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Abstract

In the aftermath of the global financial crisis and the COVID-19 pandemic, the role of public investment has regained central importance in the European economic agenda. The renewed focus on large-scale investment programmes—such as the EU Cohesion Policy and NextGenerationEU—reflects a broader shift toward using public spending not only to stabilise economies, but also to promote structural transformation, resilience, and territorial convergence. However, the persistence of wide regional disparities across Europe calls for a deeper understanding of the mechanisms through which public investment influences productivity and development outcomes. This thesis investigates the relationship between public investment and regional economic performance, emphasising the role of institutional quality, spatial heterogeneity, and macroeconomic conditions in shaping its effectiveness. Using different econometric approaches, it analyses both national and EU-wide experiences to assess how the impact of public expenditure varies across territories and over time. The findings reveal that public investment exerts a significant positive effect on regional economic performance, but its effectiveness crucially depends on the institutional and governance context. Strong institutions and capable administrations enhance the capacity to transform public resources into productive assets, while weaker environments tend to dissipate policy returns. The analysis also uncovers substantial spatial and temporal heterogeneity: investment policies tend to be more effective in regions characterised by strong structural conditions, typically in Central and Northern Europe, and during expansionary phases when priorities are strategically aligned with growth-enhancing objectives. Conversely, in periods of crisis or in structurally weaker territories, the same resources often yield limited or even negative returns. Overall, the results suggest that what matters most is not the volume of resources mobilised but the quality of their governance and their consistency with long-term development priorities such as innovation and human capital. Strengthening administrative capacity and tailoring interventions to diverse regional and macroeconomic contexts are essential to ensure that public investment supports sustainable and inclusive convergence across Europe.

Introduction to the thesis

Over the past two decades, the European Union (EU) has faced two major crises that have deeply shaped its economy. The global financial crisis of 2008 severely disrupted financial systems and production structures, leading to a prolonged period of recession and stagnation. Fiscal consolidation policies adopted in many Member States to restore public finances further slowed down the recovery, constraining domestic demand and limiting governments' capacity to invest. Just over a decade later, Europe — as well as the rest of the world — was hit by a second, even more sudden and far-reaching shock: the COVID-19 pandemic. Lockdowns, restrictions on mobility, and the breakdown of global supply chains caused an unprecedented contraction in output and employment, affecting sectors, territories, and social groups unevenly. At the same time, the health crisis revealed long-standing structural vulnerabilities, such as weaknesses in public health systems, delays in digitalisation, and unequal access to essential services.

Both crises exposed and deepened pre-existing territorial disparities within the European Union. The most developed regions (mainly located in Central-Northern Europe) characterised by diversified economies, stronger fiscal capacity, highly skilled human capital, and effective institutions, proved more resilient and better able to adapt. In contrast, Southern less developed areas, often marked by weaker institutional capacity and more fragile economic structures, experienced more severe impacts and struggled to recover. Meanwhile, several regions in Eastern Europe continued to display relatively strong growth trajectories, sustained by ongoing convergence dynamics and a rapid process of structural transformation. As a result, the geography of regional development within the EU has become increasingly polarised: while Eastern regions have continued to catch up with the EU average, many Southern ones have remained stagnant, challenging the Union's long-standing objective of promoting economic, social, and territorial cohesion.

Against this backdrop, the European Union launched NextGenerationEU, an unprecedented recovery initiative designed to repair the socio-economic damage caused by the pandemic while laying the foundations for a more sustainable and resilient future. At its heart lies the Recovery and Resilience Facility (RRF), a €650 billion programme of grants and loans that marks a historic step forward in EU economic governance. For the first time, the Union collectively issued large-scale debt to finance investment and reforms across Member States — a sign of deeper fiscal solidarity and a shared commitment to recovery. Beyond emergency support, the RRF embodies a broader strategic ambition: to use public investment as a driver of structural transformation through the digital and green transitions.

This renewed emphasis on investment marks a shift in European economic policy. Public investment is no longer conceived merely as a reactive instrument to mitigate the effects of crises, but as a proactive lever to reshape Europe's growth model and strengthen its long-term competitiveness. In Italy, this vision materialised through the National Recovery and Resilience Plan (NRRP), which allocated nearly €280 billion — almost half directed to the eight less-developed regions of the Mezzogiorno — with the dual goal of addressing long-standing structural weaknesses and narrowing the persistent North–South divide.

Although the impact of NextGenerationEU and the RRF cannot yet be evaluated, these initiatives revive fundamental questions about the effectiveness of large-scale public investment, questions that can be meaningfully explored through the experience of earlier policy frameworks. In this regard, the Italian case offers a particularly relevant context. Owing to its enduring territorial divide and the substantial resources it has received from both the NRRP and the EU Cohesion Policy, Italy provides an ideal setting to examine how investment outcomes depend on institutional capacity and governance quality. At the same time, the EU's Cohesion Policy represents a broader laboratory for understanding how territorially targeted programmes shape regional performance across Europe, revealing how diverse institutional and structural conditions mediate the capacity of regions to translate public support into sustained growth and convergence.

Since its reform in 1988, Cohesion Policy has constituted the Union's main structural instrument for reducing regional disparities and promoting balanced development. Through the European Structural and Investment Funds (ESIFs), it has channelled long-term, place-based resources into infrastructure, innovation, human capital, and institutional capacity, with the aim

of fostering convergence between less and more developed regions. Unlike the RRF, conceived as an extraordinary and temporary response to a specific crisis, Cohesion Policy embodies the EU's permanent commitment to cohesion and convergence.

More recently, the policy debate has been shaped by the publication of two influential reports: Mario Draghi's *The Future of European Competitiveness* (2024) and Enrico Letta's *Much More Than a Market* (2024). Both documents highlight the slowdown in European productivity growth and identify chronic underinvestment, particularly in infrastructure, innovation, and human capital, as a major constraint on Europe's long-term growth and competitiveness. From this perspective, investment is presented as the main lever to foster long-term growth and sustain Europe's economic position in an increasingly competitive global environment. At the same time, these contributions place relatively less emphasis on the territorial dimension through which growth-enhancing investments are implemented. While acknowledging existing disparities within the European Union, the reports largely focus on aggregate productivity and competitiveness, rather than on the role of territorial cohesion as a precondition for long-term growth. This thesis builds on the view that persistent territorial disparities—in terms of institutional quality, administrative capacity, and structural conditions—fundamentally shape the effectiveness of investment policies and therefore represent a crucial element for achieving sustainable growth in Europe.

By analysing the effects of both national and EU-funded investments, this thesis seeks to identify the conditions under which public investment contributes most effectively to regional economic performance. It is structured around three essays that, taken together, combine national and European perspectives to explore how the impact of investment policies varies across institutional settings, territorial contexts, and macroeconomic phases. Through complementary empirical approaches — ranging from panel regressions to causal identification — the essays provide a comprehensive understanding of how governance quality, spatial heterogeneity, and timing shape the outcomes of public spending. The evidence and insights derived from these analyses are essential for anticipating the potential impact of NextGenerationEU and for informing the design of future EU programming periods.

The first essay focuses on the Italian case. Italy represents a particularly interesting context, as almost half of the resources allocated through the NRRP have been directed towards the

eight less-developed regions of the Mezzogiorno, with local administrations expected to manage approximately €94 billion from the plan. This allocation has generated significant debate among economists and policy analysts, given the well-documented weaknesses of Southern Italy's local governments in terms of administrative capacity and institutional quality. To shed light on the potential effectiveness of the NRRP in this context, the essay investigates the impact of public capital on regional economic performance over the period 2000–2019, distinguishing between investments managed by central and local authorities. The results reveal persistent inefficiencies in the investments undertaken by local administrations in the South, largely attributable to institutional shortcomings, thereby reinforcing concerns about the ability of local southern bodies to invest NRRP resources efficiently. Moreover, the analysis disaggregates public capital into five broad sectors, showing that investments in intangible assets (such as human capital), infrastructure, and productive activities exert the strongest effects on regional economic performance.

The second and third essays focus on European Cohesion Policy. More specifically, the second essay examines the role of ESIFs in fostering regional productivity growth, incorporating all major funds in order to capture the diversity of their objectives and instruments. The analysis goes beyond average effects by explicitly accounting for two key sources of heterogeneity: space and time. From a spatial perspective, the European regional landscape can be broadly divided into three macro-areas — Central-Northern Europe, Southern Europe, and Eastern Europe — each characterised by distinct structural conditions, development trajectories, and economic dynamics. Given these different backgrounds, it becomes particularly relevant to investigate the role and effectiveness of ESIFs within each of these groups, in order to understand how context shapes outcomes and whether policy support translates into productivity gains under diverse territorial conditions. Temporal heterogeneity further enriches this analysis. Covering the period 2000–2019, the study captures three distinct phases that have profoundly influenced regional development and the functioning of EU policies: a pre-crisis period characterised by relatively stable growth; the years of the global financial and sovereign debt crises, marked by severe fiscal constraints and shifting investment priorities; and a post-crisis recovery phase, defined by renewed growth, during which new priorities were pursued by the ESIFs, particularly those linked to smart, sustainable, and inclusive development, reflecting the evolving strategic focus of EU cohesion policy. The results show that, overall, the European Regional Development Fund

(ERDF) is the only fund with a significant and positive influence on regional productivity, and its effects are particularly strong in Central-Northern and Eastern European regions. Importantly, the analysis also reveals that the overall impact of Cohesion Policy was considerably weaker during the crisis years, when the policy was primarily aimed at addressing the negative consequences of the economic downturn.

The third essay complements this analysis by paying closer attention to the issue of causal identification. It investigates the effect of being classified as a less-developed region within the framework of Cohesion Policy, and therefore receiving substantially larger financial support, over the period 2008–2023, which also includes the COVID-19 pandemic. The analysis exploits the GDP per capita threshold used for eligibility, applying a Regression Discontinuity Design (RDD) and incorporating treatment intensity to account for both the heterogeneous amount of funding received by less-developed regions and the fact that other regions, despite not being classified as less developed, still receive financial support. The results confirm the presence of strong temporal heterogeneity and highlight persistent inefficiencies in the allocation of resources, particularly in Southern and Eastern less-developed European regions.

Taken together, the three essays provide a coherent picture of how public investment, both nationally and at the EU level, shapes regional economic performance through the interplay of institutional capacity, spatial and temporal context. The results converge toward a central conclusion: the effectiveness of investment policies depends less on the volume of resources mobilised than on the quality of their allocation and implementation. In the Italian case, inefficiencies in locally managed capital expenditure persistently undermine the growth potential of the Mezzogiorno, underscoring the importance of administrative capacity and institutional quality in determining the returns to public capital. At the European level, the analysis of the ESIFs reveals that the European Regional Development Fund (ERDF) is the only fund recurrently associated with productivity gains, particularly in Central-Northern and Eastern regions. However, the overall impact of Cohesion Policy has varied substantially over time, weak during the crisis years and stronger in the post-2014 recovery, confirming that the design, orientation, and macroeconomic context of interventions critically shape their outcomes. The RDD applied in the third essay refines this understanding by uncovering a non-linear relationship between treatment intensity and growth in less-developed regions: while both low and very high levels of EU

support can stimulate development, intermediate allocations often generate inefficiencies. These findings reveal that simply increasing funding volumes does not automatically translate into convergence; suggesting that differences in outcomes reflect broader contextual and structural factors. Moreover, the geography of inefficiencies has evolved over time: whereas earlier weaknesses were concentrated in Southern Europe, more recent ones have emerged in several Eastern regions, reflecting new challenges linked to administrative expansion, governance quality, and the changing profile of less-developed territories.

These results prompt a critical reconsideration of the place-based approach that has traditionally guided European regional policy. While territorially tailored interventions are intended to activate bottom-up development processes, the evidence presented in this thesis indicates that their effectiveness is strongly contingent on local institutional capacity. Where such capacity is persistently weak, decentralised implementation may hinder the translation of financial support into sustained growth gains. Rather than calling the place-based paradigm into question, the findings highlight the need to complement it with policy designs that explicitly address institutional constraints.

From a policy perspective, this implies that strengthening administrative capacity is a necessary condition for converting public resources into productive capital. A more context-sensitive investment strategy—integrating territorially targeted measures with adequate institutional support and coordination—appears essential to enhance policy effectiveness. At the same time, maintaining a focus on long-term growth drivers such as innovation, human capital, and the digital and green transitions remains crucial for the sustainability of regional convergence.

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Essay 1

Public Capital, Institutional Quality, and Regional Economic Performance in Italy*

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

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1.1 Introduction

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

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

More generally, in the last decade, the economic literature has devoted increasing attention to the impact of the EU cohesion policies on regional economic outcomes. Many studies have highlighted an overall positive role of the European structural funds. At the same time, some of them have emphasized the large degree of heterogeneity of the impact across territories depending on the quality of the regional institutions and the human and social capital endowments (Dall'Erba and Fang 2017, Crescenzi and Giua 2020, Rodríguez-Pose and Ganau 2022).

More specifically, Rodríguez-Pose (2020), in an inspiring overview of the open issues on the relationship between institutions and territories, highlights that local institutions may have a direct and an indirect effect on regional economic performances. Local institutions leverage the provision of public goods (education, innovation, infrastructure) in their regions, thus directly affecting their economic performance. Moreover, local administrations play a pervasive role

in setting the normative and regulatory framework, and consequently, they influence firms' productivity (Lasagni et al. 2015). At the same time, they have indirect effects given their influence on the local effectiveness of other national or European policies (Rodríguez-Pose and Garcilazo, 2015).

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

This essay aims to contribute to the current debate on public capital effectiveness by distinguishing among the government levels responsible for the expenditure (central and local bodies) and explicitly considering local institutions' quality. Although institutional quality is getting more and more attention within the regional economic literature, accounting for the diversified role played by different government levels has been largely overlooked, mainly because of the limited data availability.

The empirical analysis focuses on Italy's regional economic performance over the past two decades—a context marked by a persistent divide between the northern and southern regions—which provides a particularly relevant case for examining how public capital and institutional levels interact in shaping economic outcomes. To this aim, we first set up a novel database on public capital at the regional level using the investment expenditures of the Extended Public Sector (Settore Pubblico Allargato, SPA) provided by Territorial Public Accounts (Conti Pubblici Territoriali, CPT). Following the methodology proposed in Marrocu and Paci (2010), we build the series on public capital stock for 21 NUTS2 Italian regions over the period 2000-2019, disaggregated by five levels of institutions responsible for the investments' implementation and by 29 economic sectors.

It is important to remark that this database provides a comprehensive measure of public capital, including all investment expenditures by national and local administrations and public companies. A noticeable share of these public investments is financed through EU structural funds, jointly

deployed at the regional level along with other funding sources. Hence, by estimating the overall effect of public capital, our analysis advances the existing literature, which has typically focused exclusively on EU structural funds while overlooking the simultaneous influence of other crucial sources of public investment.

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

The econometric specification is based on a standard Cobb-Douglas production function augmented with a measure of the institutions' quality and other intangibles and territorial factors and considering different levels of disaggregation of the public capital. An instrumental variable approach is adopted to address the potential endogeneity of the main productive inputs.

The main results highlight the positive impact of public capital on regional product levels with an elasticity higher than the private one. Another remarkable result is that the quality of institutions' variable exhibits the expected positive and significant elasticity, robust to all different specifications. When we disaggregate public capital into central and local bodies, according to the administrative entities in charge of the expenditures, significant differences between Centre-Northern and Southern regions emerge. Central bodies in the Southern regions exhibit an elasticity much higher with respect to the Northern ones. The opposite happens with the local bodies, which appear much less effective in the Southern regions. This finding is mainly due to the fact that the effectiveness of local bodies is a positive function of the level of institutional quality.

Although our analysis focuses on Italy, our results are also relevant to the rest of the European regions, which feature varying levels of institutional quality. In some countries (e.g., Romania, Bulgaria, Hungary or Greece), institutions responsible for managing and allocating public funding

have a quality level very similar to the one exhibited by the Southern Italian regions ¹.

The rest of the essay is organized as follows. In section 1.2 the literature on public capital impact is briefly reviewed. Section 1.3 deals with constructing and describing the public capital stock series. Section 1.4 presents the empirical model and a descriptive analysis of the main variables. The econometric results are discussed in section 1.5, and section 1.6 concludes.

1.2 Public capital and economic performance

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

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

Over the last two decades, the literature on public capital impact has prospered through within-country and cross-country analyses. The latter studies have proven the positive effect of public capital on economic growth in developed (Kamps 2004, Fournier 2016, Han et al. 2017) and developing countries (Gupta et al. 2014, Agénor and Neandis 2015, Santiago et al. 2020).

Numerous analyses have studied the impact of public capital stock at the regional level,

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

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

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

In general, the literature highlighted the relevant role of public infrastructures financed through EU cohesion policies. More importantly, sound evidence has been provided on the fundamental role played by the quality of local institutions in favouring the impact of public capital expenditure on economic performance.

1.3 Public capital stock at the regional level

1.3.1 Construction of public capital stock series

The data on public capital stock is not available in Italy at the regional level. The Italian National Institute of Statistics (Istat) provides data only for total capital stock at the national level without distinguishing between private or public expenditure ². Therefore, to obtain the series of regional public capital stock, we accomplish the following steps: (i) compute the series of total regional capital stock; (ii) compute the regional capital stock for the public component; (iii) decompose total capital in its public and private components.

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

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

It is worth noting that this essay adopts a broad definition of public investment. In addition to the categories "real estate assets and works" and "movable property and machinery", the analysis

²See Table A1.1 in the Appendix for data definitions and sources.

also includes “capital transfers to households and social institutions” and “capital transfers to private undertakings”. In such a way, this definition of public capital embraces the capital expenditures financed by the public sector, although the investment is realized by private entities.

The SPA dataset distinguishes five bodies responsible for the investments’ implementation. The "central administration" includes the Italian State and government agencies such as the Revenue Agency, CDP (Cassa Depositi e Prestiti), and ANAS (the National Agency for Roads). The "regional administration" encompasses the regional government and the local health units. The "local administration" embraces municipalities, provinces, and other territorial entities such as municipalities’ unions, universities, port authorities and national parks. The "national public companies" include firms under the direct control of the government. Often, they are former public monopolies transformed today into private companies listed on the stock exchange, but where the State still owns a relevant share ³. Finally, the "local public companies" level comprises firms owned by the regional and local administrations, usually operating in local public services (water, transports, energy) and agrarian consortiums and cultural foundations.

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

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

To check whether the calculation of public capital based on CPT data sounds reliable, we compare our national series with the one computed by IMF (2017), which is based on National Accounts data. IMF shows that in Italy, over the years 1999-2014, the share of public capital stock over the total is equal to 22%. This estimate is very similar to the share (24%) we have computed using the broad definition of public investment, including physical works, machinery,

³Notable examples are ENI (the energy company), ENEL (the electrical company), Poste Italiane (the postal service), and Ferrovie dello Stato (the railway company).

and capital transfers to households and firms (see Figure A1.1 for a detailed comparison over the period 2000–2015) . Based on this result, we focus on the broad definition of public capital in the empirical analysis since it appears more coherent with the National Accounts.

1.3.2 Descriptive statistics of public capital series

Figure 1.1 displays Italy's total and public capital stock series over the years 2000-2019. The total capital stock decreased notably (-1.28% yearly) during the observed period. The decline in the capital accumulation process appears even more pronounced after the financial crisis of 2008. On the other hand, the level of public capital remains almost unchanged until 2009 and starts decreasing afterwards.

Figure 1.1: Total and public capital stock in Italy, 2000–2019

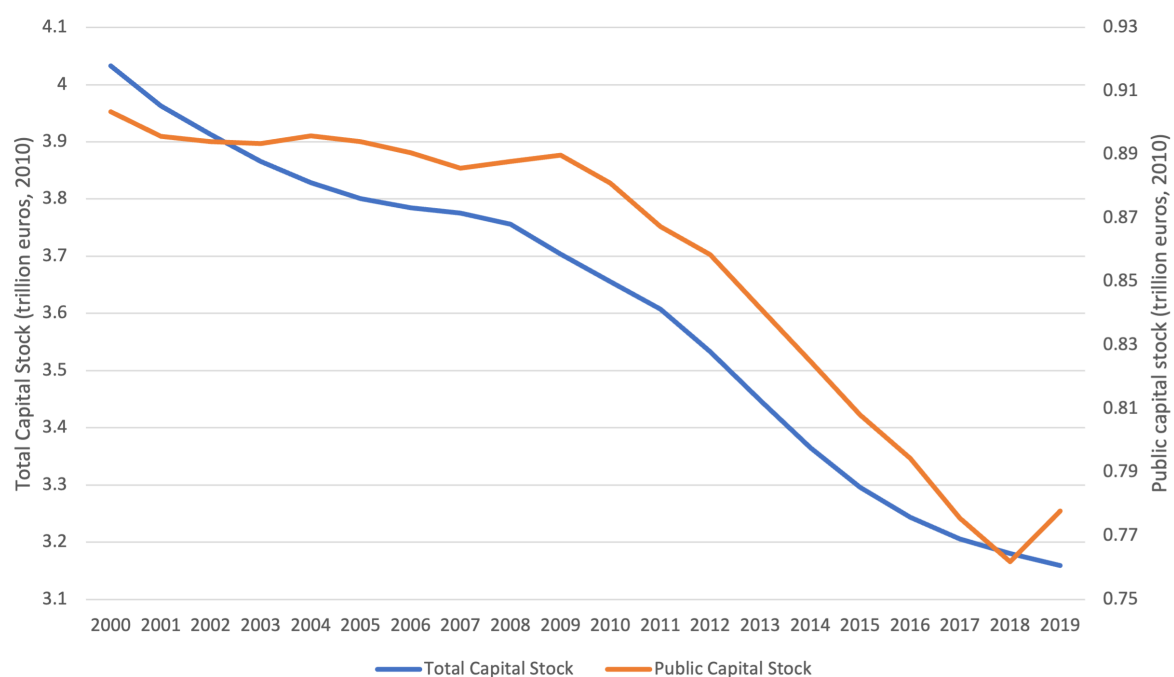


Table 1.1 reports the share of the public over total capital stock and some summary measures for the public capital stock, namely index numbers for per capita and per unit of labour ⁴. In general, the share of public capital expenditure over the total is persistently increasing, and it reaches the value of 24.6 in 2019. The public component of the capital stock is more relevant in

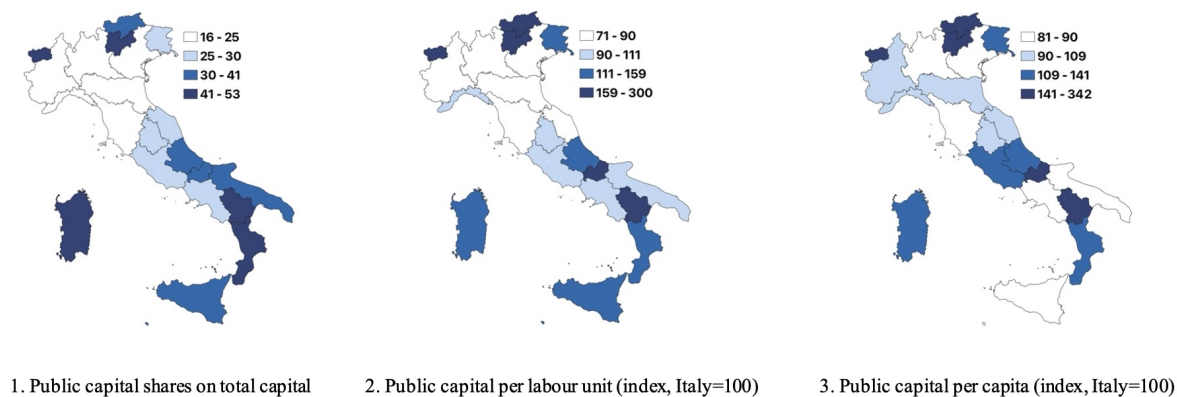
⁴The full list of the Italian regions and their macro areas are reported in Table A1.3 in the Appendix.

Southern Italy (36% in 2019). Public capital per labour unit is higher in Southern Italy although it has decreased over time, while it has increased in the rest of the country. Figure 1.2 shows the regional shares of public capital (panel 1), regional public capital per labour unit (panel 2), and regional per capita public capital (panel 3) in 2019. The maps show important differences between Northern and Southern Italy in both cases. Together with the small autonomous regions in the Alps, the Southern regions show a much higher presence of public investment.

Table 1.1: Public capital stock by macro-areas

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

Figure 1.2: Regional distribution of public capital, 2019



1.3. PUBLIC CAPITAL STOCK AT THE REGIONAL LEVEL

Table 1.2: Public capital stock by institutions and macro-areas (% share)

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

Table 1.2 describes, for the years 2000 and 2019, the share of public capital stock for the five levels of government responsible for the capital expenditure. Interestingly, local administrations in the North show the highest share of public capital in 2000, while in Southern and Central Italy the highest shares are exhibited by the central administration and national public companies. It is worth remarking that the role of the national public companies has strongly increased over time, and in 2019 they manage 36% of national public capital expenditure. On the other hand, the role of local, regional and central administrations decreases over time (by -7, -3, and -5 percentage points, respectively). The considerable differences in the share of local public companies among the areas are also interesting: they play a relevant role in the North (15% in 2019), while they control a small share of public capital stock in the Southern regions (5% in 2019).

Table 1.3 reports the average shares over the years 2000-2019 of public capital stock for the five institutional levels for each region. As expected, the highest share for the regional administrations is shown by the six territories granted an autonomous status like Trento (47%), followed by Bolzano, Valle d'Aosta, Sardegna, Sicilia and Friuli-Venezia Giulia. Considering the whole period, central administrations play a key role in Southern regions, with Calabria showing the highest share, followed by Campania. National public companies exhibit a high capital expenditure in the Central regions (especially in Lazio and Toscana), whereas they play a limited role in Southern Italy. Finally, local public companies have an essential role in Northern regions like Emilia Romagna, Lombardia and Veneto, where companies owned by local administrations control a large part of local public services like transport, water, energy.

Table 1.3: Public capital stock by institutions and regions (% share, average 2000-2019)

Region	Central adm.	Regional adm.	Local adm.	National public companies	Local public companies
Piemonte	18.8	13.7	28.2	30.5	8.9
Valle d'Aosta	6.9	37.7	20.0	13.4	22.0
Liguria	22.8	6.8	31.3	28.5	10.6
Lombardia	17.1	9.4	30.1	26.4	17.0
Prov. Bolzano	3.7	43.9	27.9	9.8	14.7
Prov. Trento	5.7	46.6	26.0	8.5	13.3
Veneto	16.6	12.2	30.1	25.3	15.8
Friuli Venezia Giulia	10.7	22.6	31.2	20.9	14.5
Emilia Romagna	14.8	11.5	26.3	28.9	18.6
Toscana	16.1	10.7	29.3	32.4	11.5
Umbria	21.1	8.1	39.5	21.9	9.4
Marche	16.0	11.8	34.8	27.7	9.7
Lazio	30.8	3.3	18.9	35.5	11.5
Abruzzo	31.1	13.8	28.8	19.6	6.7
Molise	28.9	14.1	26.8	25.1	5.2
Campania	32.0	11.0	32.2	17.0	7.8
Puglia	31.0	9.0	25.6	29.9	4.6
Basilicata	29.7	14.8	24.2	27.1	4.2
Calabria	44.3	7.3	24.5	21.3	2.6
Sicilia	26.5	23.6	21.1	22.5	6.3
Sardegna	23.2	25.9	25.2	18.2	7.5
North	15.48	15.65	28.87	25.05	14.95
Centre	24.21	6.77	25.27	32.65	11.10
South	30.68	15.35	26.19	21.79	5.99
Italy	22.69	13.70	27.16	25.44	11.01

1.3. PUBLIC CAPITAL STOCK AT THE REGIONAL LEVEL

CPT data distinguish between 29 sectors, which have been aggregated into 5 macro-sectors to allow for a more tractable and meaningful analysis (see Table A1.2 in the Appendix for the complete list)⁵. Table 1.4 displays the percentage share of public capital stock for the different economic macro-sectors series in the starting (2000) and final (2019) years. Considering the whole period, the production sector is the main component of public capital stock in Italy (32%) and its share increases over time (+10 percentage points between 2000 and 2019). Northern and Central Italy display a similar composition of public capital with a prominent and increasing role played by the production sector (respectively 36.9% and 39.4% in 2019) and relevant percentages for infrastructures (respectively 27.3% and 25.6%). In contrast, the production sector is prominent (43.7%), and infrastructures account for a much lower proportion (22.7%) in the Southern regions⁶.

