasf_ci_y (t-1)			0.3188 (0.00)			
	trasf_ci_y (t-2)			0.2700 (0.00)		-0.0448 (0.37)	
	ncf_y (t-1)	0.0550 (0.09)			0.2593 (0.000)	0.0437 (0.19)	
	trasf_ki_y (t-1)					0.2551 (0.00)	
	trasf_ki_y (t-2)					0.2005 (0.00)	
	iflpubb_y (t-1)	0.0400 (0.47)	-0.0408 (0.65)		-0.0853 (0.24)	0.0441 (0.46)	-0.1685 (0.00)
	iflpriv_y (t-1)	-0.6172 (0.03)	-1.3668 (0.00)	0.172 (0.52)		0.6862 (0.03)	
	y (t-1)		-4.1019 (0.00)		-4.7924 (0.01)		
	y (t-2)			-4.2367 (0.01)			
	tdis_f (t-2)	-0.0134 (0.18)			-0.0443 (0.00)		

	oquota_iss (t-1)				-11.7380 (0.02)		-4.3948 (0.12)
	oquota_ser (t-1)				-15.5100 (0.00)		-2.8209 (0.24)
	vquota_agr (t-1)					-21.1091 (0.02)	
	vquota_iss (t-1)			6.4859 (0.01)			
	vquota_cos (t-1)		17.7938 (0.00)				
	vquota_ser (t-1)				-4.0691 (0.28)		
	vquota_pubb (t-1)					5.6121 (0.06)	
	alignment (t-1)	-0.0739 (0.08)		-0.0419 (0.30)	0.0535 (0.35)		
	lpul_ser (t-1)	1.2056 (0.18)	2.5684 (0.06)				-0.3526 (0.59)
	Number of observations	420	440	420	440	420	460
	RSS	63.4781	184.4562	68.2195	154.504	50.4333	57.6016
	R^2	0.49	0.48	0.36	0.34	0.38	0.37
	A-B	0.75	0.21	0.63	0.48	0.35	0.49
	C-W	0.83	0.98	0.15	0.65	0.37	0.37
	R	0.43	0.17	0.16	0.02	0.11	0.51

Note: D. () are log variations. P value of t-ratios are shown in parentheses.

Tables 22 presents the main results obtained for equation (6) with the W_{rt-1} vector. As in Coppola et al. (2018), we find a positive impact of EU funds, while national funds, including the subsidies to firms financed by national funds (that were significant in Coppola et al., 2018), are not significant at all or, like the national cohesion funds, have a negative sign. Several arguments are proposed to explain the different impact such as i) the expenditure composition – in fact, national funds may finance more non-core items compared to European Structural Funds mostly focused on core assets; and, more convincingly, ii) the policy governance, revealing the effectiveness of the multilevel and multiannual programming governance of EU funds. We are aware that it has been often argued that EU funds are mismanaged in Italy (see De Angelis et al., 2021, for a recent analysis). Our results indicate that national policies could be much more decisively mismanaged than EU funds.

Tab. 22. Equation (6) with the W_{rt-1} vector[47]

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
y_{rt-1}	-0.1626	-0.2336	-0.1782	-0.1705	-0.1620	-0.1431	-0.207	-0.1751	-0.1712	-0.1449
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
iflpriv_{rt}	0.0234	0.0315	0.0227	0.323	0.0223	0.0217	0.0279	0.0210	0.0325	0.0196
	(0.01)	(0.04)	(0.01)	(0.05)	(0.01)	(0.01)	(0.03)	(0.02)	(0.03)	(0.01)
D.pop_{rt}	-1.3342	-1.2779	-1.2643	-1.22	-1.3412	-1.3359	-1.323	-1.2669	-1.2033	-1.3634
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
fdr	0.0038	0.0033	0.0041	0.0033	0.0037					
	(0.01)	(0.02)	(0.01)	(0.04)	(0.01)					
erdf						0.0032	0.0029	0.0033	0.0028	0.0032
						(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
trasf_ci_y		0.0008					0.0006			
		(0.43)					(0.54)			
ncf_y			-0.0023					-0.0022		
			(0.05)					(0.06)		
trasf_ci_y				-0.0011					-0.0007	
				(0.66)					(0.77)	
Iflpubb_y					0.0016					0.0001
					(0.45)					(0.94)
Observations	420	400	420	400	420	420	400	420	400	420
RSS	0.0634	0.0583	0.0625	0.0585	0.0631	0.0667	0.059	0.0623	0.0582	0.0658

Note: Dependent variable: D.y.; P value of t-ratios are shown in parentheses.

2.5.2 *Quality of government, public spending efficiency and policy effectiveness*

Our regression framework allows us to deal straightforwardly with another issue highly relevant to the SF literature. It has often been maintained in this literature that policy effectiveness and, more generally, growth in the lagging regions are constrained by the scarce availability of certain local public goods. Consequently, one should control for regional differences in these factors when assessing the impact of regional policies. In order to do this, we can estimate an equation with interaction terms between some indicators of the regional environment and the funds. This procedure allows for the impact of institutions on the nexus between funds, quality of the regional environment and the economy.

Coppola et al. (2018) test the impact of the quality of institutions on the funds' effectiveness, introducing interaction terms using the composite indicator developed by The QOG Institute for 2010 (Charron et al., 2014) and the index of civic sense for 1996, calculated by Il Sole 24 Ore (Cadeo, 1997).

The new equation, including interactions terms is:

$$\text{D.}y_{rt} = a_1 y_{rt-1} + a_2 \text{ifl}_{rt} + a_3 \text{D.pop}_{rt} + a_{4j}\text{SF}_{jrt} + a_{4'j} q_i \text{SF}_{jrt} + a_{5j}\text{Nat}_{jrt} + a_{5'j} q_r \text{Nat}_{jrt} + a_6 \text{PERIOD}_2 * \text{SOUTH} + a_7 \text{PERIOD}_3 * \text{SOUTH} + a_{8j} W_{rt-1} + a_r + a_t + \varepsilon_{rt}$$
[7]

The interaction terms between q_i, the time-invariant quality of the regional context, and the funds allow for the impact of institutions on the nexus between funds, quality of the regional environment and the economy. A positive $a_{4'}$ coefficient means that higher contextual quality brings about higher policy effectiveness. The results reveal that the quality of government has no relevance for European Union funds, but it enhances the impact of subsidies to firms since "the allocation mechanism of EU funds has insulated them from institutional influences (such as the managerial and political capability of local authorities) that were potentially at work, as shown by their relevance for national funds. Coppola et al. (2018, p. 5)"

[47] The Appendix A presents the main results obtained for equation (6) without the W_{rt-1} vector.

The present econometric exercise extends the exercise of Coppola et al. over the period 1993-2016. What is more, we test the interaction terms using not only Charron et al. indicator, but also the index of corruption constructed by Golden and Picci (2005) and the (mean value) of the new public spending efficiency index for all assets as well as the disaggregated indexes by asset, as a proxy of the quality of institutions.

Table 23 shows the role of various indicators of regional quality of the government on the long-run effectiveness of funds, using equation (7) with the W_{rt-1} vector[48].

Tab. 23. Equation (7). The role of regional context with the W_{rt-1} vector

<u>X = indicator of quality of government, 2010, by The QOG Institute (Charron et al., 2014)</u>

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
fdr	-0.0000	0.0016	0.0021	0.0011	0.0022					
	(1.00)	(0.64)	(0.53)	(0.76)	(0.49)					
erdf						0.0030	0.0019	0.0031	0.0023	0.0027
						(0.08)	(0.39)	(0.20)	(0.30)	(0.13)
Trasf_ci_y		-0.0043					-0.0058			
		(0.11)					(0.03)			
Ncf_y			-0.0093					-0.0089		
			(0.01)					(0.01)		
Trasf_ki_y				-0.0028					-0.0026	
				(0.62)					(0.62)	
Iflpubb_y					0.0075					0.0063
					(0.17)					(0.18)
Fdr × X	0.0000	0.0000	0.0001	0.0001	0.0000					
	(0.48)	(0.55)	(0.39)	(0.45)	(0.52)					
Erdf × X						0.0000	0.0000	0.0000	0.0000	0.0000
						(0.91)	(0.49)	(0.79)	(0.81)	(0.71)
Trasf_ci_y × X		0.0001					0.0001			
		(0.04)					(0.01)			
Ncf_y × X			0.0001					0.0001		
			(0.03)					(0.03)		
Trasf_ki_y × X				0.0000					0.0000	
				(0.75)					(0.87)	
Iflpubb_y × X					-0.0001					-0.0001
					(0.17)					(0.08)
Observations	420	400	420	400	420	420	400	420	400	420
RSS	0.0633	0.0579	0.0614	0.0584	0.0628	0.0667	0.0584	0.0612	0.0581	0.0654

Note: Dependent variable: D.y; P value of t-ratios are shown in parentheses.

<u>X = Corruption index, 1997, Golden and Picci (2005)</u>

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
fdr	0.0022	0.0019	0.0024	0.0011	0.0023					
	(0.46)	(0.49)	(0.41)	(0.71)	(0.39)					
erdf						0.0021	0.0029	0.0032	0.0021	0.0030
						(0.27)	(0.07)	(0.10)	(0.28)	(0.05)
Trasf_ci_y		-0.0023					-0.0032			
		(0.34)					(0.23)			
Ncf_y			-0.0050					-0.0051		
			(0.12)					(0.12)		
Trasf_ki_y				-0.0071					-0.0068	
				(0.18)					(0.17)	
Iflpubb_y					0.0069					0.0051
					(0.18)					(0.26)
Fdr × X	0.0019	0.0016	0.0021	0.0025	0.0018					
	(0.42)	(0.51)	(0.39)	(0.29)	(0.40)					
Erdf × X						0.0009	0.0002	0.0003	0.0008	0.0003

[48] The Appendix B presents the main results obtained for equation (7) without the W_{rt-1} vector.

						(0.65)	(0.86)	(0.86)	(0.70)	(0.84)
Trasf_ci_y × X		0.0023					0.0042			
		(0.15)					(0.02)			
Ncf_y × X			0.0020					0.0022		
			(0.32)					(0.29)		
Trasf_ki_y × X				0.0054					0.0054	
				(0.23)					(0.21)	
Iflpubb_y × X					-0.0054					-0.0051
					(0.18)					(0.13)
Observations	420	400	420	400	420	400	440	420	400	420
RSS	0.0633	0.0580	0.0622	0.0578	0.0627	0.0590	0.0674	0.0620	0.0576	0.0654

Note: Dependent variable: D.y; P value of t-ratios are shown in parentheses.

X = New index of public spending efficiency – All assets (mean)

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
fdr	0.0083	0.0089	0.0050	0.0146	0.0102					
	(0.60)	(0.62)	(0.74)	(0.42)	(0.53)					
erdf						0.0150	0.0306	0.0133	0.0224	0.0167
						(0.31)	(0.11)	(0.43)	(0.32)	(0.31)
Trasf_ci_y		0.0185					0.0278			
		(0.13)					(0.02)			
Ncf_y			0.0275					0.0283		
			(0.01)					(0.01)		
Trasf_ki_y				0.0301					0.0344	
				(0.34)					(0.26)	
Iflpubb_y					-0.0486					-0.0545
					(0.06)					(0.03)
Fdr × X	0.0412	0.0172	0.0017	0.0353	0.0201					
	(0.79)	(0.76)	(0.97)	(0.54)	(0.70)					
Erdf × X						0.0371	0.0865	0.0306	0.0617	0.0425
						(0.40)	(0.15)	(0.55)	(0.37)	(0.39)
Trasf_ci_y × X		0.0585					0.0894			
		(0.14)					(0.02)			
Ncf_y × X			0.0990					0.1008		
			(0.01)					(0.01)		
Trasf_ki_y × X				0.1003					0.1133	
				(0.33)					(0.25)	
Iflpubb_y × X					-0.1612					-0.1756
					(0.07)					(0.04)
Observations	420	400	420	400	420	420	400	420	400	420
RSS	0.0633	0.0581	0.0614	0.0582	0.0626	0.0666	0.0584	0.0611	0.0577	0.0650

Note: Dependent variable: D.y; P value of t-ratios are shown in parentheses

X = New index of public spending efficiency – Roads

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
fdr	0.0053	0.0038	-0.0001	0.0102	0.0062					
	(0.53)	(0.68)	(0.99)	(0.35)	(0.45)					
erdf						0.0091	0.0144	0.0118	0.0158	0.0090
						(0.17)	(0.05)	(0.08)	(0.02)	(0.20)
Trasf_ci_y		0.0180					0.0199			
		(0.00)					(0.00)			
Ncf_y			0.0153					0.0148		
			(0.01)					(0.01)		
Trasf_ki_y				-0.0299					-0.0252	
				(0.05)					(0.05)	
Iflpubb_y					-0.0052					-0.0104
					(0.65)					(0.38)
Fdr × X	0.0056	0.0012	-0.0172	0.0269	0.0091					
	(0.86)	(0.97)	(0.57)	(0.49)	(0.76)					
Erdf × X						0.0219	0.0412	0.0301	0.0482	0.0213

						(0.31)	(0.10)	(0.18)	(0.04)	(0.35)
Trasf_ci_y × X		0.0680					0.0756			
		(0.00)					(0.00)			
Ncf_y × X			0.0719					0.0697		
			(0.00)					(0.00)		
Trasf_ki_y × X				-0.1113					-0.0961	
				(0.05)					(0.06)	
Iflpubb_y × X					-0.0262					-0.0398
					(0.57)					(0.39)
Observations	420	400	420	400	420	440	400	420	400	440
RSS	0.0633	0.0578	0.0612	0.0578	0.0631	0.0666	80	0.0608	0.0573	0.0657

Note: Dependent variable: D.y; P value of t-ratios are shown in parentheses

<u>X = New index of public spending efficiency – Rails</u>

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
fdr	0.0041	0.0039	0.0047	0.0036	0.0040					
	(0.01)	(0.00)	(0.00)	(0.02)	(0.01)					
erdf						0.0032	0.0029	0.0035	0.0030	0.0031
						(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Trasf_ci_y		-0.0003					-0.0005			
		(0.79)					(0.59)			
Ncf_y			-0.0030					-0.0025		
			(0.01)					(0.03)		
Trasf_ki_y				-0.0010					-0.0007	
				(0.73)					(0.82)	
Iflpubb_y					0.0021					0.0008
					(0.47)					(0.78)
Fdr × X	-0.0292	-0.0426	-0.0413	-0.0356	-0.0256					
	(0.20)	(0.15)	(0.14)	(0.24)	(0.24)					
Erdf × X						0.0004	0.0054	-0.0140	-0.0141	0.0048
						(0.99)	(0.88)	(0.63)	(0.71)	(0.89)
Trasf_ci_y × X		0.0447					0.0527			
		(0.26)					(0.20)			
Ncf_y × X			0.0260					0.0123		
			(0.24)					(0.53)		
Trasf_ki_y × X				-0.0007					0.0019	
				(0.99)					(0.98)	
Iflpubb_y × X					-0.0283					-0.0465
					(0.64)					(0.43)
Observations	420	400	420	400	420	440	400	420	400	424
RSS	0.0633	0.0580	0.0623	0.0584	0.0630	0.0667	0.0588	0.0622	0.0581	0.0657

Note: Dependent variable: D.y; P value of t-ratios are shown in parentheses

<u>X = New index of public spending efficiency – Buildings</u>

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
fdr	0.0043	0.0030	0.0001	0.0096	0.0047					
	(0.59)	(0.70)	(0.99)	(0.24)	(0.54)					
erdf						0.0056	0.0088	0.0074	0.0107	0.0053
						(0.32)	(0.09)	(0.16)	(0.04)	(0.34)
Trasf_ci_y		0.0135					0.0143			
		(0.01)					(0.00)			
Ncf_y			0.0128					0.0124		
			(0.00)					(0.00)		
Trasf_ki_y				-0.0275					-0.0225	
				(0.01)					(0.03)	
Iflpubb_y					-0.0018					-0.0022
					(0.86)					(0.85)
Fdr × X	0.0023	-0.0019	-0.0211	0.0327	0.0046					
	(0.95)	(0.96)	(0.50)	(0.40)	(0.90)					
Erdf × X						0.0114	0.0272	0.0187	0.0384	0.0099

						(0.62)	(0.23)	(0.40)	(0.09)	(0.67)
Trasf_ci_y × X		0.0649					0.0692			
		(0.01)					(0.00)			
Ncf_y × X			0.0800					0.0774		
			(0.00)					(0.00)		
Trasf_ki_y × X				-0.1327					-0.1111	
				(0.01)					(0.03)	
Iflpubb_y × X					-0.0173					-0.0104
					(0.73)					(0.85)
Observations	420	400	420	400	420	420	400	420	400	420
RSS	0.0634	0.0579	0.0611	0.0575	0.0631	0.0666	0.0584	0.0608	0.0572	0.0658

Note: Dependent variable: D.y; P value of t-ratios are shown in parentheses

X = New index of public spending efficiency – Health

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
fdr	0.0072	0.0082	0.0007	0.0099	0.0093					
	(0.37)	(0.34)	(0.93)	(0.28)	(0.23)					
erdf						0.0113	0.0107	0.0076	0.0116	0.0049
						(0.03)	(0.04)	(0.16)	(0.03)	(0.37)
Trasf_ci_y		0.0136					0.0162			
		(0.03)					(0.00)			
Ncf_y			0.0240					0.0256		
			(0.00)					(0.00)		
Trasf_ki_y				0.0025					0.0067	
				(0.90)					(0.71)	
Iflpubb_y					-0.0269					-0.0248
					(0.11)					(0.09)
Fdr × X	0.0071	0.0100	-0.0077	0.0138	0.0116					
	(0.67)	(0.57)	(0.65)	(0.47)	(0.48)					
Erdf × X						0.0173	0.0156	0.0078	0.0177	0.0038
						(0.07)	80.09)	(0.42)	(0.07)	(0.70)
Trasf_ci_y × X		0.0283					0.0343			
		(0.04)					(0.00)			
Ncf_y × X			0.0588					0.0622		
			(0.00)					(0.00)		
Trasf_ki_y × X				0.0076					0.0154	
				(0.85)					(0.68)	
Iflpubb_y × X					-0.0612					-0.0535
					(0.11)					(0.14)
Observations	420	400	420	400	420	400	400	420	400	440
RSS	0.0633	0.0580	0.0604	0.0584	0.0627	0.0589	0.0585	0.0599	0.0579	0.0654

Note: Dependent variable: D.y; P value of t-ratios are shown in parentheses

X = New index of public spending efficiency – Water

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
fdr	-0.0072	-0.0049	-0.0038	-0.0063	-0.0079					
	(0.58)	(0.73)	(0.81)	(0.62)	(0.59)					
erdf						-0.0108	-0.0181	-0.0088	-0.0163	-0.0090
						(0.25)	(0.13)	(0.33)	(0.17)	(0.36)
Trasf_ci_y		-0.0157					-0.0192			
		(0.12)					(0.04)			
Ncf_y			-0.0190					-0.0196		
			(0.04)					(0.03)		
Trasf_ki_y				0.0100					0.0073	
				(0.80)					(0.83)	
Iflpubb_y					0.0036					0.0129
					(0.89)					(0.63)
Fdr × X	0.0186	0.0141	0.0135	0.0161	0.0196					
	(0.39)	(0.56)	(0.60)	(0.46)	(0.41)					

Erdf × X						0.0234	0.0355	0.0204	0.0320	0.0206
						(0.16)	(0.08)	(0.19)	(0.12)	(0.23)
Trasf_ci_y × X		0.0264					0.0321			
		(0.10)					(0.03)			
Ncf_y × X			0.0264					0.0276		
			(0.06)					(0.05)		
Trasf_ki_y × X				-0.0179					-0.0126	
				(0.78)					(0.82)	
Iflpubb_y × X					-0.0032					-0.0213
					(0.94)					(0.61)
Observations	420	400	420	400	420	440	400	420	400	440
RSS	0.0633	0.0580	0.0619	0.0584	0.0631	0.0664	0.0582	0.0615	0.0578	0.0656

Note: Dependent variable: D.y; P value of t-ratios are shown in parentheses

X = New index of public spending efficiency – Others

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
fdr	0.0033	0.0034	0.0042	0.0028	0.0031					
	(0.07)	(0.04)	(0.03)	(0.14)	(0.11)					
erdf						0.0022	0.0013	0.0026	0.0014	0.0023
						(0.03)	(0.15)	(0.01)	(0.15)	(0.03)
Trasf_ci_y		-0.0021					-0.0030			
		(0.12)					(0.04)			
Ncf_y			-0.0046					-0.0044		
			(0.01)					(0.00)		
Trasf_ki_y				0.0011					0.0013	
				(0.77)					(0.72)	
Iflpubb_y					0.0029					0.0007
					(0.37)					(0.80)
Fdr × X	0.0153	0.0060	0.0061	0.0146	0.0223					
	(0.56)	(0.82)	(0.83)	(0.60)	(0.48)					
Erdf × X						0.0300	0.0541	0.0235	0.0429	0.0257
						(0.27)	(0.08)	(0.28)	(0.15)	(0.35)
Trasf_ci_y × X		0.0651					0.0849			
		(0.04)					(0.01)			
Ncf_y × X			0.0472					0.0462		
			(0.02)					(0.02)		
Trasf_ki_y × X				-0.0571					-0.0485	
				(0.35)					(0.36)	
Iflpubb_y × X					-0.0337					-0.0204
					(0.48)					(0.67)
Observations	420	400	420	400	420	440	400	420	400	440
RSS	0.0633	0.0580	0.0619	0.0583	0.0631	0.0666	0.0583	0.0615	0.0578	0.0657

Note: Dependent variable: D.y; P value of t-ratios are shown in parentheses

Some interesting features emerge from the above estimates. The indicator of quality of government (Charron et al., 2014) is characterized by a positive influence on the effectiveness of current-account subsidies to firms and of national cohesion funds, and a negative (not easy to rationalize) influence on national public investments. The corruption index (Golden and Picci, 2005) only interacts positively with current-account subsidies to firms. The new index of public spending efficiency for all assets has a more widespread positive interaction with all national policies (but, again, negative for national public investments), although this interaction is fully significant only for current-account subsidies to firms. The spending efficiency in Roads, Buildings and Health interacts strongly and positively with the effectiveness of both current-account subsidies to firms and national cohesion funds. However, in the first two cases, it also interacts negatively with the effectiveness of national public investments. The pattern for Rails, Water and Others is, by and large, close to that of the aggregate index. All in all, the new indexes of spending efficiency seem capable to bring about interesting information in the debate about the effectiveness of regional policies. There is, however, both for some of these indexes and for the former ones (from Charron et al., and, to a lesser extent, from

Golden and Picci) a *negative* interaction between spending efficiency (or good governance) and the effectiveness of national public investments that is not easy to explain.

