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Private investment, R&D and European Structural and Investment Funds: crowding-in or crowding-out?

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Abstract

We employ a novel regional dataset on European private investment and business R&D spanning the years 2000 to 2021, along with comprehensive historical data on European Union Structural and Investment (ESI) funds, to estimate whether ESI funds have crowding-in or crowding-out effects on private investment and business R&D. Our analysis, leveraging regional variation and a fiscal instrument immune to region-specific shocks, reveals a significant crowding-in effect, with 1 euro in ESI funds increasing private investment by 1.1 euros and business R&D by 0.1 euros after two years. The effect is stronger in developed regions for private investment and in less developed regions for R&D. Additionally, crowding-in effects are stronger in regions where corporate private debt is relatively higher. Among the different ESI funds, the Cohesion Fund (CF) shows the largest estimated impact, while the European Regional Development Fund (ERDF) yields somewhat smaller but statistically more robust results.

Keywords: EU, Structural and Investment Funds, Private Investment, R&D, fiscal instruments.

JEL Codes: E22, H54, O38, O52, R11, R58

Non-technical summary

Europe faces substantial investment needs, and a strong complementarity between the public and private sectors could be crucial in effectively addressing these challenges. The debate over whether public expenditures crowd out or crowd in private investment shifts towards understanding how public investments influence private investments.

Crowding-out can occur if the supply of input (e.g. scientists) is inelastic; in this case, an increase in public investment comes at the expense of declines in private investment (e.g., as fewer scientists would be available for private projects). Moreover, it occurs when public interventions substitute private capital, reducing incentives to invest for firms. Similarly, there are several reasons for crowding-in to prevail, stemming from complementarities across public and private capital. First, in the presence of large fixed costs, public investment in technology, innovation and infrastructure may make marginal projects feasible. The typical examples are the construction of a road with public resources and the subsequent private initiative that such projects would enable. Second, there could be "spillover effects", where new technologies find different applications in the private sector. Third, credit constraints on the private sector may limit the financing of projects without government support.

Recent studies have shown that certain public investments, such as defence-related R&D, can indeed crowd in private investment. Our research broadens this analysis to include non-defence public investments, specifically through the European Structural and Investment (ESI) Funds, which aim to enhance economic cohesion across the European Union (EU). These funds focus on innovation, research, and infrastructure, raising the question of whether they encourage private investment or crowd it out by substituting private capital.

We employ a novel regional dataset on private investment and business R&D and create an instrument for ESI disbursements that is unaffected by regional shocks. The instrument leverages the correlation between planned and actual disbursements and the average absorption rate for similar regions with comparable convergence objectives in other countries.

During the 2000-2021 sample period, our findings indicate a significant crowding-in effect, with each euro of ESI funds causing an increase of 1.1 euros in private investment and 0.1 euros in business R&D after two years. The crowding-in effect is stronger in more developed regions for private investment, while it is more prevalent in less developed regions for business R&D. Moreover, we find that the crowding-in effects of ESI funds are stronger in regions with higher corporate private debt, as these funds contribute to improving access to external finance.

The crowding-in effect does not appear to be dependent on the business cycle, although it is marginally higher during low-growth regimes, especially for business R&D.

The findings also indicate that the European funds distributed via the European Regional Development Fund (ERDF) and the Cohesion Fund (CF) significantly stimulate private sector initiatives by financing innovation, research, and infrastructure projects. In contrast, the statistical outcomes for the European Social Fund (ESF) and the Youth Employment Initiative (YEI) are less definitive.

Our study contributes to the literature on fiscal spillovers in the EU, offering valuable insights for policymakers interested in effective public investment strategies. We clarify the genuine impact of public investment on private sector activity, emphasizing the importance of regional economic conditions. Our findings highlight that ESI funds are not only a tool for economic convergence but also an important investment programme that supports private investment across diverse economic contexts.

It is worth mentioning that Draghi (2024) and Letta (2024) argue that substantial resources must be allocated within Europe to bridge the significant investment gap the continent faces compared to other countries. Our findings suggest that the strong complementarity between private investment and a certain type of public investment can play an important role in effectively addressing the substantial investment needs that Europe faces.

The European Structural and Investment (ESI) Funds provide real European added value through tailored growth-enhancing investments for regional development (31/01/2023).

Valdis Dombrovskis
Executive Vice-President and Commissioner for Trade

I Introduction

The European Structural and Investment (ESI) funds, also known as EU Cohesion policy funds, primarily aim to reduce regional economic disparities across the European Union (EU). By providing co-financing and guarantees, these funds empower local public authorities to engage in projects aligned with EU priorities such as innovation, digitalization, the green transition, and social inclusion. Beyond their public mission, ESI funds also have the potential to act as a catalyst for private investment, mitigating risks and creating favourable conditions for business participation. For instance, public investments in infrastructure—such as transportation networks, digital connectivity, and energy systems—can reduce operating costs and unlock new business opportunities. Thus, it is a useful fiscal instrument to assess whether public investment stimulates private investment or whether it crowds out private initiatives.

The debate over whether public expenditures crowd out or crowd in private investment has long been a topic in the literature (e.g. Friedman, 1978; Ramey, 2011b; Antolin-Diaz and Surico, 2025).[1] More recently, researchers have focused their attention on analysing whether public investments crowd out or crowd in private investment. Moretti et al. (2023) report that defence-related R&D crowd in private R&D expenditures, Antolin-Diaz and Surico (2025) find that defence-related R&D crowds out private investment in the short term, but crowds it in over the long run, while Fieldhouse and Mertens (2024) find that increased non-defence government R&D spending fosters innovation and productivity.[2] Aschauer (1989) finds that US public infrastructure investment increases productivity.[3]

We tackle the same issue but with a different regional context, drawing insights from the experience of ESI Funds. The EU budget, representing approximately 1% of the EU Gross

[1]The traditional theory of crowding-out suggests that when the government increases its spending, it will increase the demand for goods and services, which can lead to higher inflation and higher interest rates. This, in turn, can make borrowing more expensive for private investors, reducing their ability to invest in new projects and businesses. As a result, private investment may decrease or "crowd-out" as the government spending increases. However, debt-financed deficits may crowd-in private investment, if resources were underutilised and accelerator effects are taken into account (Friedman, 1978).

[2]Other empirical studies looking at the effect of public R&D on private R&D, finding both crowding-in and crowding-out-effects, include Goolsbee (1998), David et al. (2000), Wallsten (2000), Lach (2002), Dimos and Pugh (2016).

[3]Francois et al. (2024) find that public investment crowd-in private investment in developing countries.

National Income for each programming period, allocates nearly one third of its resources to this policy. Through the ESI funds, the EU spent approximately one trillion euros over the last 25 years ending in 2020.[4] Does such fiscal instrument stimulate private investment and business R&D, or does it crowd out private initiatives? We utilise a novel regional dataset on European private investment and business R&D covering the period from 2000 to 2021 to address this question. Since our focus lies on examining a structural issue rather than mitigating cyclical fluctuations, the use of annual data proves beneficial in minimising the statistical volatility typically associated with such time series.

We find strong crowding-in effects, holding the effects of aggregate EU fiscal policy constant (Ramey, 2011a). Focusing on the impact after 2 years (e.g. Ramey, 2016; Bernardini et al., 2020), the empirical analysis suggests that 1 euro spent on ESI funds is associated with an increase of 1.1 euros in private investment and 0.1 euros in business R&D.

Fiscal effects can vary depending on the state of the economy. The crowding-in effect is found to be stronger in more developed regions for private investment, and in less developed regions for business R&D. Additionally, the crowding-in effect is more pronounced in regions with higher private debt overhang, in particular for private investment, as these funds can play a critical role in facilitating access to external finance, and it does not appear to be dependent on the business cycle. The findings further indicate that the European funds distributed through the European Regional Development Fund (ERDF), the Cohesion Fund (CF), the European Social Fund (ESF) and the Youth Employment Initiative (YEI) each individually have a significant stimulative effect on private sector initiatives, with the CF showing a comparatively higher impact.

We propose an instrument that is orthogonal to domestic regional shocks, as these shocks could be a common factor influencing both private investment and ESI funds' disbursements, potentially generating spurious correlations. We construct an instrument for ESI funds' disbursements at the regional level leveraging the product between the ex-ante planned disbursements for the subsequent years for each region – also sourced from a novel dataset –, and the contemporaneous average absorption rate computed for similar regions in other countries.

The identification strategy of the first factor exploits the lags between approval and eventual

[4]For the 2021-2027 programming period, this amounts to €392 billion. Next Generation EU (NGEU), established as an immediate response to the COVID-19 pandemic, also serves as an additional initiative to stimulate investment within the EU (Bańkowski et al., 2024). The NGEU initiative is a short-term, temporary recovery instrument designed to support the EU's recovery from the COVID-19 pandemic. It aims to foster a greener, more digital, and more resilient Europe.

disbursement of these funds to isolate a predetermined component of public spending associated with past fund approval decisions taken before the realization of shocks in a specific region. It mimics the strategy adopted by Kraay (2012, 2014), who uses a loan-level dataset covering lending by official creditors to developing country governments to construct an instrument for government spending. The selection of the second factor leverages the strong correlation between the absorption rate of a specific region and the average absorption rate in regions with comparable levels of development in other countries. The ability of regions to absorb and effectively utilise European funds, such as those provided by the ESI funds, is influenced by various factors, with the level of development being a significant determinant due to the similar challenges it presents (i.e. administrative capacity, experience with EU funding, quality of planning and project pipeline, etc.). The interaction of these two variables allows us to calculate predicted ESI fund disbursements that are exogenous to macroeconomic shocks specific to a region or country.

This approach allows to identify directly exogenous variation in regional studies, rather than relying on the Choleski identification (e.g. Bernardini et al., 2020),[5] or on the residual of an aggregate EU funds equation (e.g. Canova and Pappa, 2024),[6] or on the indirect methods such as the Bartik (1991)-instrument approach (e.g. Gabriel et al., 2023).[7]

In general, our analysis contributes to a growing literature on fiscal spillovers in the EU.[8] To our knowledge, the only studies analysing the effects of EU grants on aggregate (private and public) investment at the regional level are Coelho (2019), De Santis et al. (2022), Canova and Pappa (2024) and Fiuratti et al. (2024), while Durand and Espinoza (2021) document the fiscal spillover using country-level data. We instead collect regional private investment and business R&D data, which allows us to investigate directly the question at stake controlling

[5]Following Blanchard and Perotti (2002), Bernardini et al. (2020) use a Cholesky approach to identify fiscal shocks, assuming that regional government spending in US states does not respond contemporaneously to economic conditions within the same period due to implementation lags in fiscal policy. Regional fiscal shocks are thus identified as the residuals of the regional government spending equation. However, regional responses to fiscal shocks are more heterogeneous, influenced by local characteristics, and susceptible to contamination from other shocks or omitted variables, potentially leading to biased or imprecise estimates. Most importantly, in this setting, regional shocks that move regional government spending would be treated as fiscal shocks.

[6]Canova and Pappa (2024) use as a key variable in their local projection exercise the residuals from regressing aggregate EU funds on aggregate euro area macroeconomic variables such as GDP, employment, GDP deflator, nominal interest rate, and nominal effective exchange rate. The comovement between the variable of interest and the ESI funds owing to regional shocks is not resolved.

[7]Gabriel et al. (2023) find a strong relative government spending multiplier on private investment across euro area regions, employing the Bartik (1991)-instrument approach.

[8]Macroeconomic models have been used to quantify the fiscal spillovers in the literature (e.g. Beetsma et al., 2006; Corsetti et al., 2010; Kraay, 2012; in 't Veld, 2013; Elekdag and Muir, 2014; Kraay, 2014; Attinasi et al., 2017; Dabla-Norris et al., 2017; Cacciatore and Traum, 2022; Ilori et al., 2022; Pfeiffer et al., 2023).

for region fixed effects and time fixed effects. Canova and Pappa (2024) find that the impact of ESI funds is very weak on total investment. However, their study uses as a key variable the residuals from regressing aggregate EU funds on a set of macroeconomic variables, leaving aside the endogeneity associated to regional shocks. Instead, we address directly the potential endogeneity issue between regional shocks and regional funds. Additionally, Canova and Pappa (2024) focus on the effects of only two EU funds, whereas we assess the combined impact of four types of EU spending, excluding those related to agriculture and fishery. Notably, Canova and Pappa (2024)'s analysis excludes the Cohesion Fund (CF), which is designed to support infrastructure and sustainable development in less developed regions, particularly in Central and Eastern Europe, which are instead central to our research question.

Our work is related to other studies analysing the impact of European Funds on the macroeconomy (e.g. Boldrin and Canova, 2001; Mohl and Hagen, 2010; Becker et al., 2013; Breidenbach et al., 2019). All these papers abstract from presenting the impacts on private investment.

Finally, our results are in line with Bernardini and Peersman (2018) and Bernardini et al. (2020), who have identified for the US states significantly larger government spending multipliers during times of private debt overhang; they focus on household debt, we consider private corporate debt. These findings are supported by theoretical studies (Eggertsson and Krugman, 2012; Michaillat, 2014; Andrés et al., 2015; Canzoneri et al., 2016) mainly motivated by the global financial crisis.

The rest of the paper is structured as follows. Section II describes the regional private investment and R&D databases, the ESI funds, and other regional data more broadly. Section III presents the model and the identification strategy. Section IV discusses the key results. Section V provides further analysis on the crowding-in effects depending on the state of the economy. Section VI investigates the role played by each Fund. Section VII concludes.

II The dataset

II.A Regional Private Investment and R&D

The analysis utilizes a panel dataset comprising regional macroeconomic data provided by ARDECO and Eurostat at the NUTS2 (Nomenclature of Territorial Units for Statistics) level, for all regions within the EU.

The data for private investment is derived by excluding NACE industries O to U from total

gross fixed capital formation, as they pertain to government activities (see also Gabriel et al., 2023).[9] The regional private investment in real terms is calculated by dividing it by the regional investment deflator. The resulting measure aligns with country level data for private investment provided in Eurostat's AMECO dataset, as illustrated in Figure 1. Minor discrepancies on the real side between the total country aggregate and the regional sum of real private investment can be attributed to differences between the country investment deflator and the disaggregated regional investment deflators.

Data for business R&D and total R&D is obtained from the Eurostat's regional statistics database. The comprehensive dataset includes EU countries from 1995 to 2021, although there are some gaps due to the availability of regional data. As a result, the regional data represents 80-90% of the total R&D expenditures. To calculate the regional R&D investment in real terms, the figures are divided by the regional gross value added deflator. The discrepancy between the real R&D investment at the national level and the sum of regional investments consistently mirrors the gap observed in the nominal data.

To the best of our knowledge, this study is the first to analyse the effects of ESI funds on private investment and business R&D at the regional level.

In this context, the share of ESI funds dedicated to R&D projects has shown slight variations across different programming periods, consistently ranging between 20% and 25% of the total budget. The EU's commitment to supporting R&D through ESI funds underscores its position as a top funding priority.

II.B The European Structural and Investment (ESI) Funds

The Structural Funds, which form the cornerstone of the EU's Cohesion Policy, include the European Regional Development Fund (ERDF), the Cohesion Fund (CF), the European Social Fund Plus (ESF), and the Youth Employment Initiative (YEI). These funds represent the vast majority of the ESI Funds and are the primary focus of our analysis. Instead, the European Agricultural Fund for Rural Development (EAFRD), which supports rural areas in becoming more competitive, sustainable, and inclusive, and the European Maritime, Fisheries and Aqua-

[9] NACE is the statistical classification of economic activities. The excluded sections from O to U are defined as follows: section O: Public Administration and Defence; Compulsory Social Security; section P: Education; section Q: Human Health and Social Work Activities; section R: Arts, Entertainment and Recreation; section S: Other Service Activities; section T: Activities of Households as Employers, Undifferentiated Goods- and Services-Producing Activities of Households for Own Use; section U: Activities of Extraterritorial Organizations and Bodies.

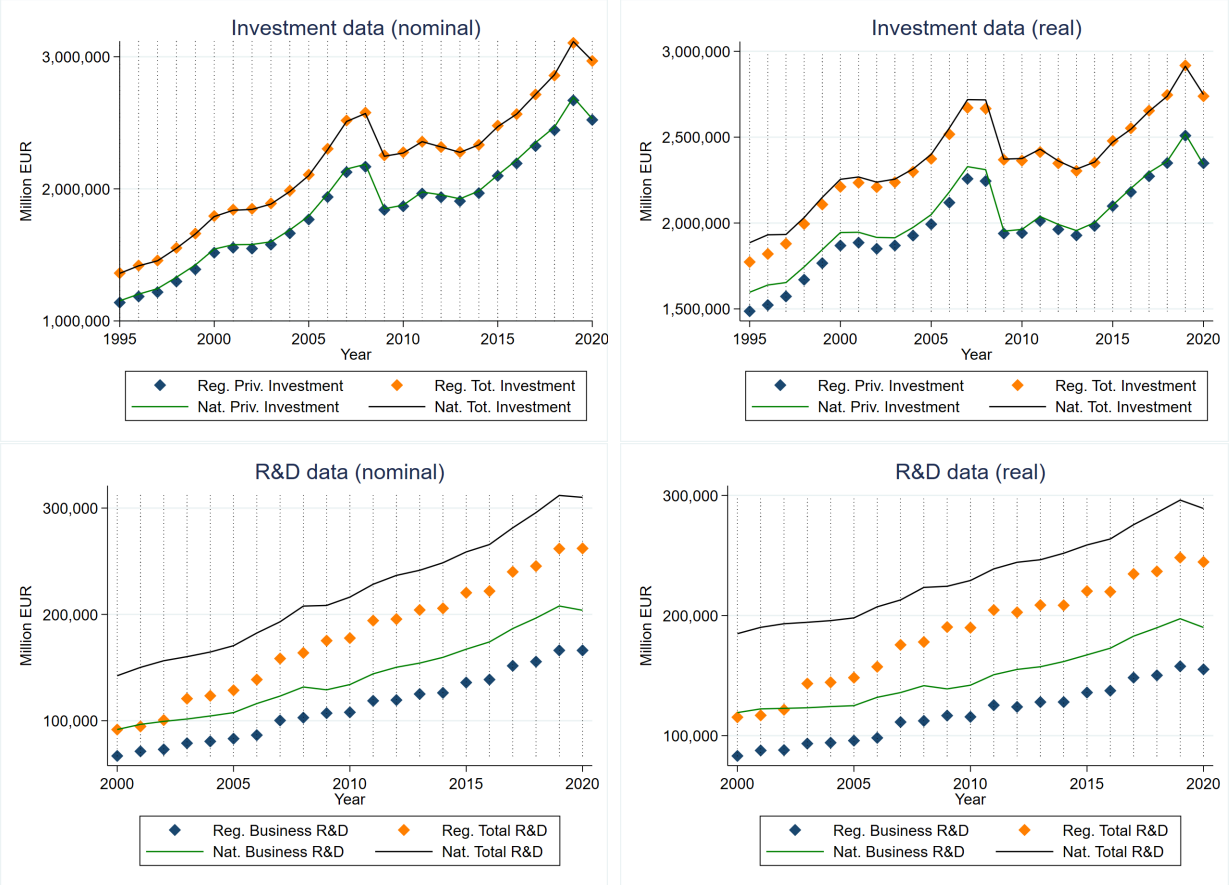

Figure 1: Private Investment and Business R&D Expenditures.
Notes: Source: Eurostat, AMECO, ARDECO. Sample period: 1995 - 2020 for private investment, 2000-2020 for business R&D.

culture Fund (EMFAF), which promotes sustainable fisheries and aquaculture while protecting marine ecosystems, are excluded from this analysis. These latter two funds constitute a marginal share of the ESI Funds and are less relevant to the research question under investigation. Our database is significantly more comprehensive than that used by Canova and Pappa (2024), who focused exclusively on the ERDF and the ESF programs.

The ERDF supports projects that drive innovation, advance research, promote the digital agenda, and foster a low-carbon economy. These funds can be utilised to finance infrastructure projects that deliver essential services, such as transportation, energy, and education. Additionally, they can be allocated to initiatives that strengthen research and innovation efforts. The CF is directed at Member States with a gross national income (GNI) per inhabitant of less than 90% of the EU average. It finances large-scale infrastructure projects in transport and environment, including trans-European transport networks and sustainable development.[10] The ESF

[10]For the 2014-2020 period these Member States are Bulgaria, Croatia, Cyprus, the Czech Republic, Estonia,

supports initiatives that enhance job prospects, promote social inclusion, and combat poverty by funding training, lifelong learning, and measures to improve the adaptability of workers and enterprises. The YEI, launched by the European Commission in 2013, provides financial resources to Member States to implement measures that directly support young people's transition into the labour market. This includes funding for job placements, apprenticeships, traineeships, continued education and training opportunities. It complements the efforts of the ESF in addressing youth employment challenges.

Based on the distribution of funds in the 2014-2020 period, when also the YEI was introduced, across the four funds, approximately half of the resources were attributed to the ERDF (56%), 18% to CF, 24% to the ESF, and 2% to the YEI. The distributions in other periods are rather similar across the three available funds.

We employ annual expenditure data included in "Historic EU payments - regionalised and modelled", as it best captures annual flows of expenditure at the regional level. The sample is available for the period 1988 to 2022, but we only employ data from 2000 in our analysis due to matching constraints with other data sources.[11] Figure 2 shows the average yearly distribution of ESI funds per capita across EU regions in the period 2000-2022. In line with EU regulations, regions lagging behind in terms of GDP per capita, which are concentrated in eastern Europe, as well as the south of Italy and Spain, Greece, and Portugal, tend to receive and spend more EU funds. In order to construct the instrument, we also employ data on European Structural Funds' historical allocations, which is made available by the European Commission, as well as country-level allocation data.[12] In particular, we employ the novel dataset included in "Integrated database of allocations and expenditure for 2000-2006/2007–2013", "ESIF 2007-2013 EU Payments (daily update)", "Data on budget commitments Period 2000-2006" and "Financial allocations 2014-2020-Available Budget by MS".

Different data sources are matched at the NUTS2 level as presented in the dataset "Historic EU payments - regionalised and modelled", and discrepancies across NUTS versions were addressed through conversion tools provided by the Commission as well as manual checks. Due to the unavailability of regional allocation data for Denmark and Slovenia, the countries are excluded from the analysis. Similarly, Ireland was excluded due to a significant NUTS2 reclassification, as well as statistical anomalies in investment accounting due to multinational

Greece, Hungary, Latvia, Lithuania, Malta, Poland, Portugal, Romania, Slovakia and Slovenia.

[11] A full description of the data on ESI funds provided can be found here.

[12] The data are available at the following links "Region" and "Country".

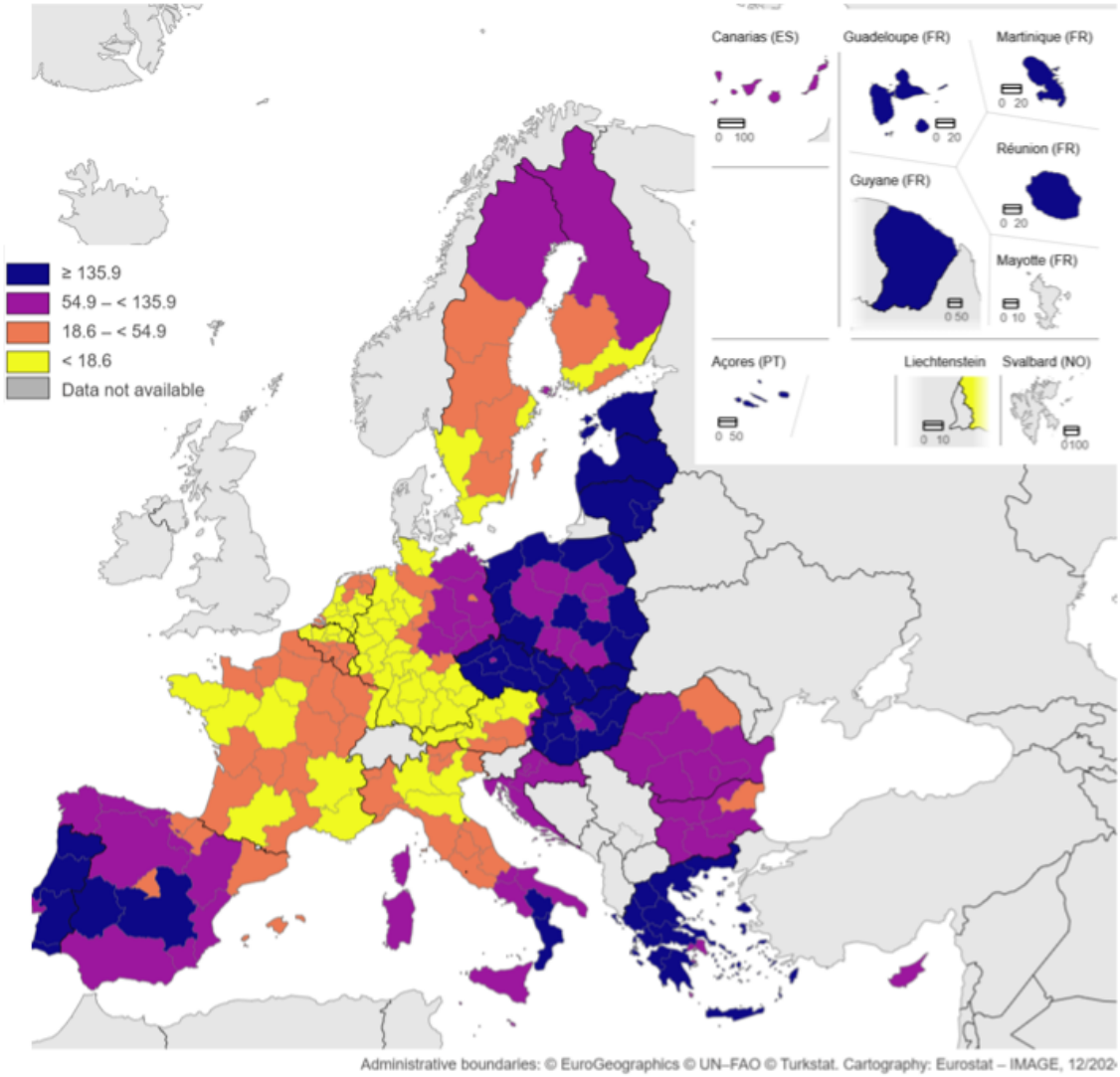

Figure 2: ESI funds spent per capita (annual average annual) 2000-2022.
Note: Denmark, Slovenia, Ireland and UK data excluded as the countries are excluded from the analysis.

corporation activities, as documented in Andersson et al. (2024).

Table 1: EU average regional data per capita at constant prices (2015 EUR)

Period	Category	Total invest.	Private invest.	Total R&D	Business R&D	ESI funds
2000-2006	LD	2921	2342	94	43	130
2000-2006	MD	7119	5924	614	383	43
2007-2013	LD	3069	2418	127	62	216
2007-2013	MD	7302	5994	712	446	31
2014-2020	LD	2511	1601	110	61	177
2014-2020	MD	7955	5062	772	487	27
2014-2020	TR	4814	2973	223	93	69

Note: "Period" provides the programming period. "Category" classifies the regions by per capita income into three groups: less developed (LD), more developed (MD), and transition (TR). "Total investment" is the sum of public and private investment. "Total R&D" is the sum of public and private R&D expenditures.

As a result of merging all available sources, the dataset we use in the analysis encompasses data for all EU27 countries, excluding Ireland, Slovenia, and Denmark, covering 246 regions for the period 2000-2021. Table 1 presents a summary of the aggregate statistics for the EU, with more detailed regional figures available in the Appendix.

A substantial portion of ESI funds is directed toward less developed (LD) regions, in line with the fiscal instrument's objectives.

The number of regions within each country is quite diverse, ranging from just one region in six smaller countries to as many as 38 regions in Germany. Approximately one-third of all countries have fewer than four regions.

The principle of additionality stipulates that contributions from ESI funds must not replace public or equivalent structural expenditure by a member state in the region. Projects are co-funded with regional beneficiaries, which can be either public or private entities. The co-financing rate ranges from 50% in more developed regions to as high as 85% in some of the less developed regions. The specific rate is determined by the European Commission upon the adoption of the operational programme. While detailed expenditure data by beneficiary type—whether private or public—is unavailable, the European Commission provides estimates of the total funds allocated directly to firms. Under the 2014-2020 Cohesion Policy programming

period, €47 billion was allocated to firms, representing approximately only 12% of the total funding across the four analysed funds.[13] Even with a co-financing rate as low as 50%, the €47 billion provided by the EU would imply an equivalent €47 billion in private sector investment, leading to a mechanical estimated impact of ESI disbursement on private investment of 24%. These calculations suggest that our estimates of the effects on private investment reflect genuine causal impacts, rather than mechanical co-financing, if the estimated parameter is negative (indicating crowding-out) or exceeds 0.24 (indicating crowding-in).

III Econometric specification and identification

We focus on the effect of ESI funds on both private investment and business R&D activity, whose direction is unknown *a priori*. The key challenge is the identification of the instrument, to ensure that EU disbursements are exogenous to region - and country - specific shocks.

III.A Econometric specification

We closely follow the regional studies by Bernardini et al. (2020) to estimate the relative effects of regional ESI funds on regional private investment and business R&D, adopting Jorda (2005)'s instrumental local projection approach, and leveraging regional variation in the fiscal shock, with region and time fixed effects. Unlike Bernardini et al. (2020), however, we deviate in the construction of the instrumental variable. Our instrument is explicitly constructed from data that are exogenous to regional economic shocks.

The model specification is the following

$$\frac{Y_{r,i,t+h} - Y_{r,i,t-1}}{V_{r,i,t-1}} = \alpha_{r,h} + \gamma_{t,h} + \beta_h \frac{X_{r,i,t} - X_{r,i,t-1}}{V_{r,i,t-1}} + \rho_h Z_{r,i,t-1} + \sigma_h W_{i,t} + \epsilon_{r,i,t+h}, \quad (1)$$

where the variable of interest, $Y_{r,i,t+h} - Y_{r,i,t-1}$, is scaled by the lagged regional real gross value added, $V_{r,i,t-1}$, and the effect is estimated on impact and up to four years ahead, $h = 0, 1, ..., 4$. The key regressor is the annual difference in real ESI funds, $X_{r,i,t} - X_{r,i,t-1}$, as a fraction of $V_{r,i,t-1}$. $Z_{r,i,t-1}$ includes the lagged dependent variable, the lagged difference in ESI funds as a fraction of regional value added, and the lagged growth rate of the regional gross value added, employed to control for regional business cycle developments. Given the reduced number of

[13] The share of funds directly allocated to firms includes categories such as 'FIRMS: Private match grant aid', 'FIRMS: Private match non-grant', and 'RTDI: Private match investment', as reported in the ESIF 2014-2020 Achievement Details time-series dataset provided by the European Commission.

regions in many countries, to account for country-time varying dynamics which could act as confounding factors, we employ the contemporaneous change in countries' government spending, normalized by dividing it by the previous year's real GDP, and the change in each country's 10-year sovereign yields, as a set of predetermined variables, $W_{i,t}$. $\epsilon_{r,i,t+h}$ is the error term. $Y_{r,i,t}$ is either private gross fixed capital formation or business R&D. We also provide the baseline results for total regional investment and general regional R&D, which include public sector activity. Variables are in real terms using the regional investment deflator for investment data and the regional gross value added deflator for business R&D, gross value added and ESI funds.

The specifications include time, γ_t, and region, α_r, fixed effects. Time dummies are used to control for aggregate shocks and aggregate policy in line with the approach of Bernardini et al. (2020), Gabriel et al. (2023) and Canova and Pappa (2024). Regional dummies are employed to account for time-invariant unobserved heterogeneity across regions, such as institutional quality, sectoral specialization, and other factors that influence both the decisions and scale of private investment and R&D.

III.B Instrument

The change in the real fund disbursement to region r of country i at time t could be influenced by shocks occurring in country i impacting public and private investment. In response to an adverse regional shock that also leads to a decline in private investment within the region, the EU, in collaboration with local authorities, might increase the disbursement rate in subsequent years. This creates a misleading negative correlation between ESI fund disbursements and private investment. As a result, estimates of the multiplier obtained through OLS would be downward biased. Conversely, the estimates would be positively biased if, as a result of a positive shock, thriving regions were to increase their successful applications for EU co-funded projects more than similar regions in other countries. If the European Commission and national authorities disproportionally support these "winners", the positive correlation between ESI fund disbursements and private investment is misleading, leading OLS to overestimate the true effect.

Therefore, we construct an instrument exploiting (i) the hypothesis that regional shocks affecting regions at a similar state of development are uncorrelated across countries and (ii) the positive correlation between the overall ex-ante planned ESI funds and overall ex-post disbursements for each region, the former being exogenous to subsequent private investment decisions.

Specifically, we use the ESI fund absorption rate in "similar" NUTS2 regions, but located in other countries, interacted with the already planned seven-year period cumulated amount for the region as an instrument to predict expenditure in a given region. "Similarity" is determined based on regional categorization according to the convergence criteria for each programming period. The Convergence Objective (Objective 1) is a key categorization for allocating ESI funds, targeting the development and adjustment of regions whose growth lags behind - specifically, those with a gross domestic product (GDP) of less than 75 percent of the EU average.[14]

The instrument for the funds' disbursement $X_{r\in(c,i),t}$ can be written as follows:

$$X^{IV}_{r\in(c,i),t} = \underbrace{P_{r\in(c,i),t\in p}}_{\text{planned cumulated}} \underbrace{\left(\frac{1}{R\in(c,j)}\sum_{r\in(c,j)=1}^{R\in(c,j)}\frac{X_{r\in(c,j),t}}{P_{r\in(c,j),t\in p}}\right)}_{\text{absorption rate in similar regions in other countries}} \quad \text{for } i\neq j,\ c=3,\ p=3, \quad (2)$$

where $P_{r\in(c,i),t\in p}$ and $P_{r\in(c,j),t\in p}$ are the ex-ante ESI funds cumulative amount to be invested in region r in country i and j, respectively, by programming period p planned before private agents make their investment decisions, expressed in real terms using the regional value-added deflator available in the year before the start of the programming period at time $t\in p$, $X_{r\in(c,j),t}$ is the disbursement in real terms in region r located in other countries j but in the same regional group c (less developed, more developed and transition regions) at time t, and $R\in(c,j)$ is the number of regions located in other countries j in the same regional group c. Therefore, $\frac{1}{R\in(c,j)}\sum_{r\in(c,j)=1}^{R\in(c,j)}\frac{X_{r\in(c,j),t}}{\hat{P}_{r\in(c,j),t\in p}}$ represents the average absorption rate in similar regions located in other countries.[15] The European Commission offers two datasets for the ex-ante planned disbursements of ESI funds: one that outlines regional allocations and another that summarizes national allocations. However, the total of the regional data at the country level does not precisely align with the national aggregate. To ensure consistency, we adjust the regional allocations by distributing the national aggregate across regions according to their respective shares in the regional data.

Economically, the greater the expected capacity of foreign regions meeting the same convergence criteria to effectively utilize their planned funds (i.e., absorption rate), and the larger the ex-ante planned cumulative disbursement allocated to the region, the higher the expected

[14] Notably, for the Programming Period 2014-2020, the Commission introduced an additional category to characterise transitioning regions (see the Appendix for the full list).

[15] The methodology is described in more detail in the Appendix.

fund disbursement flow for that region. Both factors are interacted with the additional advantage that the regressor and the instrument are in the same unit, and the interpretation of the estimated parameters is simplified.

Given that we use the regressor in first difference, also the instrument is used in first difference, $\Delta X^{IV}_{r\in(c,i),t}/V_{r,i,t-1}$. Figure 3 demonstrates strong co-movement between $\Delta X_{r,i,t}/V_{r,i,t-1}$, which is used as an endogenous variable in the first stage regression, and the instrument. The slope coefficient between $\Delta X_{r,i,t}/V_{r,i,t-1}$ and $\Delta X^{IV}_{r\in(c,i),t}/V_{r,i,t-1}$ is positive and significant, with a value of 0.49. Additionally, the linear correlation between these variables is 57.2%.

Plotting every individual data point can lead to a cluttered visualization. To mitigate this, Figure 4 shows binned scatter plots, which group the data into equal-sized bins. This approach effectively highlights patterns and trends by minimizing the noise typically introduced by individual data points. The first plot on the left transforms the data used in Figure 3. It confirms a very close relationship between ESI funds and their associated instrument. The other two plots illustrate the underlying relationships for the two subcomponents of the instrument. There is a clear and strong correlation (88%) between the absorption rate of a specific region and the average absorption rate in regions from other countries with similar levels of development, which proves particularly useful for the time-series dimension.

Similarly, there is a strong correlation (64%) between the ex-post total ESI funds received by each region and the ex-ante planned allocation for the same region within each programming period, providing valuable information for the cross-sectional dimension. The ex-post ESI funds expenditure is calculated by aggregating the ESI funds across each programming period, corresponding to the aggregate measure of the endogenous regressor at both the regional and programming period levels.[16] Both subcomponents of the instrument are equally critical, as they exhibit a strong and consistent relationship with the corresponding subcomponents of the endogenous regressor.

[16]This highlights that ex-post ESI fund expenditure should not be used in constructing the instrument, contrary to the approaches taken by Durand and Espinoza (2021) and Fiuratti et al. (2024). Moreover, they use nominal ESI fund expenditures in the construction of the disbursement rate. This approach leads to an inconsistency given that the endogenous variable is real economic activity. We address this issue by deflating ESI funds using regional gross value added deflators.

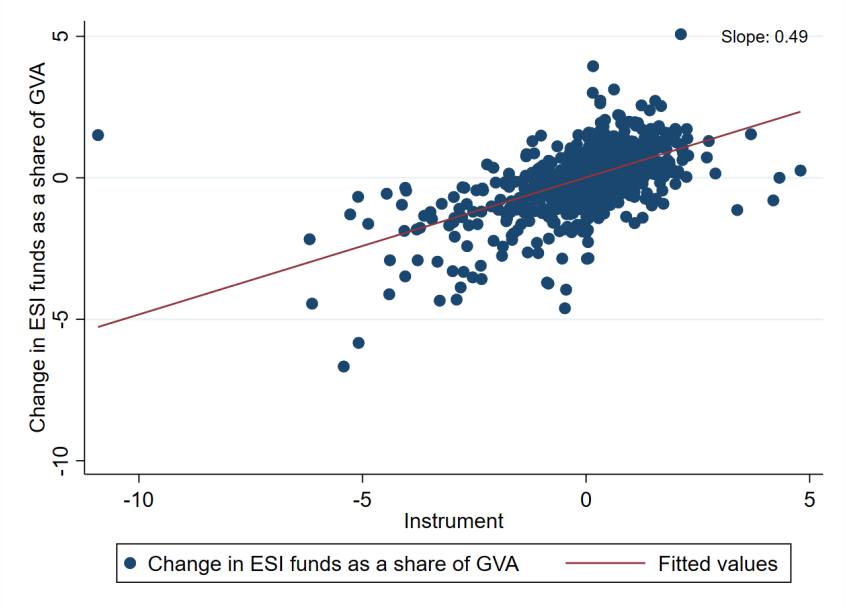

Figure 3: Change in ESI funds and instrument.
Notes: Sample period: 2000 - 2021.

IV Empirical Results

IV.A Baseline specification

We estimate (1) using instrumental local projections. First, we assess the relevance of the instrument. If the instrument is not sufficiently correlated with the ESI funds, it is considered weak, potentially leading to weak instrument bias. In our case of a single instrument and a single endogenous regressor (ESI funds) the t-value for the rejection of the weak instrument should be bigger than $\sqrt{10} \approx 3.2$ (Dautović et al., 2024). Columns (1)-(5) of Tables (2) and (3) report the t-value for the first stage regression, ranging between 9.5 and 13.5 in the case of private investment and between 6.0 and 8.0 in the case of R&D. It is well above 3.2 in all specifications, suggesting that the constructed regional variable is a sufficiently strong instrument.

We also conducted the Anderson-Rubin test (Anderson and Rubin, 1949), which, under the null hypothesis, serves as a joint test to assess both the validity of the structural parameter—specifically, the coefficient on the endogenous regressor — and the exogeneity of the chosen instrument. The results consistently show that the $\chi^2(1)$ statistics exceed 5 across various specifications. These findings provide strong evidence supporting the exogeneity of the instrument.

Table 4 and 5 present the results for private investment and business R&D, respectively, together with the Kleibergen-Paap F-statistic for a weak instrument, which is equivalent to the

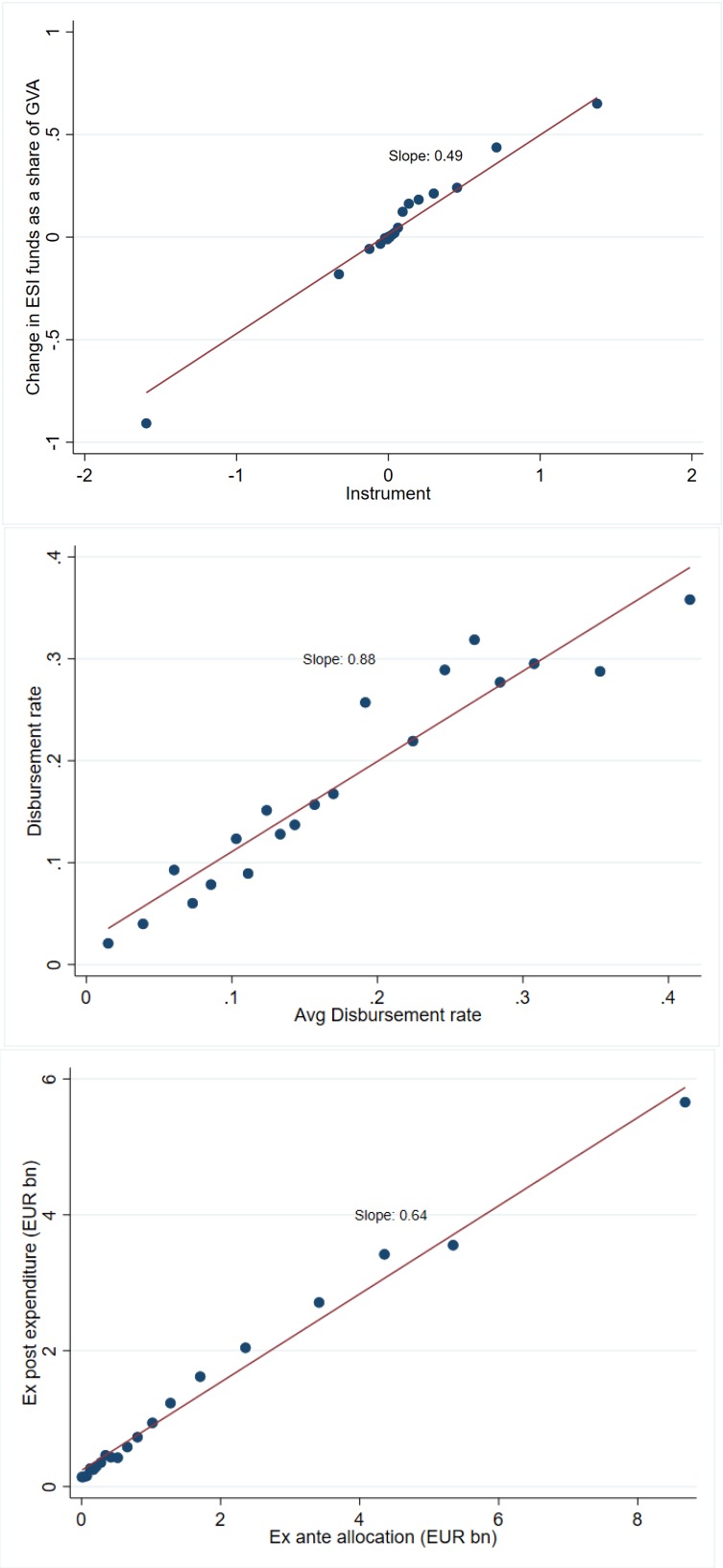

Figure 4: Binned scatter plot of ESI funds and instrument using subcomponents.

Notes: Sample period: 2000 - 2021.

Table 2: Dependent variable: ESI funds - First stage regression on Private Investment

	(1) h=0	(2) h=1	(3) h=2	(4) h=3	(5) h=4
ESI funds Instrument$_{r,i,t}$	0.393***	0.392***	0.393***	0.388***	0.382***
	(10.40)	(9.89)	(10.05)	(11.23)	(13.43)
Number of obs.	3,968	3,778	3,587	3,385	3,174

Notes: The OLS specification includes controls, time fixed effects, region fixed effects, country-crisis fixed effects and uses Driscoll-Kray standard errors. T-statistics are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021.

Table 3: Dependent variable: ESI funds - First stage regression on Business $R\&D$

	(1) h=0	(2) h=1	(3) h=2	(4) h=3	(5) h=4
ESI funds Instrument$_{r,i,t}$	0.309***	0.304***	0.311***	0.311***	0.292***
	(6.54)	(6.28)	(6.99)	(7.34)	(7.99)
Number of obs.	1,552	1,460	1,356	1,280	1,173

Notes: The OLS specification includes controls, time fixed effects, region fixed effects, country-crisis fixed effects and uses Driscoll-Kray standard errors. T-statistics are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021.

Montiel-Olea-Pflueger statistics just-identified specification.[17] The standard errors in all the estimations are based on the Driscoll and Kraay (1998) correction, which takes into account the potential residual correlation across EU regions, as well as serial correlation and heteroskedasticity among the residuals over time. The hump-shaped dynamics of the ESI funds after the fiscal shock are available in the Appendix.

Our findings indicate positive and significant effects on both investment and business R&D resulting from ESI funds, with the effects lasting three to four years. According to our instrumental variable model, 1 euro of ESI funds is associated with an increase of 0.7 euros in private investment on impact and 1.1 euros after two years, suggesting strong crowding-in effects. Similarly, business R&D exhibits crowding-in effects, amounting to 0.04 on impact, and 0.1 after three years.[18]

The estimated coefficients are approximately three times larger than those obtained using the OLS method (see Section C in the Appendix), highlighting the critical importance of addressing the issue of endogeneity bias.

Therefore, the ESI funds not only stimulate private investment, but also encourage business

[17] In the presence of heteroskedasticity and autocorrelation, the threshold is 19.7 for the 10% critical value and 23.1 for the 5% critical value (Montiel Olea and Pflueger, 2013).

[18] This corresponds to a contemporaneous increase of 3.7% in private investment and 14.1% in business R&D for each 1% of GDP increase in ESI funds.

R&D investment, likely by reducing entry barriers and fixed costs. These empirical analyses substantiate the European Commission's stance, demonstrating the effectiveness of these fiscal instruments in promoting regional development through the investment channel.[19]

Interestingly, business R&D appears unaffected by fluctuations in government spending and financing costs, likely due to its long-term objectives. In contrast, real private investment is significantly and positively influenced by real government spending, with the most substantial effect observed after two years, while it is negatively impacted by long-term interest rates over the medium term.

Throughout the estimations, our instrument constitutes a strong predictor of the endogenous regressor, with Kleibergen-Paap F-statistics well above the 19.7 critical value (Montiel Olea and Pflueger, 2013).

Table 4: Private Investment and ESI funds

	(1) h=0	(2) h=1	(3) h=2	(4) h=3	(5) h=4
ESI funds$_{r,i,t}$	0.700***	1.109***	1.107*	0.815	0.534
	(0.194)	(0.392)	(0.571)	(0.723)	(0.848)
Government spending change$_{i,t}$	0.692***	1.119***	1.130***	0.936***	0.837**
	(0.0872)	(0.188)	(0.244)	(0.267)	(0.332)
Government bond yield change$_{i,t}$	-0.115	-0.220	-0.356**	-0.446**	-0.425***
	(0.0795)	(0.138)	(0.178)	(0.180)	(0.151)
Number of obs.	3,968	3,778	3,587	3,385	3,174
Kleibergen-Paap F-statistic	108.062	97.859	100.934	126.196	180.234

Notes: The IV specification includes controls, time fixed effects, region fixed effects, and uses Driscoll-Kray standard errors. Standard errors are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021.

IV.B Leveraging Public Investment

ESI funds often complement national and regional public investments. By providing co-financing for projects, they enable public authorities to undertake larger and more impactful initiatives than would not be feasible using domestic resources alone.

When accounting for total investment, which encompasses both public and private investment, the impact of the ESI funds is even larger. The ESI funds' coefficients for total investment

[19] Coelho (2019) suggested the possibility of anticipation effects, whereby firms might adjust their behaviour in anticipation of EU fiscal policy. However, she found this channel to be insignificant. Our instrument, by design, is fully exogenous to regional dynamics and, therefore, does not suffer from anticipation effects. To further validate this, we conducted a robustness check by regressing the baseline model, where the variables of interest (private investment and business R&D) are regressed on the disbursement rate one period forward, while controlling for the other variables used in the baseline specification. The results yielded coefficients that are statistically insignificant, providing additional evidence against the presence of anticipation effects.

Table 5: Business R&D and ESI funds

	(1) h=0	(2) h=1	(3) h=2	(4) h=3	(5) h=4
ESI funds$_{r,i,t}$	0.0356***	0.0579**	0.0723**	0.116**	0.105
	(0.00840)	(0.0225)	(0.0333)	(0.0530)	(0.0699)
Government spending change$_{i,t}$	-0.0107*	-0.0119	-0.0124	-0.00749	0.00712
	(0.00638)	(0.00792)	(0.0110)	(0.0149)	(0.0137)
Government bond yield change$_{i,t}$	-0.000523	0.00451	-0.00384	-0.00412	0.00521
	(0.00356)	(0.00764)	(0.00787)	(0.0107)	(0.0143)
Number of obs.	1,552	1,460	1,356	1,280	1,173
Kleibergen-Paap F-statistic	42.763	39.394	48.914	53.806	63.886

Notes: The IV specification includes controls, time fixed effects, region fixed effects, country-crisis fixed effects and uses Driscoll-Kray standard errors. Standard errors are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021.

increase in magnitude to 0.8 immediately and 1.6 after two years. Similarly, the coefficient for total R&D expenditures increases to 0.06 on impact and 0.2 after three years (see Tables 6 and 7, respectively).

It is important to note that ESI funds are partially classified under the broader category of public investment in economic analyses and national accounts, as they entail government-funded initiatives aimed at promoting economic growth and development. Consequently, there is some direct accounting linkage. However, the observation that, after two years, the impact on both total investment (1.6) is approximately 30% greater than the corresponding effect on private investment (1.1) suggests that additional public resources are being allocated after the expenditure is carried out.

Table 6: Total investment and ESI funds

	(1) h=0	(2) h=1	(3) h=2	(4) h=3	(5) h=4
ESI funds$_{r,i,t}$	0.843**	1.177***	1.616**	1.490	1.267
	(0.419)	(0.363)	(0.649)	(0.940)	(1.023)
Number of obs.	4,317	4,317	4,127	3,937	3,746
Kleibergen-Paap F-statistic	259.800	218.617	148.741	122.694	149.161

Notes: The IV specification includes controls, time fixed effects, region fixed effects, country-crisis fixed effects and uses Driscoll-Kray standard errors. Standard errors are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021.

Table 7: Total R&D and ESI funds

	(1) h=0	(2) h=1	(3) h=2	(4) h=3	(5) h=4
ESI funds$_{r,i,t}$	0.0569***	0.0743**	0.123*	0.160*	0.150
	(0.0144)	(0.0324)	(0.0674)	(0.0961)	(0.110)
Number of obs.	1,731	1,624	1,506	1,421	1,301
Kleibergen-Paap F-statistic	47.313	44.556	49.586	58.759	76.561

Notes: The IV specification includes controls, time fixed effects, region fixed effects, country-crisis fixed effects and uses Driscoll-Kray standard errors. Standard errors are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021.

IV.C Excluding crisis periods

To ensure the robustness of our baseline results, we exclude crisis years that may contain influential observations capable of skewing the analysis. Specifically, we exclude 2009 (global financial crisis), 2011 and 2012 (euro area sovereign debt crisis), and 2020 (COVID-19 pandemic), during which investment experienced significant declines. We find that 1 euro of ESI funds is associated with an increase of 0.8 euros in private investment on impact and 1.5 euros after two years (see Table 8). Similarly, for R&D expenditures, the estimated effects are 0.03 on impact and 0.1 after three years (see Table 9). These findings confirm that the conclusions drawn from our baseline analysis remain robust and valid, because global shocks are captured by time fixed effects.

Table 8: Private Investment and ESI funds - Excluding Crisis Years

	(1) h=0	(2) h=1	(3) h=2	(4) h=3	(5) h=4
ESI funds$_{r,i,t}$	0.840***	1.500***	1.473**	0.981	0.675
	(0.185)	(0.520)	(0.744)	(0.870)	(1.097)
Number of obs.	3,155	3,124	2,948	2,739	2,528
Kleibergen-Paap F-statistic	121.189	103.928	101.799	111.873	129.935

Notes: The IV specification includes controls, time fixed effects, region fixed effects, country-crisis fixed effects and uses Driscoll-Kray standard errors. Standard errors are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021.

V The crowding-in and the state of the economy

The extent to which exogenous public sector investment encourages additional private sector investment can vary depending on the state of development of an economy and the degree of private debt overhang.

Table 9: Business R&D and ESI funds - Excluding Crisis Years

	(1) h=0	(2) h=1	(3) h=2	(4) h=3	(5) h=4
ESI funds$_{r,i,t}$	0.0288***	0.0477***	0.0596***	0.0948**	0.0805
	(0.00840)	(0.0161)	(0.0230)	(0.0400)	(0.0655)
Number of obs.	1,177	1,175	1,086	1,008	897
Kleibergen-Paap F-statistic	37.880	29.774	40.919	46.853	47.158

Notes: The IV specification includes controls, time fixed effects, region fixed effects, country-crisis fixed effects and uses Driscoll-Kray standard errors. Standard errors are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021.

In economies with a lower GDP per capita, public sector investment often focuses on closing infrastructure gaps, such as roads, electricity, water supply, and telecommunications. These investments can have a strong crowding-in effect because they reduce the cost of doing business for the private sector, improve productivity, and open new opportunities for investment (Aschauer, 1989; Fieldhouse and Mertens, 2024). However, if projects are implemented in regions with limited business opportunities or weak demand, their impact may be minimal, reducing the potential for meaningful economic benefits.

In economies with a higher GDP per capita, where infrastructure is typically well-established, the crowding-in effects of public investment may be weaker. Instead, public investment might risk crowding-out private investment, particularly if it is financed by borrowing that raises interest rates or if it competes directly with private sector projects.

The degree of corporate private debt overhang—when firms carry excessive debt that limits their ability to borrow and invest—also significantly affects how public sector investment influences private sector investment. When private debt levels are high, firms are more likely to allocate their cash flows to debt repayment rather than new investment. Even if public investment creates opportunities (e.g., through improved infrastructure), the private sector may lack the financial capacity to respond. In such cases, public investment may have a limited or delayed crowding-in effect because the private sector is constrained by its debt burden. The crowding-in effect may only materialize after balance sheets are repaired. However, in a context of heightened debt overhang, public investment could also crowd in private investment by boosting aggregate demand, improving business expectations and reducing financial constraints (Bernardini and Peersman, 2018; Bernardini et al., 2020).

To address the state dependence, the model specification (1) is allowed to depend on the

state at time $t-1$ and its interaction with all regressors, including the fixed effects:[20]

$$\frac{Y_{r,i,t+h}-Y_{r,i,t-1}}{V_{r,i,t-1}} = \alpha_{r,h}+\gamma_{t,h}+\beta_h\frac{X_{r,i,t}-X_{r,i,t-1}}{V_{r,i,t-1}}+\rho_h Z_{r,i,t-1}+\sigma_h W_{i,t}+ \\ \alpha^D_{r,h}D_{r,i,t-1}+\beta^D_h D_{r,i,t-1}\frac{X_{r,i,t}-X_{r,i,t-1}}{V_{r,i,t-1}}+ \\ \rho^D_h D_{r,i,t-1}Z_{r,i,t-k}++\sigma^D_h D_{r,i,t-1}W_{i,t}+\epsilon_{r,i,t+h} \tag{3}$$

where $D_{r,i,t-1}\in(0,1)$ is the indicator of the economic state.

Also, the instrument is interacted with the state dummy to capture its distinct impact across different economic conditions. Therefore, the instruments are $\Delta X^{IV}_{r\in(c,i),t}/V_{r,i,t-1}$ and $D_{r,i,t-1}\Delta X^{IV}_{r\in(c,i),t}/V_{r,i,t-1}$. Essentially, this approach divides the sample in two, allowing us to report the F-statistics to check for potential weak instruments in the two different regimes.[21] Notably, Gonçalves et al. (2024) and Francis et al. (2023) demonstrate that, when the state of the economy is endogenous, the local projections estimator of the response function tends to be asymptotically biased. However, given that regional ESI fund expenditures are unlikely to change the level of GDP per capita and corporate debt overhang in the short term, the assumption that the regional economy remains in the same regime at the time of impact and one year after the ESI fund disbursement is not stringent. Consequently, we report only the immediate effects and those projected one year ahead.

V.A The crowding-in and the state of development

GDP per capita is a good measure of the state of development of an economy. In the context of ESI funds, it is used to define the "Convergence regions" and the "non-Convergence regions", which are EU classifications used to allocate funding at the beginning of the programming period. "Convergence regions", with GDP per capita below 75% of the EU average, receive substantial funding to stimulate growth, create jobs, and improve infrastructure and human capital. In contrast, "non-Convergence region" (or "more developed regions"), with GDP per capita above 75% of the EU average, receive less funding, typically targeted at fostering innovation, environmental sustainability, and economic cohesion.[22]

[20] The use of one-period lagged economic state variables guarantees that the fiscal disbursement at time t is exogenous relative to the economic state.

[21] The critical values of Montiel Olea and Pflueger (2013) apply only to IV regressions with one endogenous regressor.

[22] In the programming period 2014-2020, in addition to Convergence and non-Convergence regions, the EU introduced the category of "transition regions" as part of its cohesion policy framework. The transition regions are those where the GDP per capita is between 75% and 90% of the EU average. These regions are in between

To evaluate whether the crowding-in effects of ESI funds are more pronounced in "Convergence regions" compared to "non-Convergence/transition regions", we estimate equation (3) by incorporating an interaction term with a dummy variable, which takes the value of one for regions classified by the EU as "Convergence regions" and zero otherwise.

The results presented in Table 10 suggest that ESI funds have a stronger immediate impact in more developed regions, with a broadly comparable effect emerging across both region types after one year. However, the coefficients are strongly statistically significant only for more developed regions. In Convergence regions, the effect reaches statistical significance at the 11% confidence level after one year, implying that in some less developed regions a crowding-out effect may dominate, thereby constraining the average crowding-in effect. Importantly, the significance improves when crisis years are excluded (see Table A5 in the Annex). This pattern suggests that while a crowding-in mechanism may operate in both types of regions, severe economic downturns could hinder its full realisation.

As for business R&D, less developed regions experience strong crowding-in effects, while the impact of ESI funds in more developed regions is statistically insignificant (see Table 11). Therefore, ESI funds create new opportunities to stimulate business R&D in economies with a lower GDP per capita.

These findings indicate that, while ESI funds are designed to promote economic convergence by allocating a relatively larger share of resources to less developed regions, in practice they also function as an investment programme that benefits more developed regions—often located in wealthier Member States that contribute more to the EU budget.

Table 10: Private Investment and ESI funds - State of development

	Less Developed Regions		More Developed Regions	
	h=0	h=1	h=0	h=1
ESI funds$_{r,i,t}$	0.871	1.672	1.433***	1.791***
	(0.531)	(1.033)	(0.309)	(0.463)
Number of obs.	1,492	1,414	2,476	2,364
Kleibergen-Paap F-statistic	27.634	24.603	107.997	154.969

Notes: The IV specification includes controls, time fixed effects, region fixed effects, country-crisis fixed effects and uses Driscoll-Kray standard errors. Standard errors are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021.

the Convergence and more developed regions, economically speaking. The introduction of transition regions allows for a more nuanced approach to funding allocation, recognizing that these areas may still face significant development challenges, but are not as economically disadvantaged as convergence regions. The aim is to help these regions continue to grow and develop, preventing them from falling behind while also not requiring as intensive support as Convergence regions. For the purpose of the analysis, we utilised the pre 2014-2020 binary definition.

Table 11: Business R&D and ESI funds - State of development

	Less Developed Regions		More Developed Regions	
	h=0	h=1	h=0	h=1
ESI funds$_{r,i,t}$	0.0582***	0.117***	0.00418	-0.0683
	(0.0153)	(0.0436)	(0.0420)	(0.0605)
Number of obs.	945	882	607	578
Kleibergen-Paap F-statistic	19.092	12.586	44.406	73.049

Notes: The IV specification includes controls, time fixed effects, region fixed effects, country-crisis fixed effects and uses Driscoll-Kray standard errors. Standard errors are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021.

V.B The crowding-in and and private debt overhang

Building on the work of Bernardini and Peersman (2018) and Bernardini et al. (2020), who identified significantly larger aggregate fiscal multipliers during times of household debt overhang, we investigate whether corporate debt overhang influences the crowding-in effects of ESI funds.

Since Eurostat does not provide readily available data on private corporate debt at the regional level, we construct a proxy by multiplying the total stock of debt held by non-financial corporations (NFCs) at the national level by each region's share of the country's private gross fixed capital formation. This method assumes that the country's NFC debt is distributed across regions within each country in proportion to their respective levels of private investment. Using this proxy, we create a binary indicator that equals one if a region's NFC debt-to-GDP ratio exceeded the EU cross-sectional median in the previous year, and zero otherwise. This approach allows us to investigate whether the impact of ESI funds varies between high corporate debt and low corporate debt regions.

The results available in Table 12 and 13 suggest that the crowding-in effects of ESI funds are stronger in regions facing higher corporate debt, particularly for private investment, supporting the view that these funds can stimulate investment by relaxing tighter borrowing constraints. These findings are also consistent with the work of De Sanctis et al. (2025), who investigate the effects of receiving ESI funds on firm performance. They find that firms that receive funding experience an increase in their investment and productivity, as well as their leverage ratio, suggesting that ESI funds not only crowd in private investment, but also act as a positive signal to raise external finance.

Table 12: Private Investment and ESI funds - Private Debt

	High Debt		Low Debt	
	h=0	h=1	h=0	h=1
ESI Funds$_{r,i,t}$	0.833**	0.865**	0.387	0.407
	(0.347)	(0.429)	(0.380)	(0.330)
Number of obs.	1,443	1,359	1,477	1,371
Kleibergen-Paap F-statistic	45.513	52.301	62.611	70.277

Notes: The IV specification includes controls, time fixed effects, region fixed effects, country-crisis fixed effects and uses Driscoll-Kray standard errors. Standard errors are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021.

Table 13: Business R&D and ESI funds - Private Debt

	High Debt		Low Debt	
	h=0	h=1	h=0	h=1
ESI Funds$_{r,i,t}$	0.0333**	0.0488	0.0256**	0.0302
	(0.0169)	(0.0359)	(0.0126)	(0.0213)
Number of obs.	560	533	650	583
Kleibergen-Paap F-statistic	24.428	29.383	20.637	32.006

Notes: The IV specification includes controls, time fixed effects, region fixed effects, country-crisis fixed effects and uses Driscoll-Kray standard errors. Standard errors are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021.

V.C The crowding-in and economic growth regimes

Research by Auerbach and Gorodnichenko (2012, 2013) has shown that increases in national government purchases are more effective during recessions compared to periods of expansions, and Nakamura and Steinsson (2014) found that relative multipliers are larger in periods of high unemployment. Conversely, Ramey and Zubairy (2018) do not find evidence of large multipliers when the US economy is experiencing substantial slack as measured by the unemployment rate, while Bernardini et al. (2020) found that government spending was more effective during downturns around the Great Recession period.

Building on this literature, we investigate a similar question in the context of ESI funds and their impact on private investment and business R&D. To assess this and have a sufficient number of observations in each economic state, we construct an indicator variable that takes the value of one if the annual gross value added growth in a given region exceeds the region's long-term median growth, calculated over the entire sample period. This method categorizes for each region each year as either above (high-growth regime) or below (low-growth regime) the region's long-term average growth. The results, presented in Tables 14 and 15, indicate that crowding-in

effects are evident across both growth regimes. However, these effects tend to materialize more quickly during periods of high growth, whereas they may be somewhat stronger in low-growth periods after a one-year lag, notably in business R&D. Overall, the analysis underscores that ESI funds consistently support private investment and business R&D across different phases of the growth cycle.

Table 14: Private Investment and ESI funds - Growth regimes

	Low growth		High growth	
	h=0	h=1	h=0	h=1
ESI Funds$_{r,i,t}$	0.537	1.144***	0.815***	1.070**
	(0.480)	(0.403)	(0.246)	(0.545)
Number of obs.	2,207	2,069	1,761	1,709
Kleibergen-Paap F-statistic	85.400	58.389	35.370	56.634

Notes: The IV specification includes controls, time fixed effects, region fixed effects, country-crisis fixed effects and uses Driscoll-Kray standard errors. Standard errors are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021.

Table 15: Business R&D and ESI funds - Growth regimes

	Low Growth		High Growth	
	h=0	h=1	h=0	h=1
ESI Funds$_{r,i,t}$	0.0373**	0.0546*	0.0302***	0.0354**
	(0.0154)	(0.0292)	(0.00822)	(0.0145)
Number of obs.	834	779	718	681
Kleibergen-Paap F-statistic	28.711	26.761	18.716	22.966

Notes: The IV specification includes controls, time fixed effects, region fixed effects, country-crisis fixed effects and uses Driscoll-Kray standard errors. Standard errors are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021.

VI The Analysis by Fund

The ERDF, CF, ESF, and YEI together constitute the ESI funds examined in our analysis. A key question to explore is whether certain funds play a more significant role than others in stimulating private investment and business R&D. In this section, we delve deeper into the data, disaggregated by fund type, to investigate whether the observed effects are driven by specific types of initiatives. Since YEI funds are available for a limited period and are designed to complement ESF initiatives aimed at improving job prospects, we combine YEI with the ESF for the purposes of this analysis.

We collect regional disbursement data for each fund, but national level allocation data, as the ex-ante planned allocation data at the regional level is not available. To address this limitation, we assume that the regional distribution within each country for the ex-ante planned amounts is uniform across all funds. Specifically, we define the ex-ante planned allocation data at the regional level as: $\hat{P}^F_{r\in(c,i),t\in p} = \frac{P_{r\in(c,i),t\in p}}{\sum_{r\in i}\tilde{P}_{r\in(c,i),t\in p}} P^F_{i,t\in p}$, where $P^F_{i,t\in p}$ represents the ex-ante planned allocation for fund F to country i during programming period p. Therefore, the instrument for the funds' disbursement $X^F_{r\in(c,i),t}$ available by fund F is:

$$X^{F,IV}_{r\in(c,i),t} = \hat{P}^F_{r\in(c,i),t\in p}\left(\frac{1}{R\in(c,j)}\sum_{r\in(c,j)=1}^{R\in(c,j)}\frac{X^F_{r\in(c,j),t}}{\hat{P}^F_{r\in(c,j),t\in p}}\right) \quad \text{for } i\neq j,\ c=3 \text{ and } p=3, \tag{4}$$

where $X^F_{r\in(c,j),t}$ is the disbursement in real terms in region r located in other countries j but in the same regional group c at time t by fund F. As with the aggregate disbursement of funds, the instrument for each of the three funds is constructed by multiplying its ex-ante planned cumulative allocation by the average absorption rate observed in comparable regions in other countries for that specific fund. This approach captures variations in absorption capacity at the individual fund level while accounting for cross-country differences in ex-ante allocations. Given that we use the regressor in first difference, also the instrument is used in first difference, $\Delta X^{F,IV}_{r\in(c,i),t}/V_{r,i,t-1}$.

The results concerning the effectiveness of the instrument are detailed in Tables 16 and 17. Columns (1) through (6) display the t-values from the first stage regression, for each fund across two periods. These t-values, which are crucial for determining whether the instrument is sufficiently strong, exceed 3.2 in all specifications, except for the ESF funds in the business R&D specification, where the t-value is slightly below this threshold. The estimated slope coefficients are strongly statistically significant. This suggests that the constructed regional variable is a sufficiently robust instrument.

Table 16: Dependent variable: ESI funds - First stage regression on Private Investment

	(1) (h=0) ERDF	(2) (h=1) ERDF	(3) (h=0) ESF-YEI	(4) (h=1) ESF-YEI	(5) (h=0) CF	(6) (h=1) CF
ESI funds Instrument$_{r,i,t}$	0.748***	0.746***	1.427***	1.410***	1.397***	1.335***
	(9.21)	(8.42)	(3.43)	(3.71)	(4.02)	(3.77)
Number of obs.	3,755	3,545	3,419	3,200	1,448	1,353

Notes: The OLS specification includes controls, time fixed effects, region fixed effects, country-crisis fixed effects and uses Driscoll-Kray standard errors. T-statistics are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021.

Table 17: Dependent variable: ESI funds - First stage regression on Business R&D

	(1) (h=0) ERDF	(2) (h=1) ERDF	(3) (h=0) ESF-YEI	(4) (h=1) ESF-YEI	(5) (h=0) CF	(6) (h=1) CF
ESI funds Instrument$_{r,i,t}$	0.500***	0.482***	1.602***	1.544***	1.632***	1.572***
	(4.47)	(4.22)	(2.61)	(2.79)	(4.53)	(4.02)
Number of obs.	1,441	1,345	1,344	1,239	1,062	976

Notes: The OLS specification includes controls, time fixed effects, region fixed effects, country-crisis fixed effects and uses Driscoll-Kray standard errors. T-statistics are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021.

Table 18: Dependent variable: Private Investment

	(1) (h=0) ERDF	(2) (h=1) ERDF	(3) (h=0) ESF-YEI	(4) (h=1) ESF-YEI	(5) (h=0) CF	(6) (h=1) CF
ESI funds$_{r,i,t}$	1.560***	2.089***	3.268	7.456**	1.312	3.492***
	(0.374)	(0.769)	(2.094)	(3.302)	(1.161)	(1.160)
Number of obs.	3,755	3,545	3,419	3,200	1,448	1,353
Kleibergen-Paap F-statistic	84.865	70.871	11.782	13.790	16.145	14.245

Notes: The IV specification includes controls, time fixed effects, region fixed effects, country-crisis fixed effects and uses Driscoll-Kray standard errors. Standard errors are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021.

However, the statistical strength of these results weakens when evaluated using the Kleibergen-Paap F-statistics, which test for the presence of weak instruments, for ESF-YEI fund and the CF in the case of private investment with the F-statistics below the 19.7 threshold (see Tables 18 and 19).

The instrumental local projection analysis suggests that, on average, all funds generally encourage private investment and business R&D (see Tables 18 and 19). European funds provided through the ERDF and CF effectively stimulate additional private sector initiatives with the CF showing stronger effects in both private investment and business R&D specifications, although less robust. Meanwhile, the ESF-YEI fund also suggests significant effects; however, due to weaker instruments, any final conclusions on the effects of the ESF-YEI fund remain premature.

Table 19: Dependent variable: Business R&D

	(1) (h=0) ERDF	(2) (h=1) ERDF	(3) (h=0) ESF-YEI	(4) (h=1) ESF-YEI	(5) (h=0) CF	(6) (h=1) CF
ESI funds$_{r,i,t}$	0.0691***	0.106**	0.111*	0.168*	0.0841***	0.182***
	(0.0200)	(0.0457)	(0.0655)	(0.0919)	(0.0319)	(0.0686)
Number of obs.	1,441	1,345	1,344	1,239	1,062	976
Kleibergen-Paap F-statistic	19.937	17.785	6.787	7.811	20.526	16.180

Notes: The IV specification includes controls, time fixed effects, region fixed effects, country-crisis fixed effects and uses Driscoll-Kray standard errors. Standard errors are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021.

VII Conclusion

The debate of whether public expenditures crowd out or crowd in private investment has been a longstanding issue in economic literature. We have further refined this question, investigating the specific effects of European Structural and Investment (ESI) Funds on private investment and R&D, a question which is both academically and policy relevant.

We use novel regional data on private investment and business R&D, alongside historical data on ESI funds, to estimate the effects of ESI funds on private investment and business R&D. By exploiting regional variation in ESI funds and constructing an instrument immune to regional and country-specific shocks, we find a strong crowding-in effect both immediately and over the following few years with a positive hump shape.

The analysis highlights notable variation in crowding-in effects across regions and macroe-

conomic conditions. The impact is stronger in more developed regions for private investment, likely reflecting better institutional capacity and market readiness. In contrast, R&D benefits more in less developed regions, where government support may play a greater role in overcoming innovation-related constraints. Additionally, crowding-in effects tend to materialise more quickly during periods of private debt overhang, when firms face tighter credit conditions. The crowding-in effect does not appear to be dependent on the business cycle, although it is marginally higher during low-growth regimes, especially for business R&D.

Finally, the findings indicate the European Regional Development Fund (ERDF) and the Cohesion Fund (CF) significantly stimulate private sector initiatives by financing innovation, research, and infrastructure projects. In contrast, the statistical outcomes for the European Social Fund (ESF) and the Youth Employment Initiative (YEI) are less definitive.

This analysis contributes to the growing literature on fiscal spillovers in the EU, using regional-level data and addressing the endogeneity concerns inherent in such studies. The findings underscore the potential of European fiscal instruments aimed at supporting investment, such as Next Generation EU, to boost the EU economy and foster sustainable growth across its member states.

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Appendix

A Countries and regions

Table A1: Per capita investment and ESI funds by country (average, 2015 EUR)

Country	P.P.	Category	Investment	Private inv.	Business R&D	Total R&D	ESI
AT	2000-2006	LD	5842	6419	160	179	112
AT	2000-2006	MD	7790	8829	618	867	23
AT	2007-2013	LD	4982	6713	194	219	73
AT	2007-2013	MD	6676	9300	738	1038	15
AT	2014-2020	MD	6265	10172	895	1221	13
AT	2014-2020	TR	4563	7112	211	250	24
BE	2000-2006	LD	3789	4461		298	58
BE	2000-2006	MD	6724	7710	470	786	23
BE	2007-2013	LD	4115	4884		319	66
BE	2007-2013	MD	7390	8486	584	882	20
BE	2014-2020	MD	7048	10685	811	1328	10
BE	2014-2020	TR	3428	5608		319	25
BG	2000-2006	LD	819	988	13	23	12
BG	2007-2013	LD	914	1181	20	29	102
BG	2014-2020	LD	783	1189	28	39	68
CY	2000-2006	MD	3966	4866	17	80	15
CY	2007-2013	MD	3554	4322	26	107	79
CY	2014-2020	MD	3250	4255	64	157	97
CZ	2000-2006	LD	2768	3190	95	137	31
CZ	2000-2006	MD	6933	8042	234	640	27
CZ	2007-2013	LD	2779	3473	127	185	286
CZ	2007-2013	MD	8088	9961	328	816	162
CZ	2014-2020	LD	2711	3632	156	221	185
CZ	2014-2020	MD	8611	11022	419	945	88
DE	2000-2006	LD	4158	5464	184	438	128
DE	2000-2006	MD	5767	6848	590	893	19
DE	2007-2013	LD	4379	5659	220	517	130
DE	2007-2013	MD	6271	7503	697	1038	18
DE	2014-2020	MD	4937	7963	773	1128	12
DE	2014-2020	TR	3602	6193	250	566	63
EE	2000-2006	LD	2742	3357	81	171	76
EE	2007-2013	LD	3301	4037	127	246	317
EE	2014-2020	LD	3549	4797	131	261	225
ES	2000-2006	LD	3305	4293	51	119	383
ES	2000-2006	MD	4532	5651	159	279	116
ES	2007-2013	LD	2995	3931	62	134	233
ES	2007-2013	MD	4085	5138	184	320	46
ES	2014-2020	LD	2089	3585	24	108	141
ES	2014-2020	MD	3022	4884	181	303	47
ES	2014-2020	TR	2086	3444	57	133	78
FI	2000-2006	MD	7305	8845	639	894	59
FI	2007-2013	MD	7791	9356	702	1002	34
FI	2014-2020	MD	5630	9076	591	890	27
FR	2000-2006	LD	3264	4353			184
FR	2000-2006	MD	5165	6316	1019	1518	29
FR	2007-2013	LD	3292	4377			193
FR	2007-2013	MD	5291	6424	1026	1542	26
FR	2014-2020	LD	2802	4206			125
FR	2014-2020	MD	5357	7284			16
FR	2014-2020	TR	4091	5800			26
GR	2000-2006	LD	2370	3213	15	87	280
GR	2000-2006	MD	3339	4495	30	51	389

GR	2007-2013	LD	2050	2895	16	98	276
GR	2007-2013	MD	2697	3676	38	69	245
GR	2014-2020	LD	742	1751	31	136	218
GR	2014-2020	MD	1170	2269	99	190	101
GR	2014-2020	TR	980	2386	26	99	184
HR	2007-2013	MD	1894	2338	38	83	21
HR	2014-2020	LD	1495	2379	54	111	88
HU	2000-2006	LD	1597	1905	26	49	32
HU	2000-2006	MD	2373	2893	141	238	37
HU	2007-2013	LD	1846	2201	43	66	326
HU	2007-2013	MD	2457	3086	209	298	172
HU	2014-2020	LD	1672	2816	60	84	274
HU	2014-2020	MD	1975	3957	304	388	82
IT	2000-2006	LD	3266	3932	38	140	138
IT	2000-2006	MD	5637	6885	186	327	42
IT	2007-2013	LD	2675	3418	46	149	135
IT	2007-2013	MD	5134	6191	225	377	24
IT	2014-2020	LD	1992	3266	55	153	119
IT	2014-2020	MD	4044	6423	311	476	30
IT	2014-2020	TR	2425	4128	95	211	46
LT	2000-2006	LD	1485	1864	21	80	62
LT	2007-2013	LD	1865	2360	32	107	262
LT	2014-2020	LD	1882	3184	55	141	219
LU	2000-2006	MD	12348	15799	1144	1419	23
LU	2007-2013	MD	13546	17056	852	1306	11
LU	2014-2020	MD	11511	16802	597	1133	19
LV	2000-2006	LD	2054	2476	18	55	72
LV	2007-2013	LD	2283	2853	20	71	261
LV	2014-2020	LD	1771	3171	23	83	182
MT	2000-2006	LD	2506	3136	56	93	24
MT	2007-2013	LD	3223	4080	75	126	233
MT	2014-2020	TR	3591	5569	91	149	118
NL	2000-2006	MD	6047	7760	285	589	30
NL	2007-2013	MD	6132	7915	290	591	15
NL	2014-2020	MD	4764	8506			6
PL	2000-2006	LD	1290	1474	21	52	36
PL	2007-2013	LD	1632	1860	40	78	204
PL	2014-2020	LD	1333	2023	55	91	219
PL	2014-2020	MD	2615	3828	254	382	133
PT	2000-2006	LD	2975	3697	34	103	368
PT	2000-2006	MD	3723	4740	93	221	347
PT	2007-2013	LD	2493	3099	50	122	418
PT	2007-2013	MD	2653	3505	114	246	158
PT	2014-2020	LD	1721	2796	75	149	306
PT	2014-2020	MD	1990	3359	106	229	121
PT	2014-2020	TR	2028	3299	15	71	101
RO	2000-2006	LD	1351	1632	13	29	13
RO	2007-2013	LD	1802	2124	16	38	104
RO	2014-2020	LD	965	1538	13	21	83
RO	2014-2020	MD	5268	7928	134	253	75
SE	2000-2006	MD	7704	8805	775	1129	36
SE	2007-2013	MD	8589	9775	796	1189	30
SE	2014-2020	MD	7075	10939	923	1380	22
SK	2000-2006	LD	1717	2043	22	40	42
SK	2000-2006	MD	5811	6554	100	293	39
SK	2007-2013	LD	1651	2249	27	57	222
SK	2007-2013	MD	7778	9189	162	445	263
SK	2014-2020	LD	1452	2408	43	82	202
SK	2014-2020	MD	7345	10003	236	555	92

B Instrument construction

Our methodology to construct planned amounts and absorption rates of ESI funds draws from Durand and Espinoza (2021), in line with the following steps:

1. Define bins: we create bins by grouping regions by programming period and convergence criteria status. We set convergence criteria equal to one (zero otherwise) if the region was listed as such for the 2007-2013 programming period, as described in Commission (2007). If a region was included in the convergence criteria at NUTS3 region level, the NUTS2 region level included in the data was considered included in the convergence criteria even if not all sub regions were part of the convergence criteria set. Conversely, for the 2014-2020 programming period, the updated classification into less developed, more developed and transitioning regions is applied.

2. Calculate planned expenditure: in order to construct regional ex-ante allocations we depart from Durand and Espinoza (2021), and we compute regional allocation shares from historical data made available by the Commission for the programming period 2000-2006 and 2007-2013, and apply such shares to country level allocations for each programming period, aggregated for all four Funds in the baseline and distinguishing by Fund for the analysis in section VI. As historical data on regional allocations is not available for the programming period 2014-2020, we employ data from the previous period. While this implicitly assumes that the allocation shares remain constant over time, persistence in the available data suggests this assumption is unlikely to significantly affect our results. Then we compute absorption rates as the ratio between the total expenditure in a given region and programming period and the ex ante allocation data we constructed, and trim the top and bottom 1 percent of observations. This is meant to address the possibility of measurement errors stemming from data revisions across the different data sources provided by the Commission.[23]

3. Accounting for inflation: Unlike other studies in this field, we explicitly account for the impact of inflation when constructing the instrument. This is particularly important because European Structural and Investment Funds (ESI) are planned in nominal terms, with allocations determined at the beginning of the funding period based on the European

[23] When we construct the instrument for each Fund, we trim top and bottom 5%, as the number of outliers increases.

Union's financial perspectives and regulations. These allocations rely on the prices and economic conditions prevailing at that time, without adjustments for inflation over the funding period. Consequently, while the real value of the planned funds remains fixed, the real value of the actual disbursement depends on the regional inflation rate.

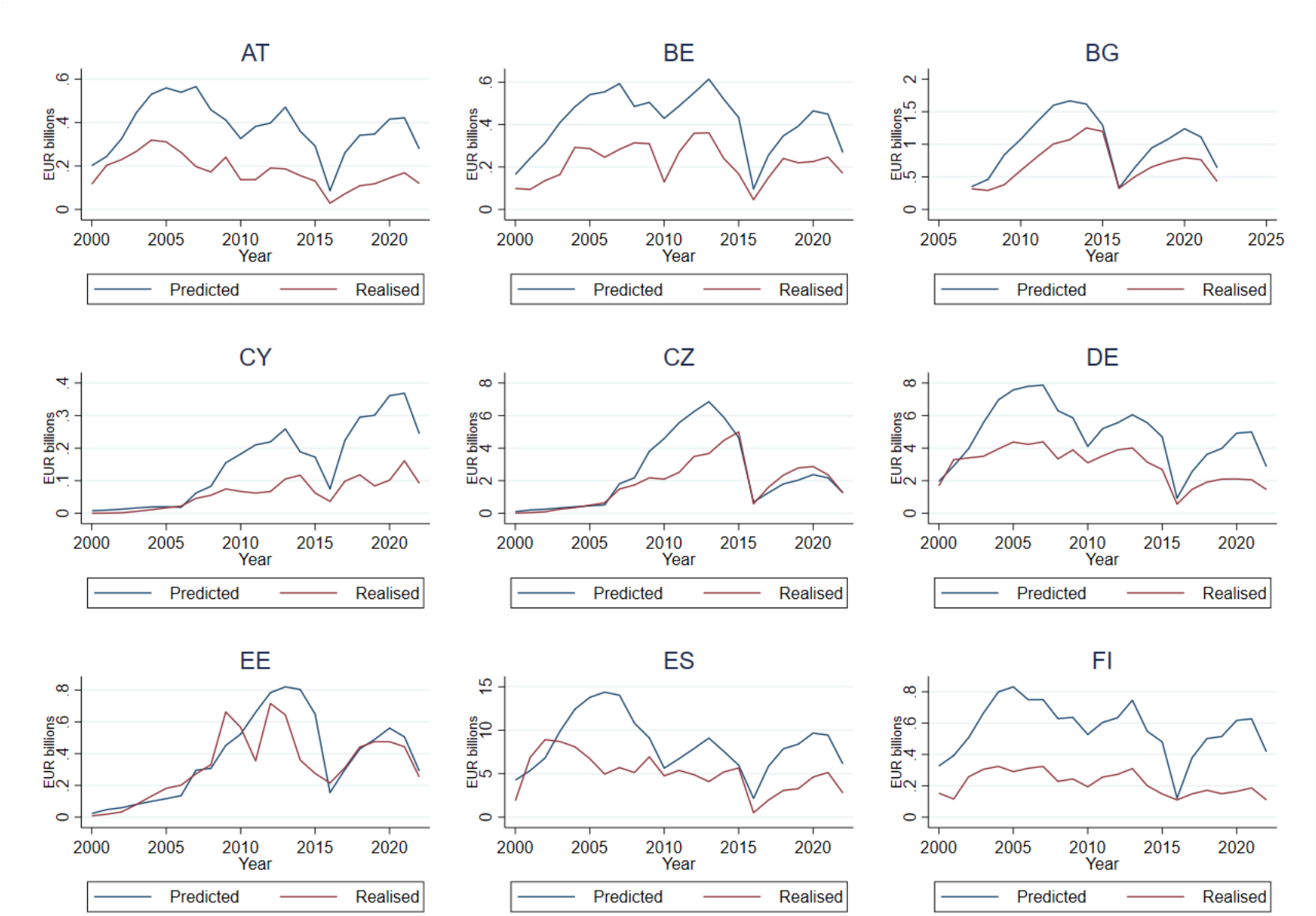

Figure A1: ESIF expenditure and predicted expenditure by Member State.

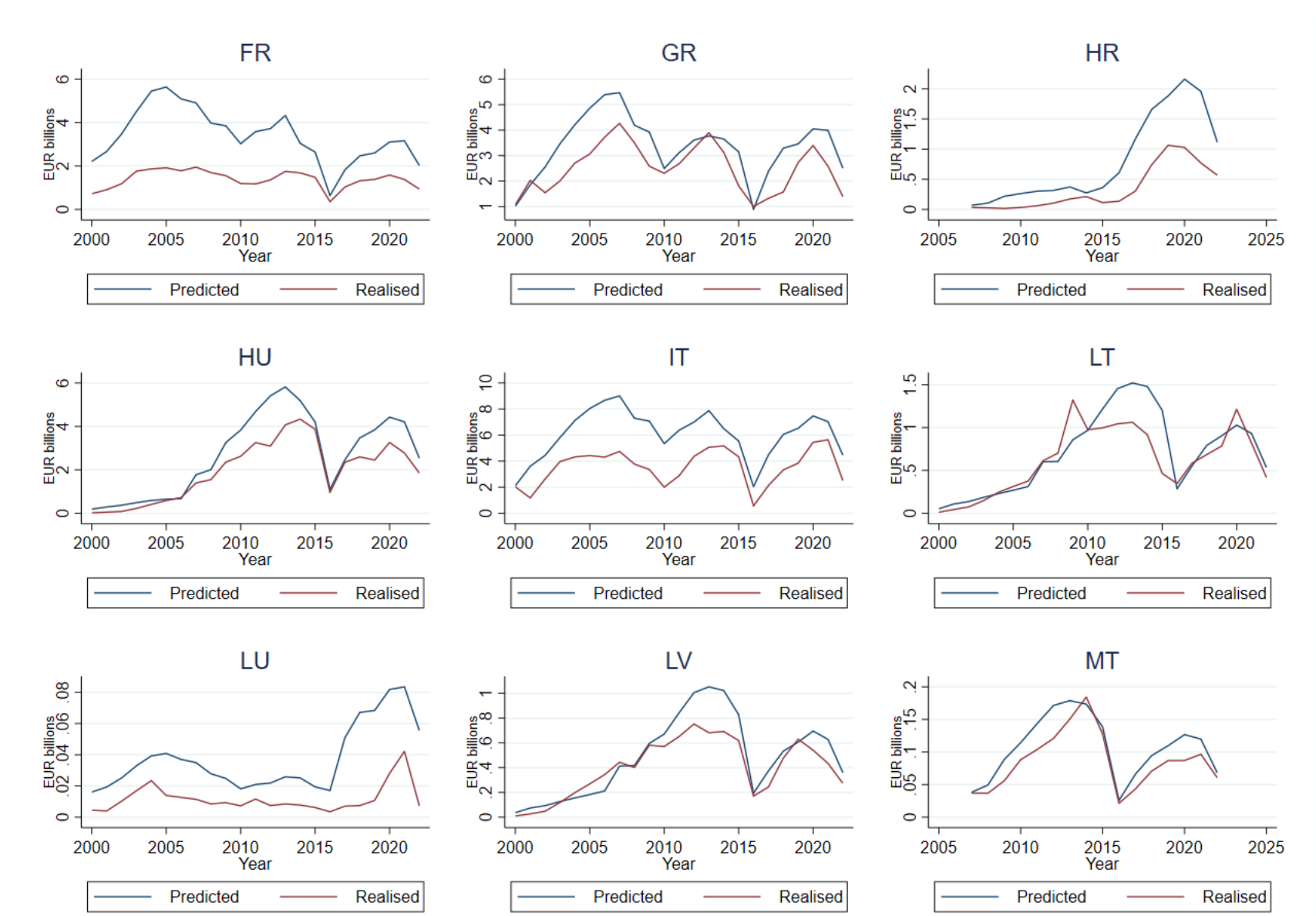

Figure A2: ESIF expenditure and predicted expenditure by Member State.

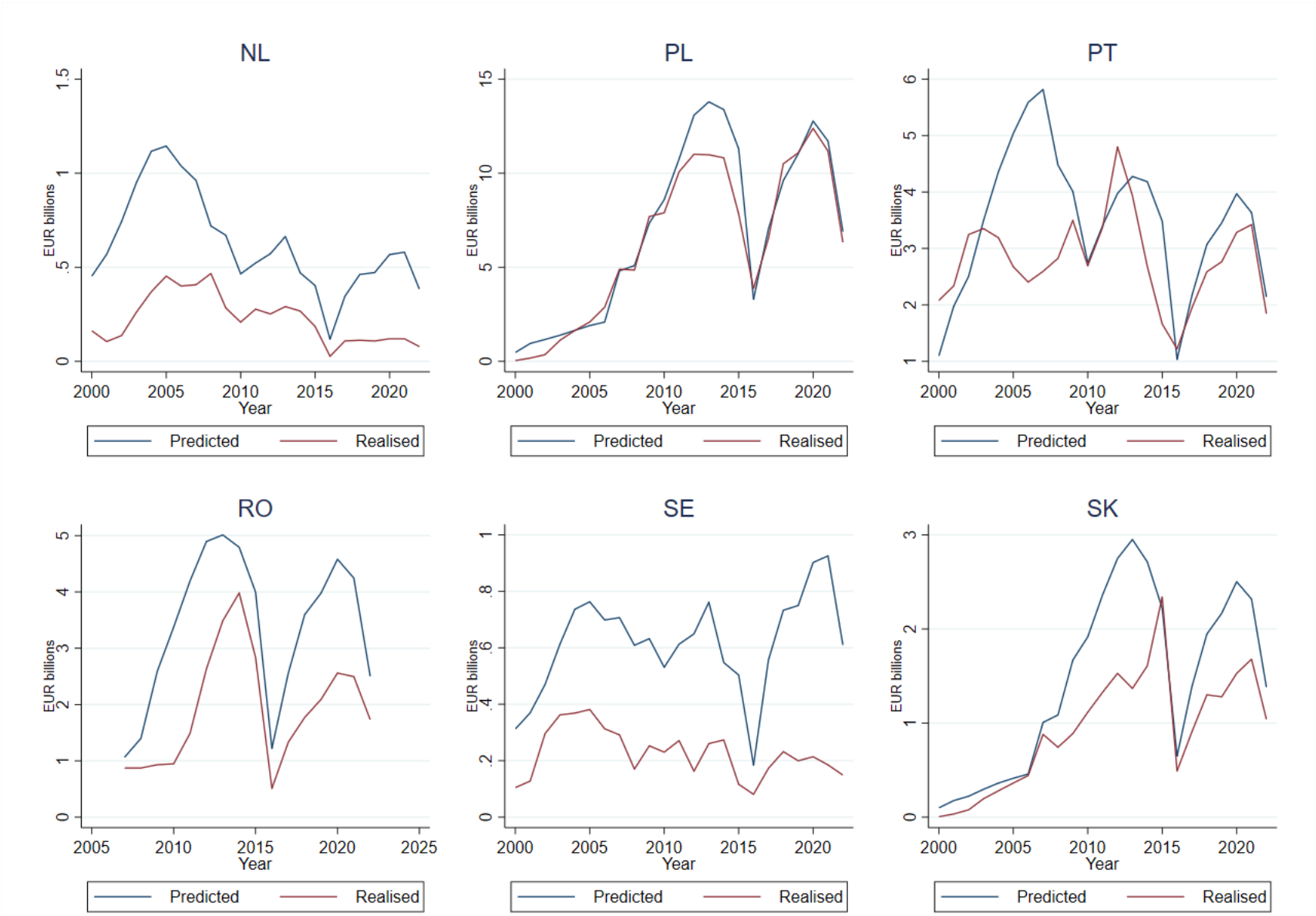

Figure A3: ESIF expenditure and predicted expenditure by Member State.

C OLS results

Table A2: Dependent variable: Private Investment

	(1) h=0	(2) h=1	(3) h=2	(4) h=3	(5) h=4
ESI funds$_{r,i,t}$	0.320***	0.413***	0.353***	0.345	0.318
	(0.0799)	(0.0883)	(0.0938)	(0.261)	(0.193)
Number of obs.	3,968	3,778	3,587	3,385	3,174

Notes: The OLS specification includes controls, time fixed effects, region fixed effects, and uses Driscoll-Kray standard errors. Standard errors-statistics are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021.

Table A3: Dependent variable: Business $R\&D$

	(1) h=0	(2) h=1	(3) h=2	(4) h=3	(5) h=4
ESI funds$_{r,i,t}$	0.0184***	0.0125**	0.0250***	0.0227**	0.0288***
	(0.00322)	(0.00514)	(0.00507)	(0.00850)	(0.00845)
Number of obs.	1,658	2,053	1,464	1,785	1,298

Notes: The OLS specification includes controls, time fixed effects, region fixed effects, and uses Driscoll-Kray standard errors. Standard errors are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021.

D Additional results

D.A ESI funds persistence

Table A4: Dependent variable: ESI funds

	(1) h=0	(2) h=1	(3) h=2	(4) h=3	(5) h=4
ESI funds$_{r,i,t}$	1.000***	1.296***	1.176***	1.083***	0.719***
	(9.26e-17)	(0.311)	(0.379)	(0.265)	(0.267)
Number of obs.	4,317	4,111	3,915	3,717	3,515
Kleibergen-Paap F-statistic	221.860	126.616	103.699	124.941	123.681

Notes: The IV specification includes controls, time fixed effects, region fixed effects, and uses Driscoll-Kray standard errors. Standard errors are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021.

D.B The crowding in effects across economic development levels excluding crisis years

Table A5: Private Investment and ESI funds - Convergence criterion - Excluding crisis years

	Less Developed Regions		More Developed Regions	
	h=0	h=1	h=0	h=1
ESI funds$_{r,i,t}$	1.036*	2.175	1.571***	2.380***
	(0.559)	(1.374)	(0.295)	(0.485)
Number of obs.	1,159	1,150	1,962	1,940
Kleibergen-Paap F-statistic	23.236	23.155	96.275	173.727

Notes: The IV specification includes controls, time fixed effects, region fixed effects, country-crisis fixed effects and uses Driscoll-Kray standard errors. Standard errors are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021. Observations pertaining to the years 2009, 2011, 2012 and 2020 are excluded.

Table A6: Business R&D and ESI funds - Convergence Criterion - Excluding crisis years

	Less Developed Regions		More Developed Regions	
	h=0	h=1	h=0	h=1
ESI funds$_{r,i,t}$	0.0518***	0.124**	0.0156	-0.0936
	(0.0164)	(0.0497)	(0.0388)	(0.0904)
Number of obs.	717	710	460	465
Kleibergen-Paap F-statistic	14.372	8.631	53.190	56.662

Notes: The IV specification includes controls, time fixed effects, region fixed effects, country-crisis fixed effects and uses Driscoll-Kray standard errors. Standard errors are provided in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The top and bottom 2% of observations for the dependent variable are winsorised. Sample period: 2000 - 2021. Observations pertaining to the years 2009, 2011, 2012 and 2020 are excluded.

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