Table 1.4: Public capital stock by macro-sectors (% share)

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

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

⁵The five macro-sectors are: "general" sector (includes general public services, public order, justice administration, health and social welfare); "intangibles" sector (education, R&D, culture and recreational services); "infrastructures" (transports and telecommunications); "environment" (waste disposal and integrated water service); "production" (sectoral economic activities).

⁶The sectoral shares at the regional level are reported in Table A1.3 in the Appendix.

1.4 Production function model and data

1.4.1 The model

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

$$Y_{it} = A_{it} L_{it}^{\alpha} K_{it}^{\beta} QI_{it}^{\delta} e^{\varepsilon_{it}} \quad (1.1)$$

where the subscript i indicates the region, while t refers to the time period; Y is regional value added in constant prices 2010, L denotes labour input, measured as thousands of labour units (Eurostat), K is total capital stock; A represents the total efficiency level. As argued in the previous sections, the total factor productivity is assumed to depend on the Quality of Institutions (QI), because it exerts a pervasive role in driving economic outcomes, especially when public bodies are directly involved in investment decisions and indirectly by setting the normative and regulatory framework.

Moreover, to control for regional heterogeneity, model (1.1) is augmented with three immaterial factors: the endowments of human capital, social capital, and technological capital, which play a decisive role in enhancing the effectiveness of production inputs. Population density is also included to account for demographic trends and possible agglomeration effects. All the exogenous variables are included with a five-year lag, which allows us to consider a period long enough for the contextual variables to exert their effects on the dependent variable and guard against the potential problem of reverse causality.

As discussed in section 1.3, the total capital stock can be disaggregated into private and public capital. The latter can also be split up according to the bodies in charge of carrying out the investments and to the sectors of activity.

The empirical specification is obtained by log-linearizing model (1.1), including other control

variables, and accounting for the lag structure discussed above:

$$\ln(Y_{it}) = \alpha \ln(L_{it}) + \beta \ln(K_{it}) + \delta \ln(QI_{it-5}) + \gamma South_i + \lambda_t + controls_{it-5} + \varepsilon_{it} \quad (1.2)$$

To deal with the issue of potential endogeneity of the main productive inputs, we adopt an instrumental variable approach and the Two Stage Least Squares (2SLS) estimation method. Following Reed (2015) and the common practice usually adopted when it is very difficult to find valid external instrumental variables, we resort to the internal ones; hence, labour and capital stock are instrumented by their own lagged variables in all the estimated models. It is worth noting that lagged variables could not be valid instruments if they are correlated with unobserved confounders (Bellemare et al., 2017), to attenuate this problem, we have considered lags of five years. Although the choice of such a long lag comes at the cost of reducing the estimation sample size, it allows us to tackle endogeneity threats more effectively with respect to the case of shorter lags. Notwithstanding such considerations, all the estimated effects must be interpreted cautiously.

In a preliminary analysis we considered estimating Equation (1.2) by including regional fixed effects. However, such specification resulted in all coefficients of the explanatory variables being not significant at conventional levels. This could be due to the small time dimension of the panel and to the fact that most explanatory variables exhibit persistent cross-region variation.

To take into account the time-invariant divide between the Centre-North and the Southern areas, we include a dummy variable *South* that takes the value of 1 for the eight Southern regions⁷. Finally, time dummies (γ_t) are included to account for common shocks at the macroeconomic level.

Before presenting and discussing the main empirical results in the next sub-section we provide a detailed description of the most salient features of the variables used in our analysis other than the stock of capital, which has already been described in section 1.3.2.

⁷In a preliminary analysis we also included a dummy variable for the 9 Northern regions, however no significant differences were found with respect to the reference group of regions, i.e. the 4 Centre ones.

1.4.2 Data

We start by providing a statistical description for the dependent variable, regional value added, followed by institutional quality and the main contextual variables: human capital, social capital and technological capital. Table 1.5 and Figure 1.3 report the summary statistics of all the variables, while the complete list of the variables and their sources is reported in Table A1.1 in the Appendix. The Italian value added (VA) series shows a sharp decrease after the financial

Table 1.5: Descriptive statistics, indices (Italy = 100)

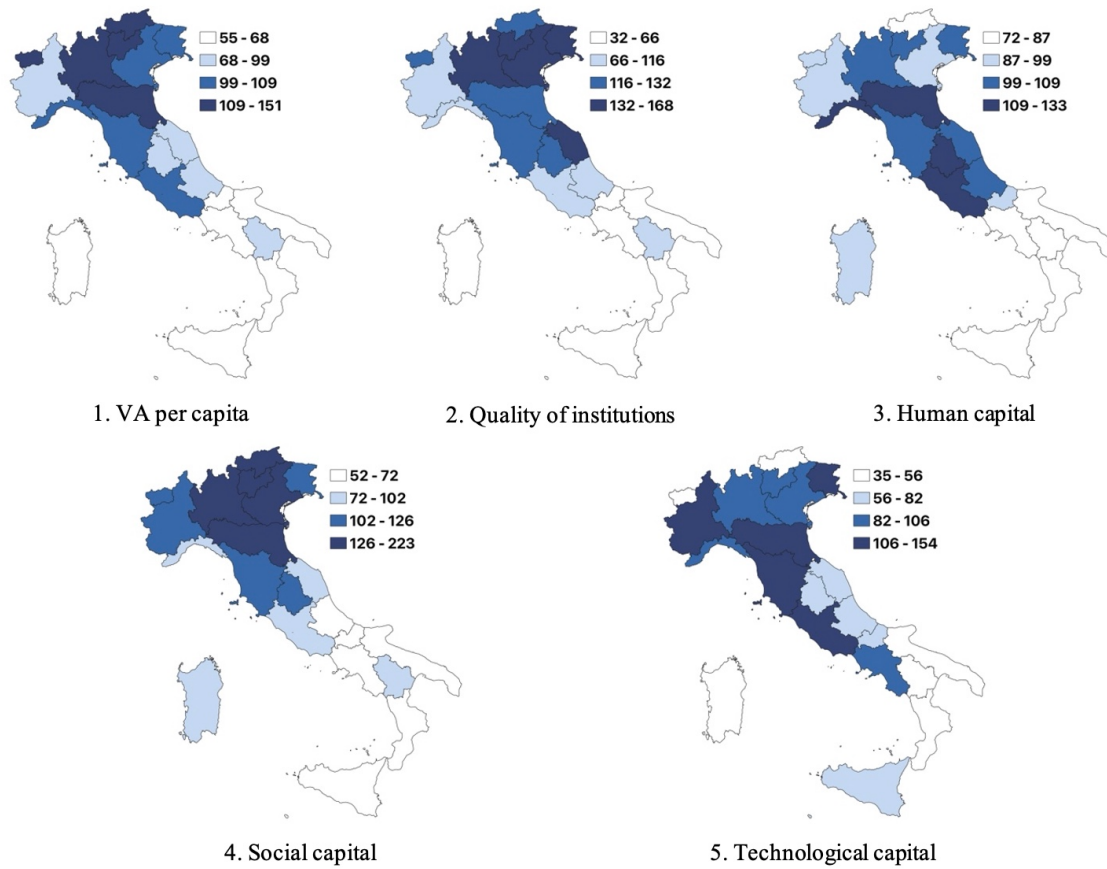
	North		Centre		South	
	2000	2019	2000	2019	2000	2019
Value Added (per capita)	113	113	105	102	63	61
Quality of Institutions (a)	135	132	112	118	54	55
Human capital	98	106	116	121	92	81
Social capital (b)	131	127	96	97	61	66
Technological capital	102	110	129	110	70	65

(a) initial year, 2004.

(b) final year, 2018.

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

In the econometric analysis, as factors influencing the economic performance at the regional level, we consider the intangible assets whose effect on production has been largely documented in the empirical literature on regional economic growth. Among them, we devote specific attention to the Quality of the Institutions since administrations and public companies implement

Figure 1.3: Regional distribution of main variables, 2019 (Indices, Italy = 100)

a large share of public investment at the local level. Seminal contributions have emphasized institutions' role in determining economic system performance (among others, North 1990, Acemoglu et al. 2001, Glaeser et al. 2004). A high-quality government ensures the provision of more efficient public services, thus supporting local economic development. More recently, the growth-enhancing effect of institutions at the regional level has been remarked by Rodríguez-Pose (2013) and Rodríguez-Pose and Ganau (2022). In this essay, we use the Quality of Institutions (QI) index computed by Nifo and Vecchione (2014) as a composite index based on various measures of corruption, government effectiveness, regulatory quality, rule of law, and voice and accountability⁸.

Regarding the other contextual variables, a large body of literature has documented the

⁸This index is similar to the Quality of Government Index computed by Gothenburg University for the European regions (Charron et al., 2015).

positive influence of human capital on economic performance at both the national (Murphy et al. 1991; Benhabib and Spiegel 1994) and regional levels (Moretti 2004). The availability of a well-educated labour force fosters the localisation of innovative firms, thereby enhancing regional productivity. Human capital is proxied by the share of the population aged 25–64 with tertiary education (ISCED levels 5–6).

The positive role played by technological capital in promoting productivity has been stressed in the literature following the original contribution by Griliches (1979). Firms may enjoy positive externalities deriving from the local availability of technology, enhancing local economic performance (Rodríguez-Pose and Crescenzi, 2008; see Audretsch and Feldman, 2004 for a comprehensive survey). Technological capital is proxied by R&D expenditure over GDP, rather than patent-based indicators, as this measure captures a broader range of innovative activities, including those that do not necessarily lead to codified knowledge.

Social capital is a complex feature of social organization which improves the efficiency of the local society and the transmission of knowledge by increasing the level of trust and thus, in turn, facilitating the cooperation among actors and reducing transaction costs for both firms and consumers (Putnam 1993, Knack and Keefer 1997, La Porta et al. 1997; De Blasio and Nuzzo, 2009 for the Italian regions). In this essay, we proxy social capital by the number of people (per 100 inhabitants over 14 years old) that have taken part at least once in the last 12 months in social activities such as voluntary service (Dettori et al. 2012, Beugelsdijk and Van Schaik 2005).

Table 1.5 and Figure 1.3 show a clear dualistic pattern between Northern and Southern Italy for all the exogenous factors considered. In the case of Institutional Quality, the Southern average is about half of the national one, while the Northern average is 2.4 times higher than the Southern one. As expected, institutional quality is particularly low in territories characterized by the presence of criminal organizations such as Sicilia (32), Calabria (32) and Campania (42). Six out of the eight Southern regions are in the lowest quartile of the Institutional Quality index distribution, whereas Centre-Northern regions display much more variability with none of them in the lowest quartile. Social capital shows a less dramatic difference, but the gap between the South and the North is still remarkable, as the two areas are, on average, 65 percentage points apart. The regional differences are very high, with Trento showing in 2019 the highest value, which is 4.3 times higher than the lowest one in Sicilia. Human capital shows a minor difference

between Northern and Southern Italy. At the same time, Central regions have the highest level of graduates with an average value of 19% higher than the national one. Differences between Northern and Southern Italy have decreased over time for social capital and institutional quality, whereas they have increased for human capital (6 percentage points in 2000 vs 25 percentage points in 2019). Technological capital is similarly distributed as human capital: Central regions display the highest mean value, even if, in this case, it decreases with time (129 in 2000 vs 110 in 2019). In this case, Southern and Northern Italy show significant and growing differences (32 percentage points in 2000 vs 45 percentage points in 2019).

It is important to remark that intangible factors exhibit positive correlations ⁹. This is particularly true for the Quality of Institutions and social capital (0.78). We will consider this issue in the econometric estimations.

1.5 Results

In this section we present the main results of the empirical analysis. We first discuss the evidence obtained by models in which the capital stock is included as an aggregate or by considering its private and public components. The analysis then proceeds by assessing whether the effects of public capital change significantly depending on the level of the administrations in charge of managing public investments (central vs local bodies) or the sector of policy interventions. Finally, we discuss the results of the most general model in which we allow the effect of public capital to change according to both levels of government and intervention sectors. Throughout the analysis we pay particular attention to the role of institutional quality and North-South differences.

1.5.1 The basic model

Table 1.6 reports the main results. The first specification considers capital stock at the most aggregate level. The elasticity of labour is 0.6, while the total capital stock shows an elasticity of 0.38. With respect to previous studies on the Italian case covering the pre-crisis period (Marrocu

⁹The matrix of correlation is reported in Table A1.4 in the Appendix.

and Paci, 2010) the estimated return appears higher for the capital input and lower for the labour input. The quality of institutions' variable exhibits the expected positive and significant elasticity.

Table 1.6: The effect of public capital on value added, 2000-2019

Dependent variable: value added

	(1)	(2)	(3)
Labour	0.602 *** (0.090)	0.463 *** (0.069)	0.461 *** (0.065)
Total capital	0.383 *** (0.094)		
Private capital		0.233 *** (0.042)	0.234 *** (0.041)
Public capital		0.362 *** (0.049)	0.365 *** (0.045)
Quality of Institutions	0.039 ** (0.018)	0.096 *** (0.018)	0.098 *** (0.019)
<i>Contextual factors</i>			
Human Capital	0.054 (0.087)	0.098 * (0.052)	0.096 ** (0.048)
Social capital	0.066 (0.047)	0.005 (0.025)	
Technological capital	0.013 (0.028)	-0.023 (0.023)	-0.023 (0.023)
Population density	0.068 ** (0.032)	0.094 *** (0.023)	0.094 *** (0.023)
South	-0.060 (0.049)	-0.082 *** (0.032)	-0.084 *** (0.027)

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

All variables are log-transformed.

Quality of Institutions and contextual variables are 5-year lagged.

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

All models include time dummies and a constant.

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

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

Cross-section observations (regions): 21.

Number of panel observations: 315.

On the contrary, the other intangible assets are not statistically significant; this unexpected result is reasonably due to the high collinearity among the contextual variables. We will return to this issue later. Among the territorial covariates, the population density shows a positive and significant impact, signalling the relevance of agglomeration effects, while the dummy South

shows the expected negative sign, although it is not statistically significant.

In column (2), the capital stock is disaggregated into its two components: private and public capital. They turn out to be both significant with the public stock displaying a higher elasticity (0.36) than the private one (0.23). The public capital elasticity results three times higher than the one Marrocu and Paci (2010) estimated for 1996-2003. Therefore, it seems that in recent years the role of public institutions in affecting production level has increased. For robustness, the model in column (2) is re-estimated using four- and six-year lags as instruments for labour and capital stock and applying the same lag structure to the control variables in place of the five-year lag. Results are reported in Table A1.5, in columns (1) and (2), respectively. Notice that the estimated coefficients for our variable of interest remain overall unchanged. Moreover, we estimate the same specification employing a more restricted definition of public capital, which excludes capital transfers to family, social institutions, and firms. Estimation results for this specification, reported in column (3) of Table A1.5, are very similar to the results of the baseline model (model 2, Table 1.6); however, the elasticity of public capital based on the narrower definition (0.29) is lower than that estimated using the broader one (0.36).

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

As expected, the social capital coefficient is still not significant due to the high correlation with institutional quality (0.78). To deal with this issue, we decompose the index into its single components and re-estimate the model including all of them simultaneously. Results reported in column (1) of Table A1.6 show that Regulatory Quality, Rule of Law, and Corruption display positive and statistically significant coefficients, while social capital remains non-significant, confirming the presence of multicollinearity with the institutional index dimensions. To mitigate this issue, we re-estimate the model including only the institutional component that is less correlated (0.42) with social capital: i.e. "Government effectiveness". As reported in column (2) of Table A1.6, both government effectiveness and social capital display positive and statistically significant coefficients, although the latter only at the 10% significance level. Moreover, the

elasticity estimated for Government effectiveness (0.017) is markedly smaller than that associated with the overall institutional quality index in the baseline model (0.096, Table 1.6), suggesting that the composite index captures a broader institutional dimension. To avoid multicollinearity problems, we exclude the social capital variable in the subsequent analysis.

Therefore, in (3) we report the estimation results obtained by excluding such variable. For the latter specification, which is the preferred one, in Table A1.7 we also report a comparison between Ordinary Least Squares (OLS) and 2SLS estimation; first stage regressions are presented in Table A1.8. It is worth noting that the labour elasticity is higher when applying the 2SLS method, whereas the opposite is the case for the private capital one. First-stage F tests are all highly significant, confirming the relevance of the instrumental variables. On model (3), we also performed diagnostic tests to check for possible spatial dependence among the territorial units, considering the inverse distance matrix. Following Kelejian and Prucha (2010), the proximity matrix is maximum-eigenvalue normalized; this normalization, while avoiding imposing strong restrictions, allows us to preserve symmetry and the importance of absolute, rather than relative, distance. Following Elhorst (2014), we consider as a starting point the flexible Spatial Lag of X (SLX) model to test for local spatial dependence. However, the coefficients of the spatially lagged variables turned out to be not significant. Moreover, Moran's I test result allowed us to exclude the existence of global spatial dependence.

1.5.2 Public capital by government bodies

In Table 1.7 we propose the results for models in which the public capital stock is included according to the institutional level of the administrative bodies in charge of carrying out public investments. We distinguish between central bodies (central administration and national public companies) and local bodies (regional and local administrations, local public companies). In model (1) of Table 1.7 we restrict the elasticities of public capital to be the same for the whole country and find that local bodies are slightly more effective (0.079) than central ones (0.060), as in Bom and Ligthart (2014).

In model (2), when we allow the elasticities to vary between the two main macro-areas of

Table 1.7: The effect of public capital by government bodies, 2000-2019

Dependent variable: value added

	(1)	(2)	(3)
Labour	0.620 *** (0.077)	0.583 *** (0.055)	0.477 *** (0.076)
Private capital	0.092 ** (0.042)	0.107 *** (0.030)	0.209 *** (0.054)
Public capital:			
central bodies	0.060 *** (0.019)	0.060 *** (0.017)	0.069 *** (0.013)
local bodies	0.079 *** (0.012)	0.092 *** (0.009)	0.084 *** (0.011)
central bodies * South		0.033 * (0.021)	
local bodies * South		-0.028 ** (0.015)	
central bodies * QI lowest quartile			0.018 (0.013)
local bodies * QI lowest quartile			-0.018 ** (0.010)
central bodies * QI highest quartile			-0.045 *** (0.013)
local bodies * QI highest quartile			0.027 *** (0.009)
Quality of Institutions (QI)	0.078 *** (0.014)	0.072 *** (0.017)	0.052 *** (0.010)
Contextual factors	yes	yes	yes
South	yes	no	yes

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

All variables are log-transformed.

Quality of Institutions and contextual variables are 5-year lagged.

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

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

All models include time dummies and a constant.

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

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

Cross-section observations (regions): 21.

Number of panel observations: 315.

See Table 1.2 for the list of bodies.

the country, sizeable and significant differences emerge ¹⁰. Central bodies in the Southern regions exhibit a significantly higher elasticity (0.093) with respect to Centre-Northern ones (0.060), whereas the opposite is the case for local bodies. Northern regions exhibit an elasticity (0.092) much higher with respect to Southern ones (0.064) ¹¹. Figure 1.4.A allows for a readily comparison of the estimated elasticities.

Since our models include the quality of institutions and several other factors which are expected to account for North-South differences, varying administrative level elasticities could be due to such variables not being adequate to control for latent traits related to institutional quality (Durlauf, 2002), as they are inherently difficult to measure.

As explained in section 1.4, low levels of institutional quality are mostly found in southern regions; thus, to gain more insights and enhance our understanding of how the functioning of the institutions may influence the effectiveness of public investment, we propose an alternative specification in model (3). This is obtained by augmenting model (1) with four interactive variables. Both central and local bodies are interacted with two dummy variables capturing low/high levels of institutional quality. More specifically, the first dummy takes the value of 1 when the regional level of institutional quality is in the first quartile of its distribution (low level of institutional quality), whereas the second dummy is equal to 1 for levels of institutional quality in the highest quartile (high levels of institutional quality).

Figure 1.4.B shows the estimated elasticities for public capital considering the different government bodies and institutional quality quartiles. When local bodies are in charge of public investments the effectiveness of public capital significantly increases with the level of institutional quality: the elasticity increases from 0.066 for the lowest levels of QI to 0.084 for the intermediate levels and up to 0.111 for the highest levels. Therefore, the high quality of regional institutions is particularly relevant for the local level of government.

As for central bodies, no significant differences in public capital elasticity (0.069) are detected between the case of regions with low vs intermediate (second and third quartiles) levels of institutional quality. On the contrary, at the highest level of institutional quality, public capital

¹⁰Note that for multicollinearity issues the dummy South is not included in model 2.

¹¹Mauro et al. (2023) argue that the decentralisation process of the 1970s allocates the provision of public capital to local institutions which, in the Southern Italian regions, are more exposed to a lower social capital and therefore are less effective in supporting the regional economic performance.

turns out to be less effective (0.024) compared to the intermediate level case. Although this result is somewhat unexpected and deserves further investigation in future research, it seems to suggest that in regions with the highest levels of *QI*, local bodies outperform central ones (public capital elasticity almost five times higher, 0.111 vs 0.024) because they are more capable of leveraging the direct knowledge of their territories and stakeholders and to benefit from a general level of trust in delivering their public interventions.

In general, the differences between central and local bodies could be related to the way of functioning of Italian public administrations, rooted in the country's historical development, so strongly influenced by its geography. As argued by Daniele et al. (2018), the process of modern growth that started in Italy in the late XIX century brought about structural changes, differentiated access to markets agglomeration dynamics that set the two macro-areas of the country on quite diverging paths, with the Northern one more densely interconnected with the wider and competitive European continental markets resulting in a more open and vibrant socio-economic environment (see also Felice 2019). Moreover, national economic policies have favored the Northern regions thus worsening the Italian territorial gap (Viesti, 2021). In recent years this process has been exacerbated by a strong migratory flow of highly qualified young people from the southern to the northern regions (Ballarino et al., 2022). This "brain drain" has further impoverished the endowment of human and technological capital in the South. Such a dualistic development process reasonably had important effects also on the administrative practices and ruling approaches of local government bodies in the North and in the South of Italy, although the legislation and the normative setting have been the same across the whole country. Additional arguments have been advanced by Bigoni et al. (2016) which, using a lab-in-the-field experiment, show that the persisting North-South divide can be explained in terms of a behavioral gap in cooperation due to differences in preferences, expectations and social norms¹². At the same time, it can be argued that such a cooperative gap may be in turn the effect of the lack of development factors in the South (public infrastructures and services, human capital, innovation) rather than its cause.

No matter what, in the last three decades, Southern territories were incapable of taking

¹²This experiment must be interpreted with caution since it is based on a small sample of 618 participants resident in only average-size cities.

advantage of the regional autonomy, enhanced by the 2001 devolution reform of Title V of the Italian constitution. For the Southern regions, the devolution resulted in a more fragmented political environment, higher pressure from specific stakeholders, and narrow administrative-decision capabilities to deal with the challenges the Mezzogiorno must confront. These include persistent issues, such as demographic trends, brain drain, low attractiveness for external investment, and the new ones brought about by the pandemic crises and the severe instability of the international scenario. These considerations help in explaining the estimated lower elasticities of Mezzogiorno's public capital once controlling for the positive role of institutional quality.

1.5.3 Public capital by macro-sectors

Table 1.8 reports the main results of the analysis carried out to assess the role of public capital according to the macro-sectors of policy interventions. Public capital elasticities are also displayed in Figure 1.4.C-D. As discussed in section 1.3 (see also Table A1.2), we distinguish among public investments related to general administration, infrastructures in the intangibles' assets, infrastructures, environment and production activities. Model (1) results indicate that the highest elasticity is exhibited by the public capital endowment in the intangibles (0.14), followed by the infrastructures (0.09) and the production sector (0.04). The high heterogeneity of the public expenditures' impact across sectors in the Mezzogiorno has been found by Albanese et al. (2020), who remarked the positive role of the investment in infrastructures. Similar results have been found by Crescenzi et al. (2016) for the impact of transport infrastructures in the European regions, which turns out to be positively associated with the quality of regional government.

Elasticities for the general and environment macro-sectors are not significant. This result might be due to a more indirect role of such kind of public capital on the production level, but also to multicollinearity issues as the variables are highly correlated. It is worth noting that results for all the other variables included in the model and previously discussed are confirmed. In models 2-4 we test whether the significant elasticities for intangible capital stock, infrastructures and production macro-sectors are the same across the Northern and Southern macro-areas of the country. Because of multicollinearity issues, we add the interactive term with respect to the South dummy one at a time while keeping all the variables already included in model 1.

Table 1.8: The effect of public capital by economic sectors, 2000-2019

Dependent variable: value added

	(1)	(2)	(3)	(4)
Labour	0.500 *** (0.056)	0.506 *** (0.058)	0.506 *** (0.057)	0.508 *** (0.058)
Private capital	0.226 *** (0.044)	0.223 *** (0.044)	0.222 *** (0.044)	0.220 *** (0.044)
Public capital:				
general	0.024 (0.023)	0.034 (0.025)	0.031 (0.024)	0.032 (0.024)
intangibles	0.144 *** (0.030)	0.142 *** (0.032)	0.141 *** (0.031)	0.139 *** (0.031)
infrastructures	0.087 ** (0.041)	0.087 ** (0.043)	0.087 ** (0.042)	0.086 ** (0.042)
environment	-0.016 (0.017)	-0.018 (0.017)	-0.017 (0.017)	-0.017 (0.017)
production	0.039 *** (0.013)	0.036 *** (0.012)	0.038 *** (0.012)	0.039 *** (0.012)
intangibles * South		-0.008 * (0.004)		
infrastructures * South			-0.006 ** (0.003)	
production * South				-0.004 ** (0.002)
Quality of Institutions	0.101 *** (0.019)	0.098 *** (0.021)	0.099 *** (0.020)	0.099 *** (0.020)
Contextual factors	yes	yes	yes	yes
South	yes	no	no	no

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

All variables are log-transformed.

Quality of Institutions and contextual variables are 5-year lagged.

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

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

All models include time dummies and a constant.

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

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

Cross-section observations (regions): 21.

Number of panel observations: 315.

See Table TA1.2 for the list of sectors.

All interactive terms are significant and exhibit a negative sign, indicating that macro-sectors elasticities are lower for Southern regions. Differences, however, are not sizeable: 0.142 vs 0.134 for intangible capital stock, 0.087 vs 0.081 for infrastructures and 0.039 vs 0.035 for the production macro-sector; in all cases, the estimated elasticities for Southern regions amount to more than 90% of those observed for the North, indicating only modest differences across macro-areas.

1.5.4 Public capital by bodies and sectors

This section considers whether significant differences in elasticities across sectors could be related to the government level in charge of public investments. Column (1) in Table 1.9 reports a specification where public capital for each of the five sectors is included separating the central or local body carrying out the expenditure. Interestingly, it emerges that the impact of central and local levels in each sector is highly differentiated (see Figure 1.4.E-F).

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

A different picture appears when we look at the sectoral effects of public capital managed by local bodies. In this case, the coefficients are not significant for the general, environment and production sectors. Contrary to what was found for the central levels, local bodies are significantly effective in providing public capital related to intangibles (education, culture, training) and infrastructure sectors. This result has relevant policy implications because increasing capital endowment in such sectors is crucial for driving regional performance along sustainable,

Table 1.9: The effect of public capital and sectors, 2000-2019

Dependent variable: value added

	(1)	(2)	(3)
Labour	0.528 *** (0.143)	0.528 *** (0.149)	0.575 *** (0.140)
Private capital	0.267 *** (0.091)	0.264 *** (0.098)	0.236 *** (0.092)
Public capital central:			
general	0.078 ** (0.035)	0.079 ** (0.036)	0.071 ** (0.036)
intangibles	-0.067 (0.057)	-0.073 (0.058)	-0.057 (0.057)
infrastructures	-0.007 (0.025)	-0.002 (0.025)	-0.011 (0.025)
environment	-0.028 *** (0.011)	-0.028 *** (0.011)	-0.027 *** (0.010)
production	0.109 ** (0.053)	0.111 ** (0.054)	0.096 * (0.053)
Public capital local:			
general	-0.054 (0.044)	-0.037 (0.041)	-0.051 (0.040)
intangibles	0.108 ** (0.054)	0.106 ** (0.054)	0.097 * (0.052)
infrastructures	0.191 *** (0.060)	0.188 *** (0.062)	0.191 *** (0.060)
environment	-0.017 (0.036)	-0.019 (0.038)	-0.024 (0.035)
production	-0.085 (0.087)	-0.087 (0.090)	-0.070 (0.086)
intangibles * South		-0.010 ** (0.005)	
infrastructures * South			-0.012 *** (0.004)
Quality of Institutions	0.092 *** (0.021)	0.090 *** (0.023)	0.079 *** (0.021)
Contextual factors	yes	yes	yes
South	yes	no	no

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

All variables are log-transformed.