A final important point is that the effectiveness of EU funds, like in Coppola et al. (2018) is impervious to the influence of the regional context. Arguably, this feature is linked to the effectiveness of the multilevel and multiannual programming governance of EU funds.

2.6 Concluding remarks

More infrastructure should in principle brings about higher GDP per capita and effectiveness of regional policies, supporting the growth process and helping to remove economic and social disparities. However, public investments may be unproductive and the expected contribution to public capital stock can be reduced by inefficiency.

Following Golden and Picci approach to measure corruption, we construct a comprehensive dataset for regional public endowment in physical terms for the period 1987-2016 for thirteen intermediate categories and six main classes of assets. Then, we compute the regional net public capital stock for 1890-2016 adopting the PIM and assuming a geometric depreciation over the updated Picci (2001) series of public investments for 9 assets. Afterward, we measure public spending efficiency using a dynamic function in which the index of public endowment in physical terms is the dependant variable and the public capital in monetary terms is the main regressor. The residuals of the regression "capture" the efficiency of public spending which is in fact the reverse of the corruption index elaborated by Golden and Picci.

The new methodology adopted, although deeply inspired by the Golden-Picci approach, differs from their measure, in terms of data on physical and monetary public capital, period of the analysis and structure of the econometric approach. It also provides a time-varying sectoral public expenditure efficiency index over 1987-2016.

The new public spending efficiency index has been used to evaluate the relevance of the regional institutional context for EU and national funds (such as Fondo Nazionale per la Coesione e lo Sviluppo (FSC)). We find a robust interaction of regional environment indicators with national Current account subsidies to firms while national cohesion funds benefits from high spending efficiency in Viability, Buildings and Health. On the other hand, like in Coppola et al. (2018), the EU funds are not influenced by the regional context.

In conclusion, this approach reiterates that strong and critical differences exist across Italian regions in terms of public expenditure effectiveness. This knowledge can be of strategic importance in improving EU and national policies to face territorial differences and delays, also in the light of the post Covid-19 stance of the EU.

A relevant limit of the new measure is related to the differing asset and sectoral classifications for physical and monetary indexes. In fact, in order to compare infrastructure endowment in physical terms to public capital to measure public expenditure efficiency, the intermediate physical indexes have been reduced to nine asset classes for public capital, merging for instance, Roads and Airports in a single class. Vice versa, the Water infrastructure index is associated to Water and Land infrastructure series. Moreover, the CPT public investments used to update the series constructed by Picci, adopt a different functional classification, which implies reducing the detailed asset breakdown by joining Ports and Rails in a unique class. Further work on the CPT and other datasets may help addressing these limitations and creating more accurate and detailed indexes for public efficiency spending.

Appendix A.

Equation (6) without the W_{rt-1} vector

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
y_{rt-1}	-0.1466	-0.1369	-0.1577	-0.1491	-0.1473	-0.1422	-0.1323	-0.1342	-0.1445	-0.1430
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$\mathrm{iflpriv}_{rt}$	0.0133	0.0127	0.0140	0.0147	0.0139	0.0146	0.0140	0.0156	0.0157	0.0152
	(0.06)	(0.09)	(0.05)	(0.05)	(0.04)	(0.05)	(0.07)	(0.04)	(0.05)	(0.03)
$\mathrm{D.pop}_{rt}$	-1.3806	-1.3401	-1.3126	-1.3626	-1.3752	-1.2578	-1.2191	-1.2154	-1.2423	-1.2514
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
fdr	0.0037	0.0035	0.0044	0.0037	0.0037					
	(0.03)	(0.03)	(0.01)	(0.03)	(0.03)					
erdf						0.0031	0.0031	0.0032	0.0031	0.0031
						(0.01)	(0.01)	(0.09)	(0.01)	(0.01)
Trasf_ci_y		0.0021					0.0021			
		(0.08)					(0.07)			
Ncf_y			-0.0024					-0.0013		
			(0.05)					(0.10)		
Trasf_ci_y				-0.0020					-0.0017	
				(0.42)					(0.50)	
Iflpubb_y					-0.0007					-0.0007
					(0.69)					(0.68)
Observations	440	440	440	440	440	440	440	440	440	440
RSS	0.0693	0.0689	0.0685	0.0691	0.0693	0.0687	0.0682	0.0724	0.0685	0.0686

Note: Dependent variable: D.y.; P value of t-ratios are shown in parentheses.

Appendix B

Equation (7). The role of regional context without the W_{rt-1} vector

X = indicator of quality of government, 2010, by The QOG Institute (Charron et al., 2014)

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
fdr	0.0000	0.0005	0.0008	0.0002	0.0002					
	(1.00)	(0.89)	(0.83)	(0.95)	(0.96)					
erdf						0.0033	0.0027	0.0038	0.0032	0.0033
						(0.05)	(0.12)	(0.03)	(0.06)	(0.04)
Trasf_ci_y		-0.0056					-0.0059			
		(0.03)					(0.04)			
Ncf_y			-0.0073					-0.0074		
			(0.06)					(0.07)		
Trasf_ki_y				-0.0038					-0.0024	
				(0.47)					(0.61)	
Iflpubb_y					0.0071					0.0070
					(0.12)					(0.14)
Fdr × X	0.0001	0.0001	0.0001	0.0001	0.0001					
	(0.17)	(0.24)	(0.14)	(0.14)	(0.18)					
Erdf × X						0.0000	0.0000	0.0000	0.0000	0.0000
						(0.88)	(0.76)	(0.91)	(0.90)	(0.95)
Trasf_ci_y × X		0.0001					0.0001			
		(0.00)					(0.00)			
Ncf_y × X			0.0001					0.0001		
			(0.14)					(0.13)		
Trasf_ki_y × X				0.0000					0.0000	
				(0.72)					(0.88)	
Iflpubb_y × X					-0.0002					-0.0002
					(0.04)					(0.04)
RSS	0.0691	0.0676	0.0676	0.0688	0.0685	0.0686	0.0669	0.0672	0.0685	0.0681

Note: Dependent variable: D.y. number of observations = 440; P value of t-ratios are shown in parentheses.

X = Corruption index, 1997, Golden and Picci (2005)

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
fdr	0.0008	0.0014	0.0015	0.0006	0.0008					
	(0.81)	(0.65)	(0.63)	(0.84)	(0.80)					
erdf						0.0034	0.0029	0.0037	0.0030	0.0033
						(0.03)	(0.07)	(0.02)	(0.06)	(0.03)
Trasf_ci_y		-0.0026					-0.0032			
		(0.29)					(0.23)			
Ncf_y			-0.0043					-0.0046		
			(0.17)					(0.15)		
Trasf_ki_y				-0.0069					-0.0059	
				(0.12)					(0.17)	
Iflpubb_y					0.0062					0.0061
					(0.15)					(0.18)
Fdr × X	0.0032	0.0023	0.0033	0.0034	0.0034					
	(0.17)	(0.31)	(0.16)	(0.12)	(0.15)					
Erdf × X						-0.0003	0.0002	-0.0003	0.0000	0.0000
						(0.81)	(0.86)	(0.82)	(0.99)	(0.97)
Trasf_ci_y × X		0.0036					0.0042			
		(0.03)					(0.02)			
Ncf_y × X			0.0014					0.0019		
			(0.43)					(0.32)		
Trasf_ki_y × X				0.0044					0.0037	
				(0.32)					(0.40)	
Iflpubb_y × X					-0.0066					-0.0065

					(0.04)					(0.06)
RSS	0.0691	0.0681	0.068	0.0684	0.0684	0.0686	0.0674	0.0677	0.0682	0.068

Note: Dependent variable: D.y. number of observations = 440; P value of t-ratios are shown in parentheses.

X = New index of public spending efficiency – All assets (mean)

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
fdr	0.0213	0.0173	0.0182	0.0233	0.0239					
	(0.18)	(0.23)	(0.22)	(0.13)	(0.16)					
erdf						0.0133	0.023	0.0142	0.0151	0.0149
						(0.35)	(0.14)	(0.35)	(0.31)	(0.34)
Trasf_ci_y		0.0339					0.0387			
		(0.00)					(0.00)			
Ncf_y			0.0156					0.0172		
			(0.12)					(0.14)		
Trasf_ki_y				0.0286					0.0206	
				(0.28)					(0.37)	
Iflpubb_y					-0.0592					-0.0560
					(0.01)					(0.02)
Fdr × X	0.0554	0.0422	0.0422	0.0611	0.0631					
	(0.29)	(0.38)	(0.39)	(0.23)	(0.25)					
Erdf × X						0.032	0.0618	0.0335	0.0377	0.0369
						(0.46)	(0.20)	(0.47)	(0.41)	(0.43)
Trasf_ci_y × X		0.1050					0.1201			
		(0.00)					(0.00)			
Ncf_y × X			0.0592					0.0637		
			(0.08)					(0.11)		
Trasf_ki_y × X				0.0980					0.0718	
				(0.24)					(0.33)	
Iflpubb_y × X					-0.1898					-0.1791
					(0.02)					(0.03)
RSS	0.0692	0.068	0.0679	0.0687	0.0683	0.0686	0.067	0.0674	0.0682	0.0678

Note: Dependent variable: D.y. number of observations = 440; P value of t-ratios are shown in parentheses.

X = New index of public spending efficiency – Roads

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
fdr	0.0126	0.0052	0.0089	0.0117	0.0139					
	(0.11)	(0.48)	(0.26)	(0.14)	(0.08)					
erdf						0.0068	0.0082	0.0069	0.0059	0.0072
						(0.28)	(0.25)	(0.28)	(0.36)	(0.28)
Trasf_ci_y		0.0307					0.0316			
		(0.00)					(0.00)			
Ncf_y			0.0090					0.0095		
			(0.10)					(0.11)		
Trasf_ki_y				-0.0163					-0.0157	
				(0.30)					(0.30)	
Iflpubb_y					-0.0152					-0.0125
					(0.17)					(0.25)
Fdr × X	0.0337	0.0045	0.0151	0.0307	0.0385					
	(0.26)	(0.87)	(0.62)	(0.30)	(0.21)					
Erdf × X						0.0135	0.0174	0.0122	0.0107	0.0149
						(0.52)	(0.46)	(0.56)	(0.61)	(0.50)
Trasf_ci_y × X		0.1132					0.1163			
		(0.00)					(0.00)			
Ncf_y × X			0.0459					0.0467		
			(0.04)					(0.06)		
Trasf_ki_y × X				-0.0561					-0.0545	
				(0.35)					(0.34)	
Iflpubb_y × X					-0.0567					-0.0458

					(0.20)					(0.29)
RSS	0.0692	0.067	0.0677	0.0688	0.0691	0.0686	0.0661	0.0672	0.0682	0.0685

Note: Dependent variable: D.y. number of observations = 440; P value of t-ratios are shown in parentheses.

X = New index of public spending efficiency – Rails

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
fdr	0.0039	0.0042	0.0049	0.0039	0.0039					
	(0.02)	(0.01)	(0.00)	(0.02)	(0.02)					
erdf						0.0031	0.0031	0.0034	0.0031	0.0031
						(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
Trasf_ci_y		0.0009					0.0012			
		(0.45)					(0.35)			
Ncf_y			-0.0027					-0.0022		
			(0.04)					(0.10)		
Trasf_ki_y				-0.0015					-0.0011	
				(0.57)					(0.69)	
Iflpubb_y					0.0002					0.0002
					(0.94)					(0.95)
Fdr × X	-0.0223	-0.0341	-0.033	-0.0274	-0.0209					
	(0.30)	(0.12)	(0.07)	(0.18)	(0.37)					
Erdf × X						0.0012	0.0051	-0.0026	-0.0016	0.0015
						(0.97)	(0.87)	(0.93)	(0.96)	(0.96)
Trasf_ci_y × X		0.0502					0.0429			
		(0.07)					(0.12)			
Ncf_y × X			0.0151					0.0054		
			(0.46)					(0.81)		
Trasf_ki_y × X				-0.0345					-0.0420	
				(0.56)					(0.49)	
Iflpubb_y × X					-0.0451					-0.0443
					(0.42)					(0.43)
RSS	0.0693	0.0685	0.0683	0.069	0.0691	0.0687	0.0679	0.0679	0.0684	0.0685

Note: Dependent variable: D.y. number of observations = 440; P value of t-ratios are shown in parentheses.

X = New index of public spending efficiency – Buildings

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
fdr	0.0092	0.0028	0.0061	0.0094	0.0099					
	(0.19)	(0.70)	(0.34)	(0.18)	(0.16)					
erdf						0.0037	0.0040	0.0030	0.0026	0.0037
						(0.47)	(0.43)	(0.53)	(0.63)	(0.48)
Trasf_ci_y		0.0253					0.0257			
		(0.00)					(0.00)			
Ncf_y			0.0084					0.0093		
			(0.02)					(0.01)		
Trasf_ki_y				-0.0142					-0.0123	
				(0.22)					(0.28)	
Iflpubb_y					-0.0065					-0.0038
					(0.54)					(0.69)
Fdr × X	0.0278	-0.005	0.0065	0.029	0.0308					
	(0.42)	(0.89)	(0.83)	(0.38)	(0.37)					
Erdf × X						0.0029	0.0035	-0.0026	-0.0019	0.0027
						(0.89)	(0.87)	(0.90)	(0.93)	(0.90)
Trasf_ci_y × X		0.1186					0.1202			
		(0.00)					(0.00)			
Ncf_y × X			0.0567					0.0596		
			(0.00)					(0.00)		
Trasf_ki_y × X				-0.0625					-0.0535	
				(0.25)					(0.32)	
Iflpubb_y × X					-0.0296					-0.0155

					(0.57)					(0.73)
RSS	0.0693	0.0672	0.0675	0.0688	0.0692	0.0686	0.0664	0.0669	0.0683	0.0686

Note: Dependent variable: D.y. number of observations = 440; P value of t-ratios are shown in parentheses.

X = New index of public spending efficiency – Health

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
fdr	0.014	0.0062	0.0091	0.0115	0.018					
	(0.05)	(0.36)	(0.21)	(0.10)	(0.02)					
erdf						0.0020	0.0028	0.0022	0.0015	0.0035
						(0.70)	(0.59)	(0.66)	(0.77)	(0.51)
Trasf_ci_y		0.0278					0.0291			
		(0.00)					(0.00)			
Ncf_y			0.0165					0.0192		
			(0.01)					(0.00)		
Trasf_ki_y				0.0104					0.0108	
				(0.51)					(0.46)	
Iflpubb_y					-0.0357					-0.0303
					(0.02)					(0.05)
Fdr × X	0.0217	0.0051	0.0091	0.0162	0.0301					
	(0.16)	(0.73)	(0.56)	(0.28)	(0.06)					
Erdf × X						-0.0022	-0.0011	-0.0032	-0.0033	0.0010
						(0.82)	(0.91)	(0.73)	(0.71)	(0.92)
Trasf_ci_y × X		0.0567					0.0595			
		(0.00)					(0.00)			
Ncf_y × X			0.0419					0.0471		
			(0.00)					(0.00)		
Trasf_ki_y × X				0.0264					0.0270	
				(0.39)					(0.34)	
Iflpubb_y × X					-0.0762					-0.0643
					(0.03)					(0.07)
RSS	0.0692	0.0674	0.0671	0.0688	0.0684	0.0686	0.0666	0.0663	0.0683	0.068

Note: Dependent variable: D.y. number of observations = 440; P value of t-ratios are shown in parentheses.

X = New index of public spending efficiency – Water

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
fdr	-0.0098	-0.0053	-0.0062	-0.0067	-0.0103					
	(0.46)	(0.71)	(0.65)	(0.57)	(0.48)					
erdf						-0.008	-0.0118	-0.0072	-0.0073	-0.0084
						(0.39)	(0.26)	(0.44)	(0.44)	(0.41)
Trasf_ci_y		-0.0217					-0.0238			
		(0.05)					(0.01)			
Ncf_y			-0.008					-0.0073		
			(0.37)					(0.45)		
Trasf_ki_y				-0.0088					-0.0040	
				(0.79)					(0.90)	
Iflpubb_y					0.0130					0.0114
					(0.64)					(0.69)
Fdr × X	0.0228	0.0156	0.018	0.0177	0.0236					
	(0.28)	(0.49)	(0.40)	(0.36)	(0.31)					
Erdf × X						0.0188	0.0254	0.0177	0.0175	0.0194
						(0.25)	(0.16)	(0.27)	(0.28)	(0.27)
Trasf_ci_y × X		0.0383					0.0419			
		(0.03)					(0.00)			
Ncf_y × X			0.0091					0.0084		
			(0.52)					(0.58)		
Trasf_ki_y × X				0.0115					0.0040	
				(0.82)					(0.93)	
Iflpubb_y × X					-0.0224					-0.0199

					(0.61)					(0.66)
RSS	0.0692	0.0681	0.0683	0.069	0.0691	0.0685	0.0671	0.0677	0.0683	0.0684

Note: Dependent variable: D.y. number of observations = 440; P value of t-ratios are shown in parentheses.

<u>X = New index of public spending efficiency – Others</u>

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
fdr	0.0023	0.0036	0.0039	0.0026	0.0019					
	(0.24)	(0.06)	(0.04)	(0.17)	(0.36)					
erdf						0.0022	0.0016	0.0028	0.0023	0.0022
						(0.04)	(0.13)	(0.01)	(0.05)	(0.05)
Trasf_ci_y		-0.0026					-0.0031			
		(0.09)					(0.07)			
Ncf_y			-0.0044					-0.0038		
			(0.00)					(0.02)		
Trasf_ki_y				-0.0003					0.0002	
				(0.94)					(0.94)	
Iflpubb_y					0.0014					0.0004
					(0.59)					(0.89)
Fdr × X	0.0422	0.0107	0.0285	0.0328	0.0562					
	(0.20)	(0.71)	(0.29)	(0.30)	(0.15)					
Erdf × X						0.0275	0.0547	0.0209	0.0238	0.0276
						(0.31)	(0.07)	(0.42)	(0.41)	(0.31)
Trasf_ci_y × X		0.1028					0.1167			
		(0.00)					(0.00)			
Ncf_y × X			0.0445					0.0388		
			(0.02)					(0.08)		
Trasf_ki_y × X				-0.042					-0.0487	
				(0.47)					(0.35)	
Iflpubb_y × X					-0.0509					-0.0261
					(0.27)					(0.53)
RSS	0.0692	0.0675	0.0677	0.0689	0.0691	0.0686	0.0664	0.0673	0.0683	0.0685

Note: Dependent variable: D.y. number of observations = 440; P value of t-ratios are shown in parentheses.

3. Convergence and Structural Funds in the European regions. Evidence from Italy and Spain.

In the last decades, despite various impressive technological waves, Italy and Spain experienced a very disappointing evolution of Total Factor Productivity (TFP) – contrary to most advanced countries. However, the two countries differ from their capital dynamics. In fact, Spain reveals a strong capital accumulation while Italy experienced a relative delay in capital growth since the 1990s. Moreover, both countries presented relevant productive fragilities and regional dualisms, characterized by disparities in local production structure and specialization, ICT pervasiveness, human capital, infrastructure endowment.

This chapter explores these similarities and differences in the two economies at the regional (NUTS2) level. We rely on the Solow neo-classical growth model for closed economies, supposing that if regions in the two countries are similar with respect to preferences and technology, they converge to a long-run steady-state per capita capital per worker (and TFP level), poor regions tending to grow faster than rich ones. This comparative convergence analysis is carried out over period 1980-2016.

In order to carry out this analysis, we construct long times series for total capital stock by asset and sector for NUTS2 regions. In doing so, we fill an important gap in the statistical information available for Italian regions. These key statistics are indeed crucial for the study of several relevant issues relative to the effectiveness of structural policies, regional growth and convergence/divergence, the disparities in productivity in Italy with their economic and social implications.

The chapter is organised as follows. Section 1 describes the methodology used to construct regional investment and capital series for Italy by assets and economic sectors, relative to the period 1970-2016. The approach is based on the EUKLEMS adaptation of the Perpetual Inventory Method (PIM), basically already used by BBVA-IVIE[1] to compute regional series for the capital stock in Spain. Section 2 exploits these data to construct and discuss beta and sigma convergence statistics for regional productive capacities over the period 1980-2016 and proposes a regional taxonomy from the convergence perspective for Italy and Spain. Section 3 explores the impact of Cohesion policies in the convergence process from two different perspectives. Section 4 concludes.

3.1 The construction of Italian regional investment and capital series

This section illustrates the estimation approach adopted to measure investment flows for eight assets and ten sectors for the Italian NUTS2 regions during period 1970-2016 and the subsequent computation of regional capital stocks. We follow the methodology developed by EUKLEMS and used by the Fundacion BBVA-IVIE on the Spanish data. In particular, the PIM is adopted in order to take into account OECD (2009) methodological recommendations, assuming a geometrical pattern of depreciation on the investment series.

3.1.1 Gross Current investment

In order to construct long series for gross regional investment in current prices for eight assets and ten sectors for period 1970-2016, we use three different data sources (Table 1).

[1] IVIE, properly *Instituto Valenciano de Investigaciones Economicas*, is a Spanish Centre associated to the University of Valencia, devoted to national and international economic research. IVIE is involved in different research areas such as, among others, Capitalization and growth, Regional economy, Knowledge economy and digital transformation (www.ivie.es).

Tab. 1. Investment series sources

Source of data	Series	Period	Territorial unit	Sectors	n. of assets
CRENOS (Istat)[2]	Current and Real Regional Fixed investment	1970-2016	NUTS2	8	0
Istat[3]	Current and Real National Fixed investment	1970-2005	NUTS1	NACE_R2[4]	9
Eurostat[5]	Current and Real National Gross fixed capital formation (flows)	1995-2016	NUTS1	NACE_R2	9

Note: different data sources (CRENOS, Istat, Eurostat) have been used to construct regional investment series for eight assets and ten sectors for period 1970-2016.

Notice that Istat and Eurostat adopted different asset classifications. Table 2 reports the economic sectors' classification.

Tab. 2. Economic sectors' breakdown

NACE code	Sectors	Italian description
A	Agriculture, forestry and fishing	Agricoltura
D + E	Electricity, gas, steam + Water supply	Energia
B + C	Mining and quarrying + Total manufacturing	Manifattura
F	Construction	Costruzioni
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	Commercio
H+J	Transportation and storage + Information and communication	Trasporti e comunicazioni
K	Financial and insurance activities	Credito
L	Real estate	
I	Accommodation and food services activities	Altro
I + M - U	Professional, scientific, technical, administrative and support service activities + Community social and personal services	

Note: a sectoral correspondence table has been used for Istat and Eurostat fixed investment in order to construct the regional series for eight assets and ten sectors for period 1970-2016.

To construct the series for gross regional investment for 1970-2016:

- we carry out a reduction from nine to eight assets, using the following correspondence table (Table 3). In order to consider the specificity of residential investments included in the Istat Total buildings investments series, we assume for the period 1970-1994, that the average share of Dwellings over Total buildings in Real estate sector is fix and equal to the average share for the period 1995-2016 computed using Eurostat data[6].

[2] https://crenos.unica.it/crenos/databases/italian-regions

[3] http://dati.istat.it/

[4] Istat produces statistics on Investments by asset for the period 1970-2005 for the merged sector Transport and Communication. A distinction among the two sectors could be more appropriate for an in-depth analysis of asset contribution to productivity, considering the different ICT content.

[5] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en

[6] This hypothesis is supported by the fact that according to Eurostat statistic, the share is steady assuming values in the range 0.88 – 0.92 and Real estate is the more relevant sector for Dwellings.

Tab. 3. Correspondence table for Istat and Eurostat asset classification

<table>
<tr><th></th><th>Dwellings (1.1)</th><th>Other buildings and structures (1.2)</th><th>Transport equipment (1.3)</th><th>Computer hardware (1.4.3)</th><th>Telecommunications equipment (1.4.4.1)</th><th>Other machinery and equipment and weapons systems (1.4.4.2)</th><th>Computer software and databases (2.1)</th><th>Cultivated biological resources (1.5)</th><th>Research and development (2.2)</th></tr>
<tr><td>Costruzioni</td><td>DWELL</td><td>OTHERBUILD</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Mezzi di trasporto su strada</td><td></td><td></td><td rowspan="2">TRANSP</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Altri mezzi di trasporto</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Macchine per ufficio</td><td></td><td></td><td></td><td>HARDW</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Apparati per le telecomunicazioni</td><td></td><td></td><td></td><td></td><td>TELECOM</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Macchine e attrezzature</td><td></td><td></td><td></td><td></td><td></td><td rowspan="2">OTHERMAC</td><td></td><td></td><td></td></tr>
<tr><td>Mobili</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Software</td><td></td><td></td><td></td><td></td><td></td><td></td><td>SOFTW</td><td></td><td></td></tr>
<tr><td>Altri beni</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">OTHERS</td></tr>
</table>

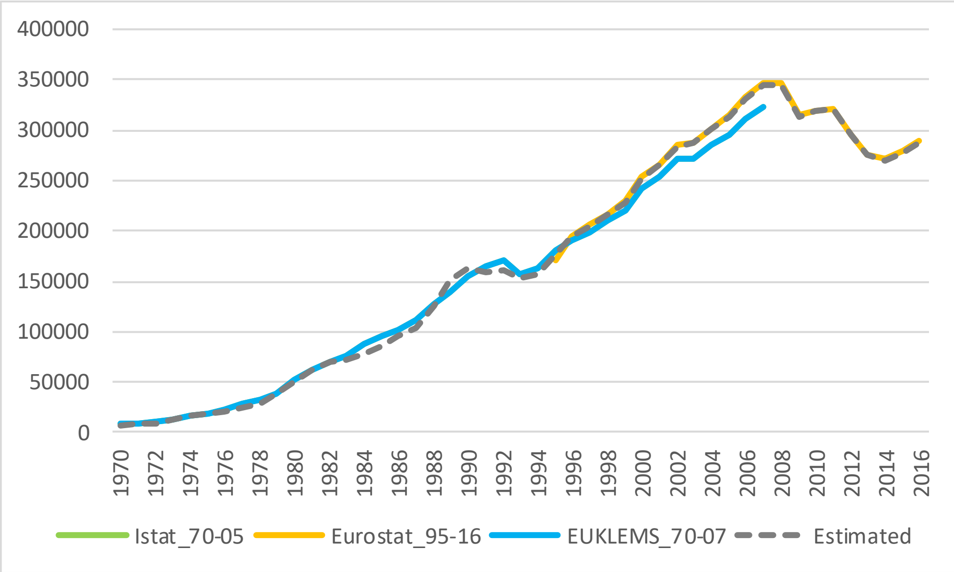
Note: a correspondence table for capital asset has been used for Istat and Eurostat fixed investment in order to construct the regional series for eight assets and ten sectors for period 1970-2016.

- we use the annual growth rate of current National fixed investment for eight assets and ten sectors for the period 1970-1995 (from Istat data) to uniform Istat and Eurostat series;

- we apply the regional share for the ten sectors to the current National fixed investment by asset (from the Crenos dataset).

In Graph 1 we compare the estimated current investment series to aggregate available series elaborated by national and international institutions.

Graph 1. Aggregate current investments (Mln euro, 1970-2016). Italy

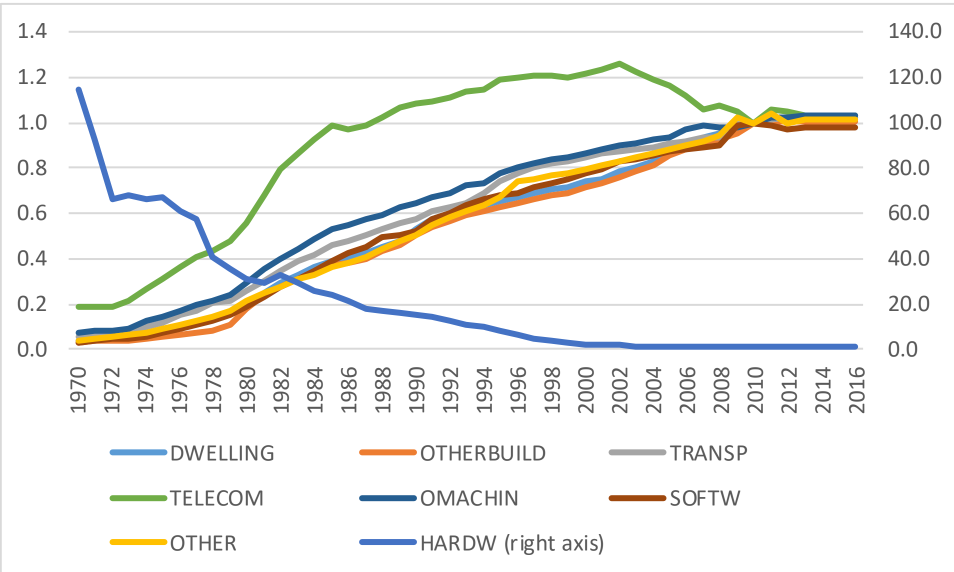


Note: Own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/)

3.1.2 Real gross investment

We calculate a price deflator by asset (base 2010), IP_t^a, from EUKLEMS data for Italy. Graph 2 reproduces the price deflator index for investments revealing the particular growth trend for Telecommunication assets and the relevant decline of Hardware prices reported on the right axis.

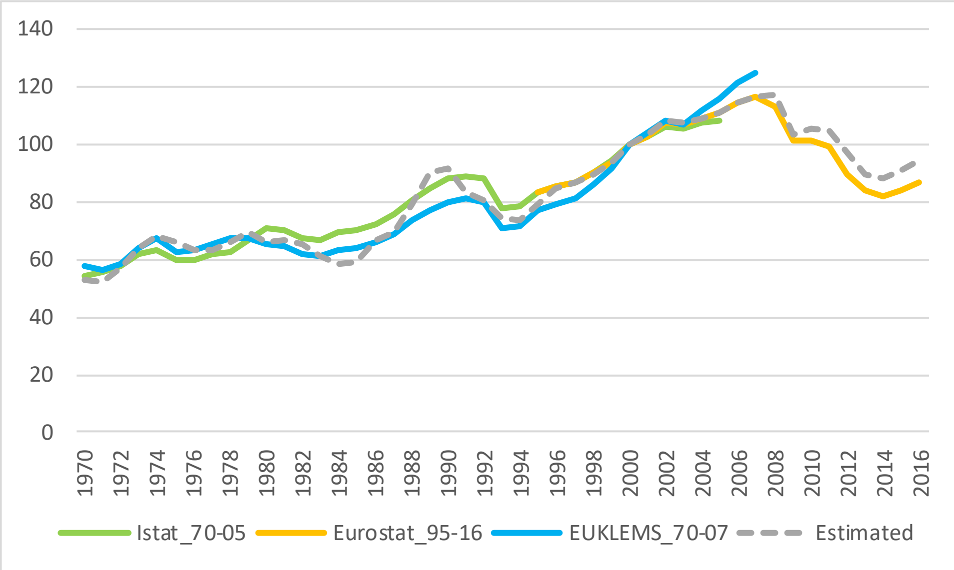
Graph 2. Price Index on national fixed investments by asset (2010=1), 1970-2016



Source: Own elaboration on EUKLEMS (https://euklems.eu/download/
Note: The price index for Hardware is reported on the right axis.

Relying on these price deflators, we computed gross investment at constant prices, and Graph 3 compares the series to available aggregate data on Italian investments at constant prices. As can be seen, we obtain a good fit.

Graph 3. Aggregate constant-price investments (2000=100, 1970-2016). Italy



Note: The dynamic of the new constant price investment index is determined by the trend of the different data sources (CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/)).

3.1.3 Depreciation function.

Once assessed the robustness of investment series, we tackle the measurement of the capital stock. As observed by OECD (2009, p.9), "Capital plays a fundamental role in the process of production and it is a significant component of wealth and source of income. It is vital that both stock and flow aspects of capital are well measured in order to support the development and monitoring of economic policy, as well as economic analysis more generally."

According to the PIM, the net capital stock is calculated by cumulating gross fixed capital formation year by year and deducting depreciation. In that perspective, the assumed depreciation function and asset lives are pivotal in capital measurement, considering that there is "no single 'correct' way" for depreciation measurement but some "prescriptions about how to measure depreciation"[7]. As a matter of fact, different kinds of assets exhibit a very wide range of depreciation profile which is, in most cases, a line which falls over time with some convexity around the origin.

Here we assume a geometrical pattern of depreciation following OECD (2009):

$$TD = \frac{\text{Declining balance rate}}{\text{Average service rate}} \qquad [1]$$

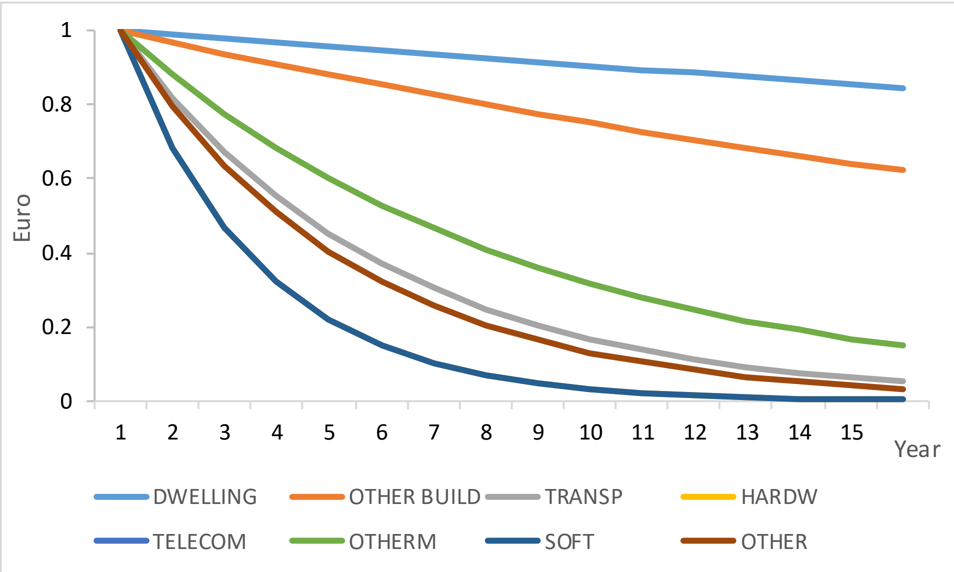
Under a "geometric" profile, the decline in efficiency is more pronounced during the first years of service life. Therefore, the price-age profiles are also convex to the origin due to this hypothesis on the depreciation

[7] OECD (2009)

model. The geometric efficiency profile is indeed used for practical reasons to approximate a combined age-price/retirement pattern (Hulten and Wyckoff, 1996).

In the absence of information on the shape of the geometric pattern, the empirical literature adopts a double-declining- balance rate. Recently, the estimates of declining balance implements new assumptions on asset lives, introducing different declining balance rates assessing the convexity profile of the depreciation function (Graph 4): higher declining balance rate (for assets like Transport equipment, Other machinery and Others) are characterized by higher convexity depreciation pattern, revealing a relevant decline in efficiency in the first asset service years; lower declining balance rate (for Dwellings) denoted a lower convexity depreciation model, showing a slight efficiency reduction in the first asset service years.

Graph 4. Convexity profile of 1 Euro investment depreciation according to IVIE hypothesis on declining balance rates



Note: Under the geometric efficiency profile, the hypothesis on the declining balance rate for each asset characterizes the convexity depreciation pattern (own elaboration on Perez F., Mas M., Martinez L. S., Jimenez E. U. (2019)).

For the combined average service life/depreciation rate and retirement function, we adopt the time-invariant geometric depreciation rate by asset provided by EUKLEMS and we assume IVIE declining balance rate (Table 4). The average service life is then deduced by the previous formula.

Tab. 4. Average service life (years) and depreciation rate by asset

	Average service life (years)			**Declining balance rate**	**Depreciation rate**
	Istat (2007)	**Istat (2015)**	**Own hypothesis**	**IVIE[8] proposal according to EUKLEMS rates**	**Elaboration on implicit EUKLEMS rates[9]**
Dwellings	35-65		83	0.912	0.011
Other buildings		35-65	39	1.231	0.031
Transport equipment	10-18	10-18	11	2.000	0.180

[8] Perez F., Mas M., Martinez L. S., Jimenez E. U. (2019).

[9] EUKLEMS provides different depreciation rates by sector for each asset. In order to compute a unique depreciation rate for total economy for each asset, we adopted a weighted depreciation rate.

Computer hardware	7	6	6	1.890	0.315
Telecommunications equipment	7	6-9	15	1.725	0.115
Other machinery and equipment and weapons systems	16-18	9-23	17	2.000	0.119
Computer software and databases	5	5	6	1.890	0.315
Others	34	8-34	10	2.000	0.202

Note: the average service life of each asset is deducted using the declining balance rate proposed in Perez F., Mas M., Martinez L. S., Jimenez E. U. (2019) and the depreciation rate computed from EUKLEMS (https://euklems.eu/download/)).

3.1.4 Net initial stock of capital

In the absence of full time series of investment, the initial capital stock must be estimated. The simple Kohli (1982) approximation cannot be used because the available investment series are too short. The estimation of the initial net capital stock by asset and sector is then given by EUKLEMS.

The regional net capital stock is assumed equal to:

$$\mathrm{SKNPRE}_{\mathrm{r},0}^{a,s} = \mathrm{SKNPRE}\_euklems_{0}^{a,s} * \frac{\mathrm{I\_R}_{r,0}^{a,s}}{\mathrm{I\_R}_{Italy,0}^{a,s}} \qquad [2]$$

where $\mathrm{I\_R}_{\mathrm{r,t}}^{a,s}$ is Real gross investment in asset a, sector s, region r, year t and $\mathrm{SKNPRE}_{\mathrm{r,t}}^{a,s}$ is real net capital in asset a, sector s, region r, year t.

3.1.5 Real net capital stock (also called Wealth capital)

The net capital stock is 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 the asset.

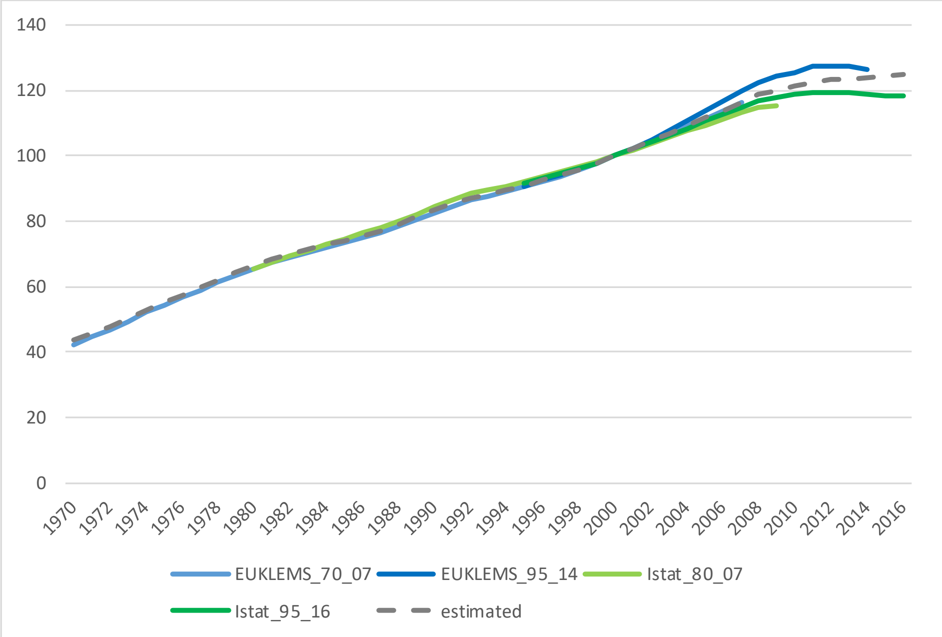
We use the PIM to annual Real fixed investment for the period 1970-2016 to compute the net stock capital for each region, sector, asset, given the depreciation profile.

$$\mathrm{SKN\_R}_{r,0}^{a,s} = \mathrm{SKNPRE}_{r,0}^{a,s} \qquad [3]$$

$$\mathrm{SKN\_R}_{r,t}^{a,s} = \mathrm{SKN\_R}_{r,t-1}^{a,s} + \mathrm{I\_R}_{r,t}^{a,s} - \underbrace{\mathrm{TD}^{a} * \underbrace{\left[\frac{\mathrm{I\_R}_{r,t}^{a,s}}{2} + \mathrm{SKN\_R}_{r,t-1}^{a,s}\right]}_{\text{Productive stock } (\mathrm{SKP\_R}_{r,t}^{a,s})}}_{\text{Consumption of fixed capital } (\mathrm{CCF\_R}_{r,t}^{a,s})} \qquad [4]$$

In Graph 5 we compare the estimated real net capital stock with available aggregate data from Istat and EUKLEMS.

Graph 5. Real net capital stock (2000=100, 1970-2016). Italy



Note: The dynamic of the new real net capital stock index is determined by the trend of investment flows (using different data sources (CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/)), and the methodology to apply the Perpetual Inventory Method with a geometric efficiency profile(Perez F., Mas M., Martinez L. S., Jimenez E. U. (2019)).

3.2 A convergence/divergence analysis on capital per worker and TFP in Italy and Spain

According to the neoclassical growth theory developed by Solow (1956), the countries (and the regions) with similar preferences, technology, population growth trends, depreciation rates converge to the same steady-state capital/labour ratios (and hence outputs per capita), supposing capital diminishing returns. In Solow's model the evolution of technology (that is technical progress) is supposed to be in practice the main driver of the steady-state equilibrium. Accordingly, a question that arises in the above-described set-up is whether economic policy, by inducing a speedier convergence of the least advanced technology states to more advanced levels, can achieve an even quicker and stronger convergence in GDP per capita.

Since 1970, the evolution of the total net capital stock in Italy and Spain has been similar for nearly 20 years. However, Spain has been more effective in seizing the opportunities during the 1990s economic boom and its capital endowment increased faster in that juncture. Both countries suffered a very dismal evolution (even a reduction for sizeable periods) of TFP since 2001. Yet, the Spanish capital stock dynamics which has been more heavily affected by the crisis of 2007-2008, has currently shown more resilience. Further details about investment and capital trends in Italy and Spain over 1970-2016 are provided in the Appendix of this chapter. The issue that we analyze here, using newly developed regional series for net capital stock, infrastructure and educational attainment (human capital), is how these aggregate developments relate to the convergence process of least advanced regions to the most advanced ones.

In this section we analyse the convergence process in Italian and Spanish regions during 1980-2016, given that both countries are characterized by a pronounced regional dualism. Firstly, we discuss β-convergence and σ-convergence in capital per worker - using the new regional capital stock series for Italy and IVIE statistics for Spain – and in TFP. Then, we adopt a simple regional taxonomy to classify regions according to their local convergence/divergence dynamics, and to gauge the strength of the regional convergence process in the two countries. In the next section, we will adopt two empirical frameworks, introduced respectively in Destefanis and Sena (2005) and in Coppola et al. (2020), to compare the influence wielded by EU and national development funds in the convergence process in Italy and Spain.

3.2.1 β-convergence

Assuming the same long-run dynamics for labour force and population, β-convergence refers to the process in which regions with lower initial capital per inhabitant/worker must grow faster than rich ones to ensure convergence to the same steady-state in terms of (capital and) GDP per capita and growth rate.

Specifically, we adopt the β-convergence concept introduced by Barro and Sala-i-Martin (1992) to test the catch-up occurring in terms of the levels of capital per worker. Convergence is found when the partial correlation between the growth rate in capital per head over time and its initial level is negative.

The methodology adopted to measure β-convergence in capital accumulation process involves estimating the following growth equation:

$$\left(\frac{1}{T}\right)\log\left(\frac{k_{r,t}}{k_{r,t-T}}\right) = \alpha_k - \beta_k \log\left(k_{r,t-T}\right) + \varepsilon_{r,t} \qquad [5]$$

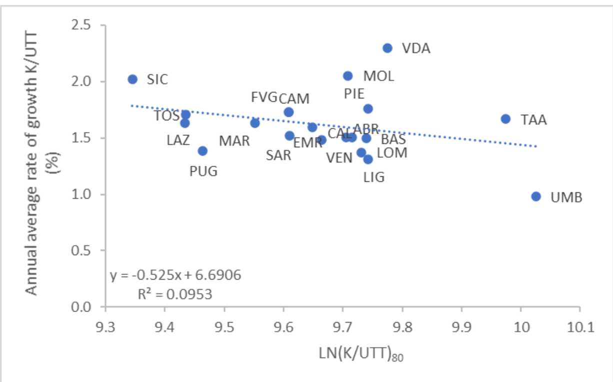
Where

$k_{r,t}$ and $k_{r,t-T}$ are the *r*th region's per capita capital at time *t* and time *t-T*, respectively; α_k is the intercept; β_k is related to the rate of convergence; and $\varepsilon_{r,t}$ is the disturbance term with zero mean and is independently distributed. One of the components of the intercept α_k, is the steady-state level of per capita capital. A positive value of β_k reveals a negative relation between growth in capital over time and its initial level, and it implies (unconditional) convergence.

Graph 6 depicts the absolute convergence in capital per worker across regions during 1980-2016 for Italy and Spain. The positive β reveals the (unconditional) convergence process to the same steady-state for both countries. However, Spain shows a higher downward sloping and a high coefficient of determination R^2, describing a more significant and robust converging process over 1980-2016.

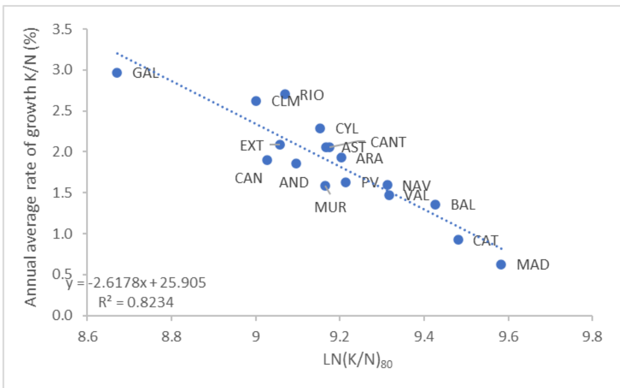
Graph 6. β-convergence on capital stock per worker across regions (1980-2016).

Italy



Data source: Own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/)), Prometeia

Spain



Data source: Own elaboration on IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/) and BDMORES (https://www.sepg.pap.hacienda.gob.es/sitios/sepg/es-

ES/Presupuestos/DocumentacionEstadisticas/Documentacion/paginas/basesdatosestudiosregionales.aspx)

We now measure Total Factor Productivity (TFP) in two different ways. The first, more traditional, one is related to the use of a Tornqvist index taking regional GDP as output and regional employment and capital stock as inputs. The second way derives from the measurement of TFP growth by the Malmquist (1953) index, according to the approach adopted by Caves et al. (1982) and Färe et al. (1994).

Let us illustrate this methodology using Destefanis et al. (2019), and considering two production sets, $\mathbf{T}^t$ and $\mathbf{T}^{t+1}$, characterised by a single output (**Q**) and a single input (**X**).

With constant returns to scale technology, the Malmquist index is equal to the product of the relative variation in technical efficiency (ΔTE) and the technical progress (TP).

$$M = \Delta TE \times TP \qquad [6]$$

In particular, the variation in technical efficiency (ΔTE) is measured by comparing the actual outputs in t, given technology T^t with the actual outputs in t+1 given technology T^{t+1}.

$$\Delta TE = \frac{D^{t+1}(\mathbf{X}^{t+1},\mathbf{Q}^{t+1})}{D^t(\mathbf{X}^t,\mathbf{Q}^t)} \qquad [7]$$

Where $D^t(\ldots)$ and $D^{t+1}(\ldots)$ are distance functions defining the output-oriented technical efficiency.

Moreover, the technical progress (TP) is the geometric means of the ratio comparing the actual outputs in t+1, given technology T^{t+1} with the optimal outputs in t+1 given technology T^t and the ratio comparing the optimal outputs in t, given technology T^{t+1} with the actual outputs in t given technology T^t.

$$TP = \left[\frac{D^t(\mathbf{X}^{t+1},\mathbf{Q}^{t+1})}{D^{t+1}(\mathbf{X}^{t+1},\mathbf{Q}^{t+1})} * \frac{D^t(\mathbf{X}^t,\mathbf{Q}^t)}{D^{t+1}(\mathbf{X}^t,\mathbf{Q}^t)}\right]^{1/2} \qquad [8]$$

Of course, a value greater than one for the Malmquist index indicates an increase in TFP due to increase in technical efficiency (even in the presence of technical regress if there is a greater increase in technical efficiency in terms of relative variations) and/or to technical progress (even in presence of decrease in technical efficiency if there is greater technical progress in terms of relative variations).

If the production function is not homogeneous and therefore the returns to scale are not constant, following Simar and Wison (1998) the Malmquist index is equal to the product of the relative variation in technical efficiency (ΔTE), the technical progress (TP), the changes over time in the distance of the true frontier from the constant-returns-to-scale benchmark frontier (Δ*Scale)* and the changes in the shape of the technology at X^t and X^{t+1} (Δ*Shape*).

$$M = \Delta TE \times TP \times \Delta Scale \times \Delta Shape \qquad [9]$$

In particular, the variation in technical efficiency and the technical progress are defined as above.

The changes over time in the distance of the true frontier from the constant-returns-to-scale benchmark frontier (Δ*Scale)* defines the relative variation of scale efficiency and is equal to:

$$\Delta Scale = \frac{\Delta^{t+1}(\mathbf{X}^{t+1},\mathbf{Q}^{t+1})/D^{t+1}(\mathbf{X}^{t+1},\mathbf{Q}^{t+1})}{\Delta^t(\mathbf{X}^t,\mathbf{Q}^t)/D^t(\mathbf{X}^t,\mathbf{Q}^t)} \qquad [10]$$

Where $\mathbf{\Delta}^t(\ldots)$ and $\mathbf{\Delta}^{t+1}(\ldots)$ are distance functions evaluated vis-à-vis constant-returns-to-scale benchmarks, even in the case where the true technology is characterised by variable returns to scale.

Finally, the changes in the shape of the technology at X^t and X^{t+1} ($\Delta Shape$) defines the relative technical progress and is equal to:

$$\Delta Shape = \left[\frac{\Delta^t(\mathbf{X}^{t+1},\mathbf{Q}^{t+1})/D^t(\mathbf{X}^{t+1},\mathbf{Q}^{t+1})}{\Delta^{t+1}(\mathbf{X}^{t+1},\mathbf{Q}^{t+1})/D^{t+1}(\mathbf{X}^{t+1},\mathbf{Q}^{t+1})} * \frac{\Delta^t(\mathbf{X}^t,\mathbf{Q}^t)/D^t(\mathbf{X}^t,\mathbf{Q}^t)}{\Delta^{t+1}(\mathbf{X}^t,\mathbf{Q}^t/D^{t+1}(\mathbf{X}^t,\mathbf{Q}^t)}\right]^{1/2} \quad [11]$$

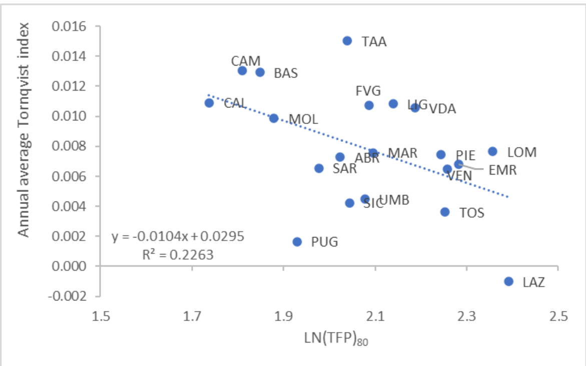
Once we have measured TFP growth through the Malmquist index we can find a measure of TFP level by cumulating the growth rates.

We compute TFP through Tornqvist[10] (TFP_T) for 1996-2016 and Malmquist (TFP_M) indexes for 1980-2016 using Prometeia databanks and our elaboration for capital stock in Italy, and BDMORES databanks and IVIE elaboration for capital stock in Spain.

The regional TFP index for Italy and Spain reveals relevant differences from the previous analysis over 1980-2016. In fact, the (unconditional) convergence of Italian regions in terms of TFP is more significant relative to Spain, with higher β and R^2 coefficients.

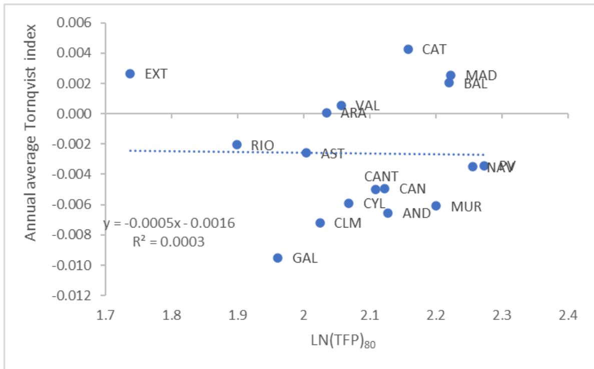
Graph 7. β-convergence on TFP across regions (1980-2016).

Italy



Data source: Own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/), Prometeia

Spain



Data source: Own elaboration on IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/) and BDMORES (https://www.sepg.pap.hacienda.gob.es/sitios/sepg/es-)

3.2.2 σ-convergence

According to Barro et al. (1992, p.227) "Convergence in the sense that poor economies tend to grow faster than rich ones, which corresponds to β>0 (…) does not necessarily imply that the cross-economy dispersion (…) declines over time."

To test if there is σ-convergence across time and regions, we measure the spread of various determinants of long-run GDP per capita across time, using their (log) standard deviation.

[10] This index is calculated using the value added, employment and capital stock data, assuming constant return to scale and a labour share of output equal to 0.6.

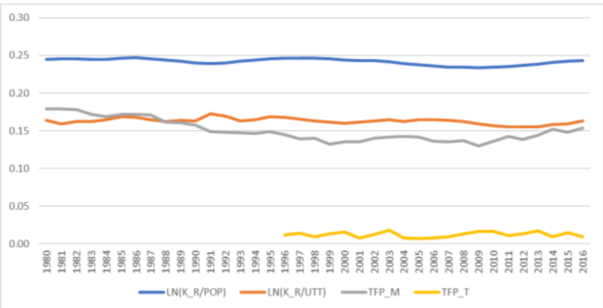
Graph 8 shows the convergence/divergence over 1980-2016 of (log) per capita capital, capital per worker and TFP (measured by Malmquist index (TFP_M) over 1980-2016 and by Tornqvist index (TFP_T) over 1996-2016) for Italy and Spain. Notice that even if there has been a very slight convergence trend across Italian regions until 2008 with a small decrease in capital per worker deviation across regions, the crisis of 2007-2008 has brought a slim dispersion in capital endowment. On the other hand, the converging path is more relevant for TFP, measured until 2005.

The reduction of inter-regional dispersion capital per worker and TFP has been impressive in Spain during 1980-2016, despite the light diverging trend after 2000. Moreover, the dispersion of per capita capital has been lower because Spain experienced higher population growth almost during the entire period (and particularly in the period 2003-2008), smoothing the impact of capital increase on per capita capital rate.

In conclusion, while the two countries benefit from different periods of capital growth acceleration during 1980-2016 (1985-1990; 1994-2002 for Italy and 1994-2007 for Spain; after 2014 (see Appendix)), only Spain has effectively reduced capital per worker and TFP dispersion.

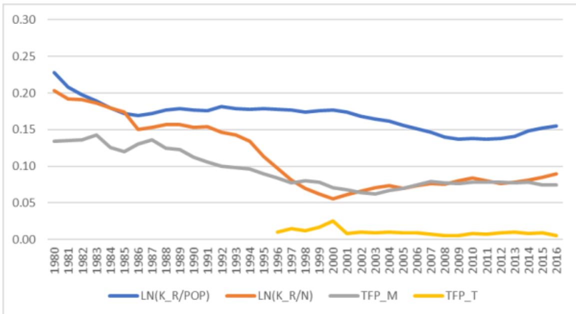
Graph 8. Dispersion of (log) capital per worker and TFP (Malmquist (TFP_M) and Tornqvist (TFP_T) indexes) across regions (1980-2016)

Italy



Data source: Own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/)), Prometeia

Spain



Data source: Own elaboration on IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/) and BDMORES (https://www.sepg.pap.hacienda.gob.es/sitios/sepg/es-

The σ-convergence analysis has been conducted also for public (Graph 9) and human capital[11] (Graph 10).

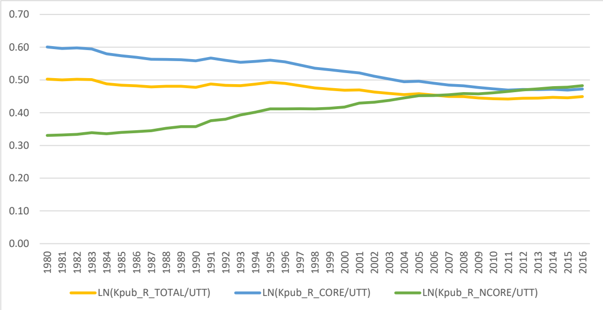
Graphs 9 and 10 reveal other relevant differences in the convergence path of Italy and Spain during 1980-2016. In particular, national public capital for core assets (Roads, Rails, Water, Land, Telecommunications, Energy) experienced an inter-regional convergence, while non-core assets (Buildings, Health, Waste) are characterized by the increase of Standard deviation due to dispersion in Buildings infrastructures. For Spain, the σ-convergence trends of Core and Non-core public capital are similar.

Finally, only Spain has a decreasing sigma value for human capital over the last 36 years.

[11] To analyze human capital convergence dynamic, we update Destefanis et al. (2004) series (see Appendix A).

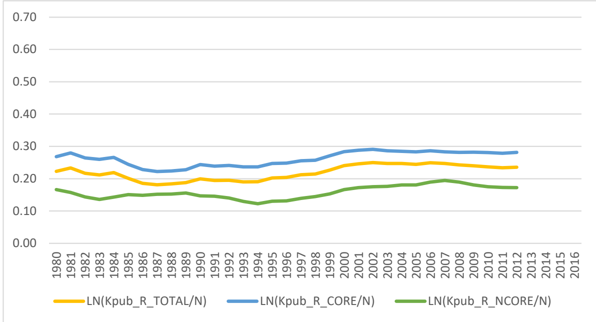
Graph 9. Dispersion of (log) public capital per worker across regions (1980-2016)

Italy



Data source: Own elaboration on Picci (2001) and CPT (https://www.contipubbliciterritoriali.it/CPTDE/catalogo/CPTDE_CatalogoCPT.html) and assuming the declining balance rate by IVIE (Perez et al., 2019) and the depreciation rate by EUKLEMS (https://euklems.eu/) for the geometric pattern of depreciation.

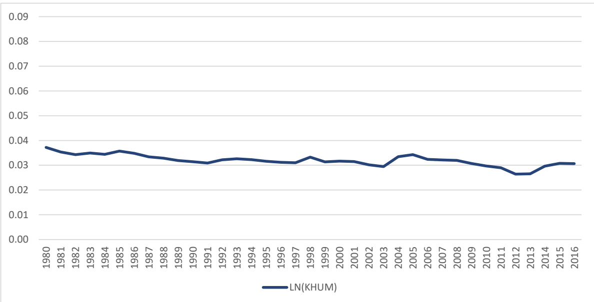
Spain



Data source: Own elaboration on IVIE (https://www.ivie.es/en_US/bases-de-datos/capitalizacion-y-crecimiento/series-historicas-de-capital-publico/) and BDMORES (https://www.sepg.pap.hacienda.gob.es/sitios/sepg/es-)

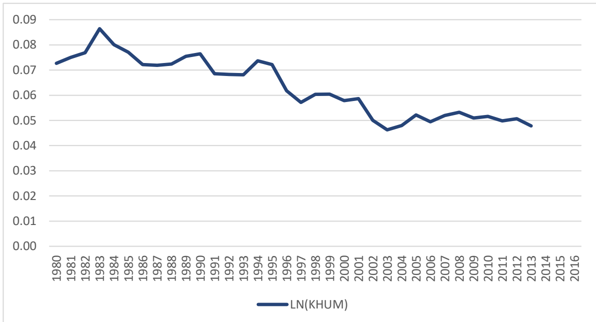
Graph 10. Dispersion of (log) human capital per worker across regions (1980-2016)

Italy



Data source: Destefanis et al. (2004), Istat (Annuario di statistiche del lavoro, Bollettino mensile di statistica, Censimento della popolazione).

Spain



Data source: Own elaboration on IVIE (https://www.ivie.es/en_US/bases-de-datos/capital-humano-y-desarrollo-humano/capital-humano/) and BDMORES (https://www.sepg.pap.hacienda.gob.es/sitios/sepg/es-)

3.2.3 Ranking regional attitude to convergence

In this section we plot regional taxonomy in capital per worker and convergence/divergence dynamics during 1980-2016. In the horizontal axis we consider initial per capital per worker and the vertical axis reports the annual average rate of capital per worker growth, both in relation to national average.

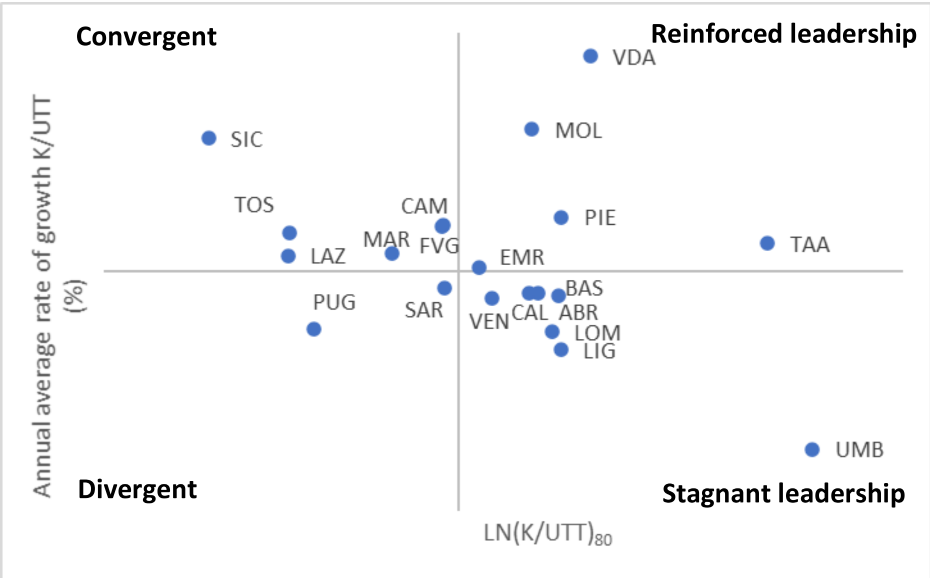
Four different quadrants are detached on the graphs.

In the top-right quadrant (quadrant I) of Graph 11 we find the *reinforced leaders* which have high initial capital per worker and improve their leadership by higher capital growth, while in the top-left (quadrant II) there are the *converging* regions with low initial level of capital per worker but higher capital growth rate than average. In the lower left quadrant (quadrant III) figure the regions with low initial per capita capital and low capital growth rates and in the lower right quadrant (quadrant IV) there are *stagnant leaders* which benefits by high initial capital per worker but have lower capital growth rates.

All the Spanish regions figured in the quadrant II and IV, revealing the converging process of all NUTS2 areas. For Italy, some diverging trends emerged for Northern regions of Aosta Valley, Piedmont, Trentino Alto Adige, the Central region of Emilia Romagna and the Southern Molise (Quadrant I) and for Southern Sardinia and Apulia (Quadrant III).

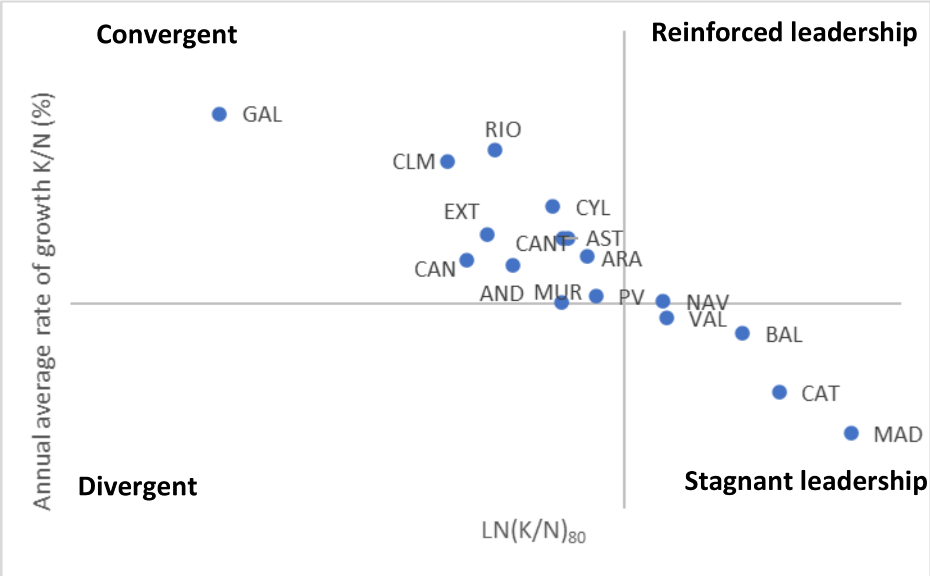
Graph 11. Regional deviation of (log) capital per worker (1980) and regional capital per worker annual growth rate (1980-2016) in relation to the national average.

Italy



Data source: Own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/)), Prometeia.

Spain



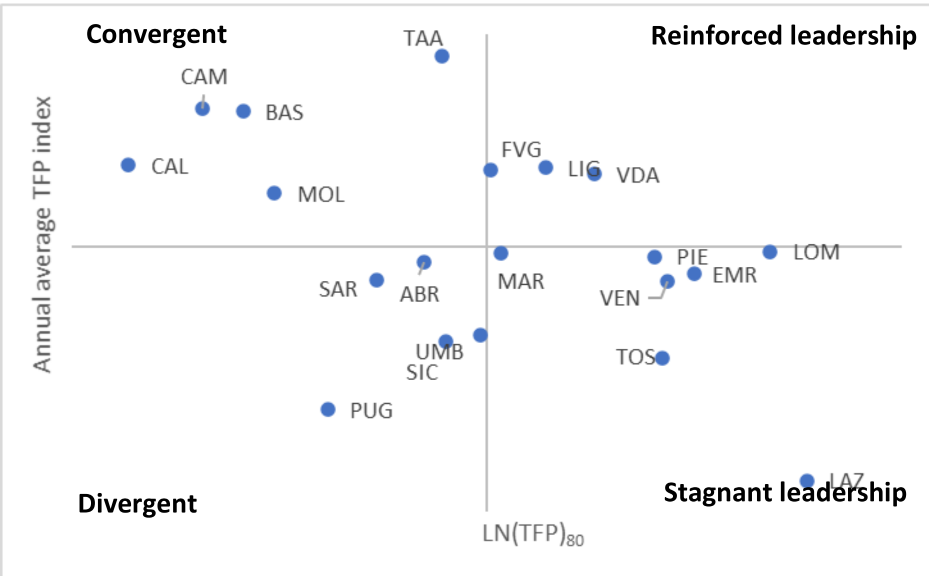
Data source: Own elaboration on IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/) and BDMORES (https://www.sepg.pap.hacienda.gob.es/sitios/sepg/es-

The same taxonomy analysis has been conducted for TFP dynamics.

For Italy, the Northern regions of Friuli Venezia Giulia, Liguria and Aosta Valley reinforced their leadership during 1980-2016 (Quadrant I), while Southern Abruzzo, Apulia, Sicily, Sardinia and the Central Umbria are divergent regions with low initial TFP and low annual average TFP index (Quadrant III). In Spain, Cataluna, Madrid Community and Balears Islands show higher TFP index with higher initial TFP and Galizia, Castilla y Leon and Castilla-La Mancha are diverging.

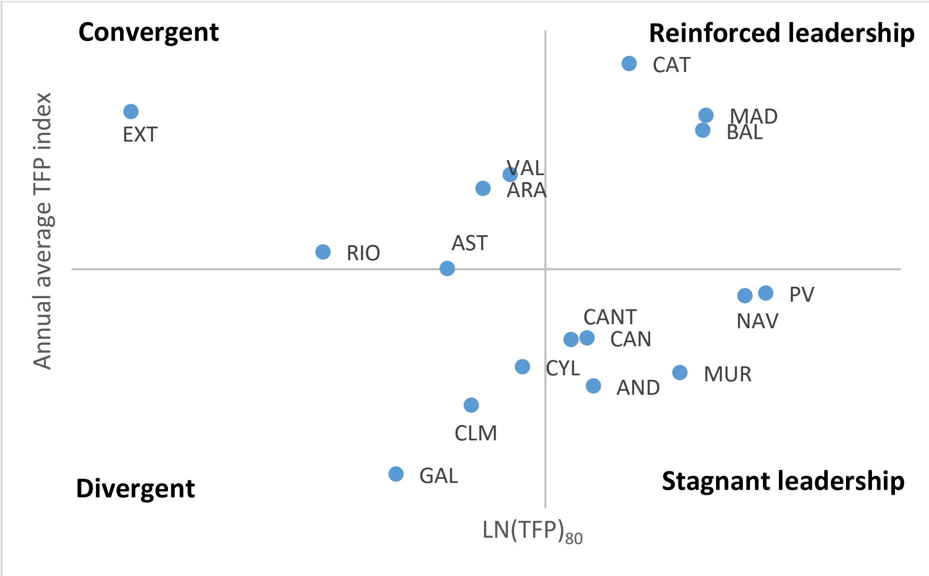
Graph 12. Regional deviation of (log) TFP (1980) and regional TFP annual growth rate (1980-2016) in relation to the national average.

Italy



Data source: Own elaboration on Picci (2001) and CPT (https://www.contipubbliciterritoriali.it/CPTDE/catalogo/CPTDE_CatalogoCPT.html) and assuming the declining balance rate by IVIE (Perez et al., 2019) and the depreciation rate by EUKLEMS (https://euklems.eu/) for the geometric pattern of depreciation.

Spain



Data source: Own elaboration on IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/) and BDMORES (https://www.sepg.pap.hacienda.gob.es/sitios/sepg/es-)

3.3 The impact of EU and national cohesion policies on TFP and GDP per capita

The previous section has highlighted that the process of convergence, both for capital per worker and TFP, has been stronger in Spain than in Italy. In this section we analyse the impact of EU and national cohesion policies on the convergence process in Italy and Spain during 1980-2016 adopting two different approaches.

First, we have updated and extended the analysis by Destefanis and Sena (2005), who considered the empirical long-run relationship between public capital and TFP across Italian regions. We now examine a more recent sample, we extend the analysis to the Spanish regions, and we consider other potential determinants of TFP, such as human capital and direct indicators of EU structural funds. We take up a panel for the 20 Italian regions and 17 Spanish regions (the autonomous communities of Ceuta and Melilla have been excluded because of the lack of relevant statistics) for the very long period 1980-2016. In this analysis, we benefit from i) the original series constructed for regional total capital (Section 1 of Chapter 3), ii) the new series for public capital (Chapter 2) and iii) the update of the series from Destefanis et al. (2004) for education attainment for the Italian regions.

More in detail, for Italy, the data on regional GDP, labour units and labour income have been taken from Prometeia. We consider the core public capital stock (Roads, Rails, Water, Land, Telecommunications and Energy). For Spain, regional GDP, labour units and labour income have been taken from BDMORES while the total, public and human capital series have been elaborated by IVIE. The core public capital for Spain includes Roads, Rails, Ports, Airports, Water and half of the Other assets. The variables are briefly described in Table 5.

Tab. 5. Summary statistics of variables used for the update and extension of Destefanis and Sena (2005) and legend of the equations

Variable	Description	Source	Country	Mean	Std. Dev.	Min	Max
tfp	(log) total factor productivity	Own elaboration	Italy	2.24	0.17	1.72	2.59
		Elaboration on IVIE and BDMORES data	Spain	2.26	0.11	1.74	2.50
funds_n	(log) ESIFs per worker	Historic EU payments by the EU Commission	Italy	-4.12	1.78	-10.91	-1.03
		Historic EU payments by the EU Commission[12]	Spain	-2.61	1.10	-6.66	-0.62
kpubc_n	(log) Core public capital per worker	Own elaboration	Italy	1.90	0.53	0.61	3.28
		IVIE	Spain	2.10	0.44	1.15	2.99
h	(log) Human capital	Own elaboration on Destefanis et al. (2004) update	Italy	2.34	0.15	1.98	2.60
		IVIE	Spain	2.18	0.19	1.75	2.54
ifl_y	(log) ratio of total investment expenditure over GDP	IVIE	Spain	-1.41	0.21	-2.05	-0.56
iflpub_y	(log) ratio of public investment expenditure over GDP	IVIE	Spain	-3.17	0.37	-4.42	-1.75
vquota_iss	Industry (value added) share	Own elaboration on BDMORES	Spain	0.22	0.08	0.06	0.43
alignment	Political alignment	Historic EU payments by the EU Commission	Spain	0.59	0.49	0.00	1.00

LEGEND OF THE EQUATIONS: Region and year fixed effects, or region-idiosyncratic trends, are always included in the estimates, and not shown in the interest of parsimony. The D. symbol stands for a first difference. R^2 is the coefficient of determination adjusted for degrees of freedom not inclusive of the effect of region and year fixed effects, Rss is the residual sum of squares. A-B is the Arellano-Bond test for serial correlation present at lags one and two C-W is the Cook-Weisberg test for heteroskedasticity, R is the Reset test for functional form and omitted variables (carried out including quadratic terms of fitted values).

We estimate the following equation:

$$\mathrm{D.tfp}_{rt} = a_1 \mathrm{tfp}_{rt-1} + a_2 \mathrm{funds\_n}_{rt-1} + a_3 \mathrm{D.kpubc\_n}_{rt} + a_4 \mathrm{kpubc\_n}_{rt-1} + a_5 \mathrm{D.h}_{rt} + a_6 \mathrm{h}_{rt-1} + + a_{7j} W_{rt-1} + a_r + a_t + \varepsilon_{rt} \qquad [12]$$

Where r = 1,…, 20 refers to regions; t = 1,…, n refers to years. Variables a_r and a_t are region and year fixed effects respectively; ε_{rt} is the customary independent and identically distributed (i.i.d.) error term. We consider an ARDL specification, broadly consistent with the analysis in Destefanis and Sena (2005). The dependent variable $\mathrm{D.tfp}_{rt}$ is the (log) variation of TFP; then we include as regressors the lagged dependent

[12] https://cohesiondata.ec.europa.eu/Other/Historic-EU-payments-regionalised-and-modelled/tc55-7ysv

variable $\mathrm{tfp}_{\mathrm{rt}-1}$ and the variations and lagged levels of kpubc_n (the log of core public capital per worker) and h (the log of human capital, measured as years of educational attainment[13]). $\mathrm{funds}_{\mathrm{jrt}}$ refers to the European SFs. In the exercise below we will take the ERDF for Italy[14] and the sum of ERDF plus Cohesion fund for Spain. Finally, as In Coppola et al. (2018), we include a vector of $\mathrm{W}_{\mathrm{rt}-1}$ variables presiding over the regional allocation of funds[15], with a view to control for the role of fund assignment (Wooldridge, 2004). In particular, we adopt the relevant $\mathrm{W}_{\mathrm{rt}-1}$variables described in Table 21 of Chapter 2 for Italy, and Table 6 shows the results for the auxiliary regressions selecting the relevant $\mathrm{W}_{\mathrm{rt}-1}$variables for Spain. The results from specifications estimated without the vector $\mathrm{W}_{\mathrm{rt}-1}$ are reported in the Appendix B.

Specifications in Table 6 only include regressors that have a t-ratio above one, or that are instrumental in getting good diagnostics, as required by the application of this control function approach (Wooldridge, 2004). Indeed, we find satisfactory diagnostics for all regressions. We have less variables than in the case of the Italian estimates, and accordingly provide specifications with and without region-idiosyncratic trends to gain further knowledge about the allocation mechanism. These trends seem to add significantly to the explanation of the fund assignment and thus we keep them in our W vector. We find rather strong complementarities among policy funds, and between the latter and investment expenditure. Policy funds are not countercyclical, and we find little role for sectoral shares. Political variables have a very marginal effect.

Tab. 6. European Union (EU) and national cohesion funds, nationally funded current account subsidies, nationally funded capital account expenditures and auxiliary regressions for the fund-allocation mechanism in Spain.

		Without trends		With trends	
		D.(EU funding)	D.(Public Investment Expenditure)	D.(EU funding)	D.(Public Investment Expenditure)
Regressors	funds_y (t-1)	0.4963 (0.00)	0.0288 (0.16)	0.4301 (0.00)	0.0272 (0.21)
	ifl_y (t-1)		0.1246 (0.09)		0.1954 (0.07)
	iflpubb_y (t-1)	0.2139 (0.03)	0.5365 (0.00)	0.2919 (0.03)	0.3832 (0.00)
	vquota_iss (t-1)		1.7215 (0.20)		
	vquota_cos (t-1)	-4.6605 (0.04)			
	alignment (t-1)		0.0144 (0.32)		0.0213 (0.15)
	lpul_ser (t-1)				-0.9686 (0.06)

[13] For Italy,

$$h = 5 * \left(\frac{\text{employees with no formal or primary education}}{\text{Total employees}}\right) + 8 * \left(\frac{\text{employees with lower secondary education}}{\text{Total employees}}\right) + 13.5 * \left(\frac{\text{employees with upper secondary education}}{\text{Total employees}}\right) + 18.5 * \left(\frac{\text{employees with tertiaty education}}{\text{Total employees}}\right)$$

[14] Estimation of a similar equation in Coppola et al. (2021) reveals that the European Regional Development Fund (ERDF) is by far the most effective of all EU funds.

[15] As in Coppola et al. (2018), W_{it-1} includes lags of SF_{jit} or Nat_{jit}, GDP per capita and gross fixed investment; measures of regional female rates of unemployment and sectoral shares of employment and value added; and politically based indicators (political orientation of each regional government and alignment of the political orientation of each regional government with the national government). We assume that funds can react only with delay to changes in the economic or political environment.

Number of observations	457	391	457	391
RSS	49.4213	9.0477	46.8270	8.0146
R^2	0.35	0.37	0.44	0.45
A-B	0.62	0.15	0.48	0.22
C-W	0.67	0.17	0.56	0.90
R	0.12	0.20	0.22	0.17

Note: D. () are log variations. P value of t-ratios are shown in parentheses.

Table 7 presents the main results for Italy and Spain which validate the descriptive evidence from the β- and σ-convergence results. In fact, only in Spain core public capital and human capital affect TFP in differences and in levels. This means that these regressors influence the steady state of TFP in Spain, thus achieving a stronger convergence process. In Italy, core public capital and human capital only affect TFP in differences, which means that they cannot influence the steady-state *level* of TFP.

Tab. 7. Impact of ESIFs, public and human capital on TFP with W_{rt-1} [16]

d.TFP (dependent variable)	Italy				Spain			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L1.TFP	-0.2658	-0.1843	-0.2613	-0.2544	-0.2331	-0.1919	-0.2835	-0.2428
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)
L1. funds_n	0.0021		0.0022	0.0024	0.0000		0.0008	-0.0028
	(0.03)		(0.02)	(0.00)	(0.99)		(0.71)	(0.20)
D1. kpubc_n		0.1121		0.0831		0.3507		0.3266
		(0.01)		(0.07)		(0.00)		(0.00)
L1. kpubc_n		0.0035		-0.0214		0.0286		0.0799
		(0.84)		(0.18)		(0.05)		(0.00)
D1.h		0.5645	0.4351	0.4493		0.0791	0.0747	0.0302
		(0.00)	(0.02)	(0.01)		(0.35)	(0.28)	(0.57)
L1.h		0.1792	-0.1265	-0.1175		0.1231	0.0356	0.1028
		(0.09)	(0.35)	(0.38)		(0.09)	(0.62)	(0.23)
N	560	720	560	560	458	544	407	390
rss	0.0725	0.11	0.0712	0.0698	0.0606	0.1263	0.0529	0.0367

Note: P value of t-ratios are shown in parentheses.

On the other hand, EU Funds are significant in Italy and not in Spain. Our interpretation, consistent with some literature (de la Fuente and Vives, 1995; de la Fuente, 2003), is that in Spain ESIFs work out their effect entirely through public capital and human capital, while in Italy they have an extra impact on TFP (because, for instance, of a relative better management of funds vis-à-vis national funds, as explained in Coppola et al. (2018).

In order to acquire further knowledge upon the role of European structural funds and of national funds in the convergence process, we extend and update the study in Coppola et al. (2018) of GDP per capita determination to both Italian and Spanish regions over 1993-2016. To that purpose, we use additional data which are briefly described in Table 8.

[16] Appendix B reports the impact of ESIFs, public and human capital on TFP without W_{rt-1}

Tab. 8. Summary statistics of variables used for the update and extension of Coppola et al. (2018) and legend of the equations

Variable	Country	Definition	Source	Mean	Std. Dev.	Min	Max
y	Italy	(log) GDP per capita	Own elaboration on Prometeia	3.21	0.27	2.66	3.62
	Spain		BDMORES	2.91	0.29	1.90	3.49
pop	Italy	(log) population	Prometeia	7.56	1.06	4.76	9.21
	Spain		BDMORES	7.42	0.90	5.53	9.04
ifl	Italy	(log) ratio of total gross fixed investment over GDP	Own elaboration (Section 3.1)	-1.57	0.18	-1.99	-1.08
	Spain		BDMORES	-1.41	0.21	-2.05	-0.56
iflpriv	Italy	(log) ratio of private gross fixed investment over GDP	Own elaboration	-1.66	0.19	-2.15	-1.14
	Spain		BDMORES	-1.62	0.24	-2.31	-0.62
iflpub	Italy	(log) ratio of public gross fixed investment over GDP	Own elaboration (Section 2.3)	-4.19	0.47	-5.61	-2.68
	Spain		BDMORES	-3.17	0.37	-4.42	-1.75
erdf	Italy	(log) ratio of ERDF funds over GDP	Historic EU payments by the EU Commission[17]	-6.79	1.23	-9.21	-3.52
funds_y	Spain	(log) ratio ESIFs per over GDP	Historic EU payments by the EU Commission	-5.61	1.21	-9.72	-3.38

LEGEND OF THE EQUATIONS: Region and year fixed effects, or region-idiosyncratic trends, are always included in the estimates, and not shown in the interest of parsimony. The D. symbol stands for a first difference. R^2 is the coefficient of determination adjusted for degrees of freedom not inclusive of the effect of region and year fixed effects, Rss is the residual sum of squares. A-B is the Arellano-Bond test for serial correlation present at lags one and two C-W is the Cook-Weisberg test for heteroskedasticity, R is the Reset test for functional form and omitted variables (carried out including quadratic terms of fitted values).

We estimate the following equation, whose dynamic structure comes from a general-to-specific search:

$$D.y_{rt} = a_1 y_{rt-1} + a_2 D.pop_{rt} + a_3 D.h_{rt} + a_4\, h_{rt-1} + a_{5j} gfi_{jrt-1} + a_6 funds_{rt} + a_7 W_{rt-1} + a_{8r}\, trend_{rt} + a_r + a_t + \varepsilon_{rt} \qquad [13]$$

Where r = 1,…, 20 refers to regions; t = 1,…, n refers to years; and j = 1,…, m refers to the type of gross fixed investment being considered. Variables a_r and a_t are region and year fixed effects respectively; $trend_{r,t}$are region-idiosyncratic linear trends, and ε_{rt} is the customary independent and identically distributed (i.i.d.) error term. The dependent variable $D.y_{rt}$ is the (log) variation of 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 (log) ratio of gross fixed investment over GDP and the (log) variation of population respectively. As hinted above, we consider various types of gross fixed investment: total (computed in the first section of Chapter 3),

[17] https://cohesiondata.ec.europa.eu/Other/Historic-EU-payments-regionalised-and-modelled/tc55-7ysv

private[18] and public[19]. $\text{funds}_{\text{jrt}}$ refers to the European SFs. As in the previous exercise below we will take the ERDF for Italy and the sum of ERDF plus Cohesion fund for Spain. We estimate specifications with and without region-idiosyncratic linear trends, which are used as controls for time-varying unobserved heterogeneity. We also extend upon Coppola et al. (2018), by including in [13] the variations and lagged levels of educational attainment (the same variable that was already included in [12]). As already done in equation [12], we control for the role of fund assignment, including in the equation a vector of $\text{W}_{\text{rt}-1}$ variables presiding over the regional allocation of funds. These variables are indeed the same that were already used for equation [12]. Table 9 sums up the main results of this empirical exercise.

Tab. 9. Impact of private, public, national and EU investments and human capital on GDP per capita growth (with the vector $\text{W}_{\text{rt}-1}$) [20].

Italy

D.ly (dependent variable)	Without trends			With trends		
	(1)	(2)	(3)	(4)	(5)	(6)
L1. ly	-0.1400	-0.1402	-0.2471	-0.2612	-0.2622	-0.2471
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
D1. pop	-1.0523	-1.0532	-1.7146	-1.5140	-1.4984	-1.7146
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)
D1.h	0.4238	0.4202	0.3949	0.3283	0.3238	0.3949
	(0.10)	(0.10)	(0.22)	(0.35)	(0.36)	(0.22)
L1.h	-0.2266	-0.2321	-0.2404	-0.3208	-0.3337	-0.2404
	(0.06)	(0.05)	(0.35)	(0.32)	(0.31)	(0.35)
L1.gfi	0.0239			0.0231		
	(0.01)			(0.13)		
L1. iflpriv		0.0194	0.0095		0.0171	0.0095
		(0.02)	(0.47)		(0.18)	(0.47)
L1. iflpub			0.0034			0.0033
			(0.07)			(0.07)
erdf	0.0038	0.0037	0.0035	0.0032	0.0032	0.0035
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
N	440	440	440	440	440	440
rss	0.0650	0.0652	0.0678	0.0593	0.0595	0.0578

Note: P value of t-ratios are shown in parentheses.

[18] Following Marrocu and Paci (2008, p.4) "the private component has been obtained as the difference between total and public investments". The elaboration of total investment series is described in Section 3.1 and the elaboration of public investment series is described in Section 2.3.2.

[19] For Spain, data on gross fixed investments are from BDMORES. For Italy, we consider the public investment series elaborated in Section 2.3.

[20] Appendix C reports the impact of private, public, national and EU investments and human capital on GDP per capita growth without the vector $\text{W}_{\text{rt}-1}$

Spain

D.ly (dependent variable)	Without trends			With trends		
	(1)	(2)	(3)	(4)	(5)	(6)
L1. ly	-0.0033	-0.0012	-0.0063	-0.0700	-0.0682	-0.0285
	(0.86)	(0.95)	(0.64)	(0.15)	(0.16)	(0.68)
D1. pop	-0.8935	-0.8942	-1.0273	-0.8677	-0.8663	-1.0637
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L1.h	0.0524	0.0550	0.0369	0.0839	0.0843	0.0646
	(0.20)	(0.18)	(0.43)	(0.28)	(0.28)	(0.30)
L1.ifl	0.0089			0.0080		
	(0.09)			(0.27)		
L1. iflpriv		0.0053	0.0035		0.0026	0.0024
		(0.13)	(0.40)		(0.63)	(0.73)
L1. iflpub			0.0082			0.0078
			(0.00)			(0.00)
L1. funds	-0.0023	-0.0022	-0.0034	-0.0016	-0.0016	-0.0026
	(0.14)	(0.16)	(0.06)	(0.32)	(0.33)	(0.19)
N	407	407	340	407	407	340
rss	0.0348	0.0350	0.0204	0.0329	0.0331	0.0207

Note: P value of t-ratios are shown in parentheses.

The regressions from Table 9 highlights again (as in Table 7) a strong independent role for ESIFs in Italy but not in Spain. On the other hand, the measures of public investment are very significant in Spain and only marginally significant in Italy. We do not find a consistent role for human capital in either country. Once more, one gets the impression that in Spain ESIFs work out their effect entirely through public capital, while in Italy they have an extra impact on TFP, which can be rationalized in terms of a better management of EU funds vis-à-vis nationally funded policies.

3.4 Concluding remarks

This chapter describes the methodology adopted to construct the long up-to-date investment and capital series over 1970-2016 for Italian regions using a state-of-the-art approach in line with OECD (2009) recommendations. This new tool is then used to investigate productive capacities disparities and convergence dynamics for Italian and Spanish regions over nearly the last half century. This comparative approach reveals some interesting characteristics of the capital accumulation process in the two countries.

In fact, there is β-convergence on Italian and Spanish regional data in capital per worker and TFP per capita for 1980-2016, but the convergence process seems to be stronger in Spain. What is more, σ-convergence shows the impressive reduction of dispersion experienced by the Spanish regions over the same period in terms of capital per worker, TFP, and human capital. The same reduction cannot be found for Italian regions. A subsequent regional taxonomy on capital per worker and TFP is used to classify the regional growth process over 1980-2016, showing the divergent situation for many Southern Italian regions.

Finally, in two different empirical exercises we update and extend the analyses of Destefanis and Sena (2005) and Coppola and al. (2018) to investigate the effectiveness of cohesion policies. We find that in Spain, unlike in Italy, cohesion policies affect the steady-state level of TFP. Furthermore, we find that ESIFs – including EFDR and the Cohesion Fund - work out their effect entirely through public capital and human capital, while in Italy they have an extra impact on TFP and GDP per capita. Apparently, Spain has completely internalised the impact of Cohesion Policy, by infrastructure endowment and worker education improvement. On the contrary, the Structural Funds have an extra effect in Italy which is not captured by public and human capital dynamics, likely because of the better management of EU funds vis-à-vis nationally funded policies.

Appendix A. Updating human capital series following Destefanis et al. (2004)

According to Destefanis et al. (2004), the interpolating procedure adopted to construct the human capital series using two sources of data, one with higher (annual) frequency, but less detailed, and another one (from census data) much more detailed, but only available at ten-years intervals, can be summarized by the following step.

Step 1: Using data of the Annuario di statistiche del lavoro and the Bollettino mensile di statistica on the annual number of employees by gender, level of education for 3 macro-sectors (Agriculture, Industry and Services) and 3 geographic areas (Northern, Central and Southern Italy) from 1970 to 2016, we construct a ratio dividing the elementary data by the total of the Italian employees, obtaining the **Interpolating Value** by gender, level of education, macro-sector and geographic area. Then these ratios have been multiplied by a total of Italian employees which allows for the methodological breaks made by ISTAT during the period under analysis. In this way we obtain our annual estimates of employees by gender, level of education, macro-sector and geographic area.

Step 2: Using census data disaggregated by gender, level of education, 8 sectors (Agriculture, Energy, Manufacturing, Construction, Trade, Transport and Communication, Finance and Insurance, Others) and 20 regions, the number of employees has been divided by the annually available data (disaggregated by gender, level of education, macro-sector and geographic area) that were more akin to them.

In order to enact this step, we have considered the data on employees by gender, level of education, sector and administrative region, from the *Censimento della Popolazione* (Census of the Population), years 1971, 1981, 1991, 2001, 2011, obtaining the **Interpolated Value** (IV).
For census year t:

$$IV_{region,sector,t} = \left(\frac{N^{census}_{region,sector}}{N^{census}_{area,macro-sector}}\right)_t$$

Where $N^{census}_{region,sector}$ is the census data of the number of employees disaggregated by gender, level of education, sector, region.

Step 3: The ratios computed in Step 2 have been linearly interpolated from one census year to the next in order to calculate the interpolated data

For year t, with t' < t < t'' and t' and t'' census years

$$IV_{region,sector,t} = \left(\frac{N^{census}_{region,sector}}{N^{census}_{area,macro-sector}}\right)_{t-1} + \frac{\left(\left(\frac{N^{census}_{region,sector}}{N^{census}_{area,macro-sector}}\right)_{t''} - \left(\frac{N^{census}_{region,sector}}{N^{census}_{area,macro-sector}}\right)_{t'}\right)}{10}$$

Where $N^{census}_{region,sector}$ is the census data of the number of employees disaggregated by gender, level of education, sector, region.

For year t, with t > 2011 and t' < t'' < t

$$IV_{region,sector,t} = \left(\frac{N^{census}_{region,sector}}{N^{census}_{area,macro-\ sector}}\right)_{t-1} + \frac{\left(\left(\frac{N^{census}_{region,sector}}{N^{census}_{area,macro-\ sector}}\right)_{t''} - \left(\frac{N^{census}_{region,sector}}{N^{census}_{area,macro-sector}}\right)_{t'}\right)}{10}$$

Step 4: Finally, the annual number of employees (N) for 8 sectors and 20 regions has been calculated multiplying the interpolating data (Step 1) by the interpolated data (Step 3), obtaining annual estimates of the number of employees disaggregated by gender, level of education, 8 sectors, 20 regions for the period 1970-2016.

By gender, level of education, 8 sectors

$N_{region,sector,t} = N^{annual}_{area,macro-sector} * IV_{region,sector,t}$

Where $N^{annual}_{area,macro-sector}$ is the annual data of the number of employees disaggregated by gender, level of education, macro-sector, area.

Appendix B

Impact of ESIFs, public and human capital on TFP without W_{rt-1}

d.TFP (dependent variable)	Italy				Spain			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L1.TFP	-0.1482	-0.0850	-0.1465	-0.1346	-0.0999	-0.1009	-0.1057	-0.1013
	(0.00)	(0.00)	(0.00)	(0.00)	(0.05)	(0.00)	(0.10)	(0.10)
L1. funds_n	0.0023		0.0023	0.0023	-0.0002		-0.0010	-0.0062
	(0.02)		(0.02)	(0.02)	(0.90)		(0.59)	(0.01)
D1. kpubc_n		0.1060		0.1210		0.3658		0.3395
		(0.01)		(0.01)		(0.00)		(0.00)
L1. kpubc_n		-0.0000		0.0072		0.0184		0.0393
		(0.99)		(0.35)		(0.04)		(0.14)
D1.h		0.6207	0.5133	0.5060		0.1142	0.0924	0.0121
		(0.00)	(0.01)	(0.01)		(0.20)	(0.47)	(0.87)
L1.h		0.1245	-0.0004	-0.0189		0.1534	0.0606	0.0803
		(0.02)	(1.00)	(0.83)		(0.01)	(0.37)	(0.26)
N	560	720	560	560	458	544	407	390
rss	0.0823	0.1189	0.0810	0.0790	0.0764	0.1377	0.0723	0.0517

Note: P value of t-ratios are shown in parentheses.

Appendix C.

Impact of private, public, national and EU investments and human capital on GDP per capita growth (without the vector W_{rt-1}).

Italy

D.ly (dependent variable)	Without trends			With trends		
	(1)	(2)	(3)	(4)	(5)	(6)
L1. ly	-0.1382	-0.1401	-0.2438	-0.2479	-0.2527	-0.2438
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
D1. pop	-1.0157	-0.9788	-1.2598	-1.2722	-1.2190	-1.2598
	(0.00)	(0.00)	(0.06)	(0.06)	(0.07)	(0.06)
D1.h	0.4718	0.4604	0.4200	0.4482	0.4292	0.4200
	(0.03)	(0.04)	(0.14)	(0.10)	(0.13)	(0.14)
L1.h	-0.2046	-0.2245	-0.2376	-0.2022	-0.2530	-0.2376
	(0.05)	(0.03)	(0.37)	(0.45)	(0.36)	(0.37)
L1.ifl	0.0243			0.0216		
	(0.01)			(0.17)		
L1. iflpriv		0.0127	0.0147		0.0066	0.0147
		(0.08)	(0.27)		(0.56)	(0.27)
L1. iflpub			0.0038			0.0038
			(0.05)			(0.05)
erdf	0.0038	0.0037	0.0031	0.0031	0.0030	0.0031
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
N	440	440	440	440	440	440
rss	0.0662	0.0670	0.0606	0.0608	0.06138	0.0606

Note: P value of t-ratios are shown in parentheses.

Spain

D.ly (dependent variable)	Without trends			With trends		
	(1)	(2)	(3)	(4)	(5)	(6)
L1. ly	-0.0296	-0.0263	-0.02303	-0.2109	-0.2096	-0.2058
	(0.43)	(0.47)	(0.46)	(0.03)	(0.03)	(0.03)
D1. pop	-0.8714	-0.8658	-0.8624	-0.7138	-0.7064	-0.7145
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L1.h	0.0803	0.0855	0.0770	0.0512	0.0511	0.0684
	(0.10)	(0.08)	(0.12)	(0.62)	(0.62)	(0.50)
L1.ifl	0.0102			0.0166		
	(0.06)			(0.04)		

L1. iflpriv		0.0039	0.0054		0.0059	0.0093
		(0.32)	(0.14)		(0.27)	(0.14)
L1. iflpub			0.0092			0.0118
			(0.07)			(0.00)
L1. funds	-0.0026	-0.0023	-0.0036	-0.0015	-0.0013	-0.0026
	(0.09)	(0.11)	(0.03)	(0.33)	(0.39)	(0.12)
N	424	424	424	424	424	424
rss	0.0588	0.0592	0.0581	0.0464	0.0470	0.0457

Note: P value of t-ratios are shown in parentheses.

Appendix D. From investment to capital stock: evidence from a comparative analysis between Italy and Spain.

The present comparative approach among Italy and Spain which figured with similar size, economic structure, and relevant productive fragilities, depicts nearly five decades of significant economic growth stopped by the last deep and pervasive crisis which has affected structural potentialities. Therefore, the capital accumulation cross-country analysis may disclose strategic perspectives to emerge from the current stagnation.

The appendix is organised as follows. Section 1 analyses the trend of investment flows of Italy and Spain during the last 46 years by asset and economic sector and Section 2 widens the in-depth comparative analysis to capital endowment. Section 3 concludes with insights on the capital accumulation process.

1. Comparing Italian and Spanish investments[21]

This section analyses the Italian and Spanish investments patterns during 1970-2016 using the own elaborations on Istat, Eurostat and EUKLEMS data for Italy just explained, and Fundacion BBVA and IVIE statistics for Spain.

In particular, the publicly available database of Fundacion BBVA-IVIE on investment and capital[22] covers the period 1964-2016, for 19 assets and 31 NACE Rev. 2 economic sectors at national level, for 19 assets and 25 economic sectors for the autonomous communities and 15 economic sectors for the provinces. Moreover, the database updates the contribution of productive capital and provides statistics on assets, including R&D expenditure.

The very long period analysed in this appendix has been characterized by the alternation of expansion and depression (in particular, 1991-1994 and 2007-2013) phases which have cyclically affected the two countries investments with many similarities and some specific differences.

The Section investigates aggregate investment in nominal and real terms, investment by asset and investment by sector. Some considerations on net investments are also presented.

1.1 Evolution of aggregate gross investment

The comparative analysis between Italy and Spain starts from nominal investments which represents the core elementary data for all economies, defining both the long profile of relevant macroeconomic variables such as Gross Domestic Product (GDP) and employment, and the national capital endowment affecting the productive capacity of the country.

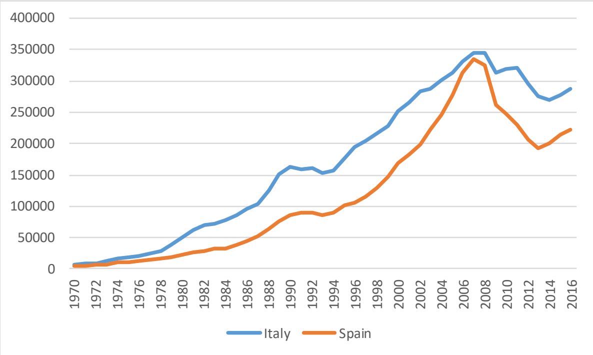
According to Graph A1, the two countries reveal an increase in nominal investments during the 46 years considered, with Italian investments larger than Spanish. Notice that during the 1995-2007 expansion investments in Spain increased more and the gap among the two countries gradually declined until the start

[21] The structure of this section on investment and the next on capital reproduces the scheme adopted in Perez et al. (2019).
[22] http://www.fbbva.es/TLFU/microsites/stock09/fbbva_stock08_index.html

of the recent economic crisis. After 2007, the nominal differences turn relevant. From 2013 in Spain and 2014 in Italy, nominal investments reverse the trend and start growing.

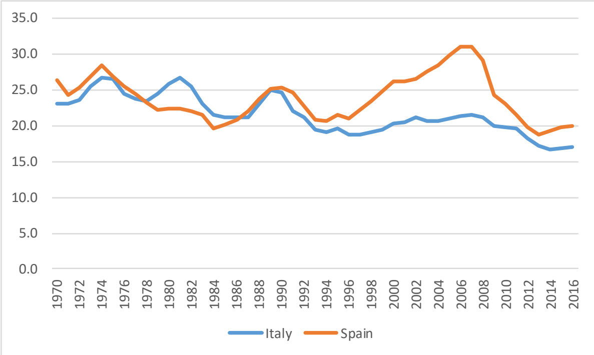
Despite the rise of nominal investments during 1970-2016, the relative share to GDP (Graph A2) decreases in Italy from 23.1% to 17.1%, highlighting a first relevant weakness in the national productive capacity and further potentialities. For Spain, although the contribution of investments characterized the years 1995-2007 of economic growth, the relative share of investments during the last recession sharply falls, indicating a more volatile and cyclical trend of nominal investments with a rate of 20% in 2016.

Graph A1. Aggregate current investments, 1970-2016 (Mln euro). Italy and Spain



Data source: For Italy, own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/); for Spain, IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/)

Graph A2. Aggregate current investments, 1970-2016 (% GPD). Italy and Spain

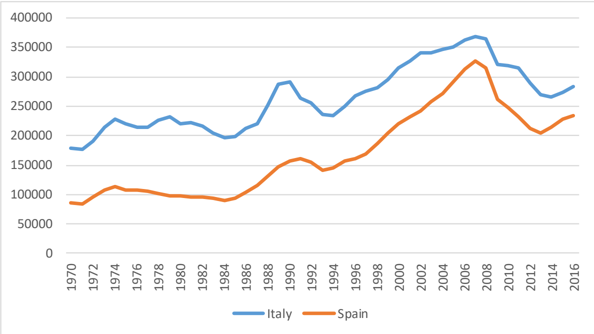


Data source: For Italy, own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/); for Spain, IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/)

In real terms the growth of investments has been less pronounced compared to nominal investments particularly before 2007, while in the last years the low inflation, which characterized the recent crisis, has contributed to similar trends for nominal and real investments. However, the constant investments are still far from pre-crisis levels for both Italy and Spain. Finally, according to Graph A3, the gap among Spanish and Italian constant investments gradually decreases from 2013.

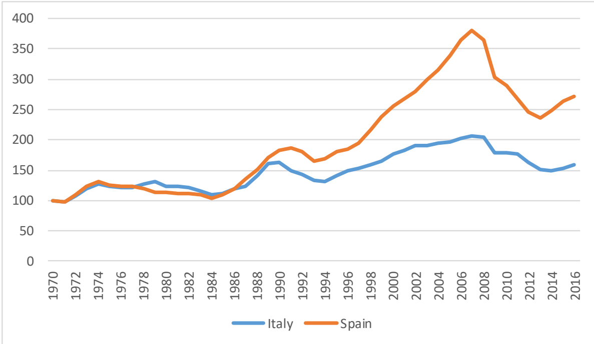
The declining difference is confirmed by Graph A4 that shows the very impressive increase of Spanish investments. In fact, the index of real investments grew up from 100 in 1970 to 272 in 2016, despite the relevant recent fall. The Spanish higher investments elasticity relative to GDP observed in nominal terms is confirmed in real data. For Italy, the index is just equal to 159 in 2016. The higher volatility of Spanish investment is even more noticeable in real than in nominal terms.

Graph A3. Aggregate constant investments, 1970-2016 (Mln euro, base 2010). Italy and Spain



Data source: For Italy, own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/); for Spain, IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/)

Graph A4. Aggregate constant investments, 1970-2016 (1970=100). Italy and Spain



Data source: For Italy, own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/); for Spain, IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/)

1.2 Gross investment by asset

The distribution of investments among the different assets affects the capital contribution to the economic growth in the long term. For instance, investments in buildings - in particular residential - improve housing services as a component of the macroeconomic component of consumption. Furthermore, buildings are capital goods preserving wealth, offering the possibility to obtain collaterals and support losses. In that perspective, housing "passively" affects growth. Other assets contribute directly and consistently to the productive process such as ICT, machineries, transport materials, and others.

In order to investigate on Italian and Spanish investment specificities by asset we adopt the following correspondence table for asset classes (Table A1).

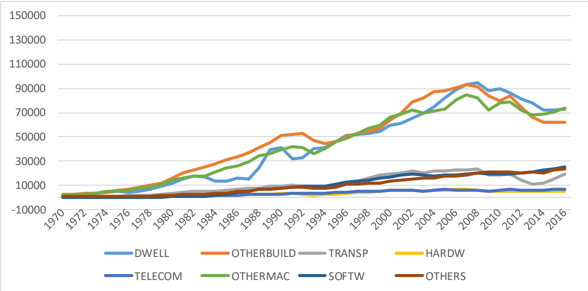
Table A1. Correspondence table for IVIE asset classification

	Dwellings (1.1)	Other buildings and structures (1.2)	Transport equipment (1.3)	Metal products (1.4.1)	Machinery and mechanical equipment (1.4.2)	Computer hardware (1.4.3)	Telecommunication equipment(1.4.4.1)	Other machinery and equipment and weapons systems (1.4.4.2)	Cultivated biological resources (1.5)	Computer software and databases (2.1)	Research and development (2.2)
DWELLINGS	X										
OTHERBUILD		X									
TRANSP			X								
HARDW						X					
TELECOM							X				
OTHERMAC				X	X			X			
SOFTW										X	
OTHERS									X		X

Graphs A5 and A6 show the current investments trend by asset during 1970-2016 for Italy and Spain and graphs A7 and A8 illustrate the relative share of each asset. Notice that the cyclical performance of nominal investments can be mostly attributed, in particular in Spain, to Total Buildings (Dwellings and Other buildings), the most relevant asset in both countries (46% of Italian current investments in 2016 and 50% for Spain) even if the relative share of this low-tech asset class sharply declined during the last 46 years.

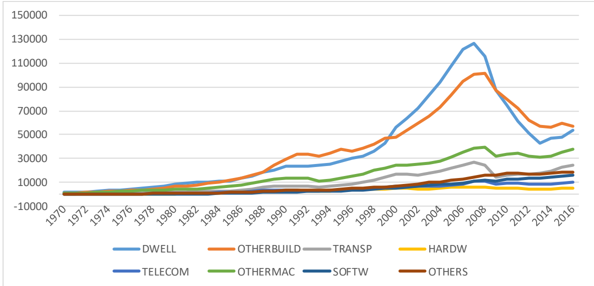
In Italy, even investments in Other machinery reveal a significant pro-cyclical trend. Moreover, the crisis that affected the Real estate sector during 1984-1987 in the country – defined as the "brick nausea" - emerges in Graph A7.

Graph A5. Current investments by asset, 1970-2016 (Mln euro). Italy



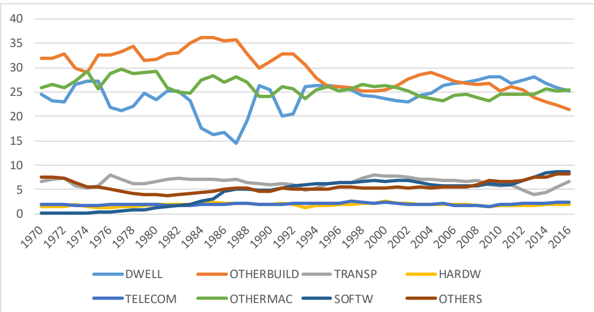
Data source: Own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/).

Graph A6. Current investments by asset, 1970-2016 (Mln euro). Spain



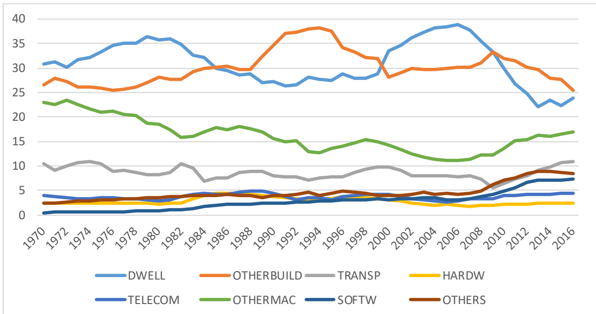
Data source: IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/)

Graph A7. Current investments by asset, 1970-2016 (% of total). Italy



Data source: Own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/).

Graph A8. Current investments by asset, 1970-2016 (% of total). Spain



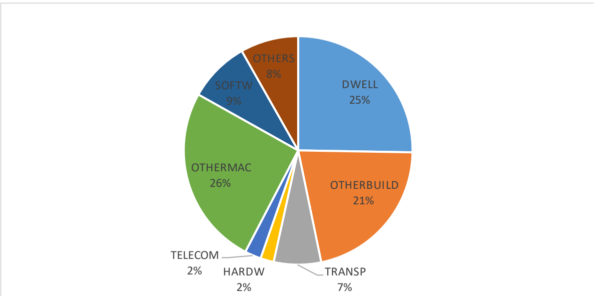
Data source: IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/)

Graph A9 and A10 show most similarities and some differences on investments composition by asset in 2016. In particular, for the two countries the main asset classes covering all together more than 2/3 of total investments are Other machinery (26% in Italy and 17% in Spain, in 2016), Dwellings (25% in Italy and 24% in Spain) and Other Buildings (21% in Italy and 26% in Spain). However, Spain is characterized by higher shares of Transport equipment (11% in Spain and 7% in Italy) and Telecommunication asset (5% in Spain and 2% in Italy), and Italy shows a higher contribution of Software asset (9% in Italy and 7% in Spain).

According to Perez et al (2019), the productivity fragility of a country can be connected mostly to three main drivers. The first cause can be attributed to the higher share of housing activities and the relative lower share of technological and immaterial asset. The second reason is the higher relevance of buildings activities and the third is the limited contribution to the potential production in term of the investment share on GDP.

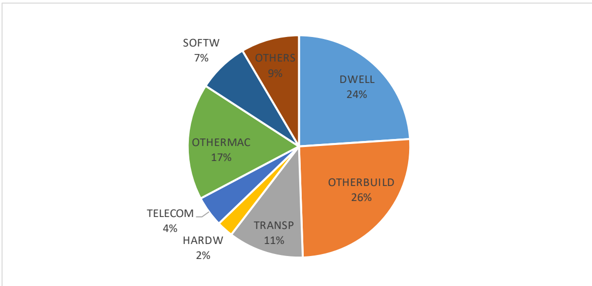
In that perspective, the comparative analysis reveals that the contribution of investments in Dwellings is similar in both countries; that Italy has a lower share of Other buildings and a higher share of Software which is the most relevant immaterial asset and that both, Italy and Spain invest a decreasing share of GDP, notably since the beginning of the crisis.

Graph A9. Investments by asset, 2016 (% of total). Italy



Data source: Own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/).

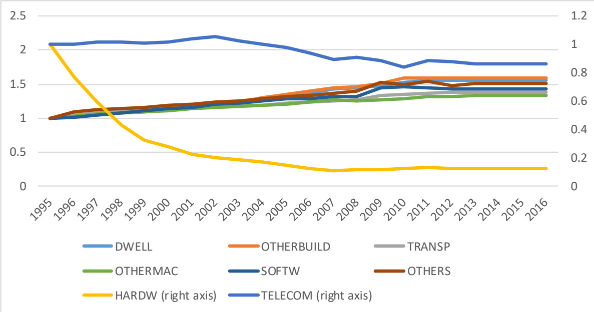
Graph A10. Investments by asset, 2016 (% of total). Spain



Data source: IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/)

The Price index trend shows relevant elements to evaluate the diversities among the countries, too. Focusing on the period 1995-2016, Graphs A11 and A12 display that price deflators of Hardware decrease in both countries, while for Telecom equipment the fall is more robust in Spain. Buildings prices gradually increase in Italy but decrease in Spain after the crisis. In general, the prices are more volatile in Spain.

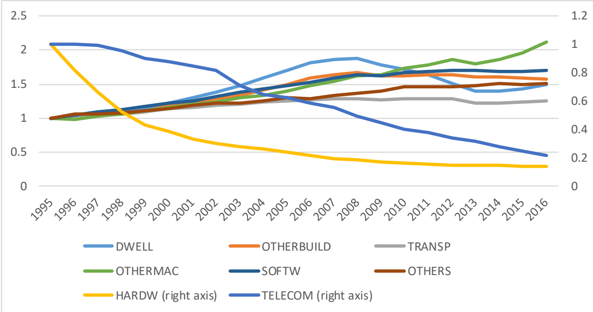
Graph A11. Price Index on national fixed investments by asset (1995=1), 1995-2016. Italy



Note: The price index for Hardware and Telecom is reported on the right axis.

Data source: Own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/).

Graph A12. Price Index on national fixed investments by asset (1995=1), 1995-2016. Spain

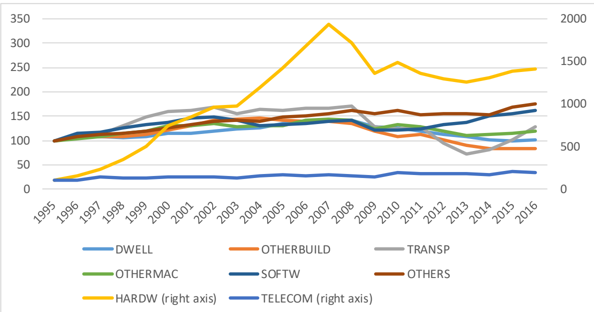


Note: The price index for Hardware and Telecom is reported on the right axis.

Data source: IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/)

The prices trend affects, of course, the constant value of the gross capital formation flows. Graphs A13 and A14 focus on real investments using an index based on 1995. The two plots are very eloquent: Italy experiences a flat trend for all assets except investments in Hardware while Spain displays a significant increase also for Telecommunication equipment. The more cyclical asset in Spain appears Transport equipment with a slowdown during 2008-2009 and a rise of real investments starting from 2013.

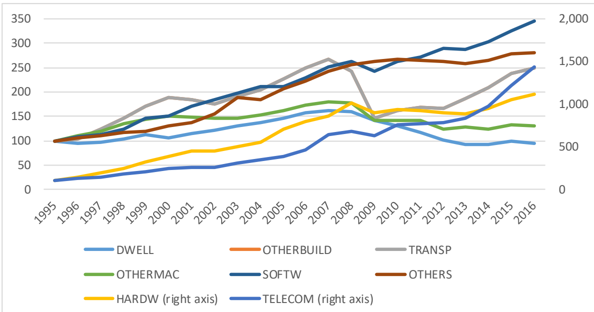
Graph A13. Constant investments, 1995-2016 (1995=100). Italy



Note: Investments in Hardware and Telecom are reported on the right axis.

Data source: Own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/).

Graph A14. Constant investments, 1995-2016 (1995=100). Spain



Note: Investments in Hardware and Telecom are reported on the right axis.

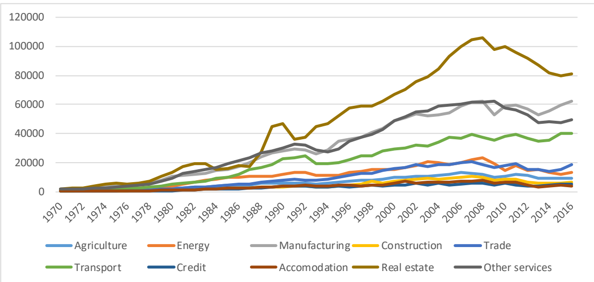
Data source: IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/)

1.3 Gross investments by sector

The analysis of investments trends by sectors (Graphs A15 and A16) shows the economic areas more affected by the crisis and the productive sectors more responsive to the recession. The analysis may consider that Transport sector includes Communications even if the two sectors contribution to the productive process is far different in particular because of their different ICT content.

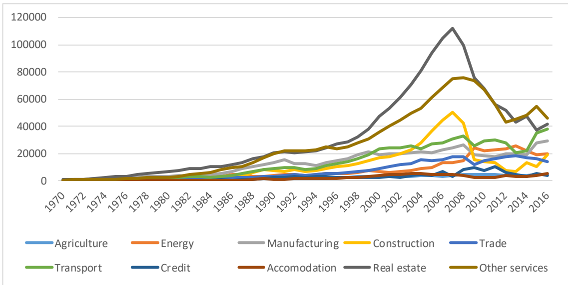
In Italy and Spain, the two sectors that recorded an abrupt reduction of investments are Real estate and the residual Other services. In particular, for Spain, the recent fall is partially due to the large drop of prices in Dwellings. On the other side, investments in Transport activities and Energy sector continue to rise in the two countries. Moreover, investments in Construction which are very volatile in Spain, have been affected by the recent economic crisis only in the Iberian country but not in Italy.

Graph A15. Current investments by sector (Mln euro), 1970-2016. Italy



Data source: Own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/).

Graph A16. Current investments by sector (Mln euro), 1970-2016. Spain



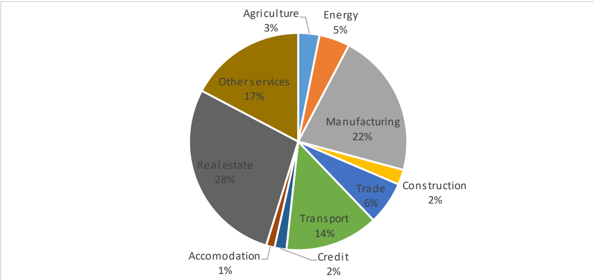
Data source: IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/)

Graph A17 shows the structure of nominal investments by sector in 2016 for both Italy and Spain. Real estate is the most relevant sector for Italy (28% of total current investments in 2016), followed by Manufacturing (22%), the residual Other services (17%) and Transport and Communication (14%). In particular, the contribution of this last sector to total investments has increased regularly starting from 1970, when the share was just 8%.

In Spain, the same 4 economic sectors play a pivotal role on investments dynamics (in 2016, the residual Other services ensure 21% of Spanish current investments, Real estate 19%, Transport 17%, Manufacturing 13%).

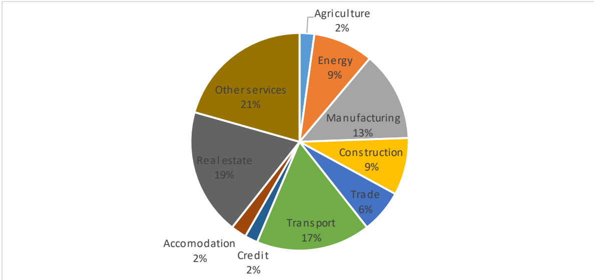
Graph A17. Current investments by sector, 2016 (% of total). Italy and Spain

Italy



Data source: Own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/).

Spain



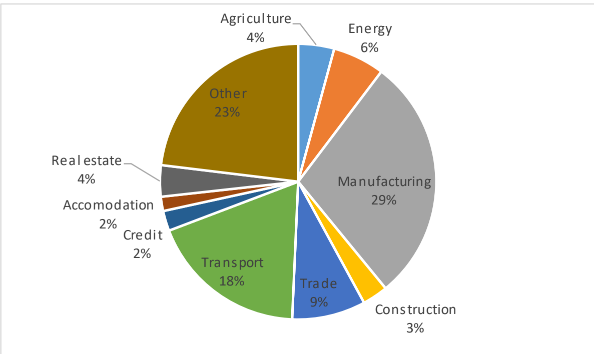
Data source: IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/)

Finally, Graph A18 displays the sector contribution to current investment excluding Dwellings to focus in the part of investment directly linked with the production process.

Non-residential investments are mostly ensured by the three sectors of Manufacturing, Transport and Other in Italy and Spain, and the share of Real estate is sharply reduced. In Italy, a significant contribution is confirmed by Manufacturing providing nearly 1/3 of total Italian non-residential investments. The higher share of Manufactures in Italy than in Spain is a differential issue that needs to be highlighted, together with the higher share of the Energy sector in Spain.

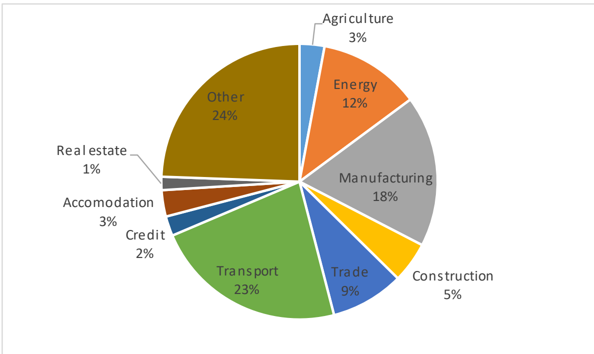
Graph A18. Current investments by sector (Dwelling excluded, 2016 (% of total). Italy and Spain

Italy



Data source: Own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/).

