Public Investment Multipliers by Functions of Government: An Empirical Analysis for European Countries

Donatella Saccone *, University of Pollenzo and OEET-Turin Center on Emerging Economies

Pompeo Della Posta, University of Pisa

Enrico Marelli, University of Brescia

Marcello Signorelli, University of Perugia

Abstract

This paper contributes to the scientific and political debate on public investment multipliers by estimating them according to their respective function of government. The analysis is conducted on a sample of 31 European countries over the period 1995-2019 and uses the local projection method to estimate the multipliers. Total public investment is confirmed to have a persistent and robust multiplicative effect on GDP, in line with the findings of previous literature. Moreover, public investment seems to be particularly effective in fostering economic growth when it supports the creation of human capital and the functioning of economic affairs and public services, which also includes basic R&D and the operability of public institutions. Such effects appear to be stronger in the post-2008 period, where significant multiplicative effects are found also when resources are invested in other functions of government such as the promotion of health, public order and safety. Our results can help informing the current debate on the selection of specific allocation of public resources to favor a faster GDP recovery after the pandemic shock.

Keywords: public investment; fiscal multipliers; functions of government; local projections.

* Corresponding author.

1. Introduction

For many years the relation between fiscal policies and GDP growth has been abundantly investigated by the economic literature from many different points of view (Nyasha and Odhiambo, 2019). In particular, a considerable number of studies have tried to quantify the multipliers of public expenditure (see Castelnuovo and Lim, 2019, for a comprehensive review) and, while the debate about their magnitude is still open, there is a quite large agreement on recognizing larger values under periods of low growth and recession (among others, Auerbach and Gorodnichenko, 2012 and 2013; Arin et al., 2015; Fazzari et al., 2015). This seems particularly true in the case of public investment (IMF, 2014; Abiad et al., 2016; Alichi et al., 2019; Deleidi et al., 2020 and 2021a; Petrović et al., 2021). Concerning the different components of public expenditure, indeed, there is an intense political debate about the role of public investment, which is seen as a crucial tool of economic policy to foster recovery after a recession because of its potentially higher multipliers if compared to consumption expenditure (see, for example, Auerbach and Gorodnichenko, 2012) as well as its capacity to expand output and productivity in the long-run (IMF, 2014; Deleidi et al., 2020 and 2021a; Petrović et al. 2021). As Deleidi et al. (2020) notice, over the last few years this role has been increasingly recognized also by international institutions like the IMF and the European Commission. Moreover, the great 2020 pandemic recession has highlighted the need for a strong fiscal policy response; among others, European countries replied both individually and with a historical joint effort with generous investment plans, that have been exemplified by the "Next Generation EU" and require special attention on the selection criteria of specific categories of public investment.

However, only a smaller group of studies has empirically estimated the real size of multipliers for public investment (Auerbach and Gorodnichenko, 2012; IMF, 2014; Abiad et al., 2016; Alichi et al., 2019; Masten and Grdović, 2019; Deleidi et al., 2020 and 2021a; Petrović et al., 2021). While these studies provide some important evidence confirming the effective role that public investment plays in promoting economic growth, the current political debate increasingly focuses on the allocation of public investment and calls for more detailed analyses that distinguish among different categories of investment and identify which ones have the highest and most persistent multiplicative effect on GDP. Our paper, then, contributes to the scientific and political debate by estimating the multipliers of public investment classified in ten functions of government; to the best of our knowledge, this level of details constitutes a novelty in the literature and allows for policy implications that may inform the discussion about fiscal allocation of public resources.

For this purpose, we extend the empirical analysis by Deleidi et al. (2020) to include the ten categories of public investment and estimate the respective multipliers through the use of local projections (LPs), as firstly proposed by Jordá (2005) and then widely adopted by the recent macroeconomic literature on fiscal multipliers (Auerbach and Gorodnichenko, 2013; IMF, 2014; Abiad et al., 2016; Ramey and Zubairy, 2018; Masten and Grdović, 2019; Deleidi et al., 2020 and 2021a; Petrović et al., 2021). The analysis is carried out over the period 1995-2019 on a sample of

31 European countries, as selected on the basis of Eurostat data availability. As the pandemic outbreak represents a disruptive event for the global economy (IMF, 2021), the analysis goes deeper testing if and how results change under a low-growth regime exploiting the post-Great Recession years as an emblematic timespan in our data, in line with Mencinger et al. (2017), Deleidi et al. (2020) and Petrović et al. (2021). This may contribute with new evidence to be used in favor of a faster GDP recovery after the pandemic shock.

The paper is structured as follows. Section 2 reviews and discusses the existing literature on fiscal policy multipliers. Data and methodology are illustrated in Section 3. Section 4 presents the key empirical results and the related robustness analysis. Finally, in Section 5 policy implications and conclusions are drawn.

2. The need for public investment and the literature on fiscal policy multipliers

Many European countries have been characterized not only by deep impacts of economic crises but also by feeble long-run economic growth. To reinforce economic growth, structural reforms – typically working on the supply side of the economy – have been frequently advocated by international institutions, like IMF and EU. However, it has been shown firstly that such reforms can only have a positive impact on potential output in the long run (e.g., De Grauwe and Ji, 2016) and, secondly, that they are insufficient as the persistence of negative output gaps and high unemployment in some countries are signs of a lack of aggregate demand (e.g. Marelli and Signorelli, 2017). In particular, De Grauwe and Ji (2016) suggest that an investment plan has a greater growth impact compared to structural reforms, that in some circumstances can even be inappropriate (see also Fitoussi and Saraceno, 2013; Cerniglia and Saraceno, 2020). Della Posta et al. (2019 and 2020) point out a key role for public investment, in addition to a relaxation of fiscal rules on national accounts (for example adopting a "golden rule"), in order to stimulate both current and medium term GDP growth and to favor sovereign debts sustainability.

Before the pandemic emerged, even international institutions started to recognize that stimulating investment and aggregate demand is essential for economic growth (e.g., Cerniglia and Saraceno 2020). The pandemic shock accelerated this recognition and, among others, the United States and the EU institutions reacted promptly.[1] The latter decided – in addition to the new extraordinary

[1] In addition to the already approved $1.9 trillion American Rescue Plan, for example, Biden's recently-proposed US Infrastructure Plan includes $621 billion for transportation projects (comprising bridges, roads, mass transit, ports, airports, and electric vehicle development), $111 billion for drinking water infrastructure improvements, and other funding for expanding broadband access and upgrading power grids.

operations undertaken by the European Central Bank[2] and some heterogeneous measures[3] – an initial response of the value of about € 540 billion (4% of EU27 GDP).[4]

The most important measure of the package was approved by the EU European Council on July 21, 2020. It was named "Next Generation EU" (NGEU) and worth € 750 billion, including €390 billion in transfers to crisis-affected countries and € 360 billion in long-term loans at very low interest rate, which will be mainly channeled through a special "Recovery and Resilience Facility" (RRF). The two most strategic items identified by the EU Commission are the green economy (at least 37 per cent of total funds) and digitalization (at least 20 per cent). The "National Recovery and Resilience Plans" (NRRP) have been presented to the EU Commission on April 30, 2021, and financial resources will be given to national governments from July 2021 until 2026.[5] Within each EU country there has been a vivid debate about the criteria and procedures for selecting investment projects with the highest multiplicative effects on the economic system.

Most of the debate on the value of fiscal multipliers dates back to the period following the 2009 Great Recession. Especially during the sovereign debt crisis in the Eurozone, the EU Commission sponsored for some years an "austerity vision" theoretically based on the "non-keynesian effects" and the so-called "expansionary austerity" (Giavazzi and Pagano 1990, 1996). According to the latter hypothesis, a cut in public expenditure is likely to lead to an increase in GDP thanks to a "crowding-in" of private investments, also due to the reduction in interest rates coming from the expected improved sustainability of public debt implying a lower risk premium. The "austerity vision" was empirically supported by a hypothesis of a low negative impact on GDP growth of restrictive policies. On the contrary, in the last decade an increasing number of empirical studies disproved this belief. Economists from leading institutions[6] found that the size of the multipliers is particularly large for public expenditure and targeted transfers. Even the IMF (2012) claimed that the fiscal multipliers increased after the Great Recession, thus suggesting a more gradual approach in the consolidation plans; in fact, in this case the typical Keynesian effects of restrictive fiscal policies emerge, and gradual consolidations are more credible and effective, if really respected, than harsh adjustment plans.

[2] The most important one is the "Pandemic Emergency Purchase Program" (PEPP), i.e. asset purchases of private and public sector securities, decided in March 2020 and extended in June and December 2020, bringing the total amount to € 1.85 trillion euro; the "full reinvestment" has been extended at least until the end of 2023.

[3] Suspension of the Growth and Stability Pact, utilization of some funds available within the EU budget such as the Coronavirus Response Investment Initiative, the EU Solidarity Fund.

[4] (i) A Pandemic Crisis Support by the European Stability Mechanism (ESM) up to 2% of GDP for each euro area country (up to € 240 bn. in total) to finance health related spending; (ii) providing € 25 bn. in government guarantees to the European Investment Bank (EIB) to support up to € 200 bn. to finance companies, with a focus on SMEs; (iii) a temporary loan-based instrument (SURE), of up to € 100 bn., to protect workers and jobs, supported by guarantees from EU Member States.

[5] High-debt countries hit hard by the pandemic (e.g., Italy, Spain) and Eastern European countries will be the biggest net beneficiaries from the RRF.

[6] IMF, OECD, European Commission (EC), European Central Bank (ECB), US Federal Reserve (FED), Bank of Canada. Such economists made use of eight different macroeconometric models (mainly DSGE models) for the US and four models for the Eurozone (see Auerbach and Gorodnichenko, 2012).

To summarize the debate on fiscal multipliers, mostly referred to a change in total public expenditure and/or in taxation, the following elements can be considered: (i) the time horizon, also distinguishing short-run and medium/long-run impacts; (ii) the cyclical phase; (iii) the monetary conditions: when the nominal interest rate is zero the multipliers can be very large, because fiscal tightening does not help in reducing interest rates, i.e. the ZLB; (iv) the fact that other trade partners consolidate at the same time; (v) the specific instrument of fiscal policy that is used. Regarding point (i), most of the recent empirical studies find high fiscal multipliers not only in the short-run but also in the medium to long-run, consistent with the presence of permanent effects; such outcomes confirm, on the one hand, the validity of the traditional Keynesian view (permanent effects of aggregate demand expansions) in contrast to the New-Keynesian models (according to which the positive impact of aggregate demand, including public expenditure increases, is only transitory) and, on the other hand, the existence of hysteresis effects of fiscal consolidation policies (Fatàs and Summers, 2018).[7] As for point (ii), there is a quite large agreement on recognizing larger multipliers under periods of low growth and recession (Auerbach and Gorodnichenko, 2012 and 2013; IMF, 2014; Arin et al., 2015; Fazzari et al., 2015; Abiad et al., 2016; Alichi et al., 2019; Deleidi et al., 2020 and 2021a; Petrović et al., 2021). For example, Auerbach and Gorodnichenko (2012) find that multipliers for the US economy in the period 1947-2008 range between 1.3-2.6 in recessions and between 0.2 and 1.4 in expansionary phases, while similar proportions are found by many other works on different countries and periods. Some authors reach such conclusions by comparing fiscal multipliers between sub-periods characterized by different average growth rates (e.g. IMF, 2014; Mencinger et al., 2017; Deleidi et al., 2020 and 2021a; Petrović et al., 2021) or by using dummy variables for recessions (Callegari et al., 2012; Abiad at al., 2016), while others employ a more complex transition function between states to obtain state dependent fiscal multipliers (among others, Auerbach and Gorodnichenko, 2012 and 2013; Arin et al., 2015; Fazzari et al., 2015; Abiad et al., 2016; Alichi et al., 2019). Regarding point (iii), many empirical studies (starting from Christiano et al. 2011) confirm the high value of multipliers in presence of a ZLB; more recently, Amendola et al. (2020), by using a panel vector-autoregressive model, find that the median cumulated multipliers range between 0.3 and 1.4 in normal times, and between 1.6 and 2.9 at the "effective lower bound".[8] An established result is obtained with regard to point (iv) as proved, for instance, by the results of the "meta-analysis" conducted by Gechert and Rannenberg (2014) and by the evidence provided by Blanchard and Leigh (2013), for whom fiscal multipliers tend to be greater than one when many countries consolidate at the same time[9] (as well as during recessions and in presence of the ZLB), leading the authors to explicitly state that "fiscal multipliers were substantially higher

[7] Fatas and Summers (2018) extend to longer horizons the methodology of Blanchard and Leigh (2013) to estimate the value of fiscal multipliers, thus corroborating the self-defeating effects of fiscal consolidations (as hypothesized by De Long and Summers, 2012, among others), because "attempts to reduce debt via fiscal consolidations have very likely resulted in a higher debt to GDP ratio through their long-term negative impact on output" (Fatas and Summers, 2018, p. 238).

[8] Another recent contribution, by Di Serio et al. (2021), attaches – as an alternative – more importance to the level of interest rate relative to the growth rate of the economy: using data for euro-area countries, the outcome is that "over the medium run (5 years), median cumulated multipliers range between 1.22 and 1.77 when r-g is negative, and between 0.51 and 1.26 when r-g is positive"; moreover, the size of the multiplier is inversely correlated with r-g and it is not driven by the state of the business cycle, the monetary policy stance, or the level of government debt.

[9] Consequently, Portes (2012) argues that "coordinated austerity in a depression is indeed self-defeating".

than implicitly assumed". As far as point (v) is concerned, Alesina et al. (2015a, 2015b) maintain that adjustments made through spending cuts are less recessionary than those achieved through tax increases; furthermore, it would be better if spending-based consolidations were accompanied by the "right" polices, including easy monetary policy, liberalization of goods and labor markets, and other structural reforms. On the contrary, other authors (including EC, 2012) find that the multipliers associated with public expenditure are, under certain conditions, higher than those observed for taxes (at least the first-year multipliers).

Regarding the estimation of public investment fiscal multipliers, the first point to stress is that such specific investigations have been rare. One of the early exceptions is provided by Perotti (2004), who use a SVAR approach and suggests that, while public investment may yield higher output effects than other spending, its effectiveness depends upon its composition, the level of government implementation, and supply side factors. By employing a regime switching vector autoregression model where transitions across different states are smooth, Auerbach and Gorodnichenko (2012) analyze some disaggregate spending variables and find that the point estimate of the multiplier of public investment is lower at impact in recessions but then it increases over time to a level around 2, becoming larger than in periods of expansion. Petrovic et al. (2021), using both a panel SVAR model and local projections (LPs), find for Central and Eastern European countries that the public investment multiplier, while low and insignificant in the high-growth period, is large and significant in the low-growth period, with positive effects also on employment (differently from an increase in public consumption); public investment is also shown to enhance private investment and does not increase the debt-to-GDP ratio, i.e. it is essentially self-financed.[10] The same conclusion was previously reached by IMF (2014), which employs LPs to estimate impulse response functions and argues that "debt-financed projects could have large output effects without increasing the debt-to-GDP ratio"; this is because "increased public infrastructure investment raises output in both the short and long term, particularly during periods of economic slack". Also Abiad et al. (2016), starting from a stylized theoretical framework and investigating 17 OECD countries for the period 1985-2013, use LPs and prove that increased public investment raises output, both in the short term and in the long term, crowds in private investment and reduces unemployment; once again, demand effects are stronger when there is economic slack and monetary accommodation, but also if public investment is financed by issuing debt (rather than budget-neutral investments financed by raising taxes or cutting other government spending) and, of course, in countries with higher public investment efficiency. One of the most recent empirical analyses was carried out by Deleidi et al. (2020). Applying the LP approach with alternative model specifications, it focuses on eleven Eurozone countries for the period 1970-2016 and finds an investment multiplier greater than one, with a permanent and persistent effect on real output (it increases in subsequent periods after the impact reaching a value about 2 five years later), an even larger value when the post-crisis period is included (thus confirming results of previous studies) and greater in Southern countries than in Northern ones. Similar results are obtained in a subsequent paper (Deleidi et al. 2021a), considering

[10] Similar results were also obtained by Masten and Grdovic Gnip (2019).

the same countries for the same period but combining SVAR modeling with the LP approach; once more, the "Keynesian effects" of public investment are confirmed.[11]

A provisional conclusion stemming from the above studies is that the fiscal multiplier of public investment is generally greater than one and higher than the multiplier of other components of public spending, and that often it reaches the highest values in the medium run, with a greater magnitude in periods of low growth. However, although relevant, such studies only focus on total public investment without discerning the effects of different categories of investment. The complete absence (to our knowledge) of a detailed empirical investigation of the effects of the key functional components of public investment is then the main motivation behind this study.

3. Data and methodology

3.1 Data

Data on public investment by functions are reported by Eurostat according to the standard Classification of the Functions of Government (COFOG), which was originally created by OECD and then adopted by many international organizations collecting statistics on the purposes of government activities (EUROSTAT, 2019). Such classification encompasses ten macro-categories of functions, further broken down into different sub-items. While data on public investment in European countries are extensively available for the ten macro-categories, the sub-classification is characterized by a lower degree of data availability. The present analysis then mainly focuses on the top-level of detail, i.e on the ten categories representing the following functions of government: general public services; defense; public order and safety; economic affairs; environmental protection; housing and community amenities; health; recreation, culture and religion; education; social protection. A description of sub-items by category is provided in Appendix (Table A1). As quarterly data on public investment by functions are not available, our dataset consists of yearly macroeconomic data for 31 European countries observed over the 1995-2019 period (list of countries in Appendix, Table A2). Also all the other selected variables are taken from Eurostat and, where necessary, they are converted into real values using the GDP deflator (see variable description and sources in Appendix, Table A3). The allocation and the rate of growth of public investment by functions of government are summarized in Appendix (Table A4).

3.2 Methodology

The effects of public investment at different horizons are estimated using local projections (LPs), as firstly proposed by Jordá (2005) and then widely applied by the recent macroeconomic

[11] Another recent study (Deleidi et al., 2021b) focuses on the Italian case and distinguishes between Centre-Northern and Southern regions: fiscal multipliers – which are generally higher for government investment than for government consumption – turn out to be greater in the former regions.

literature for estimating fiscal multipliers (among others, Auerbach and Gorodnichenko, 2013; IMF, 2014; Abiad et al., 2016; Ramey and Zubairy, 2018; Masten and Grdović, 2019; Deleidi et al., 2020 and 2021a; Petrović et al., 2021). LPs consist in the estimation of H regressions (where h represents the forecast horizon ranging from 0 to H) and allow to directly estimate the impulse response functions by projecting the macroeconomic variables of interest on past values of the fiscal variable. The large adoption of the LP method is based on a series of advantages that it presents in comparison with structural vector autoregressions (SVAR), as LPs allow to avoid dynamic restrictions on the impulse response function, are less sensitive to misspecification, can be easily estimated by single-equation OLS techniques, do not require complex specifications and easily accommodate non-linearities (Jordá, 2005).

Following Deleidi et al. (2020), we start from a simple model (Model 1) where the response of GDP to the change in public investment at each horizon *h* is modeled as:

$$\Delta y_{i,t+h} = \alpha_i^h + \delta_t^h + \beta^h I_{i,t}^g + \phi^h \Delta y_{i,t-1} + \varepsilon_{t+h} \quad [1]$$

where t and i denote respectively time and countries, α_i^h and δ_t^h are country- and time- fixed-effects, $\Delta y_{i,t+h}$ is the change in real GDP between *t* −1 and *t* + *h*, $I_{i,t}^g$ represents the rate of growth of total public investment. In order to facilitate the comparison of our results to those provided by the most recent literature on public investment multipliers in European countries (Deleidi et al. 2020 and 2021a), local projections are estimated for six years ahead (h = 0, 1, …, 6). In line with Sheremirov and Spirovska (2015), Attinasi and Klemm (2016), Deleidi et al. (2020), Petrovic et al. (2021), the fiscal shock is thus identified by the difference between actual investment and an investment benchmark, i.e. the previous year's investment. $\Delta y_{i,t-1}$ initially is the only control variable and identifies the GDP change between t−2 and t-1, with the optimum lag (equal to one) being selected through the AIC and BIC criteria. The changes in the variables between two periods are expressed by taking the logarithmic difference[12].

For our specific purpose, public investment is then broken down by functions of government and the baseline model takes the following form:

$$\Delta y_{i,t+h} = \alpha_i^h + \delta_t^h + \beta^h I_{f,i,t}^g + \phi^h \Delta y_{i,t-1} + \varphi^h I_{i,t-1}^g + \varepsilon_{t+h} \quad [2]$$

where $I_{f,i,t}^g$ is the rate of growth of public investment by the function of government *f*, while $I_{i,t-1}^g$ is used as a control variable and represents the rate of growth of total public investment at t-1 [13]. In other words, the model is alternatively estimated for each function of government *f*, where

[12] Namely, $\Delta y_{i,t+h} = \log(y_{i,t+h}) - \log(y_{i,t-1})$; $\Delta y_{i,t-1} = \log(y_{i,t-1}) - \log(y_{i,t-2})$. Analogously, the rate of growth of public investment, $I_{i,t}^g$, is measured as $\log(I_{i,t}) - \log(I_{i,t-1})$.

13 We also estimated an alternative model, where $I_{i,t-1}^g$ is substituted by $(I_{i,t} - I_{f,i,t})^g$, i.e. by the contemporaneous rate of growth of public investment for government functions ≠ *f*. While results are generally confirmed (although slightly lower values of coefficients and significance levels), the model above is preferred as the rate of growth of public investment for function *f* is highly correlated with the rate of growth of public investment for the other functions. Results are available upon request.

f=1,…,10. Initially the control variable $I_{i,t-1}^{g}$ is excluded from the model (Model 2a), while it is included in a second set of regressions (Model 2b).

Finally, as a robustness check, a set of additional control variables is added to Models 1 and 2b, which respectively become (Models 3a and 3b):

$$\Delta y_{i,t+h} = \alpha_i^h + \delta_t^h + \beta^h I_{i,t}^{g} + \phi^h \Delta y_{i,t-1} + \gamma^h X_{i,t} + \varepsilon_{t+h} \quad [3]$$

$$\Delta y_{i,t+h} = \alpha_i^h + \delta_t^h + \beta^h I_{f,i,t}^{g} + \phi^h \Delta y_{i,t-1} + \varphi^h I_{i,t-1}^{g} + \gamma^h X_{i,t} + \varepsilon_{t+h} \quad [4]$$

where $X_{i,t}$ is the set of control variables selected on the basis of the extant literature, including the long-term interest rate, which controls for monetary policy (Auerbach and Gorodnichenko, 2017; Deleidi et al., 2020), the real effective exchange rate and the current account balance as a percentage of GDP, both representing the effect of trade performance on GDP growth (David, 2017; Deleidi et al., 2020; Petrović et al. 2021). Subsequently, following Ramey and Zubairi (2018), also the GDP deflator inflation rate and the average tax rate (tax revenues as a ratio of GDP) are introduced as additional controls.

The stationarity of main variables has been confirmed by both Dickey and Fuller's ADF test (Dickey and Fuller, 1979) and Phillips-Perron's test (Phillips and Perron, 1988), that Arltovà e Fedorovà (2016) prove to have the highest power for short time series. In all regressions, the inclusion of time fixed-effects is supported by a significant Wald test statistic for the coefficients of time dummies, which suggests to prefer two-way over one-way fixed effects models. In order to obtain heteroscedasticity and autocorrelation consistent statistical inference, clustered robust standard errors are used.

A common practice to derive the multiplier from the estimated elasticities (coefficients β^h) is to multiply them by using an ex-post conversion factor represented by the sample average of the ratio of GDP to the fiscal variable (in our case, $\beta^h * Y/I$). However, Ramey and Zubairy (2018) demonstrate that, when this ratio significantly varies across the sample, the estimated multipliers are biased upward. As in our sample there is a large variation in Y/I (especially when public investment is broken down), we obtain much larger multipliers for analogous values of elasticity. In order to avoid this bias, we follow Ramey and Zubairy (2018) and, partially, Deleidi et al. (2020) and express the fiscal variable in the same unit by multiplying the rate of growth of public investment by I/Y [14]. This avoids the need to use the ex-post conversion factor. In this way, the changes in public investment are uniformly measured as a percentage of GDP, with the estimated coefficients β^h directly representing the multipliers. As we have verified, this ex-ante transformation does not change the substance of the results while yielding a more reliable size of multipliers.

[14] As in Deleidi et al. (2020), this is calculated as $[\log(I_{i,t}) - \log(I_{i,t-1})] * (I_{i,t-1}/y_{i,t-1})$.

Following Spilimbergo et al. (2009) and Ramey and Zubairy (2018), the cumulative multipliers are then defined as the cumulative change in output over the cumulative change in investment at each horizon. They are obtained by: 1) at each horizon, estimating and summing the coefficients β^h to obtain the cumulative change in output; 2) at each horizon, estimating and summing the coefficients β^h when the change in investment is used as the dependent variable, in order to obtain the cumulative change in investment; 3) for each horizon, computing the cumulative multiplier as the cumulative change in output (obtained in step 1) divided by the cumulative change in investment (obtained in step 2).

3.3 Testing the existence of reverse causality

A relevant part of the empirical literature on fiscal multipliers has raised the issue of endogeneity of fiscal variables to GDP growth. The idea is that public spending and its single components could be partially determined by the contemporaneous variation of GDP. While this is unlikely to happen within the same quarter (Blanchard and Perotti, 2002), it may represent a problem for yearly data. In order to avoid endogeneity issues, the empirical literature has frequently identified unanticipated variations in fiscal policy, i.e. fiscal exogenous shocks, using changes in military spending due to political events (Ramey, 2011; Ramey and Zubairy, 2018) or forecasts errors of government spending (Auerbach and Gorodnichenko, 2012 and 2013; Abiad et al., 2016; Ramey and Zubairy, 2018; Masten and Grdović, 2019). However, both methods are not applicable in our case. While the first approach is suitable only when historical data are analyzed, forecasts are usually reported for total public investment but are not provided for investment classified by functions of government [15].

On the other hand, Deleidi et al. (2020) extensively discuss why government spending and, more specifically, public investment can be considered exogenous within the year. Based on economic literature and examination of some recent European policies, their main argument is that, in presence of cyclical fluctuations of GDP, the quicker implementation and effectiveness of monetary policies make them usually preferred to fiscal adjustments, which, in any case, are unlikely to take place within the same year due to information, decision and implementation lags. Such an argument is much more significant in the case of public investment - which is the focus of both our and their analysis - as it is the outcome of even more prolonged institutional, bureaucratic and technical decisions that can take years to be realized. In line with the results reported by Beetsma et al. (2009) and Born and Muller (2012), the authors also demonstrate the exogeneity of investment growth rates to GDP growth within the same year by regressing the quarterly rate of growth of public investment on the lagged values of quarterly GDP growth rate and finding that the estimated coefficients are not jointly statistically significant.

[15] Also forecasts of total public investment in international databases are not available for a significant part of our sample. Such data, indeed, are mainly published by OECD and Eurostat. However, more than one third of countries in our sample either are not part of OECD or have not been OECD/EU members for a large part of the considered period.

Since the same methodology cannot be applied to our data - as quarterly data are not available for public investment by functions – we rely on an alternative identification strategy to verify the exogeneity of public investment. We regress the yearly rate of growth of public investment on the contemporaneous GDP growth by using an instrumental variables (IV) approach to identify the direction of the effect. In a similar context, Panizza and Jaimovich (2007) take inspiration from Galí and Perotti (2003) and convincingly prove that a real external shock consisting of the weighted average of economic growth in export partners is a good instrument for GDP growth, namely it is a) relevant, i.e. correlated with the instrumented variable (GDP growth), and b) uncorrelated with the error term, i.e. it only affects public expenditure through the effect that it has on GDP growth. Regarding the relevance of the adopted instrument, we perform a series of empirical test to examine such hypothesis and its strength. Conversely, the Sargan-Hansen tests of overidentifying restrictions, which verify whether the instruments are uncorrelated with the error term, cannot be used when the equation is exactly identified, like it is in our case. The arguments in favor of the validity of the exclusion restriction are then mainly theoretical than empirical and are largely based on the considerations provided by Galí and Perotti (2003) and Panizza and Jaimovich (2007), who reasonably notice how "it is hard to think that the external shock may have a *direct* effect (i.e., an effect not mediated by any other variable) on expenditure growth and, hence, this should not be a source of concern" (p.15). Conversely, one could argue that an *indirect* effect of an external shock on spending decisions may occur if it affects budget constraints by influencing trade volumes and, consequently, revenues from taxes on international trade. However, this effect is unlikely to be contemporaneous, especially in the case of public investment which, as already discussed, is the outcome of prolonged decisions that can take years to be realized. Moreover, over the analyzed period, taxes on international trade represented a negligible share of total revenues for most European countries [16] and, as such, the described indirect effect of the external shock on investment decisions is highly improbable.

For each country, the weights for export partners' economic growth are represented by the relative importance of exports in GDP and the share of exports to trading partners. Even when two countries i and j are main trading partners to each other, Panizza and Jaimovich (2007) show that the shock in country *j* can be considered exogenous because, when it feeds back again to country j, it is a minuscule fraction of the original shock that is mediated by the effect that it has on country *i* and the respective trade weights.

In a similar vein, given that the United States is the largest partner for EU exports of goods (18.3 % in 2020), we use its weighted economic growth to calculate the exogenous shock to country *i*'s GDP growth, which is defined as:

$$SHOCK_{i,t} = \frac{EXP_i}{GDP_i} * s_{i,t-1} * GDPGR_{US,t} \quad [5]$$

[16] See the WB data here: https://data.worldbank.org/indicator/GC.TAX.INTT.RV.ZS?locations=EU (accessed on 11/25/2021), based on the IMF Government Finance Statistics Yearbooks .

where $\frac{EXP_i}{GDP_i}$ represents country *i*'s average exports of goods (as a share of GDP) [17], *s* is the share of exports of goods from country *i* to the US, and $GDPGR_{US,t}$ measures GDP growth in the US. Data on exports to the US are taken from the Direction of Trade Statistics (DOTS) published by IMF, while exports expressed as a share of GDP and US GDP growth are drawn from WDI (World Bank).

Consistently with Equation 1, the shock is then used as the instrument of country *i*'s economic growth, $\Delta y_{i,t}$, to estimate the following 2SLS-IV model with robust standard errors and country and time fixed effects:

$$I_{i,t}^{g} = \alpha_i + \delta_t + \beta\, \Delta y_{i,t} + \sum_k^K \gamma_k X_{k,it} + \varepsilon_{it} \qquad [6]$$

where $X_{k,it}$ represents a set of control variables based on Panizza and Jaimovich (2007). Initially only the change in GDP is considered as regressor (Model A) ,and then the lag of the rate of growth of public investment and, additionally, the fiscal deficit over GDP at time t-1 (respectively Models B and C) are progressively introduced as control variables [18].

Table 1 reports the estimated coefficient for GDP growth (full results available upon request), that in none of the models turns out to be significant at the 5 percent level. The relevance of the instrument was examined by the Kleibergen-Paap (2006) rk LM statistic, which rejects the null hypothesis that the models are underidentified at the 2 percent level and confirms that the adopted instrument is relevant. The strength of the instrument was instead verified through the Kleibergen-Paap (2006) rk Wald F statistic [19], which was compared to the critical values from Stock and Yogo (2005) testing the null hypothesis that the maximum size distortion was greater than 10, 15, 20 or 25%. The values of Kleibergen-Paap Wald rk F statistic, mostly below the corresponding Stock and Yogo critical values in the three models, suggest that the instrument is only weakly correlated to the endogenous regressor and this may affect the estimation of confidence intervals and the level of statistical significance for β. In order to avoid such a problem, the significance of the endogenous variable is further checked through the Anderson-Rubin (1949) test, which provides weak-instrument robust inference for testing the significance of the endogenous regressor (Keane and Neal, 2021). Also in this case, the estimated coefficient for GDP growth is not found to be significantly different from 0 at the 5 percent level across the three models. As a further robustness check , the three equations are also estimated through Fuller's modified limited-information maximum likelihood (LIML) estimator (Fuller, 1977), which is more robust than 2SLS-IV in presence of weak instruments and minimize the maximum relative bias (Stock and Yogo, 2005). Again, the estimated coefficients for GDP growth do not turn to be statistically significant. It is worth mentioning that the coefficient of the instrument in the first-stage regression (around 0.0002 in all the three models) is small and this reassures about the negligible feedback that the

[17] A time-invariant measure of exports (as a share of GDP) is used to avoid that it is affected by domestic factors such as real exchange rate fluctuations (Panizza and Jaimovich, 2007).
[18] For the sake of coherence with Equation 1, the fiscal variable $I_{i,t}^{g}$ is expressed by multiplying the rate of growth of public investment by I/Y. In any case, results do not substantially change when this transformation is not applied.
[19] The Kleibergen-Paap (2006) rk Wald F statistic has to be preferred to the Cragg-Donald Wald F statistic when heteroskedasticity-robust standard errors are used.

shock may have to the US and, then, about the exogeneity of the instrument itself with respect to the endogenous regressor, as analogously proven by Panizza and Jaimovich (2007) [20].

Along with the arguments and findings of previous literature (Beetsma et al., 2009; Born and Muller, 2012; Deleidi et al., 2020), such results seem to provide evidence in favor of the exogeneity of the growth rate of public investment to contemporaneous changes in GDP. The exogeneity of the rate of growth of public investment is confirmed also when Equation 6 is alternatively estimated for public investment by each function of government. Only in the case of public investment for housing and community amenities the estimation of Equation 6 detects a significant, although very small (0.03), coefficient for GDP growth, which suggests caution in the interpretation of the corresponding results in terms of causality.

4. Results

The estimated cumulative multipliers for total public investment (Model 1) and its components (Models 2a and 2b) are reported in Table 2, while the corresponding dynamic multipliers (i.e. the estimated coefficients β^h) are plotted in Figure 1 when statistically significant. Although slightly lower, the size of multipliers for total public investment is analogous to that estimated by Deledi et al. (2020 and 2021a) [21], with a value larger than one after the first year. When public investment is broken down, it emerges that the largest and most statistically significant multiplicative effect on GDP occurs when the investment goes into education, public order and safety, general public services (also comprising basic R&D and the operability of public institutions) and, at a lesser but notable extent, economic affairs (which includes transport and communication) as well as housing and community amenities (as represented in Figure 1). Conversely, no significant effect results from the other components of public investment, apart from a contemporaneous (h=0) but not always statistically significant GDP reaction to investment in health and environmental protection. Only the multiplier for defense investment turns out to be significant after h=3, with a negative sign. This may appear in contrast to the findings of previous literature, which shows that military spending produces a positive and large effect on GDP (among others, Burriel et al., 2010; Auerbach and Gorodnichenko, 2012; Deleidi and Mazzucato, 2021), and may be due to a series of differences in the scope of the analysis. First, most of such findings are based on historical series of the US economy, where Burriel et al. (2010) show an important and persistent role of military expenses as opposed to European economies. Second, while previous studies analyze military total spending, only Deleidi and Mazzucato (2021) focus on investment, more specifically on defense government gross investment in research and development; on the contrary, our analysis considers total public investment in defense, which also encompasses other items, like foreign military aid, which are not necessarily growth-

[20] The feedback, indeed, is given by the original shock multiplied by 0.0002 and the respective export weights, that yields an insignificant fraction of the original shock. This is based on the realistic assumption that the coefficient of country i' s weighted economic growth to US economic growth is equal or smaller than 0.0002, i.e. that US economic growth influences growth in each European country more than vice versa.

[21] The period analyzed in Deleidi et al. (2020) is 1970-2016.

enhancing. Third, our analysis refers to most recent years, where probably fiscal policies aimed at producing societal and institutional changes turn out to be more relevant that military spending, as it conversely was in the Cold War period (Deleidi and Mazzucato, 2021). This said, it should be noticed that our findings are not completely dissimilar to those by Auerbach and Gorodnichenko (2012), where the multiplier of defense spending resulted to be negative after few quarters, while it remained always positive for nondefense spending.

The robustness of previous findings is then verified through the use of alternative specifications and sampling. Given the large number of estimates due to the breakdown of public investment in the ten categories, results of robustness analysis are represented in the graphs only when statistically significant and relevant, while full results are available upon request. First of all, we check the sensitivity of results when the ten categories of public investment by functions enter the regression jointly. Although this may multiply multicollinearity problems and partially reduces the number of observations, such categories are part of the same package of public investment and it is important to check how estimates are affected when their joint effect is analyzed. In this case, the positive and statistically significant multipliers are confirmed for public investment in economic affairs, education and general public services [22] (as represented in Figure 2), while the multipliers of investment in defense, housing and community amenities, public order and safety completely lose their original statistical significance; statistically insignificant multipliers are found again for the remaining categories. In addition, a Wald test is performed to verify whether there is a statistically significant difference between the estimated multipliers of the three categories of investment that were found to have a significant effect (economic affairs, education and general public services). Results are reported in Table 3. While the estimated multipliers always significantly vary when investment in economic affairs is compared to investment in education and general public services, no statistically significant difference emerges between the multipliers of investment in education and investment in general public services. However this is not surprising, as the two estimated values were very close to each other over all the considered horizons [23].

We then test the robustness of results by introducing the set of control variables to the original specification (Equations 3 and 4), initially comprising the real effective exchange rate, the long-term interest rate and the current account balance as a percentage of GDP and, then, also including inflation and taxes [24]. In this case, however, the original sample is reduced to 26 countries because of a lower data availability. The statistical significance and relative magnitude of multipliers for total public investment and for public investment in economic affairs, education and general public services are confirmed again (as reported in Figure 3), with the multiplier for

[22] The multipliers of public investment in education and general public services are largely significant (5 percent level) across all the horizons, while the multiplier of public investment in economic affairs slightly loses its statistical significance at h=2,3,4.

[23] Analogous tests have been performed to verify whether the estimated multipliers of the three categories of investment significantly differ from the estimated multipliers of total public investment. The difference in multipliers is found to be always significantly different from zero apart from general public services at horizons 5 and 6.

[24] The control variables enter the regression as contemporaneous to public investment, as illustrated in Equations 3 and 4, but results are not significantly altered when they are taken at *t+h*, i.e. as contemporaneous to the dependent variable. Analogous results are found when the average tax rate is substituted by the growth rate of real taxes.

investment in economic affairs progressively losing its significance (no longer significant at 10 percent level after h=3). In addition, also the multipliers for public investment in public order and safety and in recreation, culture and religion turn out to be significant but only at some horizons, probably due to the slightly different sample rather than because of the effect of the control variables. When the regressions are run in the same sample of 26 countries without the inclusion of the control variables (Equations 1 and 2), indeed, such findings are confirmed. This suggests that original results (Table 2) may be sensitive to the use of different samples and, therefore, it is worth verifying their robustness by using random re-sampling. For this purpose, we employ the bootstrapping technique, which iteratively resamples the dataset with replacements, drawing alternative random samples from the original data, and yields average estimates from multiple regressions. After bootstrapping, results of Table 2 are completely validated in terms of statistical significance and relative magnitude of multipliers (in this case the results, available upon request, are not reported because highly redundant with those shown in Table 2) [25].

To sum up, the first findings and the subsequent robustness checks reveal: a) a persistent and robust multiplicative effect of public investment on GDP when it is allocated in economic affairs, education and general public services, with the last two functions showing the largest multipliers; b) a variable level of statistical significance for the multipliers of public investment allocated in some of the other functions across different specifications and samples (like for defense, public order and safety, and housing and community amenities). The variable level of statistical significance for some categories of investment may be partially due to the existence of different growth regimes (low-growth and high-growth), whose effect on estimates appears when specific observations, strongly belonging to a growth regime, are excluded from the sample, as it may have happened in the above robustness checks without however emerging in average estimates obtained by bootstrapping. Previous literature on fiscal multipliers, indeed, has extensively proven that the multiplicative effect of fiscal policy tends to be higher and more statistically significant in periods of low-growth and recession (Auerbach and Gorodnichenko, 2012 and 2013; IMF, 2014; Arin et al., 2015; Fazzari et al., 2015; Abiad et al., 2016; Alichi et al., 2019; Deleidi et al., 2020 and 2021a; Petrović et al., 2021).

As a further step, then, we verify how results change across periods characterized by different growth regimes. Following Mencinger et al. (2017), Deleidi et al. (2020 and 2021a) and Petrović et al. (2021), the two states of the economy, high- and low-growth, are represented by splitting the dataset into two different sub-periods, where the Great Recession is used as the breaking point. The two sub-periods, 1995-2007 and 2008-2019, have been indeed characterized by highly diverse average growth rates (3.8 per cent in 1995-2007 and 0.7 per cent in 2008-2015, with a partial recovery over the last few years). While this strategy does not capture non-linearities in state-dependent multipliers, it allows to compare our results to those of the above-mentioned works while extending the scope to different categories of public investment. As expected and shown in Figure 4, over the low-growth sub-period larger and more statistically significant multipliers are

[25] In this case, also the multipliers for public investment in environmental protection and health gain some slight discontinuous statistically significance.

found for total public investment and for the three most robustly performing sectors (economic affairs, education and general public services). Moreover, in the sub-period characterized by lower growth, statistically significant and higher multipliers are clearly detected also for public investment in public order and safety and in health. A similar effect is observed for defense investment, although results for the second sub-period are not statistically significant, while more ambiguous results emerge for investment in housing and community amenities, whose multipliers appear significantly larger under the period of slowdown but only at some horizons; however, in the latter case, estimates may be affected by a certain degree of reverse causality, as proven in Section 3.3, and then cannot be univocally interpreted. Conversely, the remaining categories of investment continue not to show any persisting significant effect over both sub-periods (and for this reason the related results are not reported in the graphs but are available upon request). However, by performing a series of Wald tests, we find that the difference in multipliers between the two sub-periods is not always significantly different from zero. This suggests that the main contrast between the two sub-periods is mainly based on more statistically significant effects found in the low-growth sub-period, while robust conclusions cannot be drawn on the difference in the magnitude of multipliers. Analogous results also emerged if the second sub-period was limited to 2008-2015 in order to exclude the last years of partial recovery.

Finally, we verify whether results for total investment are robust when the fiscal shock is defined by using an alternative strategy. The aim of fiscal shock identification, in fact, is twice (Abiad et al., 2016): a) it allows to reduce the likelihood that the estimates reflect the potentially endogenous response of fiscal policy to business cycle conditions; b) it captures the effects of unanticipated fiscal changes isolating them from the anticipated component. While we solved (a) by excluding the endogeneity of public investment to contemporaneous changes in GDP (see Section 3.3), point (b) deserves further checks. To this end, we take inspiration from Corsetti et al. (2012), IMF (2014), Deleidi et al. (2021a) who, in line with Blanchard and Perotti (2002), define the shock as that part of the fiscal variable not explained by its lag and other lagged control variables. In other words, based on the idea that a part of public investment is determined by past information and shapes expectations, an underlying fiscal policy rule is estimated and, from this, a series of exogenous shocks are obtained (IMF, 2014). For this purpose, we re-estimate Equation 6 (Model C) by substituting the contemporaneous change in GDP with its lag and, then, the corresponding residuals are used in Model 1 to represent the shock in total investment [26]. Results are reported in Table 4 and confirm previous findings on total investment, when, in line with Sheremirov and Spirovska (2015), Attinasi and Klemm (2016), Deleidi et al. (2020), Petrovic et al. (2021), the fiscal shock was identified by the difference between actual investment and an investment benchmark, i.e. the previous year's investment. This also holds when the multipliers are estimated separately for the two high- and low-growth sub-periods.

[26] The model takes the following form: $I^{g}_{i,t} = \alpha_i + \delta_t + \beta\, \Delta y_{i,t-1} + \gamma I^{g}_{i,t-1} + \vartheta def_{i,t-1} + \varepsilon_{it}$, with ε_{it} representing the fiscal shock. As contemporaneous changes in GDP have been proven to be not statistically significant in Section 3.3, the forecasts at time *t-1* for next year's GDP growth have not been included in the equation. The equation has been estimated through fixed-effects models.

While this robustness check is performed for total investment, we assume that the decisions on allocation of public investment by function follow more complicate fiscal and, especially, political rules that are more difficult to model and anticipate. This also means, in fact, that the unanticipated component would be much higher for investments by function than for total investment and that the bias of the corresponding estimates is likely to be even smaller than that demonstrated in the case of total investment.

5. Concluding remarks

The present paper has estimated the multipliers of ten categories of public investment, classified according to the respective functions of government, and has verified the robustness of results under different specifications, samples and sub-periods. From the results, three main conclusions emerge. First, total public investment is confirmed to have a persistent and robust multiplicative effect on GDP, in line with the findings of previous literature (Auerbach and Gorodnichenko, 2012; IMF, 2014; Abiad et al., 2016; Masten and Grdović, 2019; Deleidi et al., 2020 and 2021a; Petrović et al., 2021). In particular, the persistent outcome corroborates previous findings of some recent investigations (Fatas and Summers, 2018; Deleidi et al., 2021a). So, an important policy implication is not only that fiscal consolidations implemented in many countries – especially in the EU at the time of the sovereign debt crisis – are misplaced, but also that a spur of public investment (like the one promoted by the EU institutions in 2020 through the "Next Generation EU" plan) is a fundamental strategy to sustain the economy.

Second, the multiplicative effect of public investment on GDP is particularly strong when public resources are invested in specific functions of government and, above all, in economic affairs, education and general public services, with the last two functions showing the largest multipliers. Third, under the sub-period characterized by low-growth, multipliers of public investments are generally more statistically significant and, moreover, significant multiplicative effects take place also when resources are invested in other functions of government such as the promotion of health and of public order and safety. These results seem to suggest that investments are particularly effective in fostering economic growth when they support the creation of human capital and the functioning of economic affairs and general public services, which also include basic R&D and the operability of public institutions. While the role of human capital, institutions and R&D in sustaining economic growth is indeed well documented (for a review of relevant literature, see respectively Ogbeifun and Shobande, 2021; Bernardelli et al., 2021; Deleidi and Mazzucato, 2021), economic affairs are directly related to total factor productivity, which is an essential component of economic growth (Carbonari et al., 2013 showed the permanent impact on GDP of an increase in public sector's productivity).

The findings presented in the paper give rise to the need for further investigation. First of all, future research should improve in the identification of unanticipated variations in the allocation of public investment by functions of government. Second, while we based our findings on linear models, the analysis should be extended by modeling state-dependent non-linearities and testing

if multipliers significantly vary across different growth regimes. In addition, it should be emphasized that the approach used here only captures the quantitative impact of public investment on GDP growth without any considerations about the qualitative impact in terms of sustainability of the development path. With the definition of the Sustainable Development Goals and the ratification of the Agenda 2030 (UN, 2015) by 193 UN Member States, development has been recognized as a multifaceted global goal, of which economic growth is only a part. In future research, then, it would be crucial to extend the investigation to the effects that the various categories of public investment exert on other macroeconomic variables (like unemployment and public debt) as well as on the social and environmental targets mentioned in the Agenda 2030. The fact that our data do not show significant and persistent multiplicative effects for public investments in environmental and social protection does not mean, in fact, that governments should not invest there, as they have been recognized as central functions in paving the way towards the SDGs also by European and advanced countries (OECD, 2016; European Commission, 2020). Moreover, all kinds of investment, in any category, should respect the principle "do no significant harm", as spelled out by the EU Commission in the "Next Generation EU" guidelines; a pervasive and horizontal approach should also be followed in relation to the need to fully exploit the potential of the digital economy. Finally, it would be important to assess also the (positive or negative) interactions that may take place between different categories of public investments, as they are part of a same package of fiscal policy and an integrated approach may shed further light on their effects on economic growth and other goals of public interest.

References

Abiad A., Furceri D., Topalova P. (2016), The macroeconomic effects of public investment: Evidence from advanced economies, *Journal of Macroeconomics*, 50(C), 224-240.

Alesina A,, Barbiero O., Favero C., Giavazzi F., Paradisi M.(2015a), Austerity in 2009-2013. *NBER Working Paper* No. 20827.

Alesina, A. , Favero, C. , Giavazzi, F. (2015b), The output effect of fiscal consolidation plans. *Journal of International Economics*, 96.

Alichi A., Shibata I., Tanyeri K. (2019), Fiscal policy multipliers in small states. *IMF Working. Paper* No. 19/72.

Amendola A., Di Serio M., Fragetta M. (2020), The euro-area government spending multiplier at the effective lower bound. *European Economic Review*, 127, 103480.

Anderson T. W., Rubin H. (1949), Estimation of the parameters of a single equation in a complete system of stochastic equations. *Annals of Mathematical Statistics*, 20 (1), 46–63.

Arin K.P., Koray F., Spagnolo N. (2015), Fiscal multipliers in good times and bad times. *Journal of Macroeconomics*, 44(C), 303-311.

Arltová M., Fedorová D. (2016), Selection of unit root test on the basis of length of the time series and value of AR (1) parameter. *Statistika*, 96(3), 47-64.

Attinasi M.G., Klemm A. (2016). The growth impact of discretionary fiscal policy measures. Journal of Macroeconomics, 49, 265–279.

Auerbach A. J., Gorodnichenko Y. (2017), Fiscal Stimulus and Fiscal Sustainability. *NBER Working Paper No. 23789*.

Auerbach A., Gorodnichenko Y. (2013), Fiscal Multipliers in Recession and Expansion. In *Fiscal Policy after the Financial Crisis*, edited by Alesina A. and Giavazzi F., 63–98. Chicago: Univ. Chicago Press.

Auerbach A.J., Gorodnichenko Y. (2012), Measuring the Output Responses to Fiscal Policy. *American Economic Journal: Economic Policy*, 4 (2), 1–27.

Beetsma R., Giuliodori M., Klaassen F. (2009), Temporal aggregation and SVAR identification, with an application to fiscal policy. *Economics Letters*, 105(3), 253–255 .

Bernardelli M., Prochniak M., Witkowski B. (2021), Time stability of the impact of institutions on economic growth and real convergence of the EU countries: implications from the hidden Markov models analysis. Equilibrium. Quarterly Journal of Economics and Economic Policy, Institute of Economic Research, 16(2), 285-323.

Blanchard O.J., Leigh D. (2013), Growth Forecast Errors and Fiscal Multipliers. *American Economic Review*, 103, 3.

Blanchard O., Perotti R. (2002), An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output. *Quarterly Journal of Economics*, 117(4), 1329–68.

Born B., Muller G.J. (2012), Government spending shocks in quarterly and annual time-series. *Journal of Money, Credit and Banking*, 44, 507–517.

Burriel P., De Castro F., Garrote D., Gordo E., Paredes J., Perez J.J. (2010). Fiscal Policy shocks in the euro area and the US: an empirical assessment. Fiscal Studies, 31 (2), 251–285.

Callegari G., Melina G., Batini N. (2012), Successful Austerity in the United States, Europe and Japan. *IMF Working Papers* 2012/190, International Monetary Fund.

Carbonari L., Felli E.L., Gerli M. e Tria G. (2013), Public Sector's Productivity and Macroeconomic Performance: The Case of the Italian Public Administration Reform. *International Journal of Public Policy*, 9 (4-6), 306–334.

Castelnuovo E, Lim G. (2019), What Do We Know about the Macroeconomic Effects of Fiscal policy? : A Brief Survey of the Literature on Fiscal Multipliers. *Australian Economic Review*, 52(1), 78–93.

Cerniglia F. and Saraceno F. (2020) (Eds.), *A European Public Investment Outlook*, Open Book Publishers.

Christiano L., Eichenbaum M., Rebelo S. (2011), When is the Government Spending Multiplier Large? *Journal of Political Economy*, 119(1), 78-121.

Corsetti G., Meier A., Müller G. J., Devereux M. B. (2012). What determines government spending multipliers? *Economic Policy*, *27*(72), 521–565.

David M.A. (2017), Fiscal policy effectiveness in a small open economy: estimates of tax and spending multipliers in Paraguay. IMF Working Paper, WP/17/63.

De Grauwe P., Ji Y. (2016), How to reboot the Eurozone and ensure its long-term survival, in Baldwin R., Giavazzi F. (eds), *How to fix Europe's monetary union: Views of leading economists*, VoxEU eBook, London, CEPR Press, 2016.

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

Deleidi M., Iafrate F., Levrero E. (2021a). Government investment fiscal multipliers: Evidence from Euro-area countries. *Macroeconomic Dynamics,* 1-19.

Deleidi M., Mazzucato M. (2021). Directed innovation policies and the supermultiplier: An empirical assessment of mission-oriented policies in the US economy. Research Policy, 50(2), 104151.

Deleidi M., Romaniello D., Tosi F. (2021b). Quantifying fiscal multipliers in Italy: A Panel SVAR analysis using regional data. *Papers in Regional Science*, 100(5), 1158– 1177.

Della Posta P., Marelli E., Signorelli M. (2019), An immediate solution for the euro area crisis: A Grand European Investment Plan, in Paganetto, L. (ed.), *Yearning for Inclusive Growth and Development, Good Jobs and Sustainability*, Springer, pages 113-135.

Della Posta P., Marelli E., Signorelli M. (2020), A market-financed and growth-enhancing investment plan for the euro area. *Metroeconomica*, 71(3), 604-632.

DeLong J.B., Summers L.H. (2012), Fiscal policy in a depressed economy. Brook. Pap. Econ. Act. 233–297.

Dickey D.A., Fuller W.A. (1979), Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Stat. Association*, 74, 427‑431.

Di Serio M., Fragetta M., Melina G. (2021), The Impact of *r-g* on the Euro-Area Government Spending Multiplier. *IMF Working Paper*, WP/21/39, February

European Commission (2020), *Investing in and for the Sustainable Development Goals*. Brussels.

EC, European Commission (2012), *Blueprint for a Deep and Genuine EMU*.

EUROSTAT (2019), *Manual on sources and methods for the compilation of COFOG statistics*. European Union, Luxembourg.

Fatas A., Summers L. (2018), The permanent effects of fiscal consolidations. Journal of International Economics, 112(C), 238-250.

Fazzari S.M., Morley J., Panovska I. (2015), State-dependent effects of fiscal policy. *Studies in Nonlinear Dynamics & Econometrics*, De Gruyter, 19(3), 285-315.

Fuller, W.A. (1977), Some Properties of a Modification of the Limited Information Estimator. *Econometrica*, 45, 939-953.

Gechert S. (2015), What fiscal policy is most effective? A meta-regression analysis. *Oxford Economic Papers*, 67 (3), 553–570.

Gechert S., Rannenberg A. (2014), Are Fiscal Multipliers Regime Dependent? A Meta Regression Analysis. *IMF Working paper*, No. 139.

Giavazzi F., Pagano M. (1990), Can severe fiscal contractions be expansionary? Tales of two small European countries. *NBER Macroeconomics Annual*, Cambridge (Mass.) and Londra: MIT Press, 75-111.

Giavazzi F., Pagano M. (1996), Non-Keynesian effects of fiscal policy changes: international evidence and the Swedish experience. *Swedish Economic Policy Review*, 3, 67-103.

Ilzetzki E., Mendoza E.G., Végh C.A. (2013). How big (small?) are fiscal multipliers? *Journal of Monetary Economics,* 60 (2), 239–254.

IMF, International Monetary Fund (2012), *World Economic Outlook: Coping with High Debt and Sluggish Growth*, October

IMF (2014), Legacies, clouds, uncertainties. In *World economic outlook*. IMF. October 2014.

IMF (2021), *World Economic Outlook: Managing Divergent Recoveries*. April, Washington, DC.

Jordà O. (2005), Estimation and Inference of Impulse Responses by Local Projections. *American Economic Review*, 95(1), 161-182. *a Liberal*, July 7.

Kleibergen F., Paap R. (2006), Generalized reduced rank tests using the singular value decomposition. Journal of Econometrics, 133(1), 97-126.

Keane M.P., Neal T. (2021), *A Practical Guide to Weak Instruments*. UNSW Economics Working Paper No. 2021-05c, Available at SSRN: https://ssrn.com/abstract=3846841 or http://dx.doi.org/10.2139/ssrn.3846841

Marelli E., Signorelli M. (2017), *Europe and the Euro. Integration, Crisis and Policies*, London and NewYork, Palgrave/Springer

Masten I., Grdović G.A. (2019), Macroeconomic effects of public investment in South-East Europe. *Journal of Policy Modeling*, 41(6), 1179-1194.

Mencinger J., Aristovnik A., Verbic M. (2017), Asymmetric effects of fiscal policy in EU and OECD countries. *Economic Modelling*, 61(C), 448–461.

Nyasha S., Odhiambo N.M. (2019), Government Size and Economic Growth: A Review of International Literature. SAGE Open, 9(3), pages 21582440198, September.

OECD (2016), Better Policies for 2030: An OECD Action Plan on the Sustainable Development Goals. Available at https://www.oecd.org/dac/Better%20Policies%20for%202030.pdf.

Ogbeifun L, Shobande O.A. (2021), A reevaluation of human capital accumulation and economic growth in OECD. Journal of Public Affairs, e02602.

Panizza U.and Jaimovich D. (2007), Procyclicality or Reverse Causality? (No. 4508). Inter-American Development Bank, Research Department.

Perotti R. (2004), Public investment: another (different) look. Institutional Members: CEPR, NBER e Università Bocconi, Working Paper n. 277.

Petrović P., Arsić M., Nojković A. (2021), Increasing public investment can be an effective policy in bad times: Evidence from emerging EU economies. *Economic Modelling*, 94(C), 580-597.

Phillips P.C.B., Perron P. (1988), Testing for a unit root in a time series regression. *Biometrika*, 75(2), 335‑346.

Portes J. (2012), Self-defeating Austerity. *Social Europe Journal*, 31 October.

Ramey V.A. (2011), Identifying Government Spending Shocks: It's All in the Timing. *Quarterly Journal of Economics*, 126 (1): 1–50.

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.

Sheremirov V., Spirovska S. (2015). Output response to government spending: evidence from new international military spending data. *FRB of Boston Working Paper No. 15–9*.

Stock J., Yogo M. (2005), Testing for weak instruments in linear IV regression. Identification and inference for econometric models: Essays in honor of Thomas Rothenberg, 80 (4.2), 1.

UN (2015), *Transforming our world: the 2030 Agenda for Sustainable Development*. Resolution adopted by the General Assembly (A/RES/70/1), 25 September.

Tables and figures

Table 1. Coefficient of GDP growth with public investment as dep. variable (2SLS-IV)

	Model A	Model B	Model C
GDP growth	0.1441 (1.26)	0.1750 (1.29)	0.2151 (1.44)
N of countries	31	31	31
Obs.	704	703	662
Kleibergen-Paap rk LM statistic	6.19 **	5.14**	5.02**
Kleibergen-Paap Wald rk F statistic	5.26	4.30	5.59
Anderson-Rubin Wald F statistic (p-value) for the coeff. of GDP growth	0.188	0.164	0.098
GDP growth coeff. with Fuller's modified LIML estimator	0.1353 (1.37)	0.1600 (1.43)	0.1954 (1.59)

Note: Note: *** p<0.01, ** p<0.02, * p<0.05.Robust z statistics in parenthesis. The Stock and Yogo critical values for the Kleibergen-Paap rk Wald F statistic vary between 5.53 and 16.38, indicating that the regressions may suffer from a weak instrument problem. The p-values of the Anderson-Rubin Wald F statistic are robust to weak instruments for testing the significance of the endogenous regressor. In Fuller's modified LIML estimator, the parameter alpha has been set = 1 as it has been proven to be a good choice (Stock and Yogo, 2005).

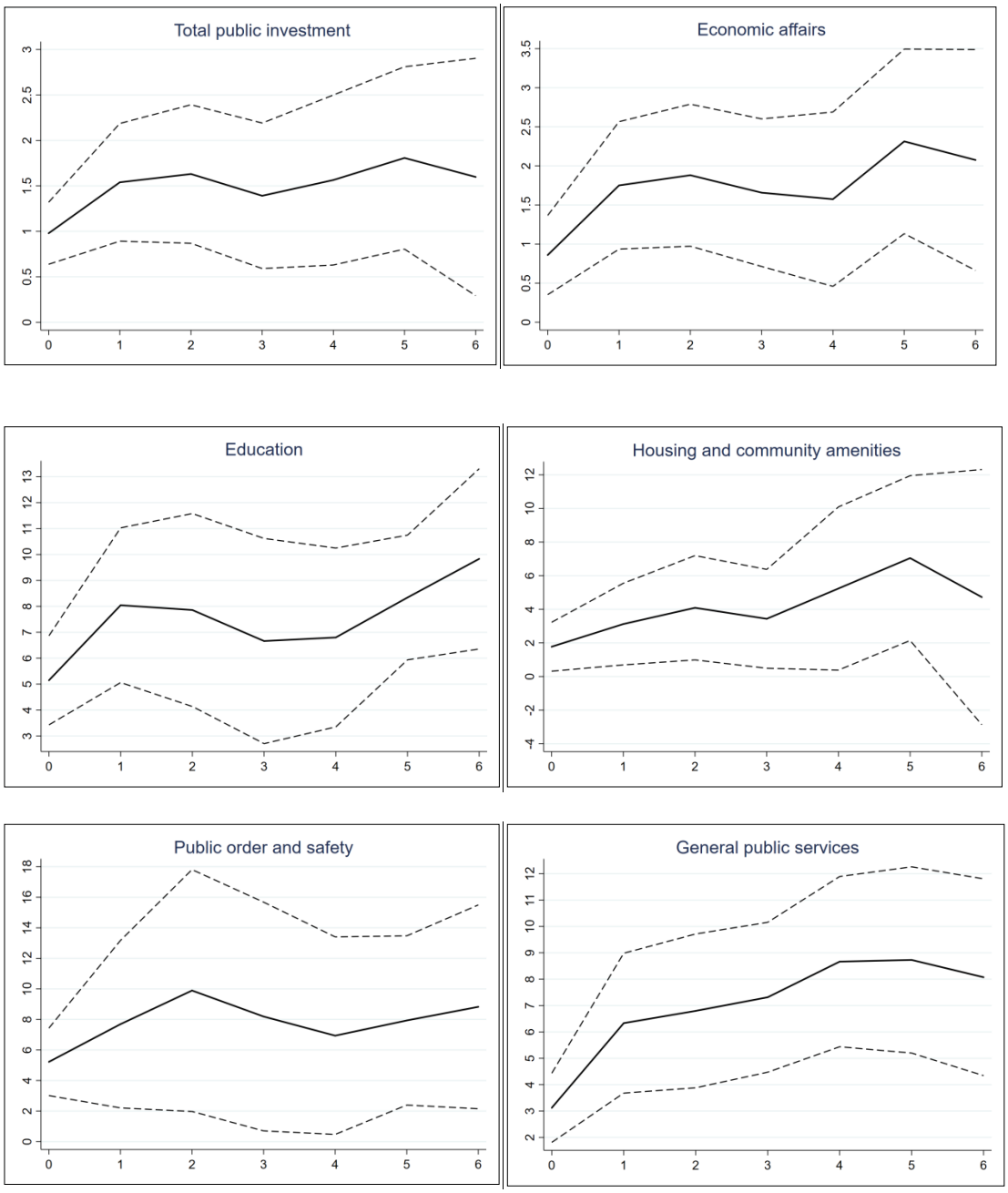
Table 2. Public investment cumulative multipliers by functions of government

	0	1	2	3	4	5	6
Total investment (Model 1)	0.979 ***	1.379 ***	1.673 ***	1.805 ***	1.925 ***	2.008 ***	2.056 *
Economic affairs							
Model 2a	0.859 ***	1.442 ***	1.857 ***	2.042 ***	2.097 *	2.261 ***	2.336 **
Model 2b	0.907 ***	1.483 ***	1.897 ***	2.079 ***	2.131 **	2.291 ***	2.362 **
Recreation, culture and religion							
Model 2a	0.855	1.444	2.331	2.911	2.884	3.045	3.000
Model 2b	1.012	1.724	2.662	3.292	3.316	3.485	3.384
Defense							
Model 2a	-0.066	-0.221	-0.512	-0.949	-1.519 ***	-1.961 ***	- 2.307 ***
Model 2b	-0.068	-0.222	-0.512	-0.950 ***	-1.520 ***	-1.957 ***	-2.302 ***
Education							
Model 2a	5.147 ***	7.139 ***	8.380 ***	9.171 *	9.978 *	10.966 ***	11.782 ***
Model 2b	5.133 ***	7.127 ***	8.387 ***	9.180 ***	9.968 ***	10.947 ***	11.767 ***
Environmental protection							
Model 2a	1.376	2.134	2.848	3.256	4.324	4.862	4.793
Model 2b	1.361*	2.116	2.832	3.245	4.327	4.898	4.877
Health							
Model 2a	1.836 *	2.066	1.700	1.008	0.403	0.429	0.688
Model 2b	1.728	1.946	1.584	0.940	0.385	0.449	0.753
Housing and community amenities							
Model 2a	1.772 **	3.481 **	5.011 **	5.845 *	7.169 *	9.055 **	9.030
Model 2b	1.683 *	3.350 **	4.888 **	5.723 *	7.074 *	9.043 ***	9.149
Public order and safety							
Model 2a	5.220 ***	9.352 **	12.964 **	15.295 *	16.023 *	17.387 **	18.332 **
Model 2b	5.353 ***	9.587 **	13.234 **	15.600 *	16.386 *	17.811 **	18.737 **
General public services							
Model 2a	3.122 ***	5.470 ***	6.899 ***	7.670 ***	8.943 ***	9.875 ***	10.461 ***
Model 2b	3.173 ***	5.538 ***	6.983 ***	7.750 ***	9.008 ***	9.927 ***	10.515 ***
Social protection							
Model 2a	0.362	0.606	0.600	0.570	0.359	-0.219	-0.860

Model 2b	0.428	0.722	0.709	0.668	0.453	-0.150	-0.824

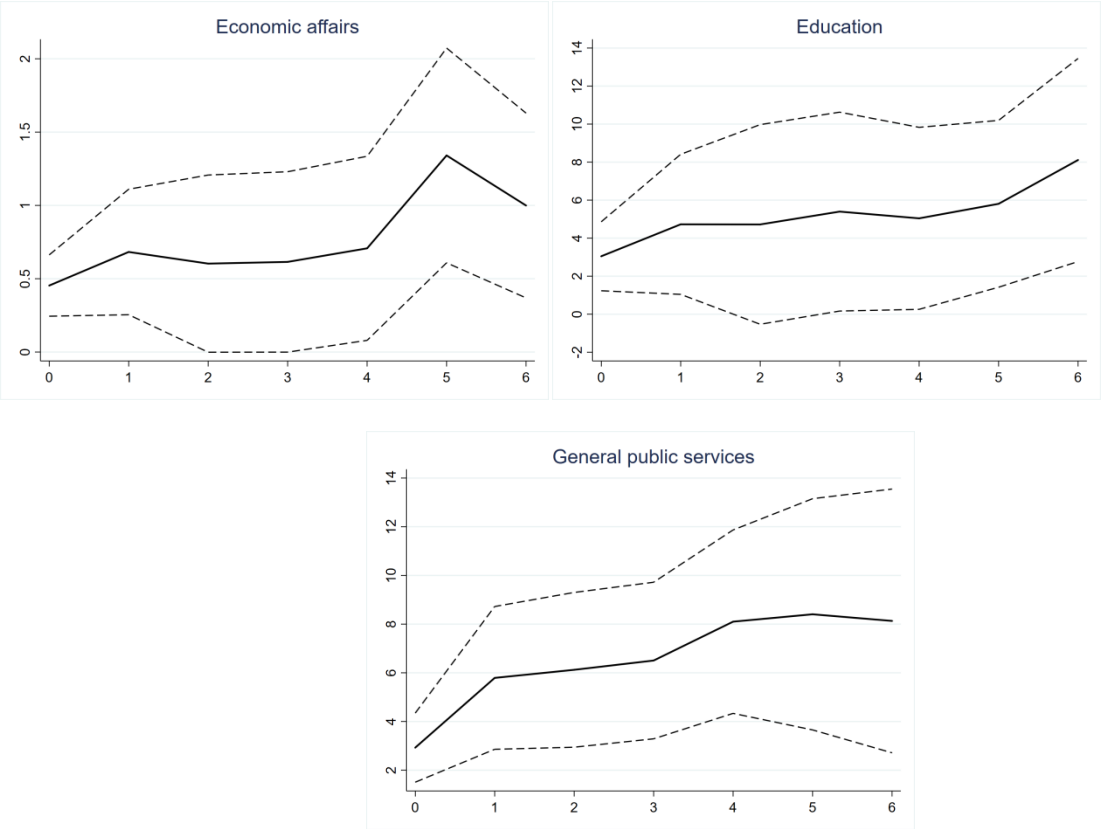
Note: *** p<0.01, ** p<0.05, * p<0.10.

Figure 1. Public investment multipliers



Note: Dashed lines denote the 95 percent confidence interval. Public investment multipliers are given by the estimated coefficients β^h, while the corresponding cumulative multipliers are reported in Table 2.

Figure 2. Robustness check: Multipliers of public investments by functions when their effect is jointly estimated



Note: Public investment multipliers are given by the estimated coefficients β^h. Dashed lines denote the 95 and 67 percent confidence interval for the first two and the third graphs respectively. Graphs are reported only for those functions of government whose respective results were confirmed. Full results are available upon request.

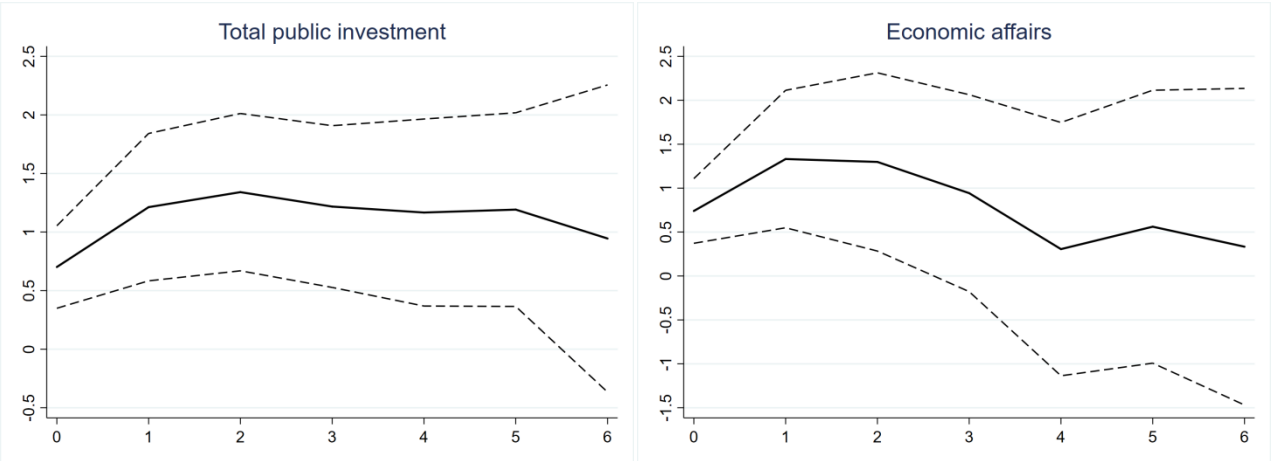
Table 3. Testing the difference between estimated multipliers for economic affairs, education, and general public services at different horizons (F values).

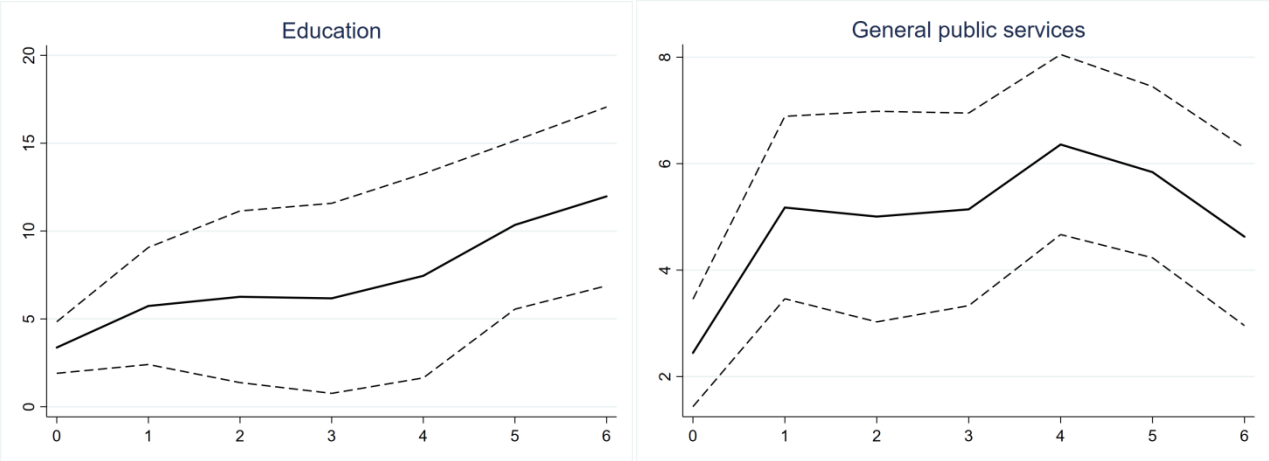
	0	1	2	3	4	5	6
H_0 a	9.53***	6.81**	3.07*	3.79*	3.68*	4.26**	8.00***
H_0 b	11.96***	10.95***	9.24***	12.03***	12.81***	7.17**	6.64**

H_0 c	0.02	0.26	0.23	0.14	1.13	0.92	0.00

Note: *** p<0.01, ** p<0.05, * p<0.10. H0 a: no difference between the estimated multiplier for public investment in economic affairs and the estimated multiplier for public investment in education. H0 b: no difference between the estimated multiplier for public investment in economic affairs and the estimated multiplier for public investment in general public services. H0 c: no difference between the estimated multiplier for public investment in education and the estimated multiplier for public investment in general public services.

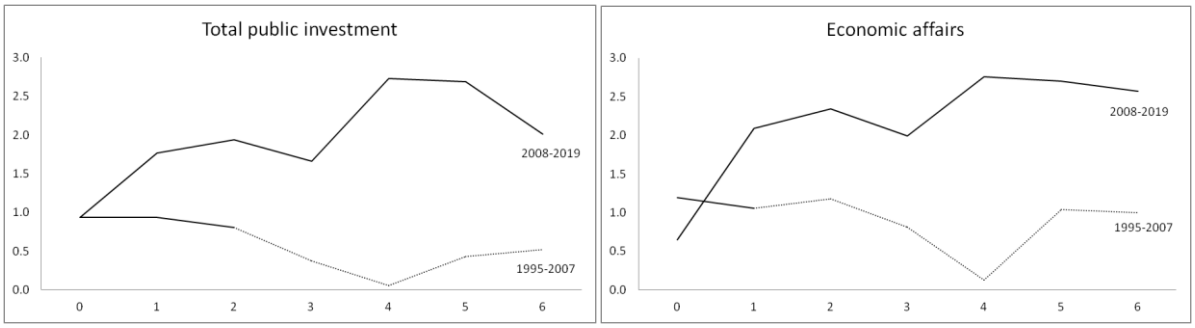
Figure 3. Robustness check: Multipliers estimated from models with control variables

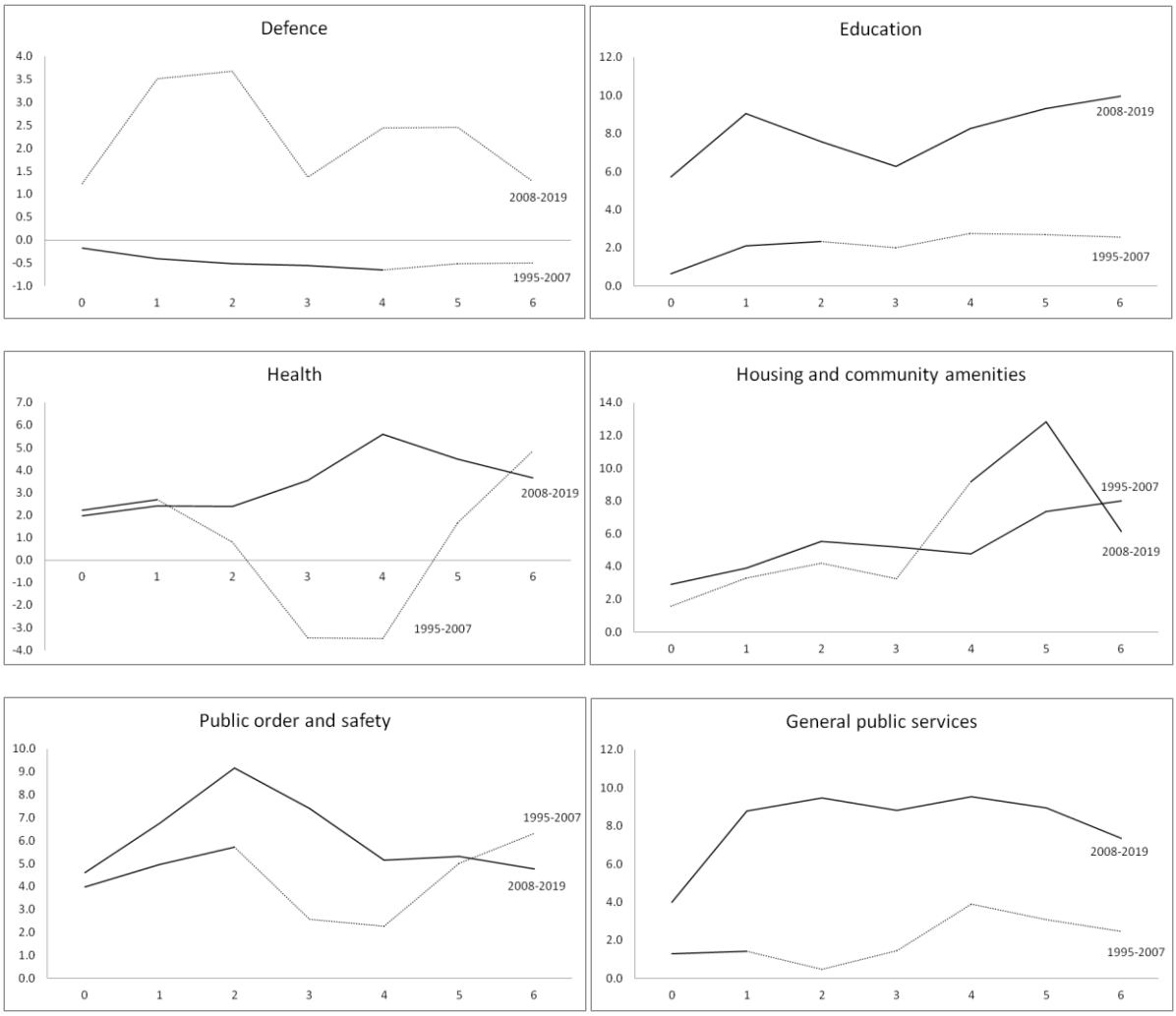




Note: Public investment multipliers are given by the estimated coefficients β^h when the real effective exchange rate, the long-term interest rate and the current account balance as a percentage of GDP are added as controls to the original specification. Very similar values are obtained when also inflation and taxes are included. Dashed lines denote the 90 percent confidence interval. Graphs are reported only for those functions of government whose respective results were confirmed. Full results are available upon request.

Figure 4. Robustness check: multipliers under different sub-periods





Note: . Public investment multipliers are given by the estimated coefficients β^h. Continuous lines indicate statistical significance at 10 percent level or less, while dotted lines denote statistically insignificant estimates.

Table 4: Cumulative multipliers of total public investment: comparison between original estimates and new estimates based on alternative fiscal shock identification.

WHOLE PERIOD							
Original estimated values	0.98***	1.38***	1.67***	1.81***	1.93***	2.01***	2.06*
New estitimated values	0.97***	1.47***	1.85***	2.04***	2.26***	2.43***	2.56***
PERIOD 1995-2007							
Original estimated values	0.94***	0.96**	1.00	0.92	0.79	0.76	1.48
New estitimated values	0.91***	1.08*	1.20	1.17	1.09	1.15	1.98
PERIOD 2008-2019							
Original estimated values	0.93***	1.60***	2.15***	2.49***	3.16***	3.50***	3.44***
New estitimated values	0.93***	1.61***	2.18***	2.54***	3.33***	3.77***	3.56***

Note: *** p<0.01, ** p<0.05, * p<0.10.

Appendix

Table A1: Classification of the Functions of Government (COFOG)

FUNCTION	SUB-ITEMS
GENERAL PUBLIC SERVICES	Executive and legislative organs, financial and fiscal affairs, external affairs; foreign economic aid; general services; basic research; R&D related to general public services; general public services n.e.c.; public debt transactions, transfers of a general character between different levels of government.
DEFENSE	Military defense; civil defense; foreign military aid, R&D related to defense; defense n.e.c.
PUBLIC ORDER AND SAFETY	Police services; fire-protection services; law courts; prisons; R&D related to public order and safety; public order and safety n.e.c.
ECONOMIC AFFAIRS	General economic, commercial and labour affairs; agriculture, forestry; fishing and hunting; fuel and energy; mining, manufacturing and construction; transport; communication; other industries, R&D related to economic affairs; economic affairs n.e.c.
ENVIRONMENTAL PROTECTION	Waste management; water waste management; pollution abatement; protection of biodiversity and landscape; R&D related to environmental protection.
HOUSING AND COMMUNITY AMENITIES	Housing development; community development; water supply; street lighting; R&D related to housing and community amenities; housing and community amenities n.e.c.
HEALTH	Medical products, appliances and equipment; outpatient services; hospital services; public health services; R&D related to health; health n.e.c.
RECREATION, CULTURE AND RELIGION	Recreational and sporting services; cultural services; broadcasting and publishing services; religious and other community services, R&D related to recreation, culture and religion; recreation; culture and religion n.e.c.
EDUCATION	Pre-primary, primary, secondary and tertiary education, post-secondary non-tertiary education, education non definable by level, subsidiary services to education, R&D; education n.e.c.
SOCIAL PROTECTION	Sickness and disability; old age; survivors; family and children; unemployment; housing; R&D; social protection and social exclusion n.e.c.

Table A2: Countries in the sample

Austria	Latvia
Belgium	Lithuania
Bulgaria	Luxembourg
Croatia	Malta
Cyprus	Netherlands
Czechia	Norway
Denmark	Poland
Estonia	Portugal
Finland	Romania
France	Slovakia
Germany	Slovenia
Greece	Spain
Hungary	Sweden
Iceland	Switzerland
Ireland	United Kingdom
Italy	

Table A3: Variable definitions and sources

Variable	**Description and source**
GDP deflator	GDP deflator (2015=100). Source: Eurostat.
GDP	Gross domestic product at market prices, million units of national currency. Source: Eurostat.
Current account balance	Current account balance (% of GDP). Source: Eurostat.
Exports of goods	Goods, value of exports (FOB), current US dollars. Source: Direction of Trade Statistics (IMF).
Exports of goods to United States	Goods, value of exports (FOB) to the US, current US dollars. Source: Direction of Trade Statistics (IMF).
Fiscal deficit	Net lending (+) / net borrowing (-) (% of GDP). Source: World Development Indicators (WDI).
GDP growth in United States	GDP growth (annual %). Source: World Development Indicators (WDI).
Long-term interest rate	Long-term interest rate, EMU convergence criterion bond yields. Source: Eurostat.
Public investment (total and by function)	Gross fixed capital formation of general government, million units of national currency (COFOG). Source: Eurostat.

Real effective exchange rate	Real effective exchange rate (deflator: consumer price index - 42 trading partners - industrial countries). Index: 2010=100. Source: Eurostat.
Taxes	Total tax revenues as a ratio of GDP. Source: Eurostat.

Table A4: Public investments by functions (1995-2019)

	Rate of growth	**Share**
Total public investment	2.8	100
Economic affairs	2.9	34.3
Recreation, culture and religion	4.1	5.7
Defense	2.5	7.4
Education	3.0	12.2
Environmental protection	1.6	5.3
Health	2.6	8.2
Housing and community amenities	2.7	5.7
Public order and safety	1.8	3.5
General public services	3.6	15.0
Social protection	0.5	2.7

Source: own elaborations on Eurostat data.