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CAUSAL MACROECONOMIC EFFECTS OF PUBLIC INVESTMENT

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Causal Macroeconomic Effects of Public Investment*

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Abstract

This paper estimates the causal impact of public investment on economic activity in European economies. While the literature generally finds that public investment multipliers exceed those of public consumption, the existing estimates vary widely, reflecting, among other factors, the challenges of identifying exogenous public investment shocks in the presence of anticipation and endogeneity. We address these challenges by using the European Commission’s public investment forecast errors as an instrument for realised public investment within an IV-LP framework. We construct a novel dataset covering 23 European countries over 2002–2023 and measure public investment forecast errors in real monetary terms rather than as differences between forecast and realised public-investment-to-GDP ratios, thereby avoiding variation arising mechanically from the GDP denominator. We estimate cumulative multipliers in a single step, allowing us to quantify their uncertainty directly. These multipliers relate the cumulative output response to the cumulative change in public investment, accounting for spending effects that persist beyond the initial shock. The findings suggest that the cumulative multiplier of public investment reaches approximately 2.1 after five years, with most of the effect materialising within the first 2–3 years. The multiplier is state-dependent: it is significantly larger during recessions, when public debt is low, and when the existing stock of public capital is relatively low.

JEL codes: E22, E62, H54, C33, C26.

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1 Introduction

Public investment can expand an economy’s productive capacity by providing infrastructure and services that firms can rely on. The insufficient provision of public infrastructure by governments—both tangible, such as roads, schools, hospitals, and military infrastructure, and intangible, such as courts, databases, public administration, and R&D—can constrain economic growth and discourage private investment (Barro, 1990). At the same time, every euro devoted to public investment has an opportunity cost: it could instead finance public consumption and essential public services, be transferred directly to households, or be used to reduce taxes, all of which may also stimulate economic activity. Moreover, some public investment may be necessary irrespective of its measured economic return. Choosing an appropriate level of public investment is, therefore, a non-trivial policy problem, and assessing its effects on current and future economic activity is central to such decisions.

The empirical literature generally finds that public investment multipliers are larger than those associated with public consumption, but estimates of their magnitude vary considerably. Estimates of the additional output generated by one euro of public investment typically range from around 1.1 to 2.5, but can be as low as 0.8 or exceed 3. Such a wide range makes it difficult to draw clear policy conclusions. Yet, obtaining credible causal estimates remains challenging, as the available identification strategies necessarily rely on assumptions about the exogeneity and timing of public investment shocks.

The effects of public investment are particularly difficult to identify because of two inherent features. The first is anticipation. Public investment projects are typically planned and implemented over extended periods, and economic agents may respond well before the corresponding expenditure is recorded. Expectations that a project will be implemented may stimulate private investment in advance, and these responses may strengthen as uncertainty about the allocation of public funds diminishes. Firms may also begin adjusting their private capital stock in anticipation of public infrastructure becoming available. Consequently, part of the economic response to public investment may precede the observed change in public investment itself, complicating the identification of its causal effects. The second challenge is endogeneity. Public investment may respond to contemporaneous economic conditions, as governments adjust investment expenditure in response to changes in tax revenues, unemployment, or other macroeconomic developments. As a result,

observed changes in public investment cannot necessarily be treated as exogenous, giving rise to reverse causality concerns.

We address these identification challenges by using European Commission public investment forecast errors as an instrument for realised public investment within an instrumental-variable local-projection (IV-LP) framework. Our contribution is threefold. First, the use of forecast errors allows us to isolate unexpected innovations in public investment, mitigating concerns related to anticipation and reverse causality. Second, we account explicitly for the dynamic response of public investment following the initial innovation and estimate cumulative multipliers in a one-step IV-LP framework. This relates the cumulative output response to the cumulative change in public investment and allows the uncertainty surrounding the multiplier to be estimated directly. Third, unlike existing studies that construct public investment forecast errors as differences between forecast and realised public investment in ratios to GDP, we construct forecast errors from public investment measured in real monetary terms. This ensures that the identified innovation reflects unexpected changes in public investment itself rather than changes in the GDP denominator, thereby avoiding a potential source of denominator bias.

Our estimates indicate that the cumulative public investment multiplier reaches approximately 2.1 after five years, with most of the effect materialising within the first two to three years. We also find substantial state dependence in the effectiveness of public investment. Multipliers are significantly larger when public debt is low, during economic recessions, and when the existing stock of public capital is relatively low. These results suggest that fiscal space, economic slack, and the relative scarcity of public infrastructure play an important role in determining the macroeconomic effects of public investment.

The remainder of the paper is structured as follows. Section 2 reviews the literature. Section 3 describes the construction of the public investment forecast error dataset. Section 4 presents the econometric methodology and the IV-LP approach. Section 5 reports the baseline multiplier estimates and robustness analysis. Section 6 examines state dependence in the public investment multiplier. Finally, Section 7 concludes.

2 Review of literature

Most studies on fiscal multipliers focus on aggregate government spending or public consumption. This largely reflects the empirical challenges associated with identifying exogenous shocks to public investment. Investment projects are typically planned well in advance and implemented gradually, creating long lags between policy decisions and recorded expenditures while giving rise to anticipation effects. At the same time, public investment decisions often respond to prevