ECONOMICS – WORKING PAPERS 2023/04

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European Investment Bank

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Published by the European Investment Bank.

Printed on FSC® Paper.

pdf: QH-BK-23-017-EN-N ISBN 978-92-861-5606-9 ISSN 2599-736X doi:10.2867/644514

Complementarities between local public and private investment in EU regions

Andrea Brasili*, Cristina Brasili**, Giorgio Musto***, Annamaria Tueske*

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Abstract

This work investigates the role of local public investment in stimulating private investment and in providing support to growth and development. The analysis is based on a combination of datasets, allowing to build an unbalanced panel for 98 NUTS2 European regions in 13 member states, and for Italy specifically, a balanced panel of 21 regions from 2000 to 2019. The empirical analysis includes both PVARs and local projections as a way to gain robustness in results. The main finding is that locally decided public investment correlates positively with private investment in the same area (with no evidence for reverse causality). The impact of public investment seems to be stronger in downturn phases. GDP growth is more sensitive to public investment in education, training and R&D, in public administration operations and in territorial infrastructures. For Italy, the impact on private investment is particularly strong for public investment in education, training and R&D. This highlights the point, rich of policy implication, that local governments may be more attentive and sensible to the needs of the private sector in terms of skills and labor supply composition and adapt to local specific features.

JEL classification: C33, E62, H72

Keywords: Fiscal multipliers, government investment, regional public investment, private investment

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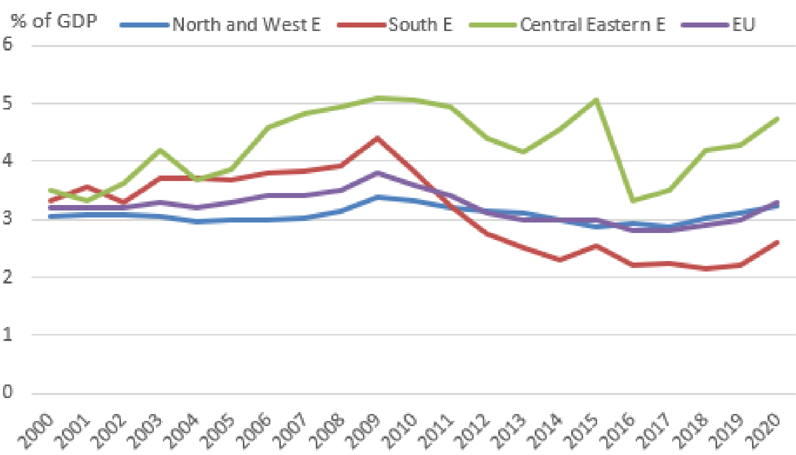
Comments and suggestions received from Jochen Schanz and Laurent Maurin are gratefully acknowledged. The views expressed in this paper are those of the authors and do not necessarily reflect the views of the European Investment Bank.

1 Introduction and motivation

The role of public investment as a tool for reviving growth and structurally improving the economy is coming back to the fore. Before the Covid-19 crisis, there was a large debate on the EU fiscal framework and its possible improvements. One of the arguments pointed out that the framework had the unintended and negative consequence of not protecting public investment spending relative to other expenditures, particularly during fiscal consolidations. Accordingly, a quite visible long trend decline in public investment followed the global financial crisis (GFC) and the European sovereign-debt crisis, with the share of public investment over GDP hitting a low in 2015. The decline was particularly strong for those countries where the consolidation needs were higher, i.e. for Southern European countries (Figure 1). Public investment is far from being a homogeneous variable: it includes various categories of expenditures and involves different operators.

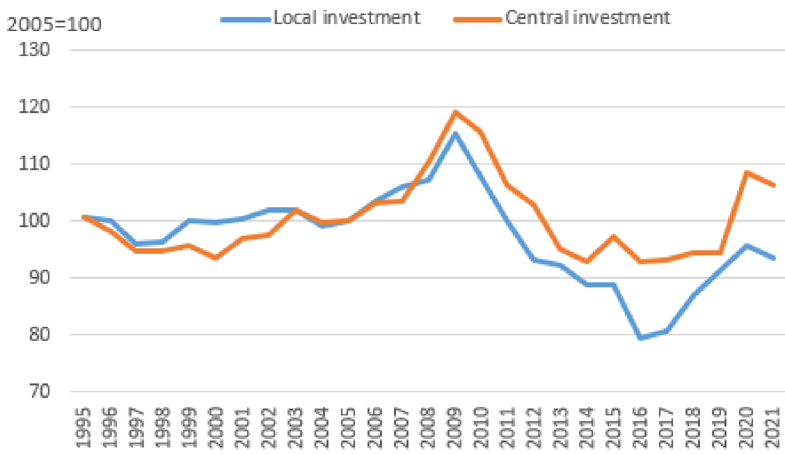
Figure 1: **Public investment in the EU**



Source: AMECO online, authors' calculations

Eurostat collects data on public investment at the national level for EU member states, categorized by the level of government where the investment decision is made. The levels include general, central, local and state government (the latter being used for member states with a federal system only, such as Austria, Belgium, Germany and Spain). Grouping together the local and state levels, one can distinguish between centrally and locally decided investment. For the reminder of the paper, the second group will be referred to as local (i.e. the sum of Eurostat state and local level). Figure 2 shows the evolution of investment as a share of GDP for both categories of investment, normalized at 100 in 2005: following the Global Financial Crisis

Figure 2: **Local and central government investment**

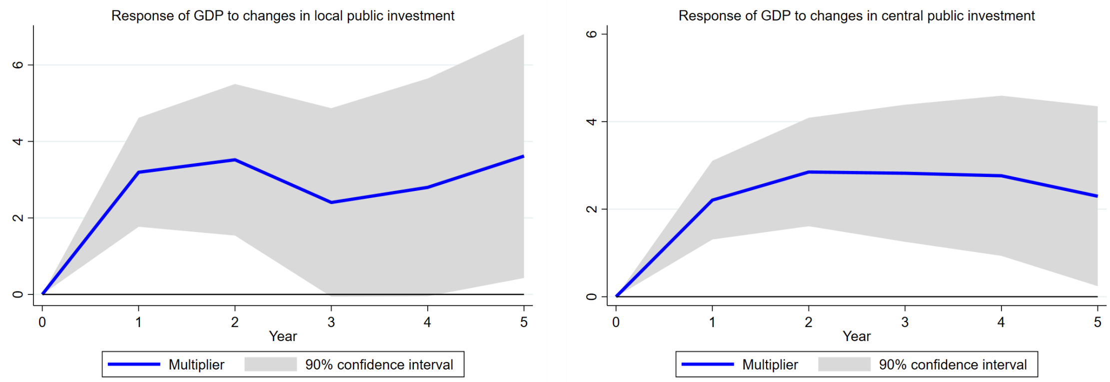


Source: Eurostat data and authors' calculations

(GFC), local investment experienced the largest decline in public investment.

It is not obvious that the economic impact of investment decided at different levels of government is the same. A first analysis of the aggregate data of the 27 Member States at country level shows that locally decided public investment seems to have a different impact than the centrally decided public investment. The aggregate multiplier of local public investment appears to be larger in general, and in particular, it seems to have a more persistent impact on growth (see Figure 3).[1]

Figure 3: **Multipliers of GDP in response to public investment by level of government**



Source: Eurostat data and authors' calculations

In order to better understand the impacts of locally decided public investment, it is better to turn to more disaggregated data. Finding data of this category at regional

[1]The graph is the result of the estimation of local projections using a panel dataset of EU countries.

level [2] is quite challenging, as one needs to resort to national sources dealing with public finances or with regional figures. In the end, many of the EU member states provide this information, however, with different degrees of completeness. With a reasonably large dataset assembled, it is possible to investigate the issue further. The aim is to better understand the relations and interactions of public investment with private investment and economic activity rather than entering into the never-ending debate on the size of the fiscal multiplier.

The paper is structured as follows: section 2 summarizes recent literature on public investment and fiscal multipliers, particularly at regional level, section 3 describes the data; section 4 focuses on the methodological approach, section 5 shows estimation results, section 6 provides some robustness checks related to causality, and section 6 draws some conclusions derived from the analysis.

2 Literature review

The economic literature has extensively investigated the relation between public investment, GDP and private sector outcomes. Through a variety of econometric techniques, research has focused on estimating multipliers of the impact of public investment on total output, to disentangle crowding in and crowding out effects and to verify whether public investment really has an overall positive effect on economic activity. This debate has become all the more relevant in the context of the GFC, following the Covid-19 pandemic, and recently the war in Ukraine, to which governments responded with starkly different measures.

Considering the impact of public expenditure or investment on GDP, there are a number of papers of interest. Using a long time series of US investment data, Ramey & Zubairy (2018) estimate the multipliers of government spending in the country to be positive and significant, between 0.6 and 1. However, they also report some mixed evidence in favor of state dependent multipliers, estimating slightly higher values in periods nearing the zero lower bound. Saccone et al. (2022), on the other hand, carry out an analysis of public investment multipliers on GDP and their variation according to the category of public spending. They conclude that investment devoted to human capital accumulation, such as investment for education and R&D is the most effective in promoting economic growth (a finding confirmed by the analysis at regional level, see below). In reference to the GDP multiplier using a completely different set-up, and in particular a CGE model named Rhomolo, Sakkas et al. (2018) suggested that

[2] NUTS 2 level, apart from NUTS 1 level.

"the reported cumulative multiplier in 2023 is around 0.6 and increases further, even though ESF investment is discontinued, and becomes larger than 1 in 2030."

A substantial portion of research also focuses specifically on the relationship between public investment and private sector outcomes, most importantly private investment, rather than looking at outcomes just in terms of output growth. Dreger & Reimers (2016), for instance, use data on countries in the Euro area to analyze the relation of cointegration between public and private investment, suggesting that public investment should be considered as an important driver of private investment. Afonso & St. Aubyn (2009) also tackle this issue, estimating a VAR model that includes public investment, GDP and private investment among the endogenous variables. They obtain heterogeneous results across countries: while for some the crowding in effects of public investment seem to prevail with a positive and significant effect on private investment, for a minority there is evidence for crowding out, with a negative effect on both GDP and private investment. Finally, in their meta-study focusing on the private output elasticity of public capital, Bom & Ligthart (2013) point out that public capital provided by local governments (as opposed to central government) is more productive, which may reflect their ability to better target public investment to the most productive alternatives. They also find that among the studies they analyze, the ones controlling for the business cycle find higher output elasticity of public capital.

While most of the literature focuses on estimating multipliers using panel data for a set of countries, or focusing on a single country over time, a growing strand of research delves into the dynamics behind sub-national public investment, such as investment at the regional or local level, and its impact on GDP. Brueckner et al. (2023), for instance, use a panel based on regional EU data to suggest that the impact of public expenditures decided by local authorities is larger the higher the degree of autonomy the authorities are endowed with.

In this context, a large portion of the literature focuses on Italy, since the data currently available for the EU's third largest economy supports this kind of detailed analysis. Acconcia & Simonelli (2014) estimate sub-national multipliers of public spending at regional level for Italy, exploiting the dismissal of the city council due to mafia infiltration as an instrument predicting the successive decline in public spending, and finding a positive and significant multiplier on GDP of around 1.5. Destefanis & Fragetta (2020) apply a Bayesian random effect PVAR model to data on investment for the 20 Italian regions, also providing positive estimates of the multiplier for

Italy and detecting higher values of the multiplier for Southern regions. Deleidi et al. (2021), on the other hand, employ a structural PVAR approach to assess the impact of government consumption and investment on regional output, finding somewhat higher values of the multiplier for Northern Italian regions than for Southern ones (around 4 and 2 respectively). In both cases, the impact of public investment on GDP is positive and significant.

This study complements the above strands of the literature by investigating the regional impact of local public investment of European regions on GDP and private investment, and looking at the differential effect across upturns and downturns of the business cycle. It also provides a more detailed analysis of the effects of different categories of public investment for a sub-sample of countries and for Italian regions specifically.

3 Data and empirical strategy

The starting point for the data collection process in this study is information provided by Eurostat on gross fixed capital formation for different levels of government, although no details are given at regional level. In its regional database, on the other hand, Eurostat provides data on GDP, unemployment and total gross fixed capital formation at current prices at NUTS 2 level but does not split private investment from public investment. ARDECO - a dataset maintained by the European Commission and including data on GFCF and deflators at regional level - constitutes a second important data source for the analysis. ARDECO includes GFCF by branch allowing only for a rough indication of the split between private and public investment (in this case the regionalized general government public investment).

Given the lack of a systematic record on public investment at regional level for EU member states that allows to distinguish local public investment from centrally decided public investment, a data set is built on investment at NUTS 2 level exploiting the information available in the national sources of member states. Table A.1 of the Appendix provides further information on the main sources used for this exercise in data collection, such as data characteristics and the data provider. The information was not available for all member states and was generally present at varying level of detail. Furthermore, some of the smaller EU member states only include one NUTS 2 region (it is the case for Malta, Cyprus, Latvia and Luxembourg): for these, Eurostat data is used directly, as it provided the requested disaggregation by level of government. Eventually, data was collected for Belgium, Cyprus, Czechia, Estonia, Spain, Finland, France, Italy, Luxemburg, Latvia, Malta, Poland and Portugal. The final dataset includes an unbalanced panel of 98 regions with yearly observations running from 2000 to 2019 on local public investment.

To check for the validity and consistency of the collected data across countries, for each member state, the sum of local investments in all NUTS 2 regions was compared with the corresponding aggregate level downloaded from Eurostat. In some cases, the sum of the collected data perfectly matched the corresponding value in the Eurostat dataset (it was the case for Spain, for instance). In other cases, minor differences persisted. These can be due to the fact that Eurostat data, similarly to National Accounts data, are collected using the "competence (or accrual) concept" i.e. when an economic event actually takes place, while local data in some case (Italy for example) refers to a simpler "cash concept" i.e. when the corresponding cash payment is done.

For the analysis solely on Italy, the data was available by NUTS 2 region and by spending category in the Territorial Public Accounts database (CPT, "Conti Pubblici Territoriali") of the Italian Territorial Cohesion Agency ("Agenzia per la Coesione Territoriale"). The information in the CPT referred to the wider concept of capital expenditures, including both public gross fixed capital formation and capital transfers. Furthermore, its categories matched the Classification of the Functions of Government (COFOG) level 2 disaggregation, thus including 30 different functions. For the purpose of the analysis, the categories were aggregated to achieve two goals: first, highlighting areas with some degree of complementarity between public expenditures and private sector investment, and second, excluding categories mainly capturing capital transfers rather than GFCF. Table A.1 shows the original COFOG categories for Italy and the selected aggregation. Eventually, a balanced panel with yearly observations running from 2000 to 2019 on local public investment for the 21 Italian NUTS 2 regions and 5 spending categories was obtained. This additional information was used to focus more specifically on the consequences of public investment in Italy to enrich the analysis.

In addition, public investment spending disaggregated by category was collected for a subset of big countries with available data (Italy, Spain and France[3]): education, training and research, public administration operations, territorial infrastructures, local transport and environmental protection. This dataset takes advantage from the

[3]Data for France and Spain have the additional limitation of presenting disaggregated data only for one of the local levels (namely NUTS 2 for Spain, NUTS 1 for France), and not for the municipal level.

fact that by aggregation across the detailed categories, some level of harmonization was reachable for the three countries. The resulting unbalanced dataset spans the period 2000 to 2019 and contains 664 observations of 50 regions.

Finally, the above databases were completed with regional-level macroeconomic figures, including regional real GDP, hours worked and employment, and regional exports. Data on private investment that is a particular focus of the analysis is derived from data available on investment by Nace 1-digit classification. As the best possible proxy of private investment, the difference between total regional investment and the sum of Nace 1 digit categories O-P (corresponding to Public Administration) was taken[4].

4 Methodology

As a first step of the empirical analysis, a panel VAR (PVAR) was estimated following Abrigo & Love (2016) as follows:

$$\Delta logY_{i,t} = \sum_{i=1}^{P} \gamma \Delta logY_{i,t-1} + \beta \Delta logX_{i,t} + \epsilon_{i,t} \tag{1}$$

where Y_{it} is a vector of endogenous variables (for region i at time t), X_{it} is a vector of exogenous variables, and $\epsilon_{i,t}$ is the error term[5]. In the analysis, Y includes regional GDP, regional private investment and local public investment (or one of the categories of public capital spending described in the data section).

Second, the PVAR analysis of public investment, GDP and private investment was complemented by an alternative panel econometric method: local projections. Following Jordà (2005), a growing literature uses local projections to estimate relations between macro variables. This method allows to construct impulse responses (IRs) without incurring the demanding requirements of more complex VAR models. Complementing the results obtained through the PVAR method, local projections are built as well. In the local projections analysis, the main variable of interest is local public investment, which is used to project values of GDP or private investment up to 5 years into the future. The regression equation takes the form:

[4] An alternative would be to use the difference between total investment and local public investment as a proxy of the private investment portion, however, this would include central government public investment, which doesn't allow to filter out all the public investment.

[5] All variables that are non-stationary i.e. GDP and investment (both public and private) enter the regressions or the PVAR in first difference of logs, i.e. in growth rates that are stationary.

$$\Delta logY_{i,t+h} = \beta \Delta logI_{i,t} + \gamma \Delta logY_{i,t-1} + \theta u_{i,t} + \mu_i + \delta_t + \epsilon_{i,t} \tag{2}$$

where $logY_{i,t+h}$ is the dependent variable, with horizon h up to 5 years. $\Delta logI_{i,t}$ is the change in public investment, u_it the rate of unemployment, μ_i and δ_t are region and time-specific effects and ϵ_{it} is the error term.

Throughout the paper, the impulse response functions (IRFs) of the PVAR estimates show the elasticities of GDP and/or private investment to local public investment. The local projection graphs may show directly the multiplier of public investments, if the variables are transformed taking into account the average ratio of public investment to GDP (or to private investment)[6] as in Figure 3 above.

5 Main estimation results

Opting for the application of a PVAR approach requires the choice of the number of lags. The most commonly used diagnostic checking[7] suggests the use of two lags, which, given the short length of the time series in the assembled panel data, is also close to the reasonable upper bound. PVAR estimates (see Table A.4 of the Appendix) suggest that local public investment is positively correlated with regional GDP and private investment as expected (all variables are expressed in growth rates).

The Granger Causality test (Table 1) supports the idea that causality runs from the former to the latter. While the null hypothesis that public investment does not Granger-cause GDP is strongly rejected, the null that GDP does not Granger-cause public investment cannot be rejected.

Using a Choleski ordering with the policy variable placed last (i.e. a shock in GDP does not contemporaneously affect local public investment while the opposite happens[8]), the computed IRF[9] with confidence bands at 90 percent shows the impact

[6]While Ramey and Zubairy (2018) recommend using the current value of the ratio, in this paper, the average within the period was used, given the limitations of our T dimension.

[7]Following Abrigo & Love (2016) the choice is made according to various information criteria, i.e. the panel version of BIC, AIC and QIC and Hansen's J statistics. See Table A.3 in the Appendix.

[8]The ordering used here is quite customary in the literature (see for example the discussion in Saccone et al. (2022) or in Deleidi et al. (2020) at page 8 referring to information and implementation delays). The choice is further strengthened by the fact that current economic dynamics at regional level become known with even larger delay than that at national level. For instance, Italian data on regional GDP at yearly frequency up to 2020 were released in December 2021.

[9]Throughout the paper, the graphs reporting Impulse response functions for PVAR have years on the X axis and response expressed in s.d. (of the response variable) on the Y axis.

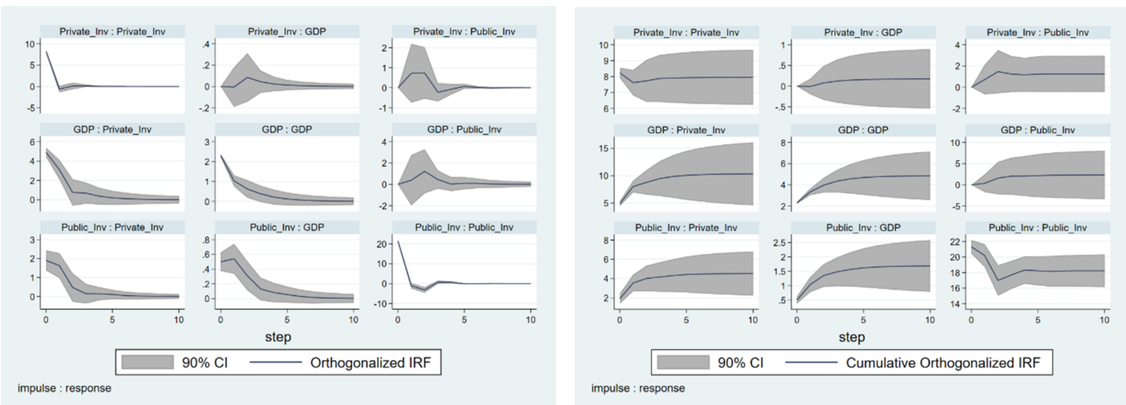
Table 1: **Granger causality test with public investment in European regions**

```
panel VAR-Granger causality Wald test
  Ho: Excluded variable does not Granger-cause Equation variable
  Ha: Excluded variable Granger-causes Equation variable
```

Equation \ Excluded	chi2	df	Prob > chi2
Public_Inv			
GDP	0.350	2	0.839
Private_Inv	1.335	2	0.513
ALL	4.515	4	0.341
GDP			
Public_Inv	6.897	2	0.032
Private_Inv	0.639	2	0.727
ALL	7.977	4	0.092
Private_Inv			
Public_Inv	9.383	2	0.009
GDP	40.592	2	0.000
ALL	57.333	4	0.000

Source: Authors' calculations

Figure 4: **IRFs from PVAR with public investment in European regions**



Source: Authors' calculations

of a shock in local public investment on real GDP (Figure 4).

Table 2: **Granger causality test with public investment in Italian regions**

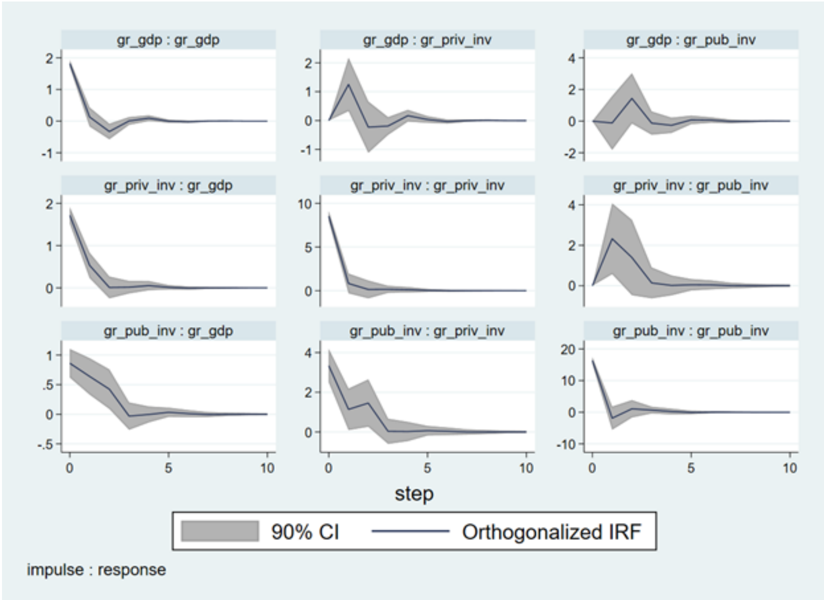
```
panel VAR-Granger causality Wald test
  Ho: Excluded variable does not Granger-cause Equation variable
  Ha: Excluded variable Granger-causes Equation variable
```

Equation \ Excluded	chi2	df	Prob > chi2
gr_pub_inv			
gr_priv_inv	4.089	2	0.129
gr_gdp	1.429	2	0.489
ALL	7.616	4	0.107
gr_priv_inv			
gr_pub_inv	3.319	2	0.190
gr_gdp	6.205	2	0.045
ALL	10.053	4	0.040
gr_gdp			
gr_pub_inv	7.443	2	0.024
gr_priv_inv	4.473	2	0.107
ALL	13.885	4	0.008

Source: Authors' calculations

Repeating the exercise on Italian data leads to similar results. As shown in Table 2, the Granger causality test strongly rejects the null hypothesis that public investment does not Granger-cause GDP. Responses of GDP and private investment to impulses in public investment are positive and significant at the 90 percent level (Figure 5).

Figure 5: **IRFs from PVAR with public investment in Italian regions**

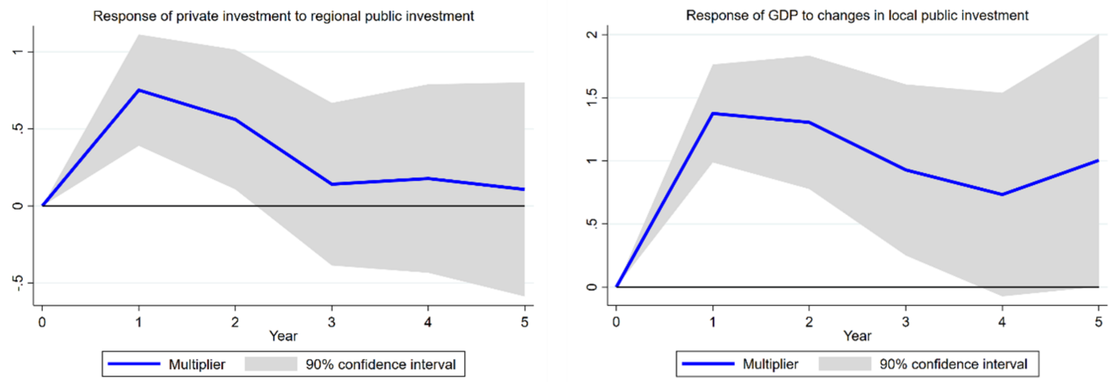


Source: Authors' calculations

To complement the results obtained via the PVAR analysis, the impact of public investment on output and private investment is estimated using local projections. The approach is less demanding than a PVAR in terms of degrees of freedom. Nonetheless, it requires some length in the time series dimension that is one of the limitations of the sample. The analysis confirms the PVAR results and provides evidence in favor of a positive and significant association between public investment and the two main independent variables.

Figure 6 shows the impulse response functions for GDP and private investment in European regions. Regarding private investment, according to local projections, the average multiplier in the first 2 periods ahead is around 0.64 meaning that for a EUR 1 billion increase in local public investment, private investment grows by EUR 0.64 billion on average in the next two years. The GDP multiplier (right panel below) is clearly positive and significant for the first three years after the shock. The point estimate in period 1 is 1.4 with the lower bound of the confidence interval above 1 in period 1. Throughout the paper IRFs estimated via local projections are expressed in terms of multipliers and they have years on the X axis and the response on the Y axis. Given the rescaling, the shock and the response are in the same metrics.

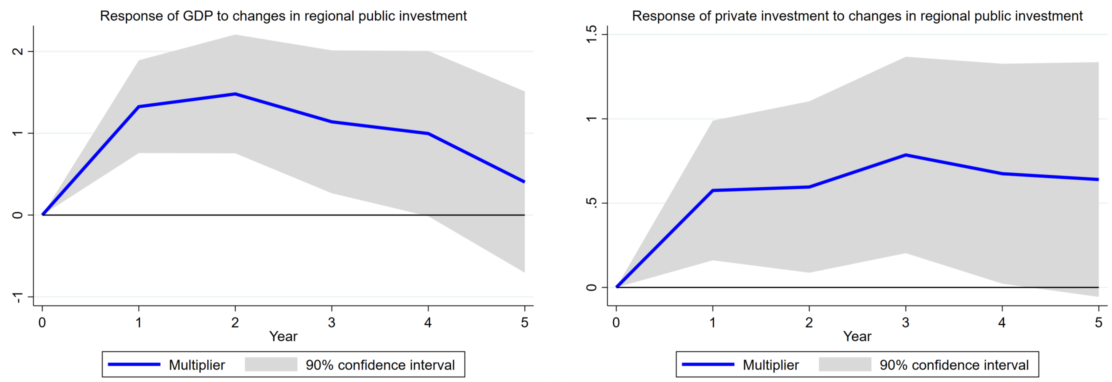
Figure 6: **Multipliers of local public investment impacting private investment and GDP in European regions**



Source: Authors' calculations

Using local projections on Italian data confirms the previous results on European regions and provides evidence in favor of a positive and significant association between public investment and the two main independent variables. Figure 7 shows the multipliers of GDP and private investment after a shock on public investment. In both cases, it is significant and persistent up to the third year after public investment was recorded.

Figure 7: **Multipliers of local public investment impacting private investment and GDP in Italian regions**



Source: Authors' calculations

6 Impact of public investment by category

In this section, the impact of five public investment categories (defined in order to have similar categories in France, Spain and Italy, aggregating COFOG categories) are estimated on GDP (see Table 3) using local projections. Considering the five ag-

Table 3: **Impact of public investment categories on GDP in European regions**

Response of GDP to:	1	2	3	4	5
Public investment	**0.0159*****	**0.0172****	0.0128	0.0124	0.00516
	-0.00469	**-0.00583**	-0.00721	-0.00943	-0.0116
gr_RES	**0.00640***	0.00128	0.00203	0.000871	-0.00121
	-0.0031	-0.00391	-0.00474	-0.00631	-0.00796
gr_Terr	**0.00433***	0.00236	0.00243	0.00261	-0.00146
	-0.00192	-0.00245	-0.00304	-0.00393	-0.00535
gr_Envi	0.00404	0.00279	0.00198	0.00355	-0.00257
	-0.0021	-0.00258	-0.0032	-0.00381	-0.00472
gr_PA	**0.00360***	0.00231	0.004	0.00302	0.00484
	-0.00167	-0.00219	-0.00284	-0.00338	-0.00394
gr_Transp	0.00345	0.000562	0.00449	0.0007	0.000554
	-0.00379	-0.00493	-0.00646	-0.00785	-0.00899

Note: The coefficients reported in the table are elasticities and not multipliers (i.e. they are not re-scaled using the ratio of the variables).
Source: Authors' calculations

gregated categories described in section 3, larger impact is found on GDP coming from investment expenditures in education, training and research, in the functioning of public administration operations and in territorial infrastructures (all of which present positive and significant impact at least at the first step of the projection). The influence of the other two categories seems weaker.

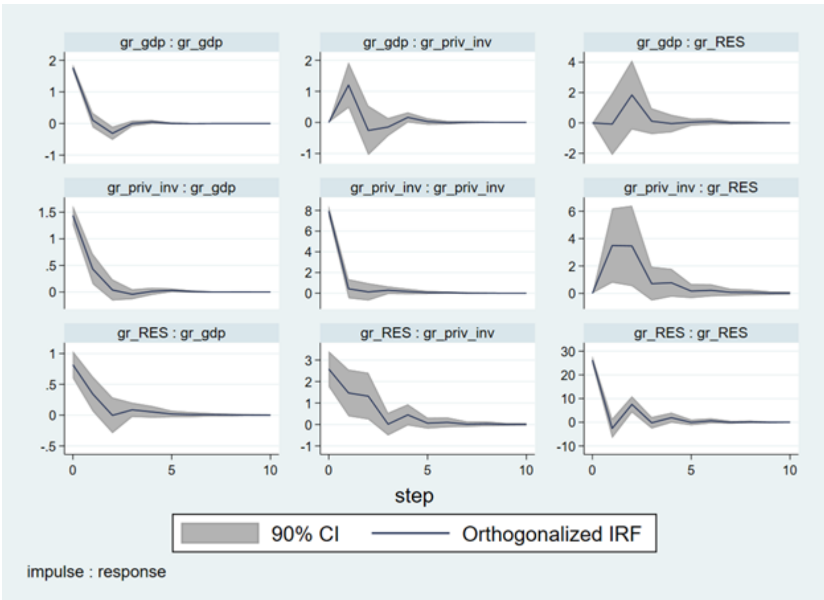
Table 4: **Granger causality test with expenditures in Education, training and R&D in Italian regions**

```
panel VAR-Granger causality Wald test
  Ho: Excluded variable does not Granger-cause Equation variable
  Ha: Excluded variable Granger-causes Equation variable
```

Equation \ Excluded	chi2	df	Prob > chi2
gr_RES			
gr_priv_inv	5.765	2	0.056
gr_gdp	0.965	2	0.617
ALL	9.991	4	0.041
gr_priv_inv			
gr_RES	6.775	2	0.034
gr_gdp	7.593	2	0.022
ALL	16.889	4	0.002
gr_gdp			
gr_RES	1.432	2	0.489
gr_priv_inv	4.936	2	0.085
ALL	7.180	4	0.127

Source: Authors' calculations

Figure 8: **IRFs from PVAR with expenditures in Education, training and R&D in Italian regions**



Source: Authors' calculations

Considering Italian regions and substituting total local public investment with the expenditure categories described in section 3 in general does not provide significant results, with one notable exception. Using expenditures in the education, training and R&D category, the Granger causality test (Table 4) and the IRFs (Figure 8) show a strong and significant impact on private investment. The relationship with GDP is positive but less significant.

7 Public investment across the business cycle

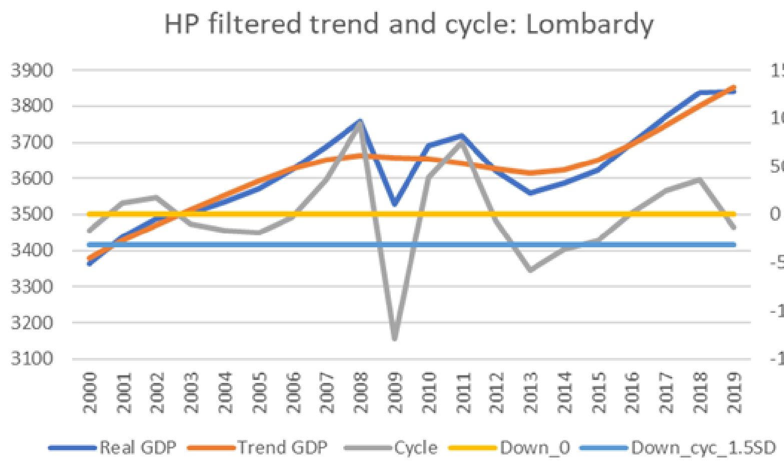
It is part of basic knowledge in economics that the use of fiscal policy as a counter-cyclical tool is a complex task and that it should rather address structural needs, while monetary policy is better suited for the fine tuning of the business cycle phases. Despite this, it can be argued that the actual impact of public investment is stronger in soft spots of economic growth, as there are more idle resources and hence no crowding out effects. In addition, public investment can help in setting favourable framework conditions for private investment to flourish.

The two most obvious ways how this can happen are the reduction of uncertainty regarding the level of demand, or the provision of infrastructures and conditions that allows private investment to be more profitable. In both cases, the impact during below-trend-growth phases can be larger than in strong growth junctures. To assess how the phase in the business cycle affects the impact of public investment on GDP growth or on private investment, a cycle-trend decomposition of GDP levels was performed using an HP filter with a relatively small smoothing parameter lambda[10].

As an example, Figure 9 shows the real and the filtered GDP levels for Lombardy (the largest Italian NUTS 2 region). The difference between the two is the HP-filtered GDP cycle. Instead of simply using a binary variable as a cyclical indicator that assumes the value of 1 when the actual GDP level is higher than the trend level GDP (i.e. when the HP-filtered GDP cycle is greater than 0) and 0 otherwise, a slightly more restrictive condition was chosen for the definition of a downturn. The motivation is that otherwise, the actual GDP is half of the time below the trend almost by construction, while a downturn or a recession happens with less frequency. Hence, instead of the zero line, a line at -3/4 of the standard deviation of the cyclical part of the decomposed trend was used at regional level (as shown in Figure 9). As a result, 76% percent of the periods are upturns and the remaining 24% are downturns in the sample.

[10]In the literature, the customary value for lambda is 1600 in quarterly data. Bakus and Kehoe set it to 100 for annual data, while Ravn and Ulhig proposed a level of 6.25. The results shown here are generated using lambda = 6.25.

Figure 9: **Cycle-Trend decomposition of GDP**



Source: Authors' calculations

This indicator variable is then applied in a local projection estimation using the same methodology as shown before. In the estimation equation, public investment growth is interacted with the indicator variable for the cycle as one of the explanatory variables for GDP. The results, one to five periods ahead, are summarized in Table 5.

As Table 5 shows, including a cyclical interaction term improves the significance of the coefficients. Public investment is strongly positively associated with GDP growth in all five equations, while its interaction with the cycle indicator (that is equal to 1 in upturns) has a negative sign. This indicates that the impact of public investment on GDP is particularly strong when the economy is in downturn. While the use of state-dependent local projection is widespread in the literature, a recent paper (Gonçalves et al. (2022)) highlights that some conditions are needed to ensure the consistency of the local projection (LP) estimators. If the state indicator is a function of endogenous model variables, the asymptotic validity of the LP estimator is not guaranteed, unless the state variable is based on lagged variables (and the longer the horizon of the LPs the longer the lag should be). Otherwise, only the impact response is consistently estimated. Hence, while the results of Table 5 should be considered with caution, the coefficients of the impact response clearly suggest that the impact of public investment is positive and larger when the economy is in a downturn.

8 Robustness check for local projections: IV Regression

The presence of reverse causality could be a source of bias for the results. Specifically, if GDP growth were to drive investment decisions from governments, the direction

Table 5: **Impact of public investment on GDP around the economic cycle in European regions**

	GDP				
Indep. Variables	1 step	2 step	3 step	4 step	5 step
A: Public Investment	0.0382	0.0484	0.0494	0.0340	0.0396
	*[0.0080]****	*[0.0103]****	*[0.0122]****	*[0.0138]***	*[0.0163]***
B: Cycle indicator	-0.467	-1.382	-1.697	-1.83	-1.421
	*[0.2675]**	*[0.3475]****	*[0.4146]****	*[0.4694]****	*[0.5206]****
A*B	-0.0211	-0.0357	-0.0485	-0.0312	-0.0333
	*[0.0091]***	*[0.0119]****	*[0.0145]****	*[0.0165]**	*[0.0197]**
GDP growth (t-1)	0.0975	0.0764	-0.0278	-0.123	-0.2093
	*[0.0505]**	*[0.0666]*	*[0.0814]*	*[0.0937]*	*[0.1008]***
Controls for regions/years					

Source: Authors' calculations

of the impact could flow both ways, leading to biased coefficients. The hypothesis of reverse causality in this context seems questionable: decisions concerning fiscal variables such as public investment are usually subject to implementation delays and, being determined by policy-makers, follow political and social dynamics not necessarily linked to output dynamics. This is even more the case for regional economic variables: the lags with which local macroeconomic data become known are much bigger than for aggregate national macroeconomic data. Hence, when the decisions regarding local public investments are made, the dynamics of GDP or private investment are largely unknown. However, it cannot be a-priori excluded that higher availability of resources, actual or expected, for example estimated true revenues collection can promote an increase in spending. An assessment of the presence of this channel is presented as follows.

In the case of PVAR approaches, a common way is to find an identification strategy, the simplest being a Cholesky decomposition in which the ordering is decided on the basis of economic theory or simple reasoning. Given the delays in releases of data records, as mentioned earlier, the typical ordering of Cholesky decompositions in VAR models in the literature places public investment first. Hence, it seems reasonable to assume a shock structure where public investment is the first variable and then the others follow. Granger causality tests confirm that while it cannot be excluded that public investment Granger-causes private investment, the opposite does not hold.

To check for the robustness of the estimates and the existence of reverse causality in the case of local projections, an instrumental variable regression is applied to control for the presence of a contemporaneous causal impact of GDP growth on public investment. For this, the approach of Saccone et al. (2022) is followed, who instrumented output growth in European countries using GDP growth in the United States, mediated by European countries' exports as a share of GDP. This approach closely follows the debate on the pro-cyclicality of output and fiscal policy in the study by Panizza & Jaimovich (2007), who argued that the eventual presence of reverse causality may lead to biased estimates in the literature and developed this instrument to assess the effect of GDP on fiscal policy in developing countries.

Because of lack of data on exports of NUTS 2 regions in Europe, the original instrument had to be modified slightly. First, the estimates of World GDP growth are used (taken from the World Economic Outlook database), which are weighted using the share of manufacturing value added on total value added at regional level (calculated using Eurostat data), as a proxy of the exposure to external shocks. The "shock" is constructed the following way:

$$Shock_{i,t} = \frac{ManVA_{i,t}}{TotVA_{i,t}} * \Delta y_t^{world} \tag{3}$$

where $ManVA_{i,t}$ represents the Manufacturing value added of region i at time t, $TotVA_{i,t}$ is the regional GDP and Δy_t^{world} the shock in global output. By virtue of this study's focus on the Italian situation, this instrument is complemented by another one focusing on Italy, exploring the country's data sources. For this second instrument, the same estimates of World GDP growth are taken from the WEO database. They are weighted, however, using total exports of each Italian NUTS 2 region as a share of regional GDP, collected from the Italian National Institute of Statistics (ISTAT). For this reason, this second instrument follows the approach of Saccone et al. (2022) more closely, and takes the following shape:

$$Shock_{i,t} = \frac{export_{i,t}}{y_{i,t}} * \Delta y_t^{world} \tag{4}$$

where $export_{i,t}$ represents the exports of region i at time t, $y_{i,t}$ is the regional GDP and Δy_t^{world} the shock in global output. As an instrument, the two "shock" variables we construct for Italian and European regions should have two characteristics: first, they should be significantly associated with the regional GDP variable, thus being relevant to explain its fluctuations. Second, they should be correlated with the target variable (public investment) only through their effect on GDP, rather than directly or through different factors. Regarding the former criterion, one channel through which global patterns in GDP are correlated with those of the European and Italian regions clearly is their ability to export and trade with other countries, which favors the relevance of the instruments. Concerning the exclusion restriction, on the other hand, it is hard to think how this instrument can directly influence decisions on public investment at the local level in a way that is not first mediated by its impact on GDP.

Finally, focusing on Italy, yet another variable is applied as an additional instrument for GDP growth: the growth of employment hours. This is defined as:

$$\Delta L_{i,t} = logL_{i,t} - logL_{i,t-1}$$

where $L_{i,t}$ is the number of hours worked in region i, time t, of the panel data. The change in employment hours can also logically satisfy both the relevance and exclusion restriction characteristics: it is positively associated with GDP growth (through increases in employment in periods of economic expansion) and it can be assumed that employment hours can only indirectly influence public investment at the local level: the most obvious way being through economic growth.

In the end, for both the wider European study and the focus on Italian public investment, these instruments are used to estimate the second stage regression:

$$\Delta I_{i,t} = \alpha_i + \delta_t + \beta \Delta y_{i,t} + \gamma I_t + \epsilon_{i,t}$$

where $\Delta I_{i,t}$, the change in the public investment variable, is regressed on the contemporaneous, instrumented growth in GDP $\Delta y_{i,t}$, while I_t is the interest rate at time t. α_i and δ_t are, respectively, region and year specific fixed effects, while $\epsilon_i t$ is the error term.

Table 6 shows the results of the IV regression: the first column reports the results for the European study, the second and third for the two instruments created for Italian regions only. In all cases, the growth in GDP is not found to alter significantly public investment, since the coefficient is not statistically significant. At the same time, the instrument is proven to be relevant in explaining GDP, since the coefficient of the first stage regression is significant, and the F statistics are consistently above the conventionally accepted values. This proves the initial point that reverse

Table 6: **Robustness Checks**

Variables	(1) EU $\Delta I_{i,t}$	(2) IT $\Delta I_{i,t}$	(3) IT $\Delta I_{i,t}$
$\Delta y_{i,t}$	4.39	-1.608	1.998
	(4.01)	(4.636)	(1.399)
Constant		15.302*	9.725**
		(7.850)	(3.758)
Observations	1045	399	399
Number of regions	95	21	21
First stage results			
$Shock_{i,t}$	58.7**	0.018**	
	(19.7)	(0.008)	
$\Delta L_{i,t}$			45.794***
			(5.599)
F-Statistic	11.72	35.39	44.51

//

Authors' calculations

causality is negligible in this context, strengthening the intuition that the direction of causality flows from public investment to GDP and private investment.

9 Conclusion

Inspired by the finding that the multiplier of aggregated local public investment (at country level) appears to be larger than that of central public investment and has a more persistent impact on GDP, the analysis focused on understanding the impact of locally decided public investment on private investment and GDP. The analysis of European regions is based on an unbalanced dataset referring to 98 regions from 14 EU Member States (including Italy) assembled using mainly the information available at national statistical offices or ministries of finance, with the available periods ranging from 2000 to 2019 (varying by country). A special focus on the Italian regions based on a balanced panel dataset of 21 regions from 2000 to 2019 is also included, benefitting from a richer dataset.

The main finding of the analysis is the positive correlation between locally decided public investment and private investment, with causality seemingly running from public to private investment. The impact of local public investment on GDP seems to be stronger in downturn phases. The results show that investments in the areas of education, training and R&D, public administration operations, and in territorial infrastructures are among the most effective in promoting economic growth. The above results illustrate the point that local governments are very important in crowding-in private investment for multiple reasons. They are more attentive and sensible to the needs of the private sector in terms of skills and labor supply composition and have the knowledge and capacity to adapt to local specific features and to create the right infrastructure and environment for them.

References

Abrigo, M. R. & Love, I. (2016), 'Estimation of panel vector autoregression in stata', *The Stata Journal* **16/3**, 778–804.

Acconcia, A.and Corsetti, G. & Simonelli, S. (2014), 'Mafia and public spending: Evidence on the fiscal multiplier from a quasi-experiment', *American Economic Review* **104/7**, 2185–2209.

Afonso, A. & St. Aubyn, M. (2009), 'Macroeconomic rates of return of public and private investment: Crowding-in and crowding-out effects', *The Manchester School* **77**, 21–39.

Bom, P. & Ligthart, J. (2013), 'What have we learned from three decades of research on the productivity of public capital?', *Journal of Economic Surveys* **28/5**, 889–916.

Brueckner, M., Pappa, E. & Valentinyi, A. (2023), 'Geographic cross-sectional fiscal spending multipliers and the role of local autonomy: Evidence from european regions', *Journal of Money, Banking and Credit* .

Deleidi, M., Iafrate, F. & Levrero, E. S. (2020), 'Public investment fiscal multipliers: An empirical assessment for european countries', *Structural Change and Economic Dynamics* **52**, 354–365.

Deleidi, M., Romaniello, D. & Tosi, F. (2021), 'Quantifying fiscal multipliers in italy: A panel svar analysis using regional data', *Papers in Regional Science* **100/5**, 1158–1177.

Destefanis, S.and Di Serio, M. & Fragetta, M. (2020), 'Regional multipliers across the italian regions', *Journal of Regional Science* .

Dreger, C. & Reimers, H. E. (2016), 'Does public investment stimulate private investment? evidence for the euro area', *Economic Modelling* **58**, 154–158.

Gonçalves, S., Herrera, A. M., Kilian, L. & Pesavento, E. (2022), 'When do state-dependent local projections work?', *CEPR Discussion Paper No. DP17265* .

Jordà, (2005), 'Estimation and inference of impulse responses by local projections', *American economic review* **95/1**, 161–182.

Panizza, U. & Jaimovich, D. (2007), 'Procyclicality or reverse causality?', *Technical report, Inter-American Development Bank, Research Department* .

Ramey, V. A. & Zubairy, S. (2018), 'Government spending multipliers in good times and in bad: evidence from us historical data', *Journal of political economy* **126/2**, 850–901.

Saccone, D., Della Posta, P., Marelli, E. & Signorelli, M. (2022), ‘Public investment multipliers by functions of government: An empirical analysis for european countries’, *Structural Change and Economic Dynamics* **60**, 531–545.

Sakkas, S., Conte, A. & Salotti, S. (2018), ‘The impact of the european social fund: The RHOMOLO assessment’, *JRC Research Reports JRC113328, Joint Research Centre* .

Appendix - Supplementary tables and figures

Table A.1: **Capital expenditures by category, Italian data**

Category in the CPT dataset	**Aggregated category**
Defense	Public administration and defense
Public security	
Justice	
Education	Research and education
Training	
Research and development	
Water services	Territorial services
Environment	
Waste management	
Other health and hygiene services	
Energy	
Other public works	
Telecommunications	Telecommunications
Transports	Transports
Viability	Others
General administration	
Cultural and recreational services	
Construction	
Health	
Social Assistance	
Job market	
Pensions	
Agriculture	
Fishing and aquaculture	
Tourism	
Trade	
Industry and manufacturing	
Others	
Others, non-classifiable	

Source: CTP

Table A.2: **Countries included in the analysis**

Country	Number and level of regions	Time span	COFOG availability	Data source
Belgium	3 Nuts 1 regions	2010-2020	No	National Statistical Office (NBB) NBB
Cyprus	1 Nuts 2 region	2000-2020	No	Eurostat
Czechia	13 Nuts 2 regions	2007-2020	No	National Statistical Office Statistics VDB
Estonia	1 Nuts 2 region	2000-2020	No	Eurostat
Finland	5 Nuts 2 regions	2015-2020	No	National Statistical Office StatFin
France	12 Nuts 1 regions	2011-2020	Yes	French Government Finances locales - Regions et CTU
Italy	21 Nuts 2 regions	2000-2019	Yes	Conti Pubblici Territoriali, Ministry of Economy and Finance CPT
Luxembourg	1 Nuts 2 region	2000-2020	No	Eurostat
Latvia	1 Nuts 2 region	2000-2020	No	Eurostat
Malta	1 Nuts 2 region	2000-2020	No	Eurostat
Poland	16 Nuts 2 regions	2010-2020	No	National Statistical Office, regional statistics AtlasRegionowMapa
Portugal	7 Nuts 2 regions	2009-2019	No	Fundação Francisco Manuel dos Santos Muni. capital exp.
Spain	17 Nuts 2 regions	2007-2019	Yes	Ministerio de Hacienda y function publica CIFRA

Note: For Portugal, comparison with Eurostat data suggested the use of total capital expenditures. For Spain, the obtained data sums up data for federal regions (Communidades Autonomas) and for lower local levels (Administration locales).
Source: National sources.

Table A.3: **Lag selection criteria for the PVAR on European regions**

```
Selection order criteria
Sample:  2005 - 2019                                    No. of obs      =       698
                                                        No. of panels   =        89
                                                        Ave. no. of T   =     7.843
```

lag	CD	J	J pvalue	MBIC	MAIC	MQIC
1	-2.209873	63.18657	.0033859	-172.5493	-8.813433	-72.11534
2	-7.092119	30.84399	.2775924	-145.9579	-23.15601	-70.63243
3	-8.347497	14.21755	.7148032	-103.6504	-21.78245	-53.4334
4	-3.572367	6.135967	.7262368	-52.79801	-11.86403	-27.68951

Source: Authors' calculations

Table A.4: **PVAR estimated coefficients, European regions**

```
GMM Estimation

Final GMM Criterion Q(b) =  5.66e-34
Initial weight matrix: Identity
GMM weight matrix:     Robust
                                                 No. of obs      =       882
                                                 No. of panels   =        95
                                                 Ave. no. of T   =     9.284
```

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
Public_Inv						
Public_Inv						
L1.	-.0600913	.0408094	-1.47	0.141	-.1400762	.0198935
L2.	-.1731276	.040899	-4.23	0.000	-.2532882	-.092967
GDP						
L1.	-.0209756	.6673402	-0.03	0.975	-1.328938	1.286987
L2.	.2117711	.5002026	0.42	0.672	-.7686079	1.19215
Private_Inv						
L1.	.0880507	.1080647	0.81	0.415	-.1237523	.2998537
L2.	.1022357	.0981347	1.04	0.298	-.0901047	.2945761
GDP						
Public_Inv						
L1.	.0148492	.0057473	2.58	0.010	.0035846	.0261138
L2.	.0020168	.0043956	0.46	0.646	-.0065984	.0106319
GDP						
L1.	.450621	.0920204	4.90	0.000	.2702644	.6309776
L2.	.0488972	.0949484	0.51	0.607	-.1371982	.2349927
Private_Inv						
L1.	-.0006576	.0143813	-0.05	0.964	-.0288445	.0275293
L2.	.0092302	.0143195	0.64	0.519	-.0188356	.037296
Private_Inv						
Public_Inv						
L1.	.0477655	.0175582	2.72	0.007	.0133522	.0821789
L2.	-.0020576	.0174255	-0.12	0.906	-.036211	.0320958
GDP						
L1.	1.511753	.311687	4.85	0.000	.9008576	2.122648
L2.	-.2648161	.2993466	-0.88	0.376	-.8515246	.3218924
Private_Inv						
L1.	-.0745021	.0563025	-1.32	0.186	-.184853	.0358487
L2.	.0048222	.0515971	0.09	0.926	-.0963062	.1059507

```
Instruments : l(1/2).(Public_Inv GDP Private_Inv)
```

Source: Authors' calculations

Table A.5: **Investment in the EU - growth rate averages**

	Total economy			General government			Local government		
	2001-2022	2001-2009	2010-2019	2001-2022	2001-2009	2010-2019	2001-2022	2001-2009	2010-2019
European Union	1.4	0.8	2.2	1.4	3.6	-0.6	1.1	3.2	-0.5
Euro area	1.2	0.5	2.0	0.9	3.1	-1.3	0.7	2.7	-1.2
Belgium	1.9	1.8	2.6	2.2	1.3	3.5	1.8	1.3	3.0
Bulgaria	4.2	12.4	-0.7	5.7	9.3	4.0	12.8	19.5	12.6
Czechia	2.7	3.5	2.7	4.2	8.5	1.3	3.8	6.1	3.1
Denmark	2.3	0.8	2.4	2.5	2.9	2.5	2.9	4.4	1.7
Germany	0.9	-0.7	2.8	1.6	1.6	1.9	1.4	0.9	1.9
Estonia	6.4	6.4	6.7	7.4	11.7	3.9	9.2	11.7	9.2
Ireland	9.2	2.7	20.8	4.0	6.1	1.8	1.1	4.0	-2.1
Greece	-0.6	2.8	-7.2	2.1	7.4	-6.4	3.2	4.8	-1.8
Spain	0.8	1.8	0.5	1.1	6.7	-5.5	1.5	7.9	-5.1
France	1.6	1.2	1.9	0.7	1.7	-0.2	0.9	1.9	0.5
Croatia	2.8	5.7	0.4	2.1	4.3	0.8	5.0	6.3	6.5
Italy	0.6	0.0	-0.7	0.4	3.7	-4.0	-0.9	1.5	-4.5
Cyprus	3.2	5.4	1.5	4.2	7.1	2.5	3.4	7.9	1.5
Latvia	4.7	7.5	3.5	12.4	28.3	3.6	13.7	32.8	2.1
Lithuania	6.5	7.1	6.8	7.6	14.5	1.5	16.3	34.9	3.5
Luxembourg	2.6	2.7	3.1	3.8	5.3	3.2	4.1	5.2	3.2
Hungary	3.3	2.3	5.1	9.2	5.9	15.1	8.1	4.3	15.1
Malta	6.7	1.7	9.7	6.8	0.3	15.3	4.4	1.7	10.8
Netherlands	1.6	1.0	2.3	1.0	3.2	-0.5	0.8	4.4	-1.8
Austria	1.3	0.1	2.6	2.5	4.7	0.8	1.4	2.6	0.8
Poland	3.7	4.5	3.7	8.3	13.3	4.5	8.3	13.1	5.4
Portugal	-0.3	-1.6	-0.1	-0.3	0.6	-4.3	-0.6	-0.7	-3.1
Romania	7.0	12.3	3.2	13.0	26.1	2.0	23.0	44.6	9.1
Slovenia	1.6	2.6	-0.3	5.4	9.2	0.1	6.0	11.2	-0.1
Slovakia	3.2	3.6	4.2	3.8	3.3	5.9	9.8	15.5	6.5
Finland	1.4	1.1	1.6	1.9	2.3	2.4	3.5	4.5	4.5
Sweden	3.0	2.1	3.5	4.3	6.0	3.7	5.4	7.2	6.5

Source: Eurostat

Complementarities between local public and private investment in EU regions

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PDF: ISBN 978-92-861-5606-9

2023-0247