Spain



Data source: IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/)

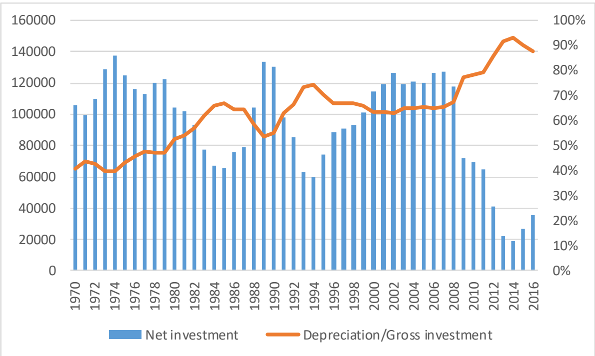
1.4 Net investments

Previous comparative analysis is focused on gross investment necessary to maintain and increase existing capital endowment which is, as a matter of fact, the most volatile GDP component. However, in a long run perspective, the economists are more interested on net investments showing the contribution of these expenditure flows on the capital stock evolution.

We define net investment as the difference between gross investment and capital consumption/depreciation, which depends on the average service life of the asset. Of course, the short-lived asset needs more investment to compensate the depreciation occurred during its use/service in the productive process. For this asset, there may be a larger difference between gross and net investment in percentage terms.

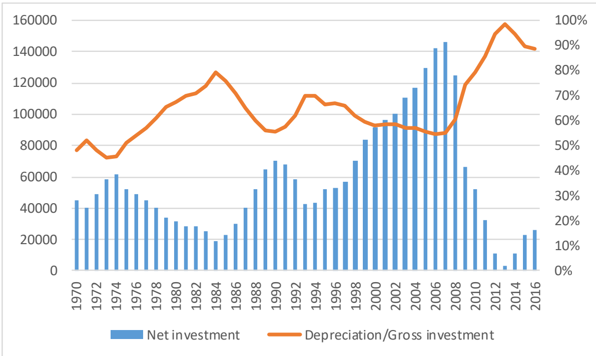
Graphs A19 and A20 reveal the part of gross investments required to "replace" the existing capital for Italy and Spain, showing a very cyclical trend for Spanish net investments while their value drastically decreased during the last 46 years especially for Italy.

Graph A19. Aggregate net investments (Mln euro, base 2010 (left axis)), Depreciation/Gross investment share (% (right axis)). Italy



Data source: Own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/).

Graph A20. Aggregate net investments (Mln euro, base 2010 (left axis)), Depreciation/Gross investment share (% (right axis)). Spain



Data source: IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/)

Moreover, the Spanish net investments are higher than Italian ones just before the last economic crisis. Indeed, Spain has been able to take advantage from the post-1995 boom since the depreciation share over gross investments was slightly above 50% in 2005-2007 (in the same period, the depreciation absorbs nearly 66% of gross investment in Italy). Thereafter, during the 2008-2014 crisis period, the combination of gross investment decline and increasing capital depreciation (in 2013, the capital depreciation absorbs 92% and 99% of constant capital formation flows respectively, in Italy and Spain) has severely eroded the net investment with relevant consequences in term of capital stock.

2. Comparing Italian and Spanish capital

The flows of gross investment occurred during a period, deducted the stock depreciation for capital use and technological obsolescence, contributes to increase the capital endowment. The capital accumulated, which is one determinant of the production function – in addition to labour and technology progress - assesses the long-term growth capacity of the country; its configuration among different assets and different sectors, in fact, defines the robustness, the speed, in short, the pattern of the economic development.

The (real) productive capital differs from the net capital by considering also the efficiency of the stock depending on the volume of services produced by each asset. In fact, the productive capital measures the potential flow of productive services that total assets can deliver in production.

The comparative capital endowment analysis is focused on the net capital, considering that the two series of capital are subjected to the same trends.

The Section analyses aggregate (net) capital stocks, capital by asset and capital by sectors.

2.1 Aggregate stock of net capital

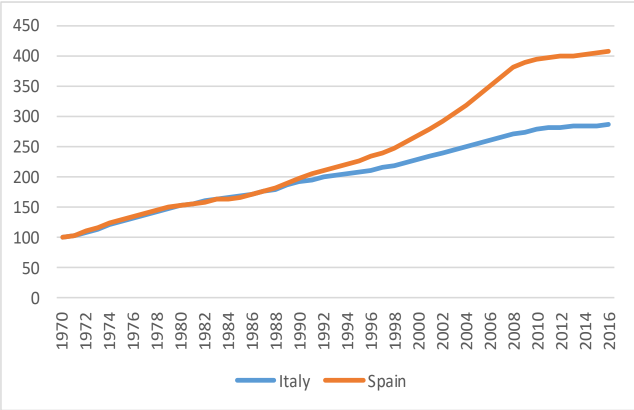
Graph A21 offers a first approximation of the net capital trend for Italy and Spain. Notice that the pattern has been similar for nearly 20 years. After 1990, the index of real net capital increases more in Spain establishing a large and rising gap among the capital endowment of the two countries up to the 2008 crisis. In fact, Spain has been more effective in seizing the opportunities during the 90s economic boom and in 46 years its real net capital index raises from 100 in 1970 to 408 in 2016 while for Italy the index is equal to 287 at the end of the period.

This relative success of Spain may be explained by different growth rates in net capital (Graph A22).

Despite more aggregate real investments, Italy which is characterized by higher real capital stocks, uses capital flows mostly to fill the capital depreciation even during the expansion phase 1995-2007 (Graph A19). Throughout the same period, the Spain reports lower depreciation/Gross investment share (Graph A20) and the net capital increases taking advantage of the favourable economic conditions.

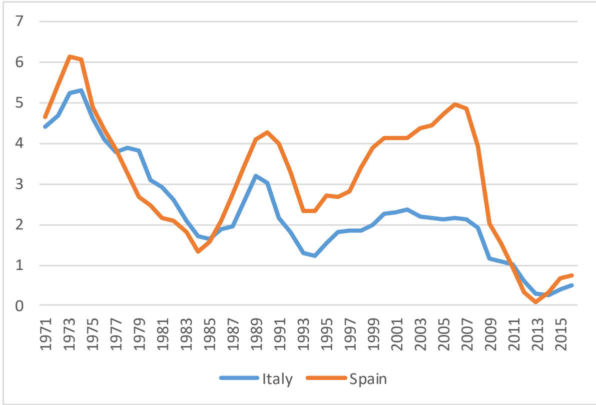
Moreover, during the analysed 46 years, we observe for the two countries four periods of capital growth acceleration (before 1974; 1985-1990; 1994-2002 for Italy and 1994-2007 for Spain; after 2014), even if the recent trend reversal is very limited (in particular for Italy), and generally, we notice for both countries an alarming slowdown in capital growth rate.

Graph A21. Aggregate real net capital (1970=100), 1970-2016. Italy and Spain



Data source: For Italy, own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/); for Spain, IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/)

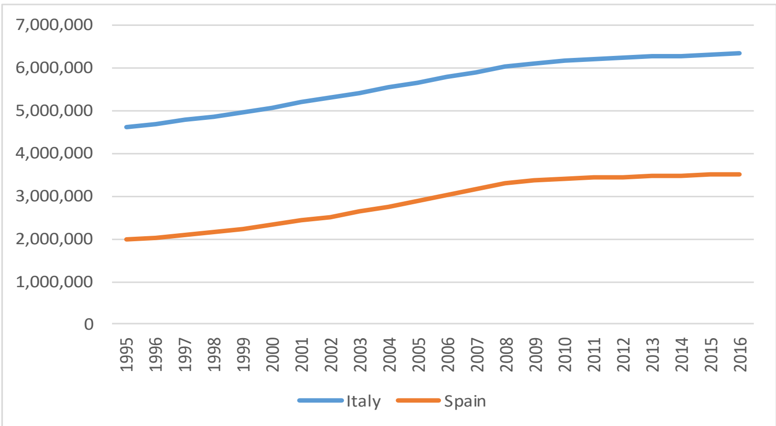
Graph A22. Aggregate real net capital (Annual % growth), 1970-2016, Italy and Spain



Data source: For Italy, own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/); for Spain, IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/)

Focusing on the last 21 years, Graph A23 reveals that real capital increases by 1.7 Bln constant euro in Italy and by 1.5 Bln constant euro in Spain, determining a capital growth of 38% in Italy and 79% in Spain.

Graph A23. Aggregate constant net capital (Mln euro, base 2010), 1995-2016. Italy and Spain

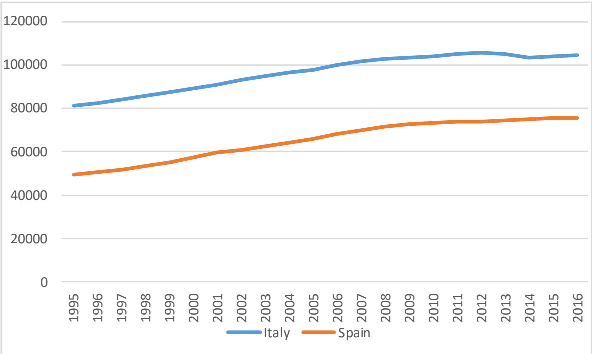


Data source: For Italy, own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/); for Spain, IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/)

Graph A24 and A25 show the trend of the rates Capital/Population and Capital/GDP. The first plot displays a constant higher per capita capital endowment for Italy. After 2008, the curve begins to flatten in both countries and capital and population follow since then, the same trend. However, the more dynamic Spain experienced higher population growth almost during the entire period (and particularly in the period 2003-2008), smoothing the impact of capital increase on per capita capital rate.

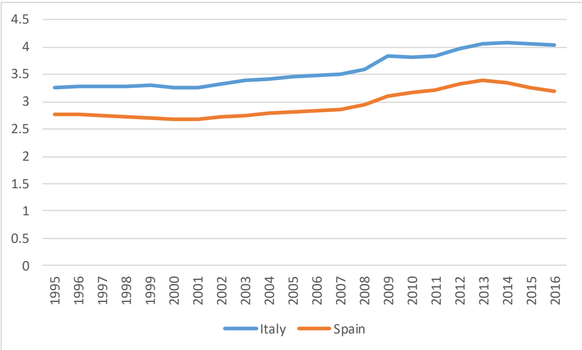
The situation is somewhat different in Graph A25 displaying higher capital stock per unit of GDP in Italy along the period (i.e lower capital returns related also to higher capital endowment) and, especially for Spain, a decrease of the share of capital over GDP in the very last years (i. e. recent increase in capital productivity). Indeed, the Spanish GDP growth in this period has been higher than capital growth while Italy experienced a phase of stagnation.

Graph A24. Aggregate constant net capital per inhabitant (euro, base 2010), 1995-2016. Italy and Spain



Data source: For Italy, own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/); for Spain, IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/)

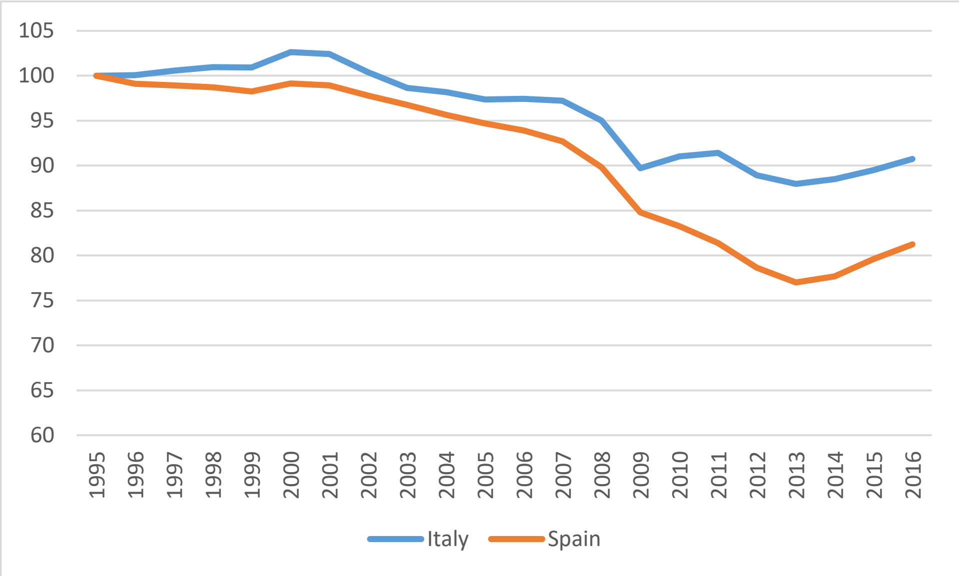
Graph A25. Aggregate constant net capital per unit of real GDP (euro, base 2010), 1995-2016. Italy and Spain



Data source: For Italy, own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/); for Spain, IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/)

Finally, Graph A26 shows the capital productivity index, revealing the dramatic impact of the recent recession for both countries, today far from the pre-crisis levels. However, the Spanish capitalization dynamics which has been more affected by the crisis, is currently more reactive in reversing the trend. Further in-depth analysis on issues affecting the growth of productivity – such as production structure and specialization, ICT pervasiveness, human capital, infrastructure endowment – must be conducted to properly arguing the low capital productivity in Italy relative to Spain and this latest rise of capital productivity in Iberian country.

Graph A26. Capital productivity (1995=100), 1995-2016. Italy and Spain



Data source: For Italy, own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/); for Spain, IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/)

2.2 Capital by asset, by sector

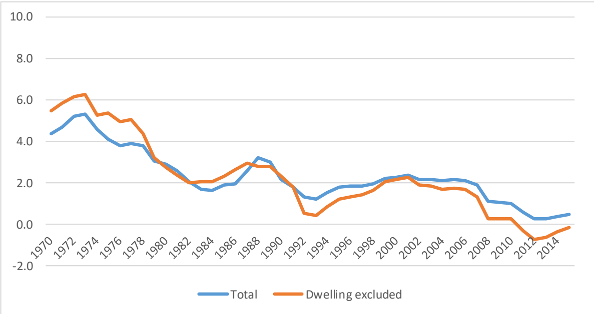
The (real net) capital composition by asset shows that the main contributing assets for both countries are Housing and the Other buildings involved in the production process. In particular, in Italy Dwellings and Other Buildings ensure respectively 50% and 36% of net capital endowment in 2016 (they accounted for 48% and 41% respectively in 1970); in Spain the Dwelling share decreases from 65% in 1970 to 47% in 2016 and the Other buildings account for 25% of total asset in 1970 and 38% in 2016.

Graphs A27 and A28 plot the annual average growth rates for total (real net) capital and for the stock excluding Dwelling. Notice that in Italy, for nearly 20 years, Housing stock growth restrained the capital net rise while the growth of total asset is less dynamic than for more productive asset. From the 90s, the annual growth of residential capital – indeed, half of the total net capital – is higher. The graph reveals that excluding Dwelling, the capital stock in Italy has been decreasing since 2012.

Conversely, Spain exhibits higher growth rate for non-residential capital for the first 30 years and starting from 2000 very similar trends in Dwellings and non-Housing asset endowment. Moreover, the net capital growth excluding residential stock is still positive even during the recent crisis. In fact, the recent decreasing slice of the Capital/GDP share observed in the previous paragraph may reflect increasing capital returns in Spain due to more efficient (i.e non-housing) investments[23].

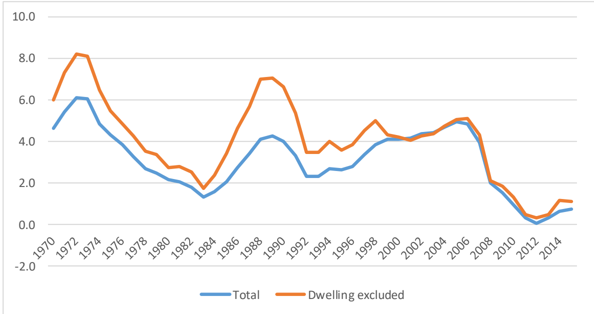
[23] As previously discussed, a specific data breakdown can reveal other "qualitative" specificities in Italian and Spanish capital. For instance, national (NUTS1) capital series by asset and sector elaborated by EUKLEMS for 1995-2014 distinguished 10 assets but for a shorter period.

Graph A27. Aggregate real net capital (Annual % growth), 1970-2016, Italy.



Data source: For Italy, own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/); for Spain, IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/)

Graph A28. Aggregate real net capital (Annual % growth), 1970-2016, Spain.



Data source: For Italy, own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/); for Spain, IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/)

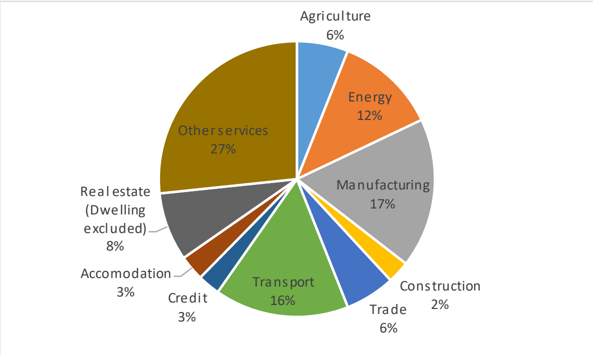
The Section ends with the net capital sectoral analysis (excluding Dwelling). According to Graph A29 the residual Other services is the main sector by capital endowment in 2016 (27% in Italy and 39% in Spain), followed by Manufacturing (17% in Italy and 13% in Spain).

Despite a larger share of investments in Transport in Spain, the relative weight in terms of capital stock is higher in Italy (16% compared to 10% in the Iberian country).

During the period analyzed, both countries experienced a reduction in Manufacturing share (more relevant in Spain considering that in 1970 the contribution of the sector to total net capital (Dwelling excluded) was 24%), Agriculture and Real estate. For other sectors such as Trade and Transport – distinguishing current inter-related economies - the capital stock increased

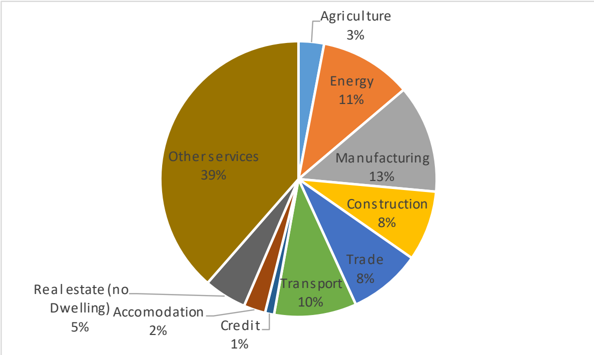
Graph A29. Real net Capital by sector (Dwelling excluded, 2016 (% of total)). Italy and Spain

Italy



Data source: Own elaboration on CRENOS (https://crenos.unica.it/crenos/databases/italian-regions), Istat (http://dati.istat.it/) and Eurostat (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_nfa_fl&lang=en and https://euklems.eu/download/)

Spain



Data source: IVIE (https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/)

3. Concluding remarks

The comparative analysis between Italy and Spain has been conducted using the latest methodologies to compute long series for regional investment flows and capital stocks in Italy and cover a statistical vacuum in order to study the dynamics of capitalization and growth.

Some relevant facts over the last half century have emerged.

In particular, Spain has been able to capture the investment opportunities during the economic boom characterizing the years around 2000. Its pro-cyclical investment attitude boosted the net investment but the real net capital is still far below the endowment of the brother-country. On the other side, the relative inelasticity of Italian investments to economic fluctuations has actually reduced the recession negative impact on investments and capital stock.

The in-depth on capital by asset analysis reveals how can be misleading an aggregate study on capital stock. As a matter of fact, the quality of the capital is also relevant, paying attention particularly to the more productive assets. As stated, Italy registered a cut in the more productive capital - i.e. without dwelling – during the last years, while the total capital recorded low but positive growth rates. On the other side, Spain discloses low and positive growth rates for total and more productive stock during the crisis.

As a result, no 'winner' emerges from the comparative analysis exclusively based on capital accumulation: in both countries, most of the investment outflows has been used to maintain the existing capital stock and were therefore inefficient, whereas the capital trend and per capita capital endowment were stagnating.

However, a 'loser' comes out: in fact, after the recent crisis, Spain which figured with higher returns on capital even after the recent dramatically halt, experienced a (relative) rise in capital productivity as a result of the (relative) higher contribution of the more productive capital, while Italy faced no improvement in capitalization returns to growth process.

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