Quality of Institutions and contextual variables are 5-year lagged.

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

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

All models include time dummies and a constant.

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

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

Cross-section observations (regions): 21.

Number of panel observations: 315.

See Table 1.2 for the list of bodies and Table TA1.2 for the list of sectors.

innovative, high-value growth trajectories.

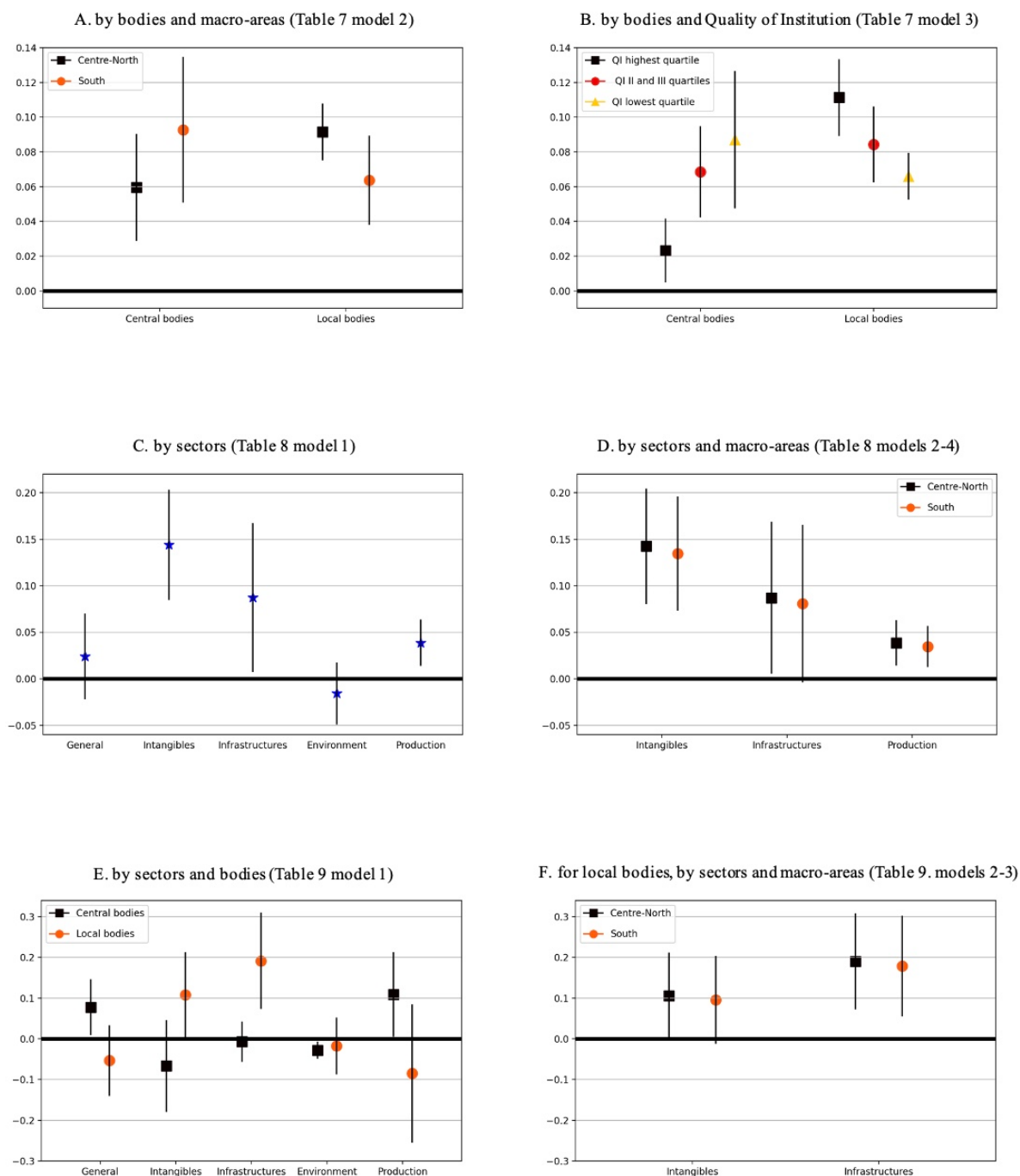
To investigate further on these positive impacts, we allow for the public capital coefficient in intangibles (column 2) and infrastructures (column 3) managed by local bodies to be different across macro areas of the country. For both sectors, the public capital managed by the Mezzogiorno local administrations exerts an impact lower than the Centre-North one.

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

1.6 Conclusions

This study has analysed how the public capital stock and the institutions' quality influence regional economic performance. Such analyses are crucial to advance our understanding of the effectiveness of European and national economic growth policies and to assess the ability of the local institutions in Italy to efficiently invest the vast NRRP resources they are about to receive to boost the economy after the pandemic crisis.

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

Figure 1.4: Public capital estimated elasticities, 95% confidence intervals

The first result is that public capital stock plays a positive role in driving the production level, with a higher elasticity with respect to the private one. Institutional quality also emerges as a key determinant of regional performance, a factor commonly neglected in earlier analyses owing to

data constraints. The positive and significant elasticity exhibited in all specifications remarks the importance of public institutions for fostering the development processes and enhancing economic growth. In this regard, more research is needed to disentangle the complex mechanisms through which local institutions, directly and indirectly, influence the regions' economic performance (Rodríguez-Pose, 2020).

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

A central result of our analysis is the considerable difference across territorial areas and sectors in the impact of capital expenditure realized by central and local institutions. Considering the disaggregation into government levels, it turns out that in Southern Italy, central bodies display a higher elasticity than the Centre-North. The opposite result is found for the local bodies, which prove much less effective in the Southern regions. Our analysis provided sound evidence that the effectiveness of public capital managed by local bodies significantly increases with the level of institutional quality, which has been persistently low in the Mezzogiorno of the country.

This might be rooted in the country's historical development strongly influenced by its geography¹³. Moreover, the macroeconomic factors and the economic policy choices of the national governments contributed to worsen the North-South gap triggering a vicious circle. The Southern regions have been characterized by less development, less provision of public services and infrastructures, less employment opportunities, brain drain, further reduction of human capital and innovation. The combination of these deep-root factors with current economic dynamics could also have shaped the different ways of public administrations functioning across macro-areas of the country.

¹³According to D'Adda e De Blasio (2017) the lower effectiveness of development enhancing policies directly implemented by local administrations in the Southern Italy territories depends on their historical legacy: i.e. having been part of the Kingdom of the Two Sicilies characterised by a high degree of autocracy.

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

Evidence from recent monitoring of NRRP implementation helps to further qualify this risk. According to the SVIMEZ–ANCE monitoring exercise (SVIMEZ, 2025), municipalities have, on average, performed better than regional administrations in implementing NRRP projects—particularly in areas such as social infrastructure—even in Southern Italy, where the implementation burden is heavier. Moreover, the speed of project execution has increased markedly compared to the pre-NRRP period: preparatory phases preceding the start of works have become significantly shorter, with improvements especially pronounced among local administrations and in regions where delays were historically more severe. At the same time, the same evidence documents the persistence of significant spatial disparities in implementation performance, with Southern regions still lagging behind the Centre–North across several dimensions of project execution, indicating that long-standing territorial gaps have been reduced but not eliminated (SVIMEZ, 2025).

Taken together, these considerations point to the need for urgent action along at least two complementary directions. In the short run, given the tight implementation timeline of the NRRP, continued central government support to local administrations is essential. Dedicated task forces and technical assistance mechanisms accompanying project design, procurement, and implementation can help mitigate local capacity constraints. While such instruments are already envisaged within the NRRP framework, the evidence presented in this study suggests that—especially in Southern regions—they should be further strengthened, more systematically deployed, and better aligned with local institutional conditions to ensure that NRRP resources are effectively transformed into productive public capital.

From a longer-term perspective, it is imperative to adopt policies aimed at addressing the profound and structural issues related to the low institutional quality of the Southern regions in Italy. As the results have shown, the Mezzogiorno's low quality of institutions is one of the most

relevant factors that continue to slow down its development. As we have discussed, the causes of such negative features are numerous, complex, intertwined, and deep-rooted in the historical and economic development of the South. Therefore, improving the quality of the local institutions is not an easy task, as demonstrated by decades of failures of the North-South territorial rebalancing policies in Italy ¹⁴. If local institutions' quality is rooted in the country's historical development and in decades of vicious economic twist, it cannot be simply changed or improved by a central government law. What is needed is a profound change in the Southern regions in people's social norms and individual behaviours, which can be attained, in our opinion, only through a long-term education policy. Investing, for a long period of time, considerable human and financial resources in the schooling and university system in the Southern regions seems the only policy able to break the persistent territorial divide in Italy and activate a virtuous and self-reinforcing mechanism by which increasing levels of human capital create a more favourable local environment for families and firms and contribute to further enhance the quality of institutions.

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

¹⁴A rapid improvement in the institutional quality can be also determined in the short run in the presence of extraordinary external shocks, like the fall of communism and the entrance in the European Union for the Central and Eastern European countries (Rodríguez-Pose (2020, p. 375)). The persistence of a low-quality institutional levels in the Mezzogiorno regions is clearly different since they have been part of a common national institutional setting over the last 150 years.

1.7 References

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1.8 Appendix

Figure A1.1: Public Capital Share in Italy: IMF vs. Authors' Computation

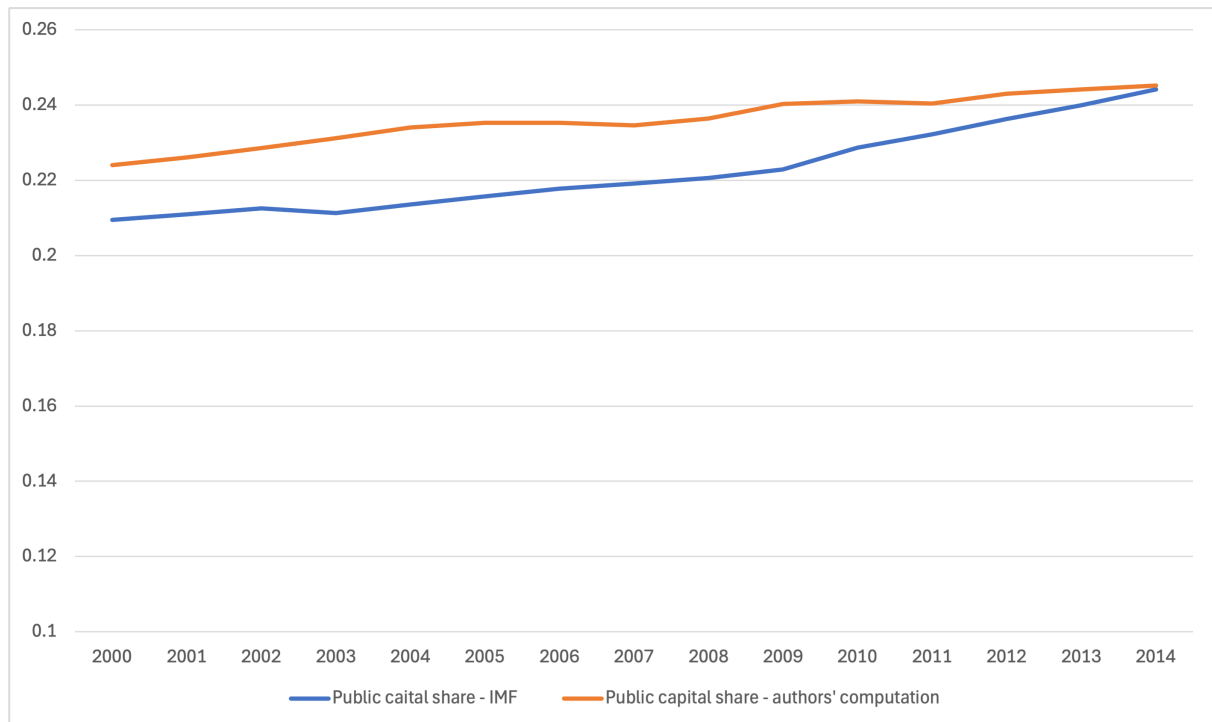


Table A1.1: Data sources and definition

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

* Year 2019 has been assumed equal to 2018.

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

Table A1.2: Public capital stock in Italy by sectors (% share)

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

Source: own calculation on Conti Pubblici Territoriali data.

Table A1.3: Public capital stock by macro-sectors (% shares, average 2000-2019)

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

Source: own calculation on Conti Pubblici Territoriali data

Table A1.4: Correlation matrix

	Value added	Labour	Private capital	Public capital	Quality of Institutions	Human capital	Social capital	Technological capital	Population density
Value added	1								
Labour	0.990	1							
Private capital	0.982	0.970	1						
Public capital	0.915	0.944	0.878	1					
Quality of Institutions	0.127	0.049	0.153	-0.147	1				
Human capital	0.152	0.133	0.066	0.033	0.343	1			
Social capital	-0.011	-0.074	0.015	-0.184	0.780	0.144	1		
Technological capital	0.462	0.459	0.437	0.450	0.335	0.531	0.130	1	
Population density	0.776	0.814	0.737	0.817	-0.119	0.157	-0.239	0.451	1

Table A1.5: Robustness checks on the baseline model

Dependent variable: value added

	(1) lag-4	(2) lag-6	(3) restricted public capital
Labour	0.458 *** (0.066)	0.465 *** (0.074)	0.504 *** (0.060)
Private capital	0.240 *** (0.039)	0.229 *** (0.047)	0.235 *** (0.048)
Public capital	0.361 *** (0.048)	0.366 *** (0.050)	0.292 *** (0.029)
Quality of Institutions	0.098 *** (0.017)	0.097 *** (0.020)	0.097 *** (0.019)
<i>Contextual factors</i>			
Human capital	0.109 ** (0.053)	0.087 * (0.052)	0.067 (0.041)
Social capital	0.001 (0.024)	0.004 (0.025)	0.013 (0.022)
Technological capital	-0.024 (0.023)	-0.022 (0.024)	-0.003 (0.023)
Population density	0.091 *** (0.023)	0.097 *** (0.023)	0.107 *** (0.022)
South	-0.082 *** (0.032)	-0.083 *** (0.031)	-0.036 (0.022)
Observations	336	294	315

Columns (1)–(2) report models estimated using alternative lags (4 and 6 years, respectively).

Column (3) uses a restricted definition of public capital, which excludes capital transfers.

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

All variables are log-transformed.

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

Quality of Institutions and contextual variables are temporally lagged.

All models include time dummies and a constant.

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

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

Cross-section observations (regions): 21.

Table A1.6: Components of the quality of institutions index and social capital

	(1)	(2)
Labour	0.439 *** (0.047)	0.560 *** (0.091)
Private capital	0.220 *** (0.036)	0.211 *** (0.058)
Public capital	0.394 *** (0.033)	0.260 *** (0.064)
Government effectiveness	0.009 (0.006)	0.017 *** (0.006)
Regulatory quality	0.085 *** (0.028)	
Rule of law	0.034 ** (0.016)	
Voice and accountability	0.019 (0.030)	
Corruption	0.073 *** (0.019)	
Social capital	-0.011 (0.018)	0.066 * (0.039)
Other contextual factors	Yes	Yes

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

All variables are log-transformed.

Quality of Institutions and contextual variables are 5-year lagged.

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

All models include time dummies and a constant.

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

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

Cross-section observations (regions): 21.

Number of panel observations: 315.

Table A1.7: Comparison between OLS and IV estimation of model (3) in Table 1.6

Dependent variable: value added

	OLS	2SLS
Labour	0.444 *** (0.060)	0.461 *** (0.065)
Private capital	0.248 *** (0.037)	0.234 *** (0.041)
Public capital	0.368 *** (0.043)	0.365 *** (0.045)
Quality of Institutions (QI)	0.097 *** (0.019)	0.098 *** (0.019)
<i>Contextual factors</i>		
Human Capital	0.098 * (0.051)	0.096 ** (0.048)
Technological capital	-0.024 (0.024)	-0.023 (0.023)
Population density	0.094 (0.026)	0.094 *** (0.023)
South	-0.081 *** (0.028)	-0.084 *** (0.027)

All variables are log-transformed.

Quality of Institutions and contextual variables are 5-year lagged.

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

All models include time dummies and a constant.

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

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

Cross-section observations (regions): 21.

Number of panel observations: 315.

Table A1.8: First stage regressions of the 2SLS estimation of model (3) in Table 1.6

Dependent variable:	First stage regressions		
	Labour	Private capital	Public capital
<i>Instrumental variables</i>			
Labour (<i>t</i> -5)	0.965 *** (0.030)	-0.003 (0.053)	-0.034 (0.091)
Private capital (<i>t</i> -5)	0.008 ()	0.951 *** ()	0.036 ()
Public capital (<i>t</i> -5)	0.055 *** (0.017)	0.088 ** (0.037)	1.027 *** (0.054)
<i>QI and Contextual factors</i>			
Quality of Institutions (QI)	0.023 *** (0.006)	0.057 *** (0.021)	0.026 (0.016)
Human Capital	0.061 *** (0.018)	0.084 * (0.046)	0.020 (0.068)
Technological capital	-0.014 * (0.008)	-0.011 (0.016)	-0.025 * (0.013)
Population density	-0.004 (0.006)	0.000 (0.013)	-0.001 (0.031)
South	-0.007 (0.008)	0.027 (0.026)	-0.018 (0.031)
First stage F test	32191.70	5860.69	893.34
p-value	0.000	0.000	0.000

All variables are log-transformed.

Instruments: five-year lag of labour, private capital and public capital.

Quality of Institutions and contextual variables are 5-year lagged.

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

All models include time dummies and a constant.

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

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

Cross-section observations (regions): 21.

Number of panel observations: 315.

Essay 2

EU Cohesion Funds and Regional TFP Growth: A Spatial and Temporal Perspective*

Abstract.

The European Union's (EU) cohesion policy aims to reduce regional disparities through the European Structural and Investment Funds (ESIFs). While previous research has documented the positive effects of ESIFs on GDP growth, the role of regional capital accumulation in the growth process remains under explored. To address this gap, the present study investigates the impact of ESIFs on regional performance by focusing on Total Factor Productivity (TFP) growth as the outcome variable. TFP is computed by accounting for the highly heterogeneous patterns of capital accumulation across 262 NUTS2 regions over the period 2000-2019. Using annualised regional expenditure data, we assess the influence of fund allocation independently of EU programming periods. Our empirical strategy accounts for temporal heterogeneity by distinguishing three distinct phases: pre-crisis (2000–2008), crisis (2008–2014), and recovery (2014–2019). It also considers spatial heterogeneity by classifying regions according to their level of economic development. Furthermore, we disentangle the effects of the main funds—namely, the European Regional Development Fund (ERDF), the European Social Fund (ESF), the Cohesion Fund (CF), and the European Agricultural Fund for Rural Development (EAFRD). The results indicate that ERDF is positively associated with regional TFP, particularly during the 2014–2019 period, contributing to the reduction of productivity gaps between Eastern and more advanced regions. EAFRD enhances agricultural TFP growth, although primarily in regions that already exhibit high productivity levels. The remaining funds do not show statistically significant effects. These findings underline the importance of accounting for investment heterogeneity when evaluating the effectiveness of ESIFs and contribute to the broader policy debate on regional development strategies within the EU.

*Part of the results presented in this essay have been published as: Aresu F., Marrocu E. & Paci, R. EU funds and TFP growth: how the impact changed over time and space. *Ann Reg Sci* 75, 1 (2026). <https://doi.org/10.1007/s00168-025-01424-z>

2.1 Introduction

The European Union's (EU) cohesion policy has long been a fundamental pillar in addressing regional disparities and fostering economic convergence among member states. Aimed at mitigating structural imbalances, particularly in regions classified as "less developed," this policy channels financial support through the European Structural and Investment Funds (ESIFs). Reflecting the EU's strong commitment to this objective, approximately 500 billion euros were allocated to ESIFs between 2009 and 2018. Among these funds, the European Regional Development Fund (ERDF) is the main structural program in terms of allocated financial resources (34.3% of all ESIFs in 2018). The European Social Fund (ESF) is dedicated to improving employability, fostering social inclusion, and supporting human capital investments. The European Agricultural Fund for Rural Development (EAFRD) promotes rural development and sustainable agriculture, while the Cohesion Fund (CF) seeks to reduce economic and social disparities in less developed regions by financing investments in environmental and transport infrastructure. In 2014, the scope of ESIFs was further expanded with the introduction of the European Maritime and Fisheries Fund (EMFF), the Fund for European Aid to the Most Deprived (FEAD), and the Youth Employment Initiative (YEI), which support maritime and fisheries sustainability, combat material deprivation, and address youth unemployment in the most affected regions, respectively.

Over the past two decades, numerous studies have examined the impact of EU funds on regional economic performance (see, among many others, Becker et al. 2010, Rodríguez-Pose and Garcilazo 2015; Dall'Erba and Fang 2017; Gagliardi and Percoco, 2017). While most of these studies indicate a positive effect of structural funds on regional GDP growth, their findings highlight significant variation depending on contextual factors and time periods.

Crucially, many of these contributions (a notable exception is Fiaschi et al. 2018) overlook the broader interplay of regional capital accumulation, due to both private investments – whose role is dominant in more advanced regions – and public expenditures from national or local governments. This is important because ESIF accounted for only 1.1% of Europe's total gross fixed capital formation during 2016-2018. Moreover, their share in total regional investments varies considerably across EU regions: in the Acores, ESIFs represent 26% of total investments,

whereas in Île-de-France, they account for only 0.05%. This highlights the need to consider all sources of investment when assessing the impact of ESIFs.

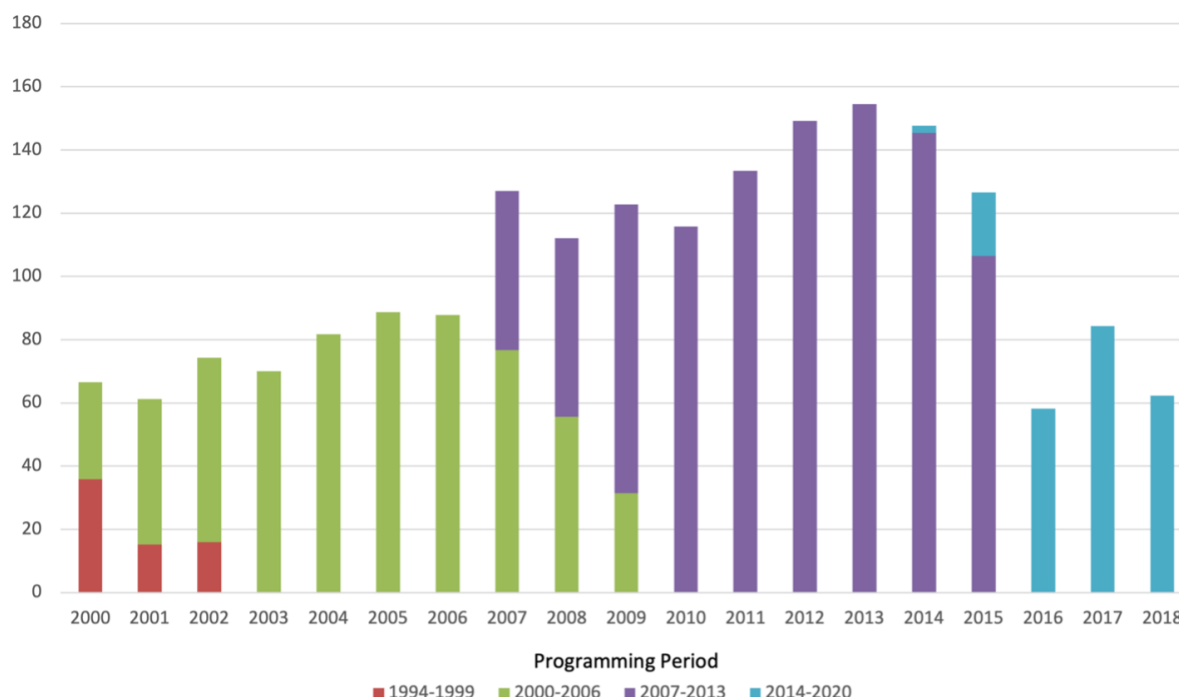
This essay contributes to the current debate on the effectiveness of ESIFs in driving regional performance by addressing these gaps in four key ways. First, we focus on Total Factor Productivity (TFP) growth, rather than GDP per capita growth, as the primary outcome variable. This allows us to assess the impact of ESIFs while accounting for other important sources of investment that contribute to capital stock formation. Furthermore, TFP growth directly captures improvements in production efficiency, which EU funds aim to enhance through infrastructure, human capital, and technology investments. Such investments are expected to boost resource allocation, improve business conditions, and support regional diversification into higher-value-added sectors.

Second, the empirical analysis covers the period 2000–2019 and is based on a panel of 262 European NUTS2 regions. We rely on annualised regional expenditure data on Cohesion Policy provided by the European Commission’s Directorate-General for Regional and Urban Policy (EC, 2017). The use of annual expenditure flows allows the relationship between EU financial support and regional TFP growth to be assessed on the basis of resources effectively disbursed in each year, rather than on allocations defined at the programming-period level. As illustrated in Figure 2.1, expenditures originating from different programming periods systematically overlap within the same calendar year, reflecting the multiannual nature of project implementation and the $n+3$ rule¹. As a result, observed expenditures typically reflect the simultaneous implementation of projects approved under different strategic frameworks, making it impossible to disentangle effects associated with specific programming periods². This identification issue also characterises empirical approaches that adopt programming periods as the primary temporal unit of analysis. Since disbursements related to a given programming cycle extend well beyond its nominal boundaries, analyses structured around programming periods are likewise unable to isolate period-specific policy effects. In this context, focusing on annualised actual disbursements provides a more transparent representation of the effective timing and intensity of Cohesion Policy support.

¹The $n+3$ rule allows funds committed in a given programming period to be spent up to three years after their commitment, implying that programmes are effectively implemented over a period longer than the nominal seven-year cycle.

²Including programming-period indicators would not resolve this issue, as overlapping disbursements prevent expenditures from being uniquely assigned to a single programming cycle.

Figure 2.1: Average annual ESIF expenditure per programming period, 2000-2018 (euro per capita, constant prices 2015)



Third, we address both temporal and spatial heterogeneity. It is important to highlight that the period under analysis encompasses major macroeconomic disruptions, most notably the 2008 global financial crisis and the subsequent European sovereign debt crisis, both of which had profound and asymmetric effects across EU regions. The use of expenditure data allows us to move beyond the conventional programming period framework and instead adopt a macroeconomic perspective that adequately accounts for the evolving economic landscape shaped by the two crises and their implications for the effectiveness of ESIFs. Thus, to address this issue, we consider three distinct phases: 2000–2008 (pre-crisis), 2008–2014 (financial crisis), and 2014–2019 (recovery phase)³. In addition to temporal heterogeneity, we also examine territorial heterogeneity by classifying regions into three main subgroups: (i) more advanced regions⁴, (ii) less developed regions within the countries that joined the EU until 1995 (EU15), and (iii)

³The definition and identification of these sub-periods are inherently subjective and should be interpreted with caution. While the proposed periodisation is broadly consistent with the aggregate trends in average regional TFP reported in Appendix Figure A2.1, not all European regions experienced the crisis and the subsequent recovery along the same timeline. We return to this issue in more detail in Section 2.5.3.

⁴More advanced regions include both “transition” and “more developed regions” (i.e. all regions with a per capita level of GDP above 75% of the EU average).

less developed regions in countries that joined the EU after 2004 (EU13) ⁵. Although transition and more developed regions differ in their level of economic development, they share a common position within the EU Cohesion Policy framework, as both lie above the eligibility threshold for the most redistributive interventions. Grouping them together therefore allows us to distinguish regions where Cohesion Policy plays a complementary role from those where it represents a core convergence instrument.

Finally, we investigate the differentiated impact of the four main funds – ERDF, ESF, CF and EAFRD – which together accounted for 97% of total ESIFs in 2014-19. Particular attention is given to the sector-specific effects of EAFRD on agricultural productivity.

The empirical strategy consists of two stages. First, we estimate a production function model with the traditional inputs – labour and capital – to compute regional TFP levels for 2000-2019. In the second stage, we assess the effects of EU funds on the TFP growth while controlling for key regional characteristics, including human capital, technological capital, institutional quality, and population density.

Given the broad geographical coverage and extended time span of the dataset, we adopt a growth regression framework that, while not suited for causal identification through methods such as Difference-in-Differences (DiD) or Regression Discontinuity Design (RDD), allows for a comprehensive analysis of the role played by ESIFs on regional TFP growth across the EU. To address potential endogeneity concerns, we complement this approach with an instrumental variables (IV) strategy and a carefully structured temporal specification of the models.

Our results indicate that the effectiveness of EU funding varies significantly across funds, regions, and time periods. We find that ERDF has a positive effect on regional TFP, particularly in the recovery phase 2014-2019, contributing to a narrowing of productivity gaps between eastern, less developed regions and more advanced ones. When we focus on the impact of EAFRD on regional agricultural TFP growth, an interesting result emerges: the enhancing growth effect is found for regions with pre-existing high levels of agricultural productivity. As for the other funds, no positive association with regional TFP growth is detected.

The remainder of the essay is structured as follows. Section 2.2 reviews the relevant literature.

⁵Less developed regions are those with a per capita GDP below 75% of the European average. The complete list of EU15 and EU13 countries is reported in Table 2.1.

Section 2.3 describes the computation of regional TFP. Section 2.4 presents the ESIF distribution across EU regions and the regional contextual variables. Section 2.5 presents the main results of our growth models along with robustness checks based on IV estimation. Sections 2.6 and 2.7 provide two extensions, focusing respectively on the territorial heterogeneity of the ERDF and the impact of the EAFRD on agricultural productivity. The final section summarises the findings and discusses their policy implications.

2.2 Literature background

The European Union has progressively increased its budget allocation to regional cohesion policy, capturing the attention of scholars and public opinion. Despite the extensive academic debate, the economic literature has not yet reached a consensus on the economic impact of ESIFs.

Early contributions employed growth regressions using GDP as the dependent variable and revealed heterogeneous results that varied by period and regional subset (Fagerberg and Verspagen, 1996; Cappelen et al., 2003). Dall’Erba and Fang’s (2017) meta-analysis further identified factors contributing to this heterogeneity, including variations in research design, data characteristics, and the choice of regressors. Many studies relying on these models (e.g., Rodríguez-Pose and Garcilazo, 2015; Pellegrini et al., 2013; Di Caro and Fratesi, 2022) often fail to account for other sources of regional investment, leading to potentially underspecified models. Notable exceptions include Fiaschi et al. (2018), who incorporated the regional average annual investment rate in their specification, and Albanese et al. (2021), who investigated ESIFs’ impact on the TFP of southern Italian local labour markets. Furthermore, the prevalent use of aggregated ESIF measures in early studies has obscured potential differences in the impacts of individual funds.

More recent studies have adopted quasi-experimental approaches, specifically the Regression Discontinuity Design (RDD), to achieve proper causal identification. These contributions have highlighted that regions classified as less developed – and therefore receiving more substantial financial support – tend to experience positive growth effects (e.g., Pellegrini et al., 2013; Becker et al., 2010; Gagliardi and Percoco, 2017). However, despite methodological advances, these studies continue to focus almost exclusively on GDP-based outcomes, overlooking alternative dimensions of regional performance such as productivity. Moreover, they do not account for

policy characteristics, such as heterogeneous funds' aims, temporal and, in most cases, also spatial distribution.

Both strands of literature have uncovered valuable insights, particularly on the role of regional contextual factors in influencing the effectiveness of ESIFs. Recent contributions show that their impact often depends on other regional factors, such as human capital, the quality of local institutions (Di Caro and Fratesi, 2022; Incaltarau et al., 2020; Becker et al., 2013) and territorial capital (Bachtrögl et al., 2020). Moreover, ESIFs tend to produce stronger effects in industry and agriculture than in services (Coppola et al., 2023), suggesting the pivotal role of the sectoral composition of regional economies in mediating policy outcomes (Percoco, 2017).

As a result, ESIF impacts remain highly heterogeneous across space. While the policy has proven effective in mature economies like Germany and the UK (Crescenzi and Giua, 2020), evidence for weaker effects in Southern Italy is reported by Albanese et al. (2021) and Ciani and de Blasio (2015). Gagliardi and Percoco (2017) find that support is particularly effective in rural areas near urban hubs. Complementary findings suggest that Cohesion Policy may have also amplified intra-regional inequalities, particularly where large urban agglomerations have disproportionately benefited, as shown in the Greek context (Psycharis et al., 2024). At the same time, evidence from López-Villuendas and del Campo (2024) points to similar dynamics at the European scale, while Capello et al. (2025) demonstrate that, at a broader territorial level, Cohesion Policy has nonetheless contributed to reducing interregional disparities across EU regions.

Some recent contributions have focused on specific ESIF funds or axes, considering their specific aims and thus investigating their impact within a more detailed framework. The analysis of Mussida et al. (2023) represents a notable example: the authors have evaluated the impact of funding allocated through the ERDF and ESF under the thematic policy objectives "sustainable and quality employment" and "social inclusion" on material deprivation in the Spanish regions. Their approach, which accounted for individual and regional characteristics, revealed that interventions aimed at social inclusion effectively mitigate the risk of individual material deprivation. Insolda et al. (2024) have investigated the role of EAFRD in the Italian context, focusing on the agricultural sector, finding a positive impact on the sectoral output and private investment but a negative impact on sectoral employment.

In this contribution, by using ESIFs expenditure data, we address the spatial and temporal heterogeneous impact of ESIF, trying to fill some of the identified gaps by considering a very comprehensive set of EU regions rather than focusing on specific countries. The concurrent role of other regional sources of capital accumulation is accounted for by employing TFP as the outcome variable. Moreover, we investigate the role of each fund on TFP growth, and we offer a more in-depth analysis of the impact of ERDF and EAFRD funds.

2.3 The computation of regional TFP

As highlighted in section 2.2, most previous contributions on the impact of EU funds have overlooked other sources of investment, both private and public, that played an important role in shaping regional development. Although sizeable in absolute terms, ESIFs constitute a small part of total investments (nearly 1% in 2018) at the regional level. Thus, it is essential to account for the other relevant channels of capital accumulation when analysing ESIFs' effect on regional economic performance. An effective way of doing so is to assess the impact of EU funds on regional TFP rather than on GDP or labour productivity, as in most previous studies. As is well known, the computation of TFP is derived from estimating a production function, which accounts for the accumulation of total investment flows. Therefore, this approach allows for a more accurate assessment of the impact of ESIFs on regional performance.

Following Marrocu et al. (2022), we compute regional TFP levels using a quasi-growth accounting approach for the 262 NUTS2 EU regions (2010 version) included in our sample over the period 2000-2019⁶. We first estimate labour and capital elasticities from a Cobb-Douglas production function model rather than imposing them. Next, we compute the regional TFP levels by applying the quasi-growth accounting method using the estimated factors' elasticities, assumed invariant over the period under study⁷.

Figure 2.2.a shows the regional TFP levels in the initial year 2000 (index, EU=100), while the regional TFP average annual growth rates for the 2000-2019 period are depicted in Figure

⁶We are including the United Kingdom since it was part of the EU during the period under study. Malta is excluded given the lack of data for value added. The extra European territories of France, Portugal and Spain are also excluded.

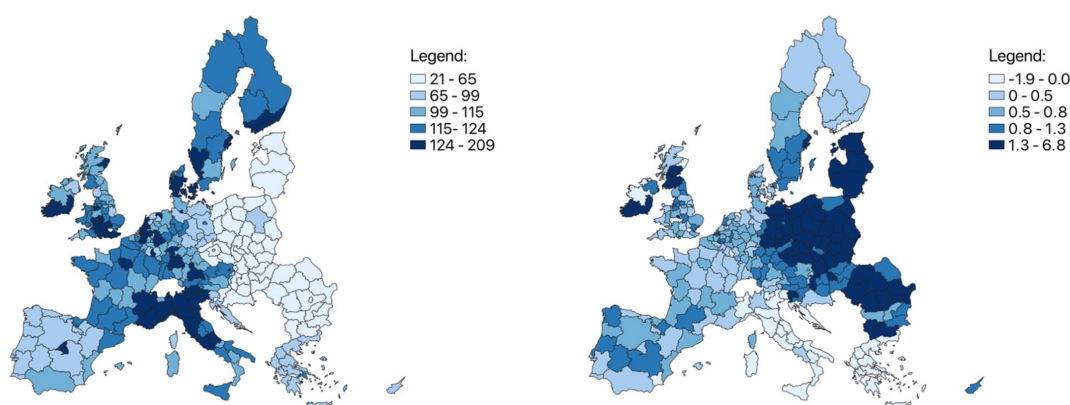
⁷The estimation procedure of the Cobb-Douglas production function is presented in the Appendix, along with the computation of the capital stock series calculation. See Table A2.1 for the definition of variables and data sources.

2.2.b. The maps show very different productivity patterns among the EU macro-areas. Regions of Central-Northern countries show high initial TFP levels and exhibit stable, albeit modest, TFP growth rates. In contrast, despite their lower initial productivity, regions of new accession countries display high and sustained growth rates. Notably, by 2019, more developed capital regions achieved TFP levels approaching the EU average, like Mazowieckie–Warsaw in Poland (index of 99), Prague in Czechia (91), and Cyprus (87). In contrast, while Southern regions initially exhibited TFP levels close to the EU average, with some highly productive areas such as Lombardy and Madrid, regions in Italy and Greece have experienced negative TFP growth over the period.

Figure 2.2: Regional TFP

Figure 2.2.a: TFP level, 2000 (Index EU=100)

Figure 2.2.b: TFP annual average growth rate, 2000-2019 (%)



Under the Cohesion Policy framework, financial resources are mainly allocated to less-developed regions, defined as regions with a per capita GDP below 75% of the European average. The classification is revised for each EU programming period, reflecting changes in regional economic conditions to ensure that support is appropriately targeted. (Figure A2.2 in the Appendix shows less developed regions for each programming period).

Therefore, given the observed spatial pattern in Figures 2.2, we classify regions into three subgroups: (i) more advanced regions, (ii) less developed regions in the EU15, (iii) less developed regions in the EU13. Additionally, we consider three distinct sub-periods to account for the economic impacts of the 2008 and 2011 financial shocks: the pre-crisis period (2000–2008), the crisis period (2008–2014), and the recovery phase (2014–2019).

The regions' classification and the TFP dynamics are presented in Table 2.1. Almost all regions within the EU13 new accession countries are included as less developed areas: indeed, only the capital city regions Prague, Cyprus, and Bratislava were classified as more advanced during the programming period 2000-2007. At the same time, the number of less developed regions in the EU15 central-northern regions has significantly decreased, falling from 13 in the first period to just two regions in the UK in the last one. The years 2008-2014 stand out for the lowest annual average growth rates across all subgroups, reflecting the severe impact of the financial crisis. TFP severely declined in EU15 less developed regions. Conversely, EU13 less developed regions show a positive, albeit moderate, annual average TFP growth rate, whereas more advanced regions display an almost stationary productivity dynamic.

The contrasting trajectories shown in Table 2.1 emphasize the heterogeneity of regional development across the EU and the sharp temporal heterogeneity. They reveal a pattern of productivity convergence in less-developed Eastern regions towards more advanced ones, contrasted with the stagnation of EU15 less-developed regions. These spatial and temporal heterogeneous economic dynamics across the EU regions will be carefully addressed in our econometric analysis since we expect that the impact of ESIF on regional economic performance varies according to the development stage of the receiving regions and the period under consideration.

2.4 Data

2.4.1 European Structural and Investment Funds

ESIFs are key EU regional policy instruments that promote economic, social, and territorial cohesion. Although they are supposed to have a supply effect on GDP in the medium-long run term, they can also significantly influence TFP by addressing investment in crucial economic areas such as physical and digital infrastructure, human capital, new technologies adoption, and collaborative networks, as well as providing support to streamline regulatory processes, reduce bureaucratic red tape and improve the ease of doing business. This way, ESIFs could lead to a more efficient allocation of resources and favour diversification into higher-value-added sectors,

Table 2.1: Regional classification and Total Factor Productivity in EU macro-areas

	More advanced regions	EU15 less-developed regions	EU13 less- developed regions	European Union
Number of regions				
2000-2008	164	44	38	246
2008-2014	183	26	53	262
2014-2019	196	16	50	262
Index TFP level, EU=100				
2000	116	87	47	100
2008	117	83	51	100
2014	114	78	51	100
2019	112	82	55	100
TFP annual average growth rate, %				
2000-2008	0.88	0.43	2.81	1.09
2008-2014	0.08	-0.65	0.43	0.08
2014-2019	0.56	1.02	2.02	0.86

EU15: Austria, Belgium, Denmark, Germany, Greece, Finland, France, Luxembourg, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, United Kingdom.

EU13: Bulgaria, Croatia, Cyprus, Czechia, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia.

Less developed regions: regions whose per capita GDP is lower than 75% of the EU average in each programming period.

For 2000-2008 and 2008-2019 we respectively employ 2000-2006 and 2007-2013 regions' classification.

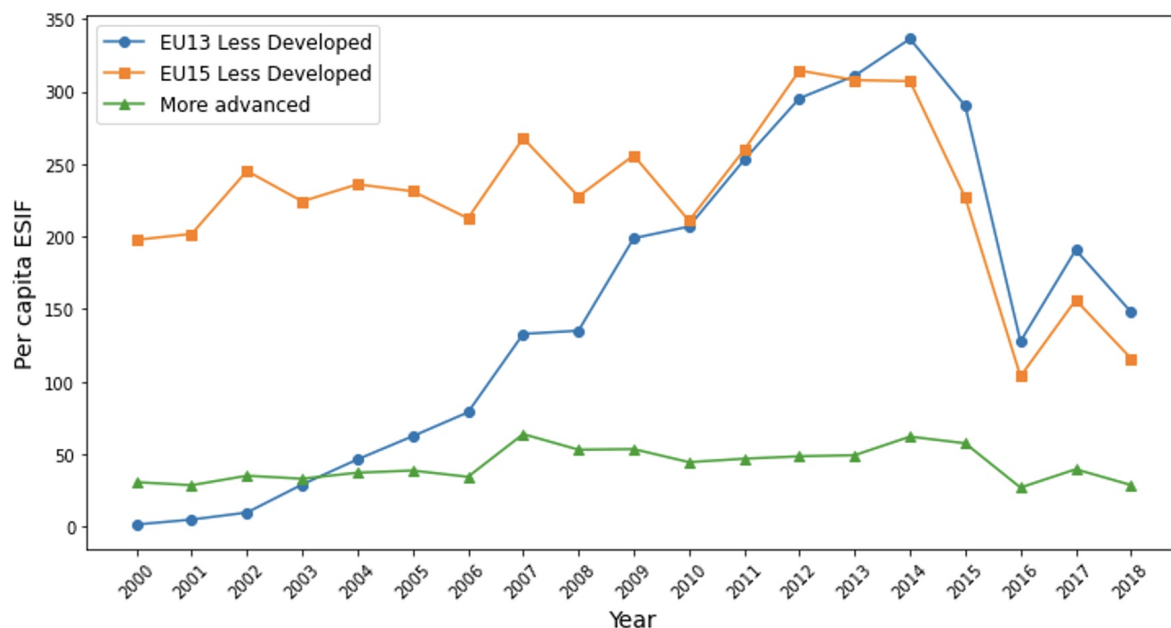
Bulgaria, Romania and Croatia are not considered in the first period.

moving regions away from low-productivity industries.

The analysis employs a novel dataset on ESIFs compiled by the Directorate-General for Regional and Urban Policy of the European Commission (EC, 2017). This provides annualised regional-level expenditure data for the period 1986-2018 based on actual EC payments, representing a methodological advancement over previous studies that relied on commitment data. The distinction is critical, as commitments often diverge significantly from disbursed funds, as noted by Fratesi (2016). Importantly, the dataset exclusively captures EU payments, omitting national and regional co-financing. Furthermore, it enables the examination of annual expenditures independently of their original programming period – a key consideration given the frequent temporal overlap of expenditures across different funding cycles, as illustrated in Figure 2.1 and discussed above.

Figure 2.3 displays the evolution of per capita ESIF expenditures across three macro-areas between 2000 and 2018. Expenditures in more advanced regions remained relatively stable throughout the period, whereas less developed EU13 regions experienced a pronounced increase:

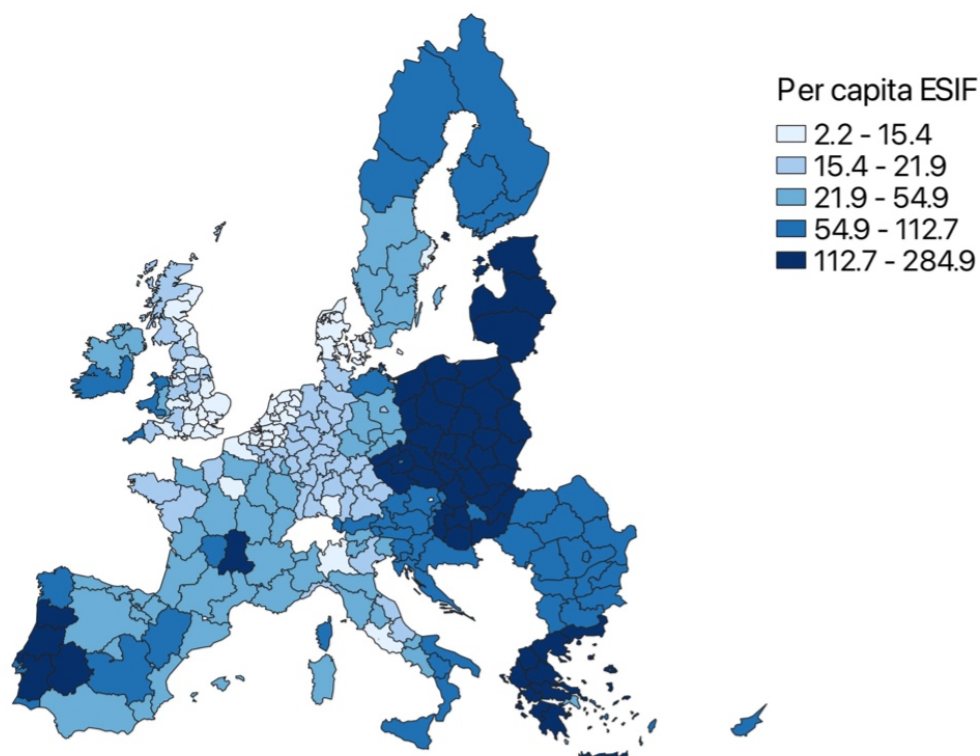
Figure 2.3: ESIF expenditure per group of regions (euro per capita, constant prices 2015)



from an average of just 1.3 euros per capita in 2000 to substantially higher levels by 2014 (336 euros). Around 2010, this spending converged with that observed in the less developed areas of the EU15, mirroring the EU Cohesion Policy objective of channelling resources toward economically weaker regions. However, expenditures in these regions declined significantly after 2014, possibly because of delays in the payments related to the 2014-20 programming period.

Figure 2.4 shows the distribution of per capita ESIF across European regions in 2018. As expected, less developed regions received an average of 139 euros per capita, far exceeding the 28 euros per capita allocated to more advanced areas. Funding was heavily concentrated in eastern Europe – Estonia reported the highest per capita amount (285 euros) – as well as in parts of southern Europe, particularly Portugal and Greece.

As remarked in the Introduction, ESIF comprise seven distinct instruments, of which four – ERDF, ESF, EAFRD and CF – account for approximately 97% of total allocations (see Table 2.2). The remaining three funds—the EMFF, FEAD, and YEI—were introduced only in the 2014–2020 programming period and represent a relatively small share of total funding. Consequently, our econometric analysis focuses exclusively on the four main funds. For simplicity, however, we continue to refer to their aggregate as ESIF. The eligibility criteria for these funds differ, leading

Figure 2.4: ESIF expenditure across regions, 2018 (euro per capita, constant prices 2015)

to differences in financial allocation across macro-areas. Notably, the CF is allocated exclusively to Member States with a per capita Gross National Income below 90% of the EU-27 average. Therefore, for EU13 countries, the CF represents a significant proportion of total ESIF resources, accounting for 31% in 2018.

2.4.2 Regional contextual factors

As discussed in section 2.2, several studies on ESIFs' economic impact have highlighted the pivotal role of some regional contextual factors. Intangible assets have been shown to influence regional economic performance and productivity growth (see, among others, Dettori et al., 2012; Peiró-Palomino, 2016; Gumbau-Albert and Maudos, 2022). In line with these findings, our analysis includes a set of such contextual variables, namely: regional endowment of human and technological capital, quality of institutions, and population density. Detailed definitions and

Table 2.2: EU Funds (average % shares on total)

Fund		2000-2007	2008-2013	2014-2018
ERDF	European Regional Development Fund	53.7	43.2	38.1
ESF	European Social Fund	24.8	19.0	16.0
CF	Cohesion Fund	11.4	15.1	17.2
EAFRD	European Agricultural Fund for Rural Development	10.0	22.7	25.7
YEI	Youth Employment Initiative			1.9
FEAD	Fund for European Aid to the Most Deprived			0.6
EMFF	European Maritime and Fisheries Fund			0.5
Total		100	100	100

sources of these variables are reported in Table A2.1.

Human capital is measured as the percentage of people aged 25-64 with a tertiary education level (ISCED 5-6), reflecting the workforce's overall level of advanced skills. A well-educated labour force encourages the localisation of highly innovative firms, thereby exerting a significant influence on aggregate TFP. Its positive impact on regional and national economic performance has been discussed by a large body of literature (among others: Benhabib and Spiegel, 1994; Murphy et al., 1991; Moretti, 2004; Faggian et al., 2017).

Technological capital is included in terms of per capita R&D expenditure. This measure covers a broader range of innovative activities than patent-based measures, including those that do not lead to codified knowledge. Technological capital supports both product and process innovation (García-Pozo et al., 2021) and generates externalities that improve firm-level productivity, ultimately reinforcing regional economic performance (see Audretsch and Feldman, 2004 for a comprehensive review).

The quality of the institutions at the regional level is mainly based on the European Government Quality Index developed by the University of Gothenburg (Charron et al., 2019), which covers corruption, impartiality, and public service quality. This index has been available since 2013; thus, we extend the series backwards using the Worldwide Government Index of the World Bank Institute following the methodology of Charron et al. (2014). A high-quality government promotes the efficient allocation of public resources and the delivery of effective public services, thereby fostering local economic development (Rodríguez-Pose and Ganau, 2022; Aresu et al.,

2023).

Finally, population density allows us to control for possible agglomeration externalities, which may favour specializations in specific sectors (Marrocu et al., 2013).

Table 2.3 reports the descriptive statistics for the contextual variables in 2000 and 2018, disaggregated by the three macro-areas. As expected, more advanced regions systematically exhibit higher values across all indicators. The gap in intangible assets has widened within the EU15, reflecting a concentration of knowledge and innovation capacity in the most developed territories. However, less developed EU13 regions have progressively narrowed their disadvantage, particularly in human and technological capital, signalling ongoing convergence dynamics. Institutional quality remains markedly heterogeneous across Europe, with persistent divides between Northern and Southern EU15 regions and generally lower values in the EU13 area. Population density patterns have remained largely stable, continuing to mark a divide between highly urbanised, innovation-intensive cores and more peripheral, sparsely populated areas. Overall, these patterns point to persistent structural imbalances that influence how regions absorb and benefit from Cohesion Policy interventions.

Table 2.3: Regional contextual factors for macro-area (index, EU=100)

	More advanced regions		EU15 less- developed regions		EU13 less- developed regions	
	2000	2018	2000	2018	2000	2018
Human capital	113	108	90	67	69	79
Technological capital	149	126	36	31	13	16
Quality of Institutions	109	108	95	79	82	77
Population density	115	111	80	106	88	69

See Table 2.1 for territorial classification.

2.5 Econometric modelling and results

2.5.1 Econometric modelling

As discussed in the previous sections, the aim of the analysis is to assess the role of ESIFs on regional TFP growth, which already accounts for other sources of regional capital accumulation, while controlling for a comprehensive set of regional contextual factors. Our analysis refers to the years 2000-2019, which are also divided into three sub-periods 2000-2008, 2008-2014, 2014-2019.

The analysis is conducted employing a regression growth model which, although not directly addressing causal identification, allows for examining key policy features, such as ESIFs' diverse objectives and their spatial and temporal heterogeneity.

For the whole period, we estimate the following panel specification:

$$\begin{aligned} \Delta TFP_{i,t-\tau} = & \beta_0 + \beta_1 ESIF_{i\tau} + \sum_{j=2}^5 \beta_j controls_{ji\tau} \\ & + \beta_6 LD_EU15_{i\tau} + \beta_7 LD_EU13_{i\tau} + \beta_8 TFP_{i\tau} + \delta_t + v_{i,t-\tau} \end{aligned} \quad (2.1)$$

where the dependent variable ($\Delta TFP_{i,t-\tau}$) is the regional annual TFP average growth rate for 262 territorial units over three sub-periods, with $t=2008, 2014, 2019$, and $\tau=2000, 2008, 2014$, respectively. The windows considered are expected to smooth out potential short-term business cycle variations. Our variable of interest, ESIFs, is incorporated into the analysis on a log-transformed per capita basis, both in aggregate form and disaggregated into the four main funds – ERDF, EAFRD, ESF, and CF – reflecting the expectation of differentiated effects on TFP growth. More specifically, we expect a positive effect, especially for the first two funds, as they are more directly meant to sustain productive activities, whereas the latter two might be more effective in enhancing broader social and environmental initiatives. As highlighted before, for each fund, we consider the total allocations, irrespective of the programming period, acknowledging that expenditure often overlaps across programming cycles, as previously discussed.

Contextual factors are included as control variables; they are log-transformed and entered at

their initial period values (τ), which is expected to mitigate possible reverse causality concerns. To distinguish between the three different territorial groups described in section 2.3, we include the dummy variables LD_EU15 and LD_EU13 . Finally, the initial productivity level ($TFP_{i\tau}$) controls the regional convergence process, and it is expected to negatively affect its following growth rate.

As anticipated above, our analysis does not directly address causal identification. Estimating "true" causal effects of policy interventions on regional TFP growth in Europe is particularly challenging, given the inherent limitations of commonly used identification strategies. In this context, difference-in-differences (DiD) and regression discontinuity design (RDD) approaches are difficult to implement convincingly, as the necessary assumptions—such as parallel trends or sharp assignment rules—are rarely satisfied at the regional level.

Moreover, we think that endogeneity issues due to reverse causality are more likely to arise when modelling the level rather than the growth rate of TFP. It is worth highlighting that when modelling growth rates, region-specific unobserved heterogeneity is effectively removed because TFP growth rates are computed as differences of TFP log-levels. Notwithstanding these considerations, we aim to provide estimates which are as informative as possible on the driving role of ESIF in enhancing productivity growth. For this reason, ESIFs, as well as all control variables, enter the model with their initial-period values (at time τ). These lags—of at least five years—are expected to be sufficiently long to break any correlation with the error term, thereby addressing potential endogeneity concerns. Despite these precautions, a more in-depth analysis of endogeneity is provided in section 2.5.4, where we assess the robustness of our main findings.

2.5.2 Panel results

The results for the panel estimation over the period 2000-2019 are reported in the first two columns of Table 2.4. In column (1), ESIFs are considered as an aggregate single fund, and they exhibit a positive but non-significant coefficient. Meanwhile, the contextual variables – human capital, technological capital, institutional quality, and population density – all show significant coefficients with the expected signs, indicating their effectiveness in capturing other determinants of TFP growth, possibly correlated with ESIFs. The initial TFP level presents a negative and

significant coefficient, signalling a convergence process whereby less productive regions tend to grow faster. After controlling for regional contextual factors, the positive and significant coefficient for the EU13 less developed regions, coupled with the non-significant coefficient for the EU15 less developed regions, is also evidence of the closing gap between the former group of regions and the more advanced ones.

When we distinguish the four main ESIFs (column 2), a different and more engaging picture emerges: the ERDF has a positive coefficient, whereas the CF has a negative one; the EAFRD and the ESF do not seem to affect total TFP growth. The estimated ERDF coefficient implies a non-negligible effect on the level of TFP in the long run: a 10% increase in ERDF investments entails an increase in total productivity of around 0.8%. This result indicates that the ERDF is effective at promoting regional productivity growth, most likely through its focus on infrastructure development, support for small and medium-sized enterprises (SMEs), and investment in innovation and technology, which directly impact regional productivity and competitiveness.

To assess the robustness of these results, we re-estimated the model in column (2) of Table 2.4 by introducing alternative specifications for the control variables (Table A2.3). Specifically, the measure of technological capital (R&D expenditure) was replaced with the stock of EPO patent applications; the indicator of institutional quality was substituted with an index of social capital; and a measure of regional specialisation in knowledge-intensive services was included. EPO patent applications show a positive and significant association with TFP growth, confirming the relevance of technological accumulation. When institutional quality is replaced by social capital, the coefficient is positive but not significant, indicating that social cohesion and trust do not capture the same institutional mechanisms relevant for productivity dynamics. The measure of specialisation in knowledge-intensive services is also not significant, suggesting a limited role of sectoral composition once structural factors are controlled for.

Across all robustness checks, the coefficient associated with ERDF remains positive and statistically significant, confirming the stability of its estimated impact on regional TFP growth. The coefficients of CF, ESF, and EAFRD remain stable in both sign and significance, with CF retaining a weakly negative coefficient and the others remaining insignificant. These results corroborate that the positive association between ERDF and productivity growth is not driven by the particular model specification or by alternative proxies for technological or institutional

Table 2.4: EU Funds and TFP growth

Dependent variable: TFP annual average growth rate

	Panel models		Cross-section models		
	(1)	(2)	(3)	(4)	(5)
	2000-2019	2000-2019	2000-2008	2008-2014	2014-2019
Total ESIF	0.0007 (0.0006)				
ERDF		0.0014 *** (0.0006)	0.0010 * (0.0005)	0.0015 * (0.0009)	0.0024 ** (0.0011)
ESF		-0.0006 (0.0009)	-0.0009 (0.0008)	-0.0024 (0.0015)	-0.0034 * (0.0019)
CF		-0.0008 ** (0.0004)	-0.0016 *** (0.0004)	-0.0016 ** (0.0007)	0.0018 * (0.0010)
EAFRD		0.0000 (0.0007)	-0.0010 (0.0008)	0.0001 (0.0012)	0.0009 (0.0015)
Human Capital	0.0069 *** (0.0013)	0.0074 *** (0.0014)	0.0074 *** (0.0016)	0.0088 *** (0.0023)	0.0017 (0.0030)
Technological Capital	0.0022 *** (0.0006)	0.0021 *** (0.0006)	0.0026 *** (0.0008)	0.0004 (0.0012)	0.0010 (0.0011)
Quality of Institutions	0.0069 * (0.0039)	0.0064 * (0.0040)	0.0098 *** (0.0039)	0.0194 *** (0.0064)	-0.0088 (0.0072)
Population density	0.0020 *** (0.0004)	0.0020 *** (0.0005)	0.0012 ** (0.0006)	0.0018 ** (0.0009)	0.0021 ** (0.0009)
EU15 less-developed	-0.0022 (0.0019)	-0.0024 (0.0020)	0.0013 (0.0018)	-0.0021 (0.0034)	-0.0003 (0.0031)
EU13 less-developed	0.0061 ** (0.0026)	0.0072 *** (0.0028)		0.0085 ** (0.0038)	0.0043 (0.0046)
Initial TFP level	-0.0164 *** (0.0030)	-0.0175 *** (0.0031)	-0.0244 *** (0.0040)	-0.0132 *** (0.0051)	-0.0040 (0.0067)
Adjusted R ²	0.2742	0.2799	0.5473	0.2104	0.2924
Observations	729	729	205	262	262

All right-hand side variables are per capita, log-transformed and refer to the initial year of the period considered.

EU13 regions are not included in the first sub-period 2000-2008.

Time dummies included in panel models.

Robust Standard Error, in parentheses.

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

factors. Moreover, when a single dummy for less-developed regions is included instead of separate dummies for EU15 and EU13 less-developed regions (column 4, Table A2.3), its coefficient is not statistically significant, further confirming that the differentiated specification is necessary to capture the heterogeneity in TFP growth dynamics across European regions. However, a positive and significant association between ERDF and TFP growth is still captured, reinforcing the robustness of the main finding.

To further address potential endogeneity concerns, we performed Granger-causality tests on ERDF, the most relevant fund within the ESIF framework. For all specifications considered in this section—both for the full panel and for sub-period estimations—we regressed the current level of ERDF on past TFP growth rates (Table A2.4). In all cases, the coefficients of the lagged regressors turned out to be not significant. Although these tests cannot fully rule out reverse causality, the lack of statistical significance indicates that past TFP growth does not predict current ERDF allocations. This evidence mitigates endogeneity concerns and strengthens the credibility of the estimated relationship between ERDF and productivity growth.

The not statistically significant coefficients for EAFRD and ESF seem to indicate, in line with evidence provided by Coppola et al. (2024) for the Italian context, that they do not have an enhancing effect on overall TFP growth. It is important to note that these funds pursue distinct policy objectives – such as social inclusion in the case of ESF and enhancing competitiveness in the agricultural sector for the EAFRD – which may not primarily focus on boosting aggregate production efficiency. Moreover, during the period under examination, two severe financial crises disrupted local economies worldwide. In response, ESF and CF allocations were largely directed toward supporting employment and reinforcing resilience, particularly in lagging behind regions. This might have had adverse effects on efficiency.

2.5.3 Temporal heterogeneity

As previously outlined, there are relevant temporal changes that affect our analysis. Eastern countries joined the EU in 2004, receiving substantial financing only afterwards. Additionally, the subprime global crisis in 2008 and later the sovereign debt crisis had a significant economic impact across Europe. Hence, we identify three sub-periods: the pre-crisis years (2000-2008), the

global financial crisis followed by the sovereign debt crisis (2009-2013), and the recovery phase (2014-2019). This breakdown allows us to better evaluate the potential temporal differences in the ESIFs' economic impact.

Columns (3)–(5) of Table 2.4 display the empirical results disaggregated by sub-period and fund. A key finding is that the ERDF coefficient is positive and significant across all three sub-periods, with its effect strengthening over time and reaching its highest level during the recovery phase. Specifically, a 10% increase in per capita ERDF during this phase corresponds to a substantial 6% rise in TFP, highlighting the importance of these policy-driven interventions.

This outcome may be attributed to the 2014–2020 Cohesion Policy reforms (EU Regulation, 2013/1303), which emphasised support for innovation, the digital and green transitions, and SMEs, notably through initiatives like the Smart Specialisation Strategy (Foray, 2009; Marrocu et al., 2023). The reformed policy also introduced a stronger results-oriented approach, simplified regulatory procedures, and conditionalities for funding. These elements appear to have played a key role in revitalising EU economies (EC, 2024; Serafini et al., 2025; Santos et al., 2023).

Regarding the other funds, the CF exhibits negative and significant coefficients in the first two sub-periods, turning positive during the recovery phase. The unexpected negative effect in the initial period may stem from the fact that only Greece, Spain, Portugal, and Ireland were eligible for CF support at the time. Furthermore, as the fund is primarily aimed at supporting environmental objectives and infrastructure development, its impact on productivity may manifest over a longer time horizon than that considered in our analysis. This result contrasts with the positive and statistically significant effect estimated for the 2014–2019 period, when the sample includes both EU15 and EU13 regions—the latter having become major recipients of CF support only after 2007. To explore potential territorial heterogeneity in the fund's impact, we augment the model for this later period by introducing an interaction term between CF and a dummy variable identifying the three EU15 beneficiary countries Greece, Spain, and Portugal (see column 1 of Table A2.5 in the Appendix)⁸. The CF coefficient remains positive and significant, suggesting a favourable effect on TFP growth in EU13 regions benefiting from the fund. By contrast, the negative and significant interaction term points to a weaker impact in the three EU15

⁸It is worth noting that Ireland did not receive CF resources during the 2014–2020 programming period, as its Gross National Income (GNI) per capita exceeded 90% of the EU average.

countries. This pattern is consistent with Di Comite et al. (2018), who show that Cohesion Policy investments in transport infrastructure have been particularly effective in stimulating growth in Eastern regions by enhancing accessibility. Conversely, in countries like Spain, a portion of the EU-funded infrastructure was perceived as redundant or misaligned with regional needs, raising concerns about inefficiency and limited territorial effectiveness (Medeiros, 2017).

By contrast, the coefficients associated with the other funds remain statistically insignificant in the sub-period analysis, consistent with the results obtained from the full panel specification. A noteworthy exception emerges for the European Social Fund (ESF) during the 2014–2019 period, where its coefficient is negative and statistically significant. This finding is somewhat unexpected and warrants further consideration. It is important to note that the primary policy objective of the ESF—emphasised in the 2014–2020 Cohesion Policy reform—is to foster social inclusion across the EU. Specifically, the ESF supports interventions aimed at improving access to employment, enhancing labour mobility, supporting marginalised communities, investing in education and training, and strengthening institutional capacity. These goals are primarily oriented toward improving social cohesion and human capital outcomes, such as reducing disparities and increasing employability (Fusaro and Scandurra, 2023), rather than directly stimulating growth in TFP.

Regarding the agricultural fund, although the EAFRD coefficient is not statistically significant, it shifts from negative in the first period to positive thereafter, suggesting a possible change in its influence. Given the specificities of the agriculture sector, the role of EAFRD will be examined in section 2.7 with respect to its own sectoral TFP.

As noted in the Introduction, defining the years 2008–2014 as a unified “crisis period” may be open to debate, given the heterogeneous timing of the financial crisis and subsequent recovery across European countries. Between 2010 and 2013, after the global financial crisis, some countries in the EU (Greece, Ireland, Portugal, Spain, Italy) were affected (to varying degrees and at different times) by a second shock: the sovereign debt crisis. In contrast, other member states (like France, Belgium, and the Netherlands) experienced only a moderate slowdown, while the Eastern European countries exhibited persistent growth. To account for these divergent patterns, we re-estimate the model for the sub-period 2008–2014, introducing a dummy variable for the five countries most affected by the sovereign debt crisis (column 2 in Table A2.5). The

dummy coefficient turns out to be statistically insignificant. However, the estimates for our main variables of interest remain robust, including the positive and significant effect of ERDF. The only notable change is that the negative coefficient associated with ESF becomes statistically significant, confirming its specific goals highlighted before. As a further robustness check, we re-estimate the model excluding the year 2014 and thus considering the period 2008–2013. Main results are virtually unchanged (column 3 in Table A2.5).

The sub-periods analysis also allows us to observe how the convergence process varied over time: the estimated coefficient for the initial TFP level reveals that convergence was faster during the first period, while it slowed down during the second and stagnated during the recovery phase. Interestingly, the estimated coefficients for regional contextual factors are not statistically significant during the recovery phase (2014-19) when regional productivity growth appears to have been primarily driven by the funds' financial support ⁹.

2.5.4 Robustness checks based on IV approach

Before discussing the extensions of our analysis, in this section we present an in-depth investigation of our main specifications with respect to endogeneity concerns.

As argued in section 2.5.1, estimating causal effects of policy interventions on regional growth is very difficult, not only due to the limitations of applying the DiD or RDD approaches across all 262 EU NUTS2 regions, but also because the instrumental variable (IV) estimation method faces substantial obstacles. Finding credible and valid sources of exogenous variations, i.e. the variables which affect the outcome only through the treatment, is exceptionally difficult. Caselli et. al. (1996) and Temple (1999) emphasised the scarcity of suitable instruments, as most candidate variables are at risk of being endogenous in growth model settings. A possible exception is the morphological structure of a country's geography. In practice, the use of weak or invalid instruments may introduce more bias and inconsistency than standard least squares estimation, ultimately leading to unreliable inference. Therefore, while acknowledging that the issue of potential endogeneity may also affect our analysis, we adopt a cautious empirical strategy aimed

⁹When we extended the analysis to the period 2019-22, a period strongly affected by the COVID-19 pandemic, the results indicated no significant effects for all the funds considered. This might be due to the pervasive effects of the pandemic disruptions and to the fact that most of the ESIF funds were re-directed to provide income and health-system support.

at mitigating bias without resorting to instruments of questionable validity.

Following Caselli et al. (1996) and Dall’Erba and Le Gallo (2008), we adopt a geography-based instrumental variable, which is the inverse distance (in km) between Brussels and each region included in our sample. This instrument is considered relevant because ESIFs are distributed spatially according to a centre-periphery pattern. Since our analysis considers four distinct EU funds, we require at least three additional instrumental variables to estimate the models presented in Table 2.4. Following Dall’Erba and Le Gallo (2008) and Kennedy (2008), we use the rank order of the lagged values of each fund as a potential instrument. These instruments satisfy the relevance condition, as they are, by construction, correlated with the explanatory variables. Given the lag structure, they are also supposed to be uncorrelated with the current error term. As our analysis employs five instrumental variables, we test for their joint exogeneity by carrying out the test for overidentifying restrictions.

The main results of the IV analysis are reported in Table 2.5. Column (1) presents the IV estimates corresponding to model (2) in Table 2.4. Overall, the new estimates confirm previous findings, highlighting the effectiveness of ERDF in enhancing TFP growth. Previous results on the other funds, as well as on the control variables, are also corroborated ¹⁰. It is worth noting that the results of the first-stage F tests show that the set of instruments is relevant, while the Hansen J test indicates that the joint null hypothesis on the instruments’ exogeneity cannot be rejected.

To assess the robustness of our main results with respect to the panel time structure, column (2) of Table 2.5 reports estimates from a six-period panel specification. In this case, the dependent variable is computed over shorter sub-periods of three years each, except for the final sub-period which covers four years ¹¹. All right-hand side variables are measured at the initial year of each sub-sample, and the set of instruments is recomputed to account for the new lag structure. The new results provide further support for the effectiveness of ERDF, which now exhibits a slightly larger coefficient. The main difference compared to the previous specification concerns the ESF, which becomes statistically significant at the 5% level. First-stage F tests and the Hansen J test confirm the adequacy of the instruments used in model (2).

¹⁰Note that results are very similar also in the case in which we consider only the set of instruments based on the ranks of the explanatory variables.

¹¹We have not considered shorter sub-periods to avoid undue effects from business cycle dynamics

Table 2.5: EU Funds and TFP growth – IV estimates

Dependent variable: TFP annual average growth rate

<i>Time structure</i>	Panel models			Cross-section models		
	(1)	(2)	(3)	(4)	(5)	(6)
	3 sub-periods	6 sub-periods	6 sub-periods	2000-2008	2008-2014	2014-2019
ERDF	0.0014 *** (0.0005)	0.0018 *** (0.0005)	0.0012 ** (0.0005)	0.0009 * (0.0005)	0.0022 ** (0.0009)	0.0019 * (0.0010)
ESF	-0.0004 (0.0009)	-0.0019 ** (0.0008)	-0.0012 (0.0009)	-0.0004 (0.0009)	-0.0031 ** (0.0014)	-0.0024 (0.0018)
CF	-0.0009 ** (0.0004)	-0.0012 *** (0.0004)	-0.0007 (0.0013)	-0.0016 *** (0.0004)	-0.0017 ** (0.0007)	0.0018 * (0.0010)
EAFRD	0.0001 (0.0008)	-0.0005 (0.0007)	-0.0007 (0.0006)	-0.0007 (0.0009)	-0.0009 (0.0012)	0.0011 (0.0015)
Controls	yes	yes	yes			
Time dummies	yes	yes	yes	-	-	-
Country dummies	no	no	yes	-	-	-
First stage F tests						
ERDF	2296.99 (0.0000)	2441.58 (0.0000)	2159.86 (0.0000)	1154.75 (0.0000)	1292.89 (0.0000)	998.46 (0.0000)
ESF	588.31 (0.0000)	1522.66 (0.0000)	1833.19 (0.0000)	177.55 (0.0000)	455.38 (0.0000)	459.71 (0.0000)
CF	955.48 (0.0000)	1246.04 (0.0000)	358.74 (0.0000)	572.95 (0.0000)	2096.67 (0.0000)	455.73 (0.0000)
EAFRD	397.01 (0.0000)	423.39 (0.0000)	433.71 (0.0000)	69.12 (0.0000)	126.74 (0.0000)	1052.58 (0.0000)
Hansen J test	1.010 (0.3148)	0.829 (0.3625)	2.433 (0.1188)	2.267 (0.1321)	0.097 (0.7559)	0.438 (0.5083)
Adjusted R ²	0.2795	0.3252	0.3616	0.5457	0.2060	0.2900
Observations	729	1401	1401	205	262	262

Instrumental variables: inverse distance from Bruxelles, rank order for each lagged EU Fund.

Controls: Human and Technological Capital, Quality of Institutions, Population Density, Initial TFP level, EU15/EU13 less-developed dummies.

Panel models. Column (1): 2000-08, 2008-14, 2014-19. Columns (2) and (3): 2000-03, 2003-06, 2006-09, 2009-12, 2012-15, 2015-19.

All right-hand side variables are per capita, log-transformed and refer to the initial year of the period considered.

EU13 regions are excluded in column (1) and (4) for 2000–2008, and in columns (2) and (3) for the first three sub-periods.

Robust Standard Error, in parentheses.

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

In column (3), we conduct an additional robustness test to assess whether the results are influenced by potential remaining unobservable heterogeneity. To this end, we augment model (2) by including a wide set of country dummies ¹². Even with a now highly saturated model, the ERDF coefficient remains statistically significant, although its magnitude decreases to 0.0012 – implying a long-term effect of 0.046% for a 10% increase in the fund amount. None of the other funds display statistically significant coefficients. The results of the first-stage F tests and the Hansen J test are similar to those previously discussed.

Finally, in the last three columns of Table 2.5, we test the robustness of our main results across the sub-periods proposed in the previous section to analyse the inter-temporal heterogeneity. Using the same kind of instruments as above, IV estimates continue to support our main findings. More specifically, ERDF shows a positive and significant coefficient in all sub-periods. Notably, in the last sub-period, both ERDF and CF attain statistical significance at the 10% level, marking an improvement relative to the corresponding results in Table 2.4.

Overall, the IV approach, combined with a richer temporal structure in the panel models, confirms that our main results are robust with respect to serious endogeneity concerns and offer valuable evidence on the role of ESIF funds in promoting TFP growth across the EU regions. A proper causal analysis, based on DiD or RDD approaches, is left to future research, where the focus will shift to narrower subsets of regions observed at a finer spatial scale.

2.6 ERDF and territorial heterogeneity

In sections 2.3 and 2.4.1, we documented notable differences in productivity trends and fund allocation among EU regions, suggesting that ESIF impacts may vary spatially. Moreover, Table 2.1 illustrates that less-developed regions exhibit distinct economic dynamics depending on their territorial position, while divergent regional objectives may also lead to varying outcomes. Di Comite et al. (2018) emphasise that ESIFs have significantly contributed to the development of new transport infrastructure in emerging EU regions. This strategic choice has strengthened economic relationships between peripheral eastern territories and central European manufacturing

¹²Dummies are included for all the countries (19) with at least three NUTS2 regions. Results are very similar in the case the entire set of country dummies is included in the model

hubs, thereby reshaping the EU economic framework. Therefore, in this section, we examine in detail the funds effects considering the territorial heterogeneity of the European regions.

Given that the ERDF is the more sizeable fund and the only one showing a consistently positive impact on regional TFP growth over the three periods, our spatial heterogeneity analysis focuses on this fund. We investigate differential effects by introducing in Table 2.6 interaction terms between ERDF and spatial dummies for EU13 less-developed and EU15 less-developed regions, while aggregating the other three funds in the “Other funds” variable.

Table 2.6 reveals pronounced spatial and temporal heterogeneity. In the first period, the ERDF had a positive and statistically significant effect across all regions considered ¹³, with no significant differences detected for EU15 less-developed regions. Between 2008 and 2014, an interesting result emerges: while the ERDF coefficient is not significant for either advanced regions or EU15 less-developed ones, a positive and significant differential effect (0.0023) is detected for less-developed regions in EU13 which obtain an overall effect of 0.033. These findings suggest that, during the financial crisis, the benefits of ERDF support accrued primarily to the less-developed regions of the EU13. This pattern may reflect a deliberate strategic reorientation of ESIF priorities aimed at mitigating the crisis’s adverse effects on the most vulnerable territories. The experience of subsequent shocks—such as the COVID-19 pandemic and the energy and inflation crises triggered by the Russia–Ukraine war—further underlines the critical importance of appropriately reallocating EU funds effectively to enhance regional resilience and cohesion in times of systemic stress.

During the recovery phase, the ERDF continued to yield significant positive effects, with an estimated coefficient of 0.0018 for advanced regions. While no significant differences are found for less developed territories in the EU15, those in the EU13 continue to exhibit stronger performance. With a differential impact of 0.0016, their overall effect reaches 0.0034. This more pronounced impact suggests that the fund has contributed to narrowing the productivity gap between advanced and EU13 less-developed regions.

Overall, since their accession, EU13 less-developed regions have benefited substantially from ERDF allocations, while advanced regions have experienced consistent productivity gains, except

¹³It is important to note that the EU13 new accession countries are excluded from the first period, as they did not receive significant cohesion funding from the European Union during that time.

Table 2.6: ERDF and TFP growth in regional subsets and sub-periods

Dependent variable: TFP annual average growth rate

	(1)	(2)	(3)
	2000-2008	2008-2014	2014-2019
ERDF	0.0011 ** (0.0005)	0.0010 (0.0008)	0.0018 * (0.0009)
ERDF * EU15 less-developed	0.0003 (0.0003)	-0.0003 (0.0007)	-0.0002 (0.0006)
ERDF * EU13 less-developed		0.0023 *** (0.0008)	0.0016 * (0.0009)
Other Funds	-0.0013 *** (0.0003)	-0.0015 *** (0.0006)	0.0002 (0.0009)
Controls	yes	yes	yes
Adjusted R ²	0.5488	0.2238	0.2644
Observations	205	262	262
Linear combinations			
EU15 less-developed	0.0014 *** (0.0005)	0.0007 (0.0009)	0.0015 (0.0014)
EU13 less-developed		0.0033 *** (0.0012)	0.0034 ** (0.0014)

All right-hand side variables are per capita, log-transformed and refer to the initial year of the period.

Controls: Human and Technological Capital, Quality of Institutions, Population Density, Initial TFP level.

EU13 regions are not included in the first sub-period 2000-2008.

Robust Standard Error, in parentheses.

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

during the crisis period. In contrast, EU15 less-developed regions benefited only in the initial sub-period; after the financial crisis, they underperformed, as indicated by non-significant ERDF coefficients. This underperformance, concentrated in territories located in Portugal, Spain, Southern Italy and Greece, may be attributed to structural challenges, including limited human capital, low institutional quality (Aresu et al., 2023; Incaltarau et al., 2020), and a shift in EU priorities that increasingly favoured the economic integration of newer eastern member states over less-developed areas within the EU15.

Our results not only complement prior research highlighting the positive effects of Cohesion Policy for less developed regions (Becker et al., 2010; Pellegrini et al., 2013), but also reinforce the empirical evidence on the spatial heterogeneity of these effects across the EU. By examining a comprehensive set of regions, our findings corroborate and extend the heterogeneity patterns documented by Di Caro and Fratesi (2022) and Crescenzi and Giua (2020), who focused on a more limited subset of EU territories.

2.7 EAFRD and agricultural productivity

The analysis of ESIF has revealed a positive and significant, albeit highly heterogeneous, impact of ERDF on regional TFP growth. In contrast, other funds have not shown a positive effect on regional productivity growth. These findings highlight the need for more targeted analyses of funds that pursue specific objectives, which should be evaluated using alternative frameworks and outcome variables.

This section focuses on EAFRD and investigates its impact on regional agricultural productivity growth. As shown in Table 2.2, financial allocations to this fund have steadily increased, reinforcing the importance of conducting a more focused assessment of its economic impact. EAFRD replaced the Guidance Section of the former European Agricultural Guidance and Guarantee Fund (EAGGF), the so-called second pillar of the Common Agricultural Policy (CAP), in 2007 under EC Regulation No 1290/2005. According to EC Regulation No 1698/2005, the EAFRD finances initiatives aimed at improving "the competitiveness of agriculture and forestry; the environment and the countryside; and the quality of life and management of economic activity in rural areas." More details on the characteristics of the fund can be found in Soldi (2016).

In this context, we assess EAFRD impact following the same methodological framework employed in section 2.5. Using sectoral data on value-added, employment, and gross fixed capital formation, we first compute the agricultural regional TFP annual average growth rates as in section 2.3, including country dummies instead of regional fixed effects. The estimated elasticity is around 0.54 for both the capital stock and the labour input.

The descriptive statistics for agricultural TFP (Table A2.2) reveal a more complex and varied temporal and spatial pattern compared to overall TFP. A preliminary analysis based on the previously used regional categorisation proved inadequate to capture this complexity. Therefore, we address territorial heterogeneity by accounting for initial conditions, as the initial level of agricultural regional productivity may play a pivotal role in determining the effectiveness of the fund.

Considering the high temporal heterogeneity identified in the previous analysis, we report the impact of EAFRD separately for each sub-period. The main results are presented in Table 2.7. In this analysis, we not only control for human capital and the quality of institutions, as in the previous sections, but also incorporate sector-specific control variables. Specifically, we include the regional number of patent applications in the agricultural field submitted to the European Patent Office (EPO) as a proxy for sectoral technological capital and the Revealed Comparative Advantage (RCA) index in the agricultural sector, based on sectoral employment. A strong concentration of employment in agriculture may signal a reliance on traditional production structures, potentially limiting the scope for productivity-enhancing shifts toward higher value-added activities. Overall, the coefficients of contextual variables exhibited the expected sign, except for the quality of institutions, for which we obtained a negative coefficient despite being significant only in the last sub-period.

In column (1), the panel estimation over the entire 2000–2019 period shows a negative and non-significant coefficient for EAFRD, suggesting that, on average, this fund has not exerted a systematic effect on agricultural productivity growth across European regions. When the analysis is disaggregated by sub-periods, however, EAFRD exhibits a positive coefficient in all cases, reaching statistical significance only in the pre-crisis period (0.006). This temporal pattern may reflect both cyclical and policy-related dynamics. In particular, the Fischler Reform of 2003 (EC Regulation No. 1782/2003) redirected a larger share of resources from the first pillar

Table 2.7: EAFRD and agricultural TFP growth

Dependent variable: agricultural TFP annual average growth rate

	(1) Panel	(2) 2000-2008	(3) 2008-2014	(4) 2014-2019
EAFRD	-0.0008 (0.0016)	0.0064 *** (0.0022)	0.0033 (0.0035)	0.0038 (0.0049)
Agriculture technological capital	0.0089 (0.0064)	0.0318 *** (0.0103)	-0.0123 (0.0089)	0.0222 (0.0142)
RCA _{Ag}	-0.0191 (0.0140)	-0.0920 *** (0.0186)	-0.0453 ** (0.0200)	0.0097 (0.0286)
Human Capital	-0.0071 (0.0048)	0.0097 (0.0066)	-0.0010 (0.0080)	0.0005 (0.0133)
Quality of Institutions	0.0022 (0.0130)	0.0003 (0.0192)	0.0190 (0.0171)	-0.0711 * (0.0366)
Initial agriculture TFP level	-0.042324 *** (0.0057)	-0.0487 *** (0.0060)	-0.0474 *** (0.0127)	-0.0191 * (0.0108)
Adjusted R ²	0.129	0.410	0.189	0.087
Observations	729	205	262	262

All right-hand side variables are per capita, log-transformed and refer to initial year of the period considered.

EU13 regions not included in the first sub-period.

Robust Standard Error, in parentheses.

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

of the CAP (direct farmer support) to the EAFRD, enhancing its focus on rural infrastructure, diversification, and innovation in the agricultural sector (Insolda et al., 2024). By contrast, the effects in the subsequent sub-periods appear muted, possibly due to the reorientation of funds during the financial crisis toward stabilisation and social support measures, rather than productivity-enhancing investments ¹⁴.

To deepen our understanding of the temporal heterogeneity of our findings, we refine the analysis by examining EAFRD impact across regions with different initial levels of agricultural productivity. Regions were categorized into three groups: lowest productivity (1st quartile group), highest productivity (4th quartile), and those with productivity levels within the interquartile range. Accordingly, we re-estimated the sub-period models by introducing interaction terms between EAFRD funding and indicators for the highest and lowest initial TFP quartiles.

Results are presented in Table 2.8. The estimates confirm a positive and significant effect of EAFRD (0.0045) during the pre-crisis period, with no significant differences across regions with varying levels of initial TFP. However, following the financial crisis and the Fischler reform, the estimated coefficients for regions within the interquartile range of initial productivity become non-significant in the last two sub-periods. Less productive regions even exhibit a negative and statistically significant differential effect during the crisis period, which becomes non-significant in the final period. In contrast, only the most productive regions (4th quartile) display a positive and significant differential effect of EAFRD, which tends to increase over time, even if the total effect amounts to 0.012 in the second sub-period and to 0.01 in the final one.

Overall, the results indicate that the EAFRD effectively stimulates productivity growth primarily in regions with already high levels of agricultural productivity, particularly after the financial crisis and the Fischler reform. In these regions, EAFRD funding may have complemented existing strengths, amplifying its impact on productivity. The Fischler reform, which aimed to enhance the competitiveness of the agricultural sector, may have further contributed to this dynamism by disproportionately benefiting regions that were already well-positioned for growth.

In contrast, EAFRD's impact on productivity growth in less productive regions is notably limited. While it does not exhibit a significant positive effect on sectoral TFP growth in these

¹⁴Financial flows under the first pillar of the CAP are not included in the analysis. To the authors' knowledge regional data covering all European countries is not publicly available, limiting the scope of this analysis.

Table 2.8: EAFRD, agricultural growth, and initial agricultural TFP levels

Dependent variable: agricultural TFP annual average growth rate

	(1) 2000-2008	(2) 2008-2014	(3) 2014-2019
EAFRD	0.0045 * (0.0027)	0.0049 (0.0033)	0.0027 (0.0051)
EAFRD * TFP lowest quartile	0.0034 (0.0024)	-0.0087 ** (0.0036)	-0.0029 (0.0044)
EAFRD * TFP highest quartile	0.0023 (0.0034)	0.0070 * (0.0038)	0.0073 * (0.0043)
Agriculture technological capital	0.0319 *** (0.0101)	-0.0079 (0.0091)	0.0211 (0.0142)
RCA _{Ag}	-0.0945 *** (0.0195)	-0.0401 ** (0.0204)	0.0039 (0.0274)
Human Capital	0.0093 (0.0067)	-0.0030 (0.0080)	-0.0021 (0.0137)
Quality of Institutions	-0.0020 (0.0193)	0.0221 (0.0191)	-0.0694 ** (0.0341)
Initial agriculture TFP level	-0.0477 *** (0.0094)	-0.0786 *** (0.0224)	-0.0415 * (0.0237)
Adjusted R ²	0.408	0.233	0.092
Observations	205	262	262
Linear combinations			
TFP lowest quartile	0.0079 *** (0.0031)	-0.0039 (0.0051)	-0.0003 (0.0066)
TFP highest quartile	0.0068 ** (0.0032)	0.0119 *** (0.0042)	0.0099 * (0.0058)

All right-hand side variables are per capita, log-transformed and refer to initial year of the period considered.
EU13 regions not included in the first sub-period.

Robust Standard Error, in parentheses.

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

areas, it may still generate other benefits, such as supporting farm incomes. Many of the lowest TFP regions are concentrated in Eastern Europe, where, following EU accession, the productive systems underwent profound restructuring. This transformation involved a shift in specialization from agriculture to low-tech manufacturing. Meanwhile, western regions redirected low-tech activities eastward and focused on high-tech, knowledge-intensive sectors, including precision farming, leveraging advancements in green technologies (Marrocu et al., 2013).

In EU13 less-developed regions, administrative absorptive capacity remains limited, and the paying agencies encounter difficulties in converting program allocations into reimbursable expenditures (Raicov et al., 2021), particularly due to the prevalence of small, fragmented farm structures. Weak governance of the agricultural payment agencies can hinder the formation of local partnerships and complicate ex-ante evaluations, thereby increasing transaction costs for potential rural beneficiaries. In such contexts, reallocations of resources toward short-term crisis responses risk displacing long-term productivity-enhancing investments, precisely the kind of structural support that low-performing rural areas require most.

The long-term orientation of EAFRD investments, designed to gradually enhance the competitiveness and sustainability of the agricultural sector, may require extended timeframes for their effects to fully materialise, particularly in the aftermath of economic crises and amid the ongoing reconfiguration of production structures. This transformation is increasingly influenced by global megatrends, including the restructuring of global value chains and the twin green and digital transitions. For less-productive regions, these dynamics underline the critical need to reinforce technical assistance, strengthen administrative absorptive capacity, and invest in the upskilling of farmers and rural SMEs. Such measures are essential to ensure that these territories can fully capitalise on the opportunities offered by EU funding instruments, especially in a period marked by intensified global uncertainty.

2.8 Conclusions and policy implications

This study investigates the relationship between ESIFs and regional TFP growth, offering a more rigorous and comprehensive analysis than previous research. Our contribution is fourfold. First, we adopt TFP growth—rather than the more commonly used GDP per capita growth—as the

outcome variable. This choice enables us to incorporate domestic investment into the analysis, thereby providing a more accurate assessment of ESIFs' effectiveness. Second, we employ expenditure data instead of commitment data, allowing us to estimate the effects of financial resources that regions have actually absorbed and utilised, rather than those merely allocated on paper. Third, we explicitly account for the temporal and territorial heterogeneity of EU funding by disaggregating the analysis across fund types, time periods, and regional classifications. Fourth, our empirical analysis spans the years 2000 to 2019 and encompasses a comprehensive sample of 262 NUTS2 regions, representing one of the most extensive and detailed assessments of ESIFs' impact to date. Finally, it is worth noting that our results have undergone a series of robustness checks. Although our growth regression approach—combined with the broad geographical coverage, long time span of the sample, and the distinction among different funds—did not allow for the application of DiD or RDD methods to identify causal effects, endogeneity concerns were thoroughly addressed through an IV estimation strategy and a carefully specified temporal structure of the models.

Our results indicate that the effectiveness of ESIFs is highly context-dependent and exhibits substantial variation over time. Among the different funds, the ERDF stands out as the principal catalyst of regional productivity growth. Its impact is especially marked in the less-developed regions of the EU13 member states, particularly during the post-crisis recovery period. This enhanced effectiveness can be attributed to the reform of the Cohesion Policy, which placed greater emphasis on innovation, digital transformation, and SME support. Nevertheless, persistent challenges remain. The redirection of resources during financial crises and the continued underperformance of less-developed regions within the EU15 underline the urgent need for more tailored, adaptive, and resilient funding strategies in an era of mounting global pressures.

In response to the COVID-19 pandemic, ESIF resources were reallocated to strengthen healthcare systems and provide support to SMEs (EU Regulation, 2020/460). Further regulatory flexibility allowed for the reprogramming of funds across regional priorities (EU, Regulation 2020/558). More recently, structural funds have also been deployed under the Repower EU initiative to address the energy crisis stemming from the Russia–Ukraine conflict. While such reallocations are often justified by urgent needs, they also carry the risk of diverting resources away from the ERDF's core objectives of promoting regional development and convergence.

Looking ahead, it will be crucial to evaluate the post-COVID performance of EU funding—once longer time series become available—to determine whether the effectiveness of these instruments has been restored or further eroded in the aftermath of successive crises.

The specific evaluation of the EAFRD indicates that its ability to stimulate agricultural productivity depends on regions' initial productivity levels: we detect a positive effect in regions with high levels of agricultural productivity (mainly in the EU15 countries) while the influence is notably limited in less productive regions (mainly in the Eastern countries). This finding suggests that a one-size-fits-all approach is unlikely to meet the diverse needs of rural areas and highlights the importance of designing targeted interventions that account for regional structural differences.

Based on our results, we propose several policy recommendations. First, to sustain the ERDF's core objectives of fostering long-term regional convergence and economic growth, future programming periods should continue emphasising innovation and digitalisation while maintaining an appropriate balance with crisis-response initiatives. Second, addressing persistent disparities – particularly in underperforming regions – requires targeted capacity-building efforts, improvements in institutional quality, and investments in human capital. Third, the heterogeneous impact of the EAFRD highlights the importance of designing policies that are tailored to the distinct structural features of regional agricultural sectors. More specifically, in the EU's least productive rural areas, a carefully calibrated policy mix is required, combining front-loaded technical assistance, extended implementation horizons, and sustained investment in farmers' skills and local governance capacities.

Finally, future research should continue to distinguish between the distinct effects of each ESIF fund on regional economic performance. As demonstrated by our evaluation of the EAFRD, funds must be assessed considering their specific policy objectives, with carefully selected outcome variables that capture their targeted impacts. Moreover, as Capello and Cerisola (2024) emphasise, more granular territorial data, particularly at the NUTS3 level, are essential for assessing intra-regional disparities and understanding the distributional effects of EU funding. To facilitate this line of research, it is crucial that the EU Commission makes more disaggregated territorial data publicly available.

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2.10 Appendix

2.10.1 A1. Computation of Total Factor Productivity at the regional level

Following Marrocu et al. (2022), we compute regional TFP levels using a quasi-growth accounting approach. We first estimate labour and capital elasticities from a Cobb-Douglas (CD) production function, and then we compute the regional TFP levels for 2000-2019 by applying the growth accounting method using the estimated factor elasticities, assumed invariant over the considered period.

The CD is log-linearised as follows:

$$\ln(GVA_{it}) = \beta_K \ln(K_{it}) + \beta_L \ln(L_{it}) + \alpha_i + \delta_t + \varepsilon_{it} \quad (A1)$$

where $i = 1, \dots, N$ (262 regions); $t = 2000, \dots, 2019$ (20 years); GVA is Gross Value Added, K is capital stock, and L are units of labor; α_i are regional fixed effects, δ_t are time dummies, and ε_{it} is the error term. The procedure to construct the capital stock is described in the next section. To deal with the usual production function endogeneity problem, we apply the Fixed Effects Two Stage Least Squares (2SLS) estimation method, employing the one-year lagged input factors as instrumental variables. Similar results are obtained using the two-year lagged factors as instruments. The estimated elasticities are 0.3 for the capital stock and 0.62 for the labour input.

2.10.2 A2. Capital stock computation

Since the lack of data on regional capital stock, the series has been built by employing data on national capital stock published by the IMF (sum of public, private and PPP capital stock) (2017). To fully exploit the IMF dataset, for the 11 Centre-North and 4 Southern countries, we use series for 1990-2020 by computing the initial value of capital stock in 1989 as the mean value of the national capital stock for 1988-1989. For the other 12 new accession countries, the series has been calculated for 2000-2020, computing the initial value in 1999, considering the annual mean value of national stock for 1996-1999.

The capital stock initial value at the regional level has been computed using the methodology proposed by Gleed and Rees (1979): the initial regional value is based on the regional share of investments (weight 0.75) and the regional share of labour units (weight 0.25) for 1988-1989 for the first group of countries and 1996-1999 for the other. Initial regional capital values have been measured in constant prices (2015) employing the AMECO deflator. The rest of the series have been calculated using the perpetual inventory methodology, which states that the value of the capital stock at time t is equal to the value at time $t-1$, augmented by investment measured at time t and diminished by depreciation (we assume a 10% depreciation rate). The series of the stock of capital is expressed in constant euros 2015 to avoid variations caused by inflation.

Figure A2.1: Evolution of Average Regional TFP in the EU, 2000–2019 (2000 = 100)

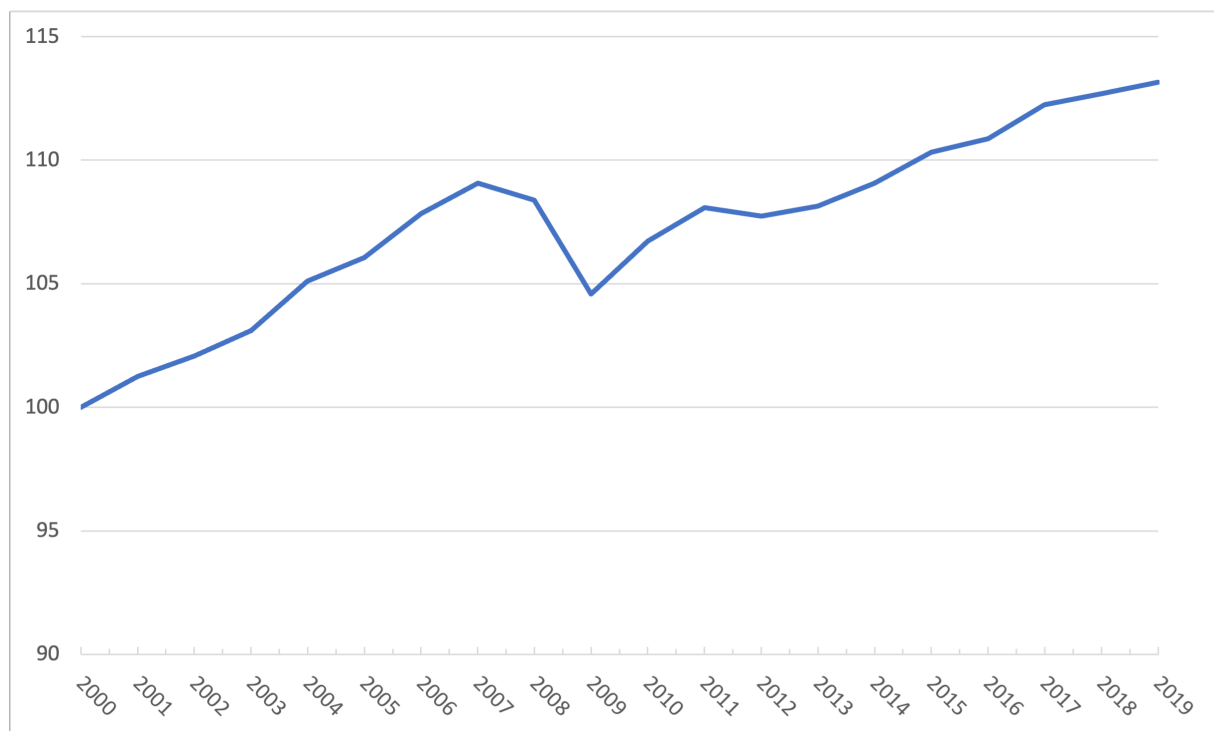


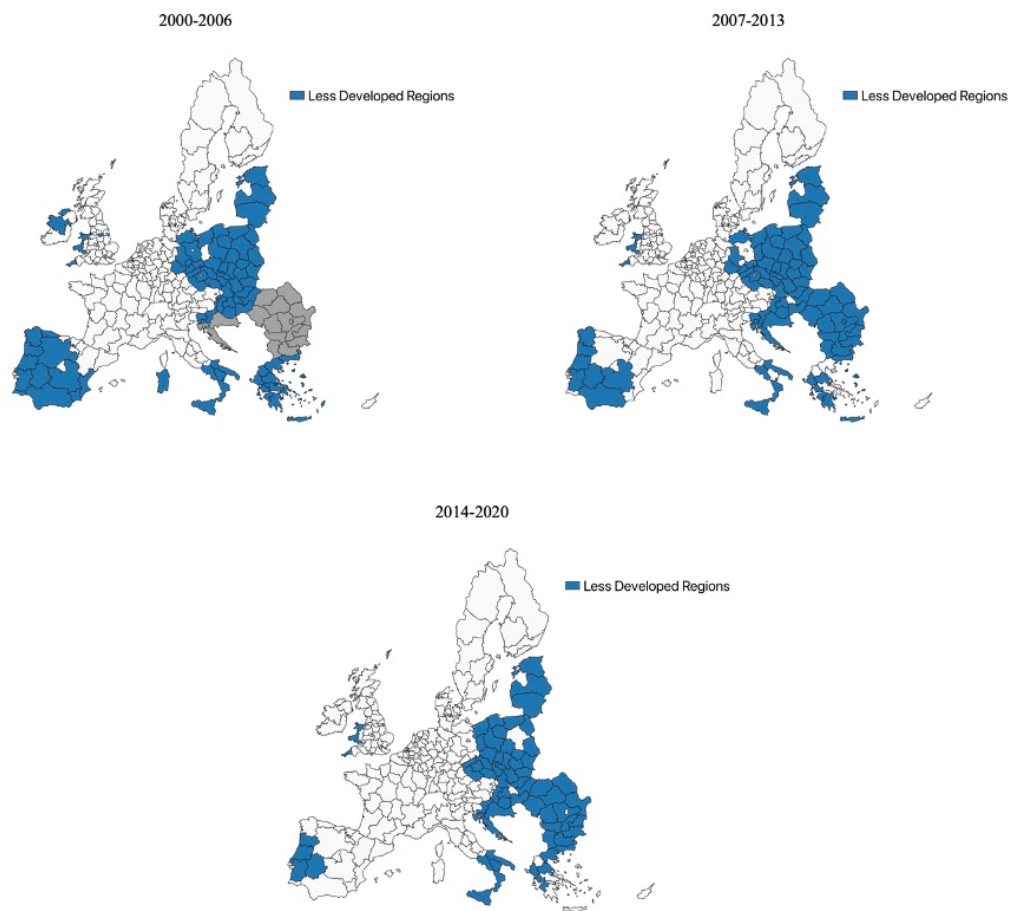
Figure A2.2: Less developed regions for programming periods (NUTS2 2010 version)

Table A2.1: Variables definition and sources

Variable	Label	Description	Primary Source
Value Added	GVA	Gross VA, constant values at 2015 price	EUROSTAT
Labour Units	L	Units	EUROSTAT
Gross fixed capital formation	GFCF	Constant values at 2015 price	EUROSTAT
Capital stock	K	Constant values at 2015 price	Own calculation
Total Factor Productivity	TFP	Estimated index	Own estimation
European Structural and Investment Funds	ESIF	Sum of all funds, per capita values (constant price 2015)	European Comission
European Regional Development Fund	ERDF	Per capita values (constant price 2015)	European Comission
European Social Fund	ESF	Per capita values (constant price 2015)	European Comission
European Agricultural Fund Rural Development	EAFRD	Per capita values (constant price 2015)	European Comission
Cohesion Fund	CF	Per capita values (constant price 2015)	European Comission
Human capital	HK	% people 25-64 years with a tertiary education level (ISCED 5-6)	EUROSTAT
Technological capital	TK	R&D expenditure, per capita (constant price 2015)	EUROSTAT
Quality of Institutions	QI	Quality of Institutions composite index	Univ. Gothenburg, World Bank
Population Density	PD	Resident population per square km	EUROSTAT
Patent applications	PAT	Stock of patent applications at European Patent Office per 100,000 inhabitants	Maraut et al. (2008); OECD (2009); Eurostat (2011)
Social capital	SK	% people who have worked in a volunteer organization	Own elaboration on European Social Survey (ESS ERIC)
Production structure	RCA	Revealed Comparative Advantage, various sectors, based on employment data	EUROSTAT
Agriculture technological capital	ATK	Patent applications at European Patent Office per 100,000 inhabitants in group A01	OECD

Table A2.2: Agricultural Total Factor Productivity in EU regions

	EU more advanced regions	EU15 less-developed regions	EU13 less-developed regions	European Union
Index TFP level, EU=100				
2000	108	112	52	100
2008	111	97	64	100
2014	110	89	63	100
2019	108	93	69	100
TFP annual average growth rate, %				
2000-2008	1.19	-0.63	4.55	1.38
2008-2014	0.35	1.18	-0.07	0.35
2014-2019	-1.44	0.62	0.67	-0.91

Table A2.3: EU Funds and TFP growth, robustness checks - Panel

Dependent variable: TFP annual average growth rate

	(1)	(2)	(3)	(4)
ERDF	0.0019 *** (0.0006)	0.0014 *** (0.0005)	0.0014 *** (0.0005)	0.0010 * (0.0006)
ESF	-0.0006 (0.0009)	-0.0003 (0.0008)	-0.0005 (0.0009)	-0.0012 (0.0009)
CF	-0.0006 (0.0004)	-0.0009 ** (0.0004)	-0.0008 * (0.0005)	-0.0004 (0.0004)
EAFRD	0.0002 (0.0007)	0.0001 (0.0007)	0.0000 (0.0007)	-0.0006 (0.0007)
Human Capital	0.0084 *** (0.0014)	0.0082 *** (0.0012)	0.0076 *** (0.0018)	0.0070 *** (0.0014)
TK (EPO patents)	0.0027 *** (0.0007)			
TK (R&D exp.)		0.0022 *** (0.0006)	0.0022 *** (0.0006)	0.0022 *** (0.0006)
Quality of Institutions	0.0044 (0.0042)		0.0064 * (0.0039)	0.0076 * (0.0040)
Social Capital		0.0023 (0.0017)		
Population density	0.0022 *** (0.0005)	0.0020 *** (0.0005)	0.0020 *** (0.0005)	0.0019 *** (0.0005)
RCA _{KIS}			-0.0006 (0.0051)	
Less-developed				0.0008 (0.0018)
EU15 less-developed	-0.0022 (0.0019)	-0.0028 (0.0019)	-0.0024 (0.0019)	
EU13 less-developed	0.0063 ** (0.0028)	0.0073 *** (0.0028)	0.0072 *** (0.0029)	
Initial TFP level	-0.0154 *** (0.0028)	-0.0017 *** (0.0031)	-0.0174 *** (0.0032)	-0.0227 *** (0.0027)

All right-hand side variables are per capita, log-transformed and refer to the initial year of the period considered.

EU13 regions are not included in the first sub-period 2000-2008.

Time dummies included.

Robust Standard Error, in parentheses.

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

Table A2.4: Granger-causality tests

Dependent variable: ERDF

	(1)	(2)	(3)	(4)
	Panel	2008	2014	2018
lagged TFP growth	4.4465 (8.1874)	0.2111 (4.8071)	8.2662 (5.6124)	1.0485 (4.0084)
Other Funds	yes	yes	yes	yes
Territorial dummies	yes	yes	yes	yes
Controls	yes	yes	yes	yes
Observations	467	205	262	262

Robust Standard Error, in parentheses.

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

Controls included as in Table 2.4.

Lagged TFP growth refers to the period preceding each ERDF allocation.

Table A2.5: Robustness checks on sub-periods and funds

Dependent variable: TFP annual average growth rate

	Country differences for CF	Country differences during crisis	
	(1)	(2)	(3)
	2014-2019	2008-2014	2008-2013
ERDF	0.0020 ** (0.0010)	0.0016 * (0.0009)	0.0016 * (0.0010)
ESF	-0.0030 (0.0019)	-0.0026 * (0.0015)	-0.0023 (0.0016)
EAFRD	0.0009 (0.0015)	0.0002 (0.0012)	0.0001 (0.0012)
CF	0.0037 *** (0.0014)	-0.0020 *** (0.0008)	-0.0018 ** (0.0008)
CF * D3	-0.0032 * (0.0016)		
D5 countries		0.0029 (0.0027)	
Controls	yes	yes	yes
Adjusted R ²	0.3105	0.2104	0.1897
Observations	262	262	262

All right-hand side variables are per capita, log-transformed and refer to the initial year of the period considered.

Robust Standard Error, in parentheses.

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

Controls included as in Table 2.4.

D5: Dummy for the five countries (Greece, Ireland, Italy, Portugal, Spain) effected by the sovereign debt crisis.

D3: Dummy for the three EU15 countries (Greece, Portugal, Spain) that received CF in 2014-2019.

Essay 3

EU Cohesion Policy and Regional Development: a Regression Discontinuity Analysis

Abstract. This essay investigates the causal impact of EU Cohesion Policy on regional economic performance across 262 NUTS-2 regions in the EU-27 over the period 2008–2023. Building on the continuous-treatment Regression Discontinuity Design (RDD) proposed by Cerqua and Pellegrini (2018), we account for two defining features of the policy: (i) all regions receive financial support, albeit at varying intensities, and (ii) treatment intensity differs substantially both across and within eligibility groups. Unlike previous studies, we construct a novel temporal framework based on annualised payments data, departing from the conventional programming-period approach and aligning the analysis with major macroeconomic phases — the global financial and sovereign debt crises (2008–2013), the post-crisis recovery (2013–2018), and the COVID-19 shock (2018–2023). Our results reveal that Cohesion Policy exerts only a modest average treatment effect, with treatment status alone failing to produce significant growth impacts. Growth effects are strongly shaped by treatment intensity and display marked non-linearities. For less-developed regions, both low and very high levels of expenditure are associated with positive outcomes, while intermediate allocations often generate negative marginal effects. Non-treated regions generally use EU funds more efficiently, though their effectiveness declines over time, partly reflecting changes in the composition of this group following EU enlargement. Temporal heterogeneity further highlights the importance of policy design: crisis-oriented interventions during 2009–2013 yielded limited long-term benefits, whereas the strategic reorientation of Cohesion Policy after 2014 enhanced its growth impact in the subsequent period. Overall, the findings indicate that Cohesion Policy retains significant potential to foster regional convergence, but its effectiveness depends critically on the scale and quality of spending, institutional capacity, and alignment with productivity-enhancing investments.

3.1 Introduction

Since its inception, the European Union has pursued the reduction of economic, social, and territorial disparities, a commitment progressively codified in the Treaties and made operational with the 1988 reform of the Structural Funds, which established Cohesion Policy as a core EU investment instrument. Organised in multiannual programming periods, the policy's strategic priorities have evolved over time, shifting from growth and competitiveness to sustainability and resilience. Its central organising principle, however, has remained unchanged: the concentration of resources on less-developed regions, defined as those with a per capita GDP below 75% of the EU average. Cohesion Policy pursues its objectives primarily through the European Regional Development Fund (ERDF), which finances infrastructure, supports business activity, and promotes research and innovation, and the European Social Fund (ESF), which invests in human capital by raising employment, improving skills, and strengthening social protection. A third instrument, the Cohesion Fund (CF), follows a different allocation rule: it is reserved for Member States with a Gross National Income (GNI) per capita below 90% of the EU average and co-finances major transport and environmental projects, particularly those linked to the green transition. Over time, Cohesion Policy has absorbed an increasing share of the EU budget, with almost €400 billion allocated for the 2021–2027 programming period.

Considering both its ambitious objectives and substantial budget, Cohesion Policy has been the focus of intense academic scrutiny and remains a central theme in the regional economics literature. Numerous studies have examined its effectiveness at both the national (e.g., Di Cataldo, 2017; Coppola et al., 2023) and the EU-wide level (e.g., Di Caro and Fratesi, 2022). The literature has reached heterogeneous conclusions; however, more recent contributions that place greater emphasis on causal identification tend to provide more optimistic evidence, pointing to an overall positive impact of Cohesion Policy. Among the various methodological approaches employed to estimate such causal effects, the Regression Discontinuity Design (RDD) has emerged as particularly well-suited to the specific features of the policy, since its eligibility criterion has remained constant over time, providing a stable basis for causal identification.

The evolution of this methodology has yielded important insights into the effectiveness of Cohesion Policy (e.g. Percoco, 2017; Crescenzi and Giua, 2020). However, because it relies on a

binary distinction between treated and non-treated regions, it fails to capture some fundamental features of the policy. In reality, Cohesion Policy is not a dichotomous intervention: financial support is allocated to all regions, including those not classified as less developed — which, within the RDD framework, are typically considered non-treated — albeit with a larger amount of resources in favour of the less developed regions. Throughout the analysis, the terms “treated” and “non-treated” are therefore used in a relative sense and refer to the policy-induced classification of regions rather than to the presence or absence of Cohesion Policy funding. Regions above the 75 per cent GDP threshold are labelled as non-treated solely for identification purposes, as they do not experience the classification-induced discontinuity in funding intensity, despite still receiving EU transfers. Moreover, the intensity of support varies substantially across regions, even among less-developed ones, revealing a key limitation of the traditional RDD design. To overcome this, Cerqua and Pellegrini (2018) extend the framework to a continuous-treatment setting, allowing causal effects to be estimated along the entire distribution of funding intensity.

While existing studies provide valuable evidence for earlier programming periods, the most recent period, particularly the years encompassing the COVID-19 shock, remains largely unexplored. We address this gap by estimating the causal impact of Cohesion Policy on regional per capita GDP in the EU-27 over 2008–2023, employing the continuous-treatment RDD approach proposed by Cerqua and Pellegrini (2018). This methodology identifies a Local Average Treatment Level Effect (LATLE) — the causal effect of being classified as a less-developed region, conditional on a given level of support — thereby capturing how policy impacts evolve with the magnitude of transfers.

Unlike previous contributions (e.g., Di Caro and Fratesi, 2022; Becker et al., 2013; Cerqua and Pellegrini, 2018), we do not use programming periods as the temporal reference. The reason lies in the functioning of the $n+3$ rule (Reg. No 1303/2013), which allows annual commitments to be used within three years of allocation. This rule systematically generates overlaps across programming cycles, as resources formally allocated in one period can continue to be disbursed in the following one. As a result, the timing of actual expenditures does not align neatly with the formal programming framework, making it difficult to clearly distinguish between periods.

Rather than adhering to the standard programming period approach, our empirical strategy employs annualised, regionalised data on Cohesion Policy payments provided by the European

Commission (EC, 2017). These data enable us to move beyond the conventional programming cycle framework and adopt a temporal structure that reflects the major macroeconomic events shaping the European economy over the last two decades. Specifically, we distinguish three sub-periods: 2008–2013, encompassing the global financial crisis and subsequent sovereign debt crisis; 2013–2018, corresponding to the recovery phase; and 2018–2023, marked by the economic shock associated with the COVID-19 pandemic. The choice of these sub-periods reflects distinct phases in regional economic dynamics, as illustrated by the evolution of real GDP per capita reported in Figure A3.1 in the Appendix. To account for potential delays in the transmission of policy effects and to mitigate concerns about reverse causality, we introduce a temporal lag between the disbursement of funds and the observed outcomes. Specifically, expenditures from the 2004–2008 period are matched with outcomes from 2008–2013, those from 2009–2013 with outcomes from 2013–2018, and those from 2014–2018 with outcomes from 2018–2023.

Building on this structure, the analysis proceeds in two complementary steps. First, we estimate the overall impact of Cohesion Policy on regional per capita GDP over the entire 2008–2023 period using a panel model that incorporates the three sub-periods. Second, we assess temporal heterogeneity by estimating separate cross-sectional models for each sub-period.

The empirical specification is further enriched by including variables that capture other key determinants of regional economic performance. Previous contributions have evaluated the role of Cohesion Policy in regional development without controlling for other sources of regional capital accumulation, even though Cohesion expenditure only represents a marginal portion of overall regional investments, a point emphasised by Aresu et al. (2026). To address this limitation, our specification includes regional total investment as a proxy for overall capital formation. In addition, we control for human and technological capital, which are key determinants of productivity dynamics, as well as institutional quality and population density, which capture, respectively, the efficiency of governance systems and the structural characteristics of regional economies, such as market size and agglomeration effects.

Results reveal marked differences in the way regions have translated Cohesion support into economic growth. Overall, non-treated regions — that is, those not classified as less developed but still receiving financial support — have used Cohesion Policy resources more efficiently, achieving consistently higher growth impacts than less-developed ones. Over time,

however, the effectiveness of support in these regions has declined, as marginal effects become weaker, statistically insignificant, or even negative. By contrast, less-developed regions exhibit a systematic U-shaped pattern of marginal effects: while low and very high levels of support are associated with positive impacts, intermediate allocations yield negative and statistically significant effects, indicating persistent inefficiencies in the use of resources. Taken together, these results suggest that, although Cohesion Policy has the potential to foster regional growth, regions most in need have often failed to translate intermediate levels of funding into growth-enhancing outcomes, raising concerns about both the quality of policy implementation and the structural capacity to channel transfers effectively.

The rest of the essay is structured as follows. Section 3.2 reviews the related literature. Section 3.3 presents the data on regional Cohesion expenditures and economic growth. Section 3.4 outlines the empirical methodology, while Section 3.5 discusses the results. Section 3.6 concludes and discusses policy implications.

3.2 Literature Background

The Cohesion Policy, together with the Common Agricultural Policy, is the most important and enduring EU policy. Its longevity and substantial budgetary allocations have attracted sustained scholarly attention, making it one of the most debated topics in the regional economic literature. The first systematic contribution assessing its role in regional growth was by Cappelen et al. (2003), who, employing a standard growth regression, found a positive effect of Cohesion support. Numerous subsequent studies adopted similar approaches (e.g., Ederveen et al., 2006; Rodríguez-Pose and Fratesi, 2007; Mohl and Hagen, 2010).

Over time, however, the literature has increasingly moved beyond growth regressions and devoted greater attention to causal identification, with the aim of more rigorously isolating the impact of Cohesion Policy. Instrumental variable estimations have been used to address endogeneity in fund allocation (Crescenzi and Giua, 2016; Dall’erba and Le Gallo, 2008), while difference-in-differences designs have exploited temporal and spatial variation between funded and non-funded areas (Bachtrögler et al., 2020). Continuous-treatment estimators such as the generalized propensity score have been applied to trace the dose–response relationship between

funding intensity and economic performance (Becker et al., 2012; Cristofolletti et al., 2024). Synthetic control methods have been employed to evaluate the counterfactual trajectory of regions experiencing a change in eligibility or treatment status (Barone et al., 2016; Cerqua and Pellegrini, 2023).

Among these strategies, Regression Discontinuity Design (RDD) has become the most widely employed, largely due to the institutional structure of the policy, which directs the majority of its resources to less-developed regions defined as those with per capita GDP below 75% of the EU average. This allocation rule represents a constant eligibility threshold over time that lends itself to RDD analysis. Becker et al. (2010) were the first to apply this method, examining three programming periods between 1989 and 2006 with a panel dataset at the NUTS3 level. Their results, based on a parametric fuzzy RDD, point to a positive effect of being classified as a less-developed region on economic growth. Similar findings were reported by Pellegrini et al. (2013), who employed both parametric and non-parametric specifications for the period 1994–2006.

More recent contributions have employed RDD to investigate both spatial and temporal heterogeneity in a causal framework. Gagliardi and Percoco (2017) analysed the 2000–2006 programming period at the NUTS3 level, showing that Cohesion Policy was more effective in rural areas located near urban agglomerations. Crescenzi and Giua (2020) applied a spatial RDD to the 2000–2014 period, highlighting cross-country differences: support proved particularly effective in Germany and the UK, while still producing positive effects in Italy. For the Italian case, Giua (2017) provided earlier evidence for 1991–2001, also finding positive impacts. Becker et al. (2018), examining 1989–2013, documented that the policy's impact weakened during the 2008 financial crisis, especially in countries most severely affected.

In parallel, methodological extensions of the RDD framework have been developed to capture heterogeneity in treatment effects. Becker et al. (2013) introduced an approach to estimate a Heterogeneous Local Average Treatment Effect (HLATE), showing that human capital and institutional quality are key factors in shaping the effectiveness of being classified as less developed. Percoco (2017) explored the role of regional economic structure, finding that areas with a less developed service sector benefited more from the less developed status. Despite these advances, a fundamental limitation remains: the distinction between treated and untreated

regions is not clear-cut, as all territories receive some degree of funding, and the intensity of treatment varies considerably across eligible regions, as discussed in the subsequent section. To address this, Cerqua and Pellegrini (2018) extended the framework to estimate a Local Average Treatment Level Effect (LATLE) for 1994–2007. Their results identify an optimal per capita funding level, beyond which the marginal returns turn negative, indicating potential inefficiencies in resource allocation.

Despite these advances, important gaps remain. Most studies have concentrated on earlier programming cycles, leaving the most recent years, especially those shaped by the 2014–2020 reform and the COVID-19 shock, largely unexplored. In addition, existing analyses typically adopt programming periods as their temporal reference, thereby often overlooking how major macroeconomic shocks condition the effectiveness of Cohesion Policy. This contribution addresses both gaps by introducing a temporal framework centred on macroeconomic events and by extending the analysis to 2008–2023, offering novel evidence on the policy’s performance during one of the most turbulent decades in recent European history.

3.3 Data

3.3.1 Cohesion Policy classification and expenditures

The empirical analysis relies on data provided by the Directorate-General for Regional and Urban Policy of the European Commission (EC, 2017). The dataset contains annual regional-level information on actual payments for the period 1986–2022, offering a more precise representation of Cohesion Policy expenditure than earlier studies, which typically relied on planned commitments. This distinction is crucial, as the amounts initially committed often diverge significantly from the funds ultimately disbursed (Fratesi, 2016). Another key advantage of the dataset is its annual structure, which allows expenditure flows to be analysed beyond the formal boundaries of programming periods, an essential feature given that, under the $n+3$ rule, resources allocated in one cycle may continue to be spent in the following three years, blurring the temporal distinction between funding rounds.

Figure 3.1 captures this dynamic by showing the regional annual average of total expenditure

financed by the European Structural and Investment Funds (ESIFs)¹ across programming periods. It shows that spending from one cycle frequently extends into the early years of the next, with regions often relying on residual resources before new allocations ramp up. This pattern is particularly visible during the 2014–2020 period, when disbursements accelerated only after 2016. As a result, the chronology of actual payments often fails to align neatly with the official programming framework, complicating the attribution of observed outcomes to specific programming periods. A direct implication of the implementation of Cohesion Policy is that expenditures cannot be uniquely linked to the thematic objectives and strategic priorities defined *ex ante* for each programming period. While programming documents specify policy goals at the beginning of each cycle, the overlap in actual disbursements generated by the $n+3$ rule implies that expenditures observed in a given year may reflect commitments originating from multiple programming frameworks. As a result, annual payment data capture the effective timing and magnitude of Cohesion Policy spending, while programming-period-specific priorities remain inherently intertwined. The sub-periods adopted in the empirical analysis nevertheless capture broad changes in the policy environment over time.

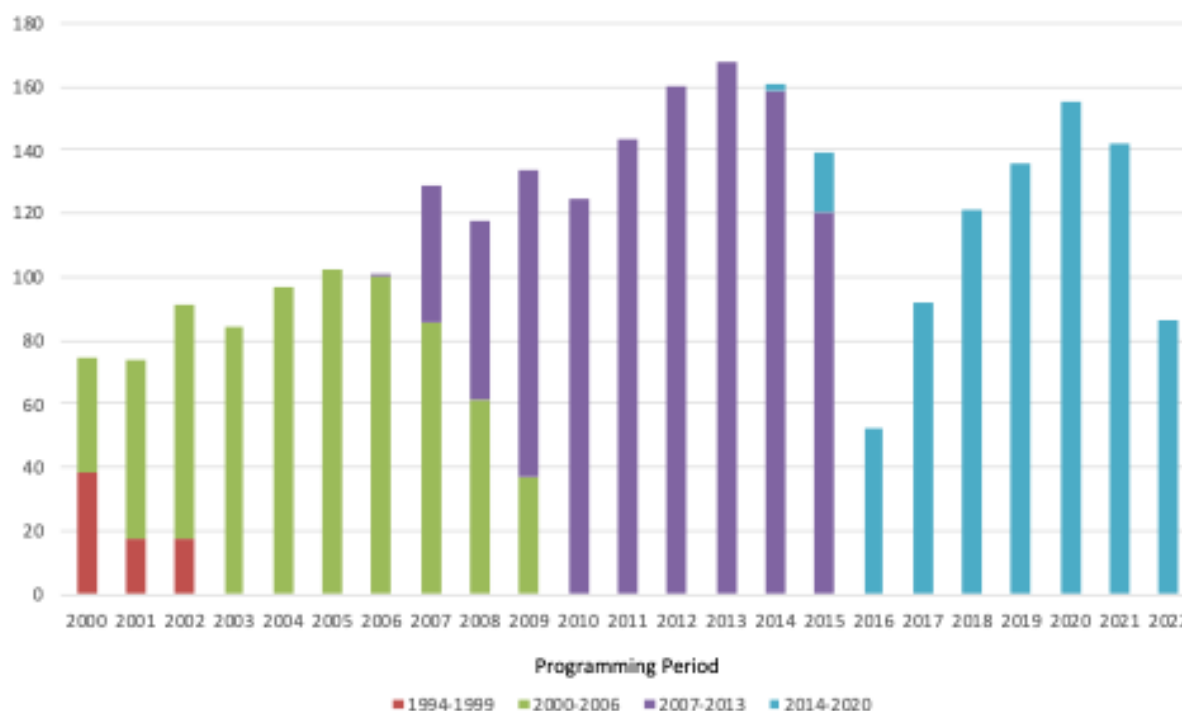
While Figure 3.1 includes all ESIFs, for the purposes of this study, we restrict the focus to the ERDF and the ESF. These two funds represent the core pillars of Cohesion Policy and are the only ones whose allocation is directly determined by the regional eligibility criteria underpinning the policy’s redistributive logic. Other funds follow distinct allocation mechanisms and are therefore excluded from the analysis, differently from Cerqua and Pellegrini (2018).

The analysis covers the EU-27² countries, excluding overseas territories, for a total of 262 NUTS2 regions. Coherent with the policy’s redistributive rationale, resources are predominantly directed to less-developed regions, defined as those with a GDP per capita below 75% of the EU average. Table 3.1 documents, for each programming period, the number of treated regions (i.e., classified as less developed), non-treated regions, and the corresponding breakdown by eligibility status. The number of regions in the sample gradually increases over time due to the accession of EU13 countries after 2004. However, in each programming period, a certain degree

¹ESIFs include ERDF, ESF, EAFRD, CF, EMFF, FEAD, and YEI.

²Croatia is excluded from the sample, as the eligibility rule for the 2014–2020 programming period, which forms the basis for the analysis over 2018–2023, was defined with reference to the EU-27 average, prior to Croatia’s accession.

Figure 3.1: Average annual ESIF per capita expenditures by programming period (constant 2015 prices)



of non-compliance with the eligibility rule emerges: some regions falling below the threshold are not classified as less developed, while others above it are nonetheless treated.

Figure 3.2 further explores ERDF and ESF expenditure patterns by displaying the annual regional average across the sub-periods that serve as treatment windows in our empirical analysis, together with the initial GDP per capita threshold used to determine eligibility. For each sub-period, the eligibility threshold corresponds to the one established at the beginning of the considered Cohesion Policy programming period — 2000–2006, 2007–2013, and 2014–2020 — based on the 75% of the EU average GDP per capita criterion³. As expected, eligible regions consistently received and spent substantially larger amounts of Cohesion Policy resources than their non-eligible counterparts. During the 2014–2018 period, for example, average per capita expenditure amounted to €151 in eligible regions compared with only €31 in non-eligible ones. Over the same years, the figures highlight a remarkable degree of heterogeneity within

³The eligibility thresholds are based on average GDP per capita in the three years preceding each programming period: 1994–1996 for 2000–2006 (Council Regulation No 1260/1999), 2000–2002 for 2007–2013 (Council Regulation No 1083/2006), and 2007–2009 for 2014–2020 (Regulation No 1303/2013).

Table 3.1: Eligibility and actual treatment

	Less-Developed Treatment		
Eligible for treatment	No	Yes	Total
2000-2006			
No	154	5	159
Yes	6	40	46
Total	160	45	205
2007-2013			
No	178	6	184
Yes	4	59	63
Total	182	65	247
2014-2020			
No	192	4	196
Yes	5	60	65
Total	197	64	261

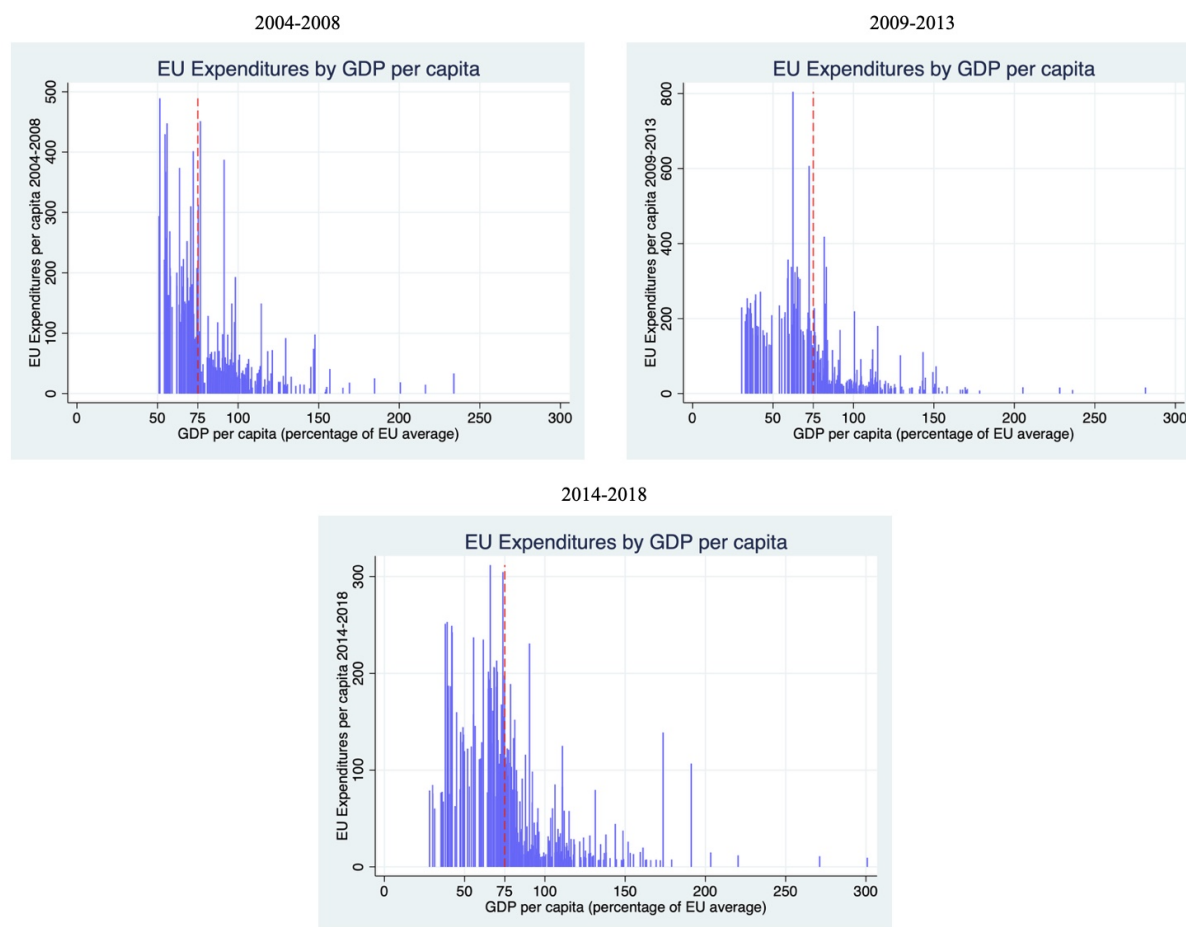
both groups, underscoring the importance of accounting for treatment intensity in the empirical analysis. Among eligible territories, per capita expenditure ranged from a minimum of €39 in Hainaut (Belgium) to a maximum of €312 in Eastern Macedonia and Thrace (Greece), whereas among others it ranged from €6 in Surrey, East and West Sussex (UK) to €231 in the Ionian Islands (Greece).

3.3.2 GDP Growth

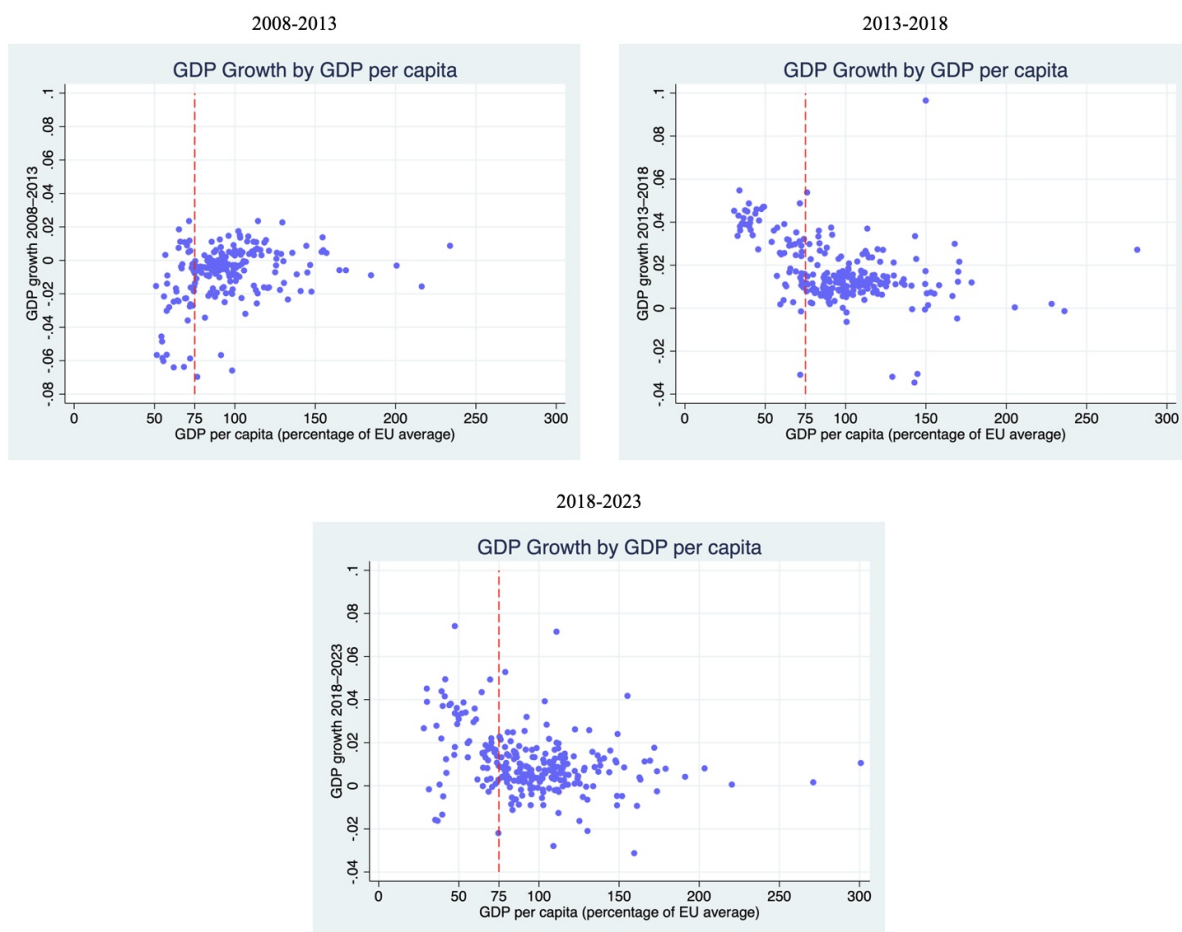
We measure policy outcomes in terms of real GDP per capita growth, expressed in 2015 euros. Figure 3.3 reports average growth rates by initial GDP levels across sub-periods. In 2008–2013, coinciding with the global financial crisis, eligible regions recorded markedly lower—and often negative—growth rates, reflecting their vulnerability to adverse shocks. Greek regions were especially affected, registering some of the sharpest declines.

In contrast, the following two sub-periods display clear signs of convergence. Between 2013–2018 and 2018–2023, less-developed regions systematically outperformed more advanced ones, with average growth nearly doubling that of non-eligible territories. Within these broad

Figure 3.2: EU expenditures per capita by initial GDP per capita across sub-periods (constant 2015 prices)



patterns, however, substantial heterogeneity emerges. Among non-eligible regions, Southern and Eastern Ireland achieved some of the highest growth rates, while among eligible regions, several Eastern European economies posted particularly strong performances. Overall, these descriptive patterns show that the global financial crisis disproportionately affected eligible regions, but also that in subsequent recovery and expansion phases, they tended to converge more rapidly than their more advanced counterparts.

Figure 3.3: Regional real GDP per capita growth by initial GDP per capita level

3.4 Methodology

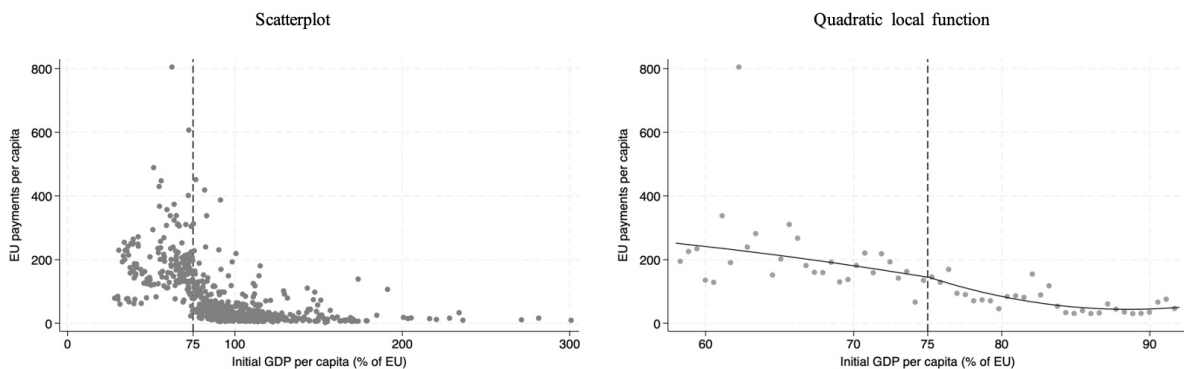
The aim of this contribution is to evaluate the impact of Cohesion Policy while accounting for two of its distinct features. First, all EU regions receive financial support, not only the less-developed ones. Second, treatment is heterogeneous, as the amount of resources allocated and absorbed varies substantially across territories, as previously discussed in section 3.1. To capture these features in the empirical strategy, we adopt the approach of Cerqua and Pellegrini (2018), who extend the standard RDD to the case of continuous treatment.

This methodology enables the estimation of a Local Average Treatment Level Effect (LATLE), specifically the impact of being treated at a particular level of treatment intensity. The approach derives from Becker et al. (2013), who developed a framework for estimating a Heterogeneous

Local Average Treatment Effect (HLATE). Cerqua and Pellegrini (2018) adapt their assumptions to the case of continuous treatment. In addition to the standard identifying condition of continuity of outcomes at the threshold, two further requirements must be satisfied:

A.1. Continuity of treatment intensity at the threshold: ensures that the only discontinuity at the cut-off comes from treatment eligibility, not from a mechanical jump in transfer intensity. This condition allows us to distinguish between the effect of treatment status—captured by the average difference in intensity between treated and untreated regions at the cut-off—and the effect of treatment intensity itself, measured as deviations from the mean within each group. In the context of our analysis, this condition appears to hold, as evidenced in Figure 3.4: both the scatter plot and the quadratic local polynomial fit show a smooth relationship in EU payments per capita around the cut-off, with no visible discontinuity.

Figure 3.4: EU payments per capita and the 75 percent GDP threshold



A.2. Random assignment of treatment intensity conditional on observables: after controlling for the forcing variable and the baseline covariates, the intensity level, measured as deviations from the mean within each group, is assumed to be independent of the unobserved component of the outcome equation.

A further key component of our empirical design is the temporal structure of the analysis. Rather than adhering to the formal programming periods, we estimate the model over three sub-periods — 2008–2013, 2013–2018, and 2018–2023 — which both align with major macroeconomic phases (the global financial crisis, the post-crisis recovery, and the expansion/COVID-19 period) and capture the actual timing of Cohesion Policy disbursements. Due to the $n+3$ rule, resources from one programming period are often spent during the initial years of the subsequent one,

blurring the boundaries between cycles and making it challenging to attribute observed outcomes to a specific period.

Formally, two treatment statuses (S) are defined. A high-treatment status (S_h) corresponds to treated regions which display higher levels of Cohesion expenditures, whereas a low-treatment status (S_l) corresponds to non-treated regions. Treatment varies continuously around its mean within each group, with the condition $E(S_h) > E(S_l)$. To make outcomes comparable between the two groups, treatment intensity is expressed as deviations from each group's mean: $t_h = S_h - E(S_h)$ and $t_l = S_l - E(S_l)$.

Given imperfect compliance with the assignment rule, as shown in Table 3.1, we implement a fuzzy RDD. The first-stage equation is specified as:

$$D = a + f_0(x) + \lambda_0 t + \lambda_1 R + \lambda_2 t \times R + f_1(x) \times R + h(Z) + \varepsilon \quad (3.1)$$

In which D is the treatment dummy, equal to 1 for regions classified as less-developed; R is the eligibility dummy, equal to 1 for regions whose initial GDP per capita is lower than 75% of the EU average; x is the forcing variable, namely the initial level of per capita GDP; and t is treatment intensity. Unlike previous contributions (e.g., Cerqua and Pellegrini, 2018; Rodríguez-Pose and Garcilazo, 2015), we measure treatment intensity using lagged Cohesion expenditures: for each period, we take the average annual expenditures of the preceding five years, independently of programming cycles⁴. This choice avoids potential reverse causality issues, as when different programming periods are considered together, GDP growth might influence future funds' allocations. We include sufficiently smooth polynomial functions of x ($f_0(\cdot)$ and $f_1(\cdot)$) and t ($\lambda_0(\cdot)$ and $\lambda_1(\cdot)$), allowing the coefficients associated with both the running variable and treatment intensity to vary on either side of the cut-off.

We include a set of controls (Z), measured at the initial year, to account for regional characteristics that may influence both regional economic performance and the effectiveness of the funds. Human capital, measured as the share of the population aged 25–64 with tertiary

⁴For each sub-period, the regional classification, and thus treatment assignment, refers to that established under the programming period in force during the first years of the corresponding expenditure window. For instance, for the 2008–2013 sub-period — where treatment intensity is measured using expenditures from 2004 to 2008 — we adopt the classification defined for the 2000–2006 programming period.

education, is a well-established determinant of regional development (Gennaioli et al, 2013). Institutional quality is proxied by the European Quality of Government Index (Charron et al, 2019), which can shape both absorptive capacity (Incaltarau et al., 2020) and the efficiency of resource use (Aresu et al., 2023). Technological capital, proxied as per capita expenditure in research and development, has been shown to underpin regional competitiveness and innovation-driven growth (see Audretsch and Feldman, 2004 for a comprehensive review). Finally, we include population density to proxy agglomeration economies, which are associated with knowledge spillovers and higher growth potential (Marrocu et al., 2013), as well as per capita gross fixed capital formation to account for overall investment intensity and capital deepening, a major driver of regional productivity differentials (Gardiner et al., 2020).

In the second stage, we exploit the estimated probability of treatment to assess the policy impact on regional real GDP per capita growth by estimating the following global parametric model.

$$Y = a + b_0(x) + g_0t + g_1\hat{D} + g_2t \times \hat{D} + b_1(x) \times \hat{D} + c(Z) + \mu \quad (3.2)$$

As before, we specify smooth functional forms for the forcing variable and treatment intensity, allowing polynomial terms to differ on either side of the cut-off.

3.5 Results

3.5.1 Panel results

Before investigating potential temporal heterogeneity, we first assess the overall impact of Cohesion Policy over the entire period under analysis (2008–2023). Table 3.2 reports the results from a panel specification that pools the three sub-periods previously discussed. The models include both period and country fixed effects, thereby controlling for unobserved country-specific heterogeneity and common macroeconomic shocks, as well as the set of control variables discussed in the previous section. Column (1) presents the estimates from the baseline RDD specification, in which the forcing variable enters linearly, and treatment is modelled through a simple binary indicator, distinguishing only between less-developed regions and all other ones. The coefficient on the treatment dummy is not statistically significant, indicating that being

treated, per se, does not exert a detectable effect on per capita GDP growth. In Column (2), we adopt a cubic polynomial specification of the forcing variable to capture potential nonlinearities in the relationship between initial GDP per capita and subsequent growth. Yet, even under this more flexible functional form, the coefficient for the treatment dummy remains insignificant, suggesting that treatment status alone does not translate into higher growth. Column (3) augments the baseline specification by including treatment intensity. Estimates indicate that neither being treated nor the amount of financial support received exerts a significant effect on regional growth. In column (4), we extend the model by introducing a cubic polynomial in treatment intensity. While the treatment dummy continues to be non-significant, the quadratic and cubic terms for intensity are statistically significant, pointing to a non-linear relationship between the scale of transfers and growth. Finally, Column (5) presents the fully specified model, in which the interaction between treatment status and the cubic terms of intensity allows for the estimation of the Local Average Treatment Level Effect (LATLE). In this case, only the cubic term shows a significant coefficient, and no systematic difference emerges between treated and non-treated regions in the effect of financial support on growth. Regarding the control variables, only human capital displays a positive and significant coefficient in Columns (1)–(2). However, when intensity is introduced in the specification, its coefficient becomes non-significant.

While point estimates do not reveal systematic differences between treated and non-treated regions, plotting the marginal effects of treatment intensity allows us to uncover heterogeneous patterns. Figure 3.5 (left panel) reports the marginal effects and 90% confidence intervals of EUF expenditures over the observed range of per capita allocations, separately for treated and non-treated regions. In both groups, marginal effects display a U-shaped pattern. For non-treated regions, effects remain close to zero at low expenditure levels and become positive and statistically significant only once allocations exceed €274 per capita. In treated regions, effects are positive for expenditures below €224 and above €559 but turn negative and significant between €249 and €534. This intermediate interval comprises 21 regions, pointing to inefficiencies in the allocation and use of transfers at these levels. Interestingly, this interval is mainly composed of European Southern regions, specifically for the Greek and Portuguese ones. This pattern resonates with a well-established strand of the literature documenting the relatively weaker effectiveness of Cohesion Policy in these areas (Aresu et al., 2026; Di Caro and Fratesi, 2022).

Table 3.2: GDP per capita growth, continuous fuzzy RDD. Panel estimates (2008-2023)

Dependent variable: average GDP per-capita growth rate

	(1)	(2)	(3)	(4)	(5)
Less developed	-0.0005 (0.0033)	-0.0027 (0.0069)	0.0010 (0.0075)	0.0039 (0.0081)	0.0105 (0.0076)
Intensity			1.2800 (2.2500)	5.1000 (4.1300)	9.1600 (7.7600)
Intensity Squared				-0.0516 * (0.0276)	-0.1000 (0.0811)
Intensity Cubic				0.0001 ** (0.0000)	0.0003 * (0.0002)
Intensity*D					-3.3600 (7.7600)
Intensity Squared*D					-0.0038 (0.0856)
Intensity Cubic*D					-0.0002 (0.0002)
Human Capital	0.0004 * (0.0003)	0.0004 * (0.0003)	0.0004 (0.0003)	0.0004 (0.0002)	0.0003 (0.0002)
Quality of Institution	-0.0042 (0.0060)	-0.0038 (0.0058)	-0.0046 (0.0056)	-0.0042 (0.0057)	-0.0046 (0.0056)
Technological Capital	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)
Population Density	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)
Total Investments	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)
Polynomial order forcing variable	1	3	3	3	3
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	713	713	713	713	713

Clustered standard errors at the country levels in parenthesis.

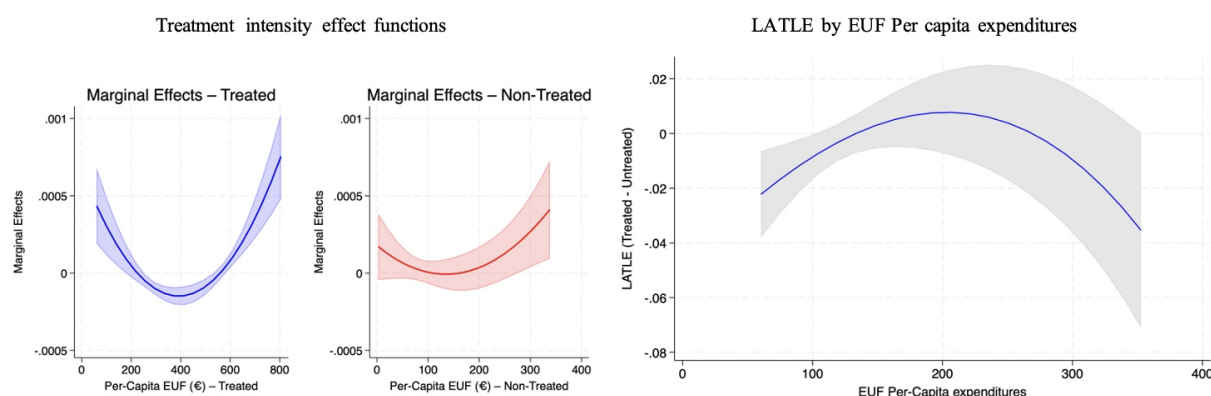
Significance levels: *** (1%), ** (5%), * (10%).

Polynomial functions are allowed to have different parameters to the left and the right of the threshold.

Coefficients and standard errors associated with intensity and its interactions are multiplied by 10^4 for ease of readability.

Consistently, Fiaschi et al. (2018) show that marginal effects of Cohesion expenditures tend to decrease and become statistically insignificant in Southern regions during the 1991–2008 period. Comparable evidence is provided by Cerqua and Pellegrini (2018), who identify 11 EU15 regions where significant inefficiencies emerged between 1994 and 2007. Despite differences in period, methodology, and sample composition, the results indicate a persistent challenge in translating large transfers into sustained growth in these territories.

Figure 3.5: The effect of EUF expenditures on regional GDP growth, 2008-2023



By contrast, and differently from Cerqua and Pellegrini (2018), our findings for non-treated regions are more optimistic, as we do not detect any significant negative marginal effects. Moreover, these regions appear to make more efficient use of Cohesion resources, as illustrated by the LATLE estimates in the right panel of Figure 3.5. The figure plots the difference, along with its confidence interval, between the impacts observed in less-developed and other regions across the distribution of per capita EU expenditures. Results indicate that, at least for cohesion expenditures below €103 per capita, the LATLE is negative and statistically significant. This suggests that, at such low levels of spending, EUF contributes more effectively to stimulating growth in non-treated regions, highlighting their greater capacity to translate even modest amounts of funding into tangible economic gains compared with less-developed areas. One possible interpretation is that these regions benefit from more favourable structural conditions, such as stronger institutional quality, better-developed productive systems, or more efficient project selection and implementation, which allow them to exploit even relatively small transfers more effectively.

3.5.2 Time heterogeneity

The period under analysis has been marked by major macroeconomic shocks that have significantly affected the economies of European regions. Cohesion Policy has been progressively adjusted to serve as an instrument capable of responding to such challenges. Building on the evidence provided by Aresu et al. (2026), who document strong temporal heterogeneity in the effects of ESIFs, we explicitly assess whether policy impacts varied across different phases. In what follows, we focus on the major macroeconomic events that occurred during the period and their potential influence on Cohesion Policy effectiveness.

Table 3.3 reports the estimates for the three sub-periods. For 2008–2013, the coefficient on the treatment dummy is negative but not statistically significant, indicating that, *ceteris paribus*, less-developed regions did not experience differential growth in per capita GDP. With respect to intensity, only the squared term is positive and significant, pointing to a non-linear relationship between expenditure levels and growth in non-treated regions. At the same time, the interaction terms with the treatment dummy reveal a significant difference in the effect of Cohesion Policy expenditures between treated and non-treated areas. For 2013–2018, the coefficient on the treatment dummy remains non-significant. Likewise, no significant effect is detected for intensity, suggesting that EUF resources spent in 2009–2013, covering the financial crisis and the subsequent sovereign debt crisis, did not foster growth during the recovery phase. This result is consistent with the crisis-response orientation of Cohesion Policy at the time, when a series of regulatory amendments (Reg. 284/2009; Reg. 539/2010; Reg. 1311/2011) prioritized liquidity support, simplified disbursement, and higher EU co-financing rates to ease fiscal pressures. While these measures accelerated absorption and stabilized economies, they mainly provided short-term relief rather than long-term productivity gains, which explains the absence of detectable growth effects in subsequent years. By contrast, for 2018–2023, a positive and significant coefficient for the treatment dummy is estimated, indicating that, *ceteris paribus*, being classified as a less-developed region during the 2014–2020 programming cycle contributed to higher per capita GDP growth in the subsequent years. This outcome is consistent with the substantial reform of Cohesion Policy introduced by Regulation 1303/2013, which shifted the policy away from short-term crisis management toward a more strategic and results-oriented

framework. In particular, thematic concentration channelled a large share of resources toward growth-enhancing areas such as innovation and SME competitiveness. No significant effect is detected for EUF expenditures in non-treated regions; however, the significant interaction terms confirm that the impact of expenditures differs systematically between treated and non-treated regions.

Table 3.3: GDP per capita growth, continuous fuzzy RDD. Sub-periods.

Dependent variable: average GDP per-capita growth rate

	(1)	(2)	(3)
	2008-2013	2013-2018	2018-2023
Less developed	-0.0001 (0.0179)	0.0100 (0.0082)	0.0151 * (0.0076)
Intensity	-3.3900 (4.4900)	0.6940 (10.0000)	10.0000 (10.0000)
Intensity Squared	0.1970 * (0.1030)	-0.0449 (0.1220)	0.0839 (0.1590)
Intensity Cubic	0.0002 (0.0004)	0.0002 (0.0003)	-0.0005 (0.0006)
Intensity*D	-20.0000 ** (10.0000)	-4.9500 (10.0000)	-20.0000 * (10.0000)
Intensity Squared*D	-0.3370 ** (0.1240)	0.0051 (0.0953)	-0.0399 ** (0.1900)
Intensity Cubic*D	0.0007 (0.0004)	-0.0015 (0.0003)	0.0027 *** (0.0008)
Controls	Yes	Yes	Yes
Observations	205	247	261

Clustered standard errors at the country levels in parenthesis.

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

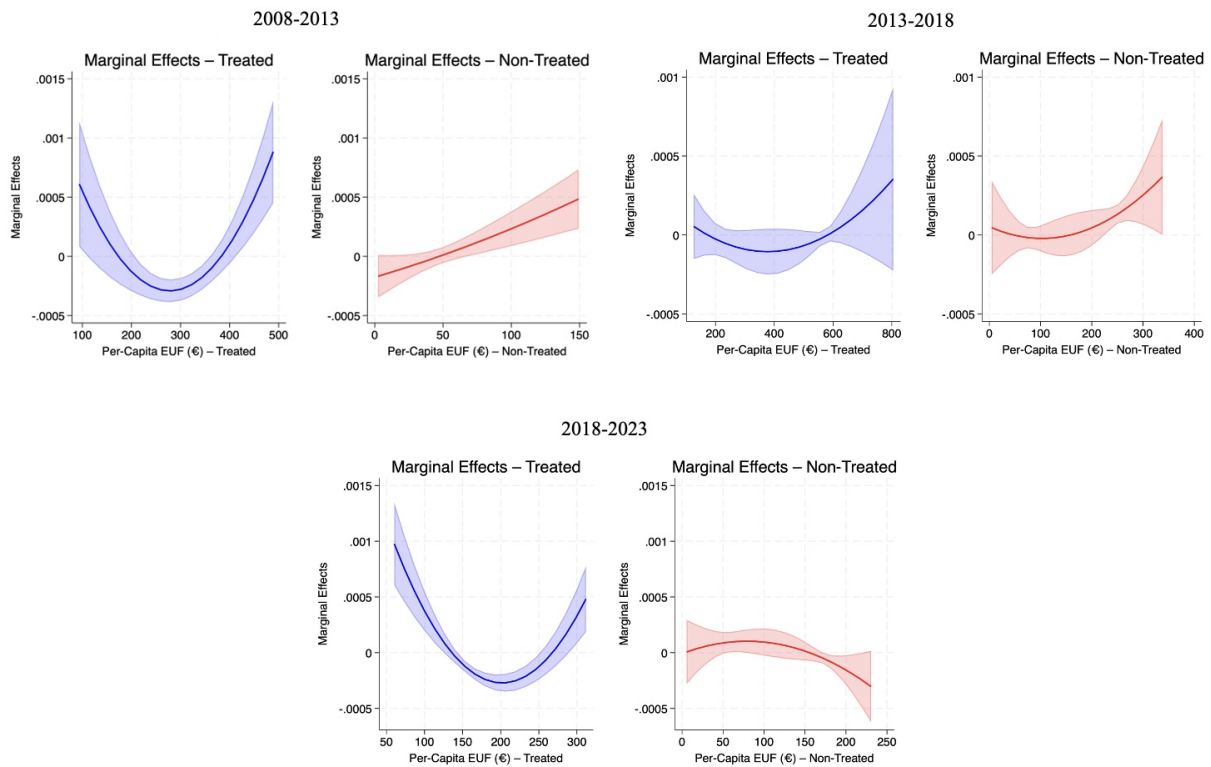
Polynomial functions are allowed to have different parameters to the left and the right of the threshold.

Coefficients and standard errors associated with intensity and its interactions are multiplied by 10^4 for ease of readability.

Figure 3.6 plots the marginal effects of EUF payments for each sub-period, illustrating how the impact of Cohesion Funds has differed between treated and non-treated regions over time. In less-developed regions, the marginal effects of EUF expenditures consistently display a U-shaped pattern. By contrast, in non-treated regions, the trends vary across sub-periods: linear and increasing in the first, U-shaped in the second, and inverse U-shaped in the last. Moreover,

in the first two periods, the marginal effects for non-treated territories become positive and statistically significant once expenditures exceed €67 and €224 per capita, respectively, while in the last period, they remain non-significant up to €172 per capita and then turn negative and significant. Taken together, these dynamics suggest a progressive deterioration in the impact of EUF expenditures in non-treated regions. One possible explanation is that several Southern European regions, traditionally characterized by inefficiencies in fund allocation (Medeiros, 2017), were initially classified as less-developed but lost this status following the accession of poorer EU13 countries after 2004. Their inclusion in the group of non-treated regions may have contributed to the weaker and eventually negative effects observed over time.

Figure 3.6: Marginal effect of EUF expenditures on regional GDP growth, sub-periods

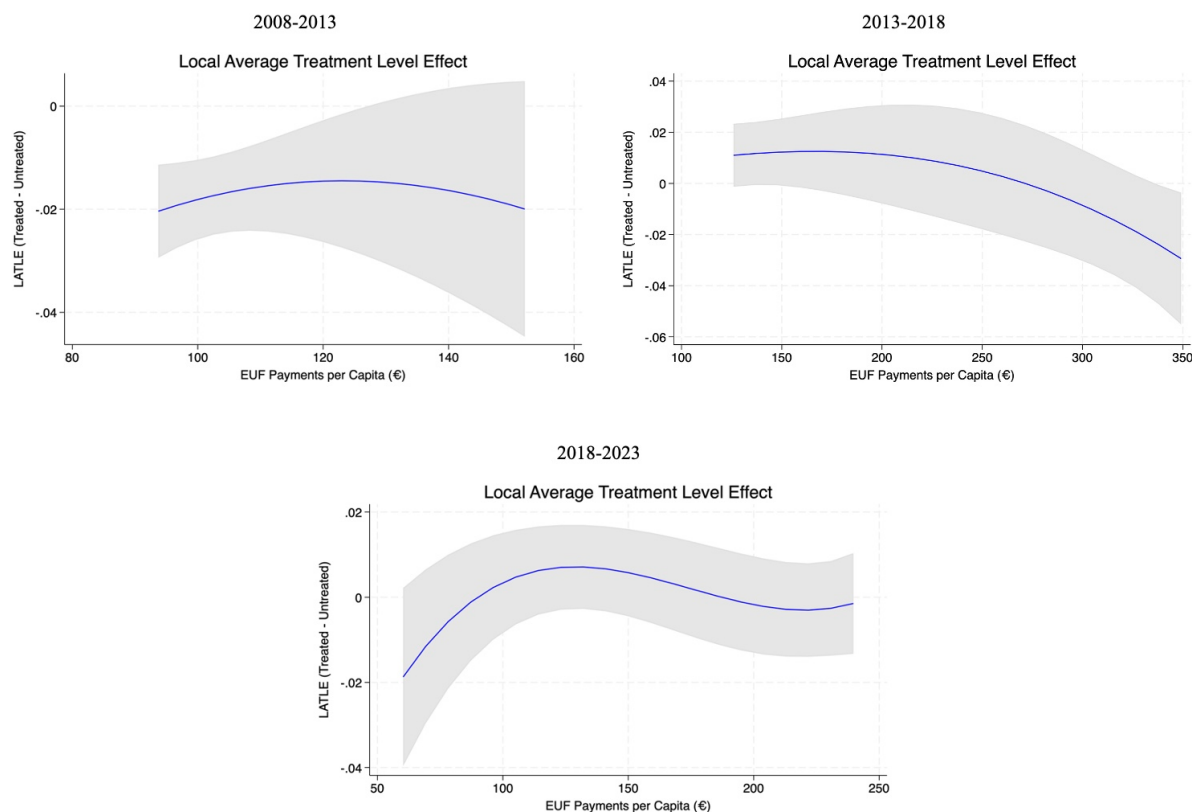


The marginal effects plots show that EUF expenditures did not exert a statistically significant impact on regional economic growth in less-developed territories during the recovery phase (2013–2018). At the same time, the effects appear highly heterogeneous across expenditure levels in the first and last sub-periods. In particular, during 2008–2013, negative and significant marginal effects were estimated for 11 less-developed regions. In contrast, by 2018–2023, this

number had increased to 27, encompassing a larger share of treated regions and indicating a worsening pattern of inefficiencies over time. Notably, in the first sub-period, such negative effects were concentrated mainly in Southern European regions, whereas in the most recent period, they emerged predominantly in several Eastern European regions, including those in the Czech Republic, Hungary, and Poland. This shift partly reflects the reclassification of many Southern European regions: territories that were previously less developed, and showed weaker growth responses, moved above the eligibility threshold after the 2004 enlargement and are no longer part of the treated group in the later period. Their exit from the category of less-developed regions and the simultaneous entry of several Central and Eastern European territories contributed to reshaping the geography of inefficiencies and altering the profile of Cohesion Policy challenges. Although earlier inefficiencies were linked to persistent development traps and limited absorptive capacity in the southern periphery, their recent concentration in Eastern Europe remains largely unexplored in the literature. However, some plausible explanations can be advanced. As these economies converge toward higher income levels, traditional infrastructure and capital investments may yield diminishing returns, and the absence of complementary factors — such as innovation capacity, institutional quality, and human capital — can limit the transformative potential of EU transfers. Differences in governance and administrative capacity, as well as the rapid scaling-up of funds in recent programming periods, may further constrain project selection and implementation.

Finally, Figure 3.7 reports the LATLE diagrams for each period. Interestingly, they show that less-developed regions were particularly inefficient during the first sub-period, where a significant and negative coefficient is estimated for expenditure levels below €127 per capita. This pattern may reflect the reclassification of several Southern European regions, which lost their less-developed status following EU enlargement. As a result, the difference in the economic impact of EUF between treated and non-treated regions appears to diminish over time.

Figure 3.7: LATLE by EUF expenditures, sub-periods



3.6 Conclusions and Policy Implications

This contribution examines the causal impact of Cohesion Policy on regional economic growth across the EU27 over the period 2008–2023. The analysis adopts the continuous-treatment RDD methodology developed by Cerqua and Pellegrini (2018), which accounts for two key features of the policy: all EU regions receive some degree of funding, and treatment intensity varies substantially across territories. A central novelty of this study is the employment of annual regional Cohesion expenditure, and thus in its temporal framework, which departs from programming periods and is instead anchored to major macroeconomic events. We distinguish three five-year phases—2008–2013, covering the global financial and sovereign debt crises; 2013–2018, corresponding to the recovery phase; and 2018–2023, marked by the COVID-19 shock. To capture longer-term impacts and mitigate reverse causality concerns, treatment

expenditures are lagged relative to the economic outcomes under analysis.

The results point to three main findings. First, the average treatment effect of Cohesion Policy is modest, and being classified as a less-developed region does not, per se, guarantee higher growth. Instead, growth impacts are shaped by treatment intensity and exhibit pronounced non-linearities. Second, non-treated regions have, on average, used Cohesion resources more efficiently, with positive and significant effects at higher levels of funding; however, their efficiency has deteriorated over time, with marginal effects becoming weaker and eventually negative in the most recent period; a potential explanation would be the reclassification of several Southern European regions since EU enlargement, traditionally characterized by weaker administrative capacity. Third, less-developed regions consistently display U-shaped effects of EUF expenditures: while low and very high levels of support are associated with positive impacts, intermediate allocations generate significant inefficiencies. These patterns culminate in the finding that in 2018–2023, a growing number of less-developed regions, 27 in total, experienced negative marginal effects, highlighting a worsening misallocation of resources.

A closer look at temporal heterogeneity sheds further light on the dynamics of Cohesion Policy. Expenditures allocated during 2009–2013, largely oriented toward crisis-response measures, did not translate into growth during the recovery phase of 2013–2018, suggesting that short-term liquidity support and simplified disbursement rules were insufficient to generate durable growth gains. By contrast, resources disbursed in 2014–2018 proved more effective in the subsequent period (2018–2023), particularly in less-developed regions. This outcome is coherent with the strategic reorientation introduced by the 2014–2020 reform, which emphasised thematic concentration and channelled funds toward innovation, SME competitiveness, and human capital development. These results underscore that the timing and design of interventions, whether crisis-driven or strategically growth-oriented, play a decisive role in shaping their long-term effectiveness.

Overall, the evidence suggests that Cohesion Policy retains the potential to foster growth, but its effectiveness critically depends on both the scale and the quality of expenditure. Less-developed regions have often struggled to translate intermediate levels of support into performance-enhancing investments, reflecting persistent weaknesses in absorptive capacity, institutional quality, and project selection. The analysis also highlights marked spatial heterogeneity in policy effectiveness

within this group. While inefficiencies were historically concentrated in Southern Europe, many of these regions have since moved above the eligibility threshold following EU enlargement, and new inefficiencies have emerged in several Eastern European areas. This shift reflects a broader change in the profile of less-developed regions: territories that were once the main source of inefficiencies are no longer classified as less developed, while new entrants face different structural challenges. As a result, Cohesion Policy must adapt to these evolving regional contexts, ensuring that interventions are tailored to each territory's development stage and structural characteristics.

From a policy perspective, the findings call for a more careful calibration of Cohesion allocations. Simply increasing funding volumes is unlikely to deliver sustained benefits unless resources are better targeted, managed, and absorbed. Strengthening institutional capacity, ensuring alignment with productivity-enhancing priorities such as innovation and human capital, and closely monitoring the effectiveness of expenditures are essential.

Further research is needed to examine how institutional quality influences the management and, consequently, the effectiveness of Cohesion Policy resources. In particular, it remains unclear whether and how the capacity of regional institutions conditions the impact of large-scale financial transfers, and whether a relationship exists between the amount of resources allocated, the quality of governance, and subsequent economic outcomes. A deeper understanding of these interactions would provide valuable insights into the mechanisms through which Cohesion Policy translates into regional growth and would help explain the heterogeneity of its effects across territories. Similarly, the COVID-19 shock necessitates more targeted analyses that explicitly account for the severity of the pandemic and the heterogeneity of containment measures across regions, as both factors are likely to have influenced growth trajectories and the effectiveness of EU support during this turbulent period.

3.7 References

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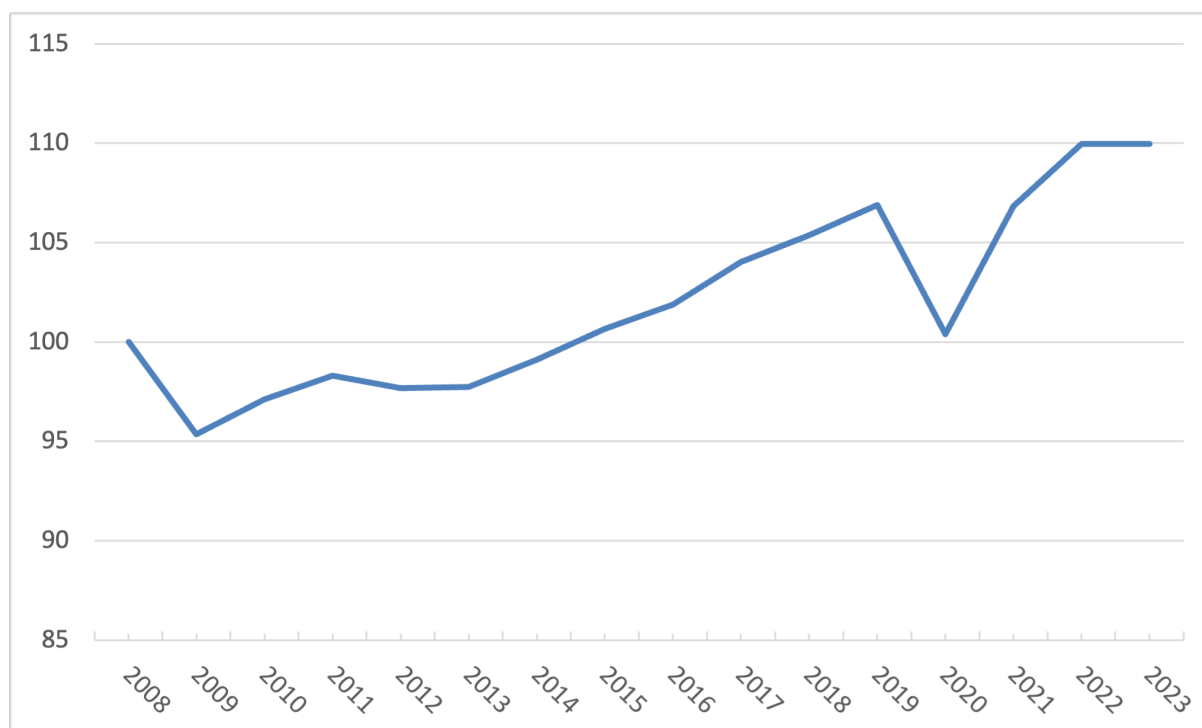
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3.8 Appendix

Figure A3.1: Evolution of Average Regional Real GDP per Capita in the EU, 2008–2023 (2000 = 100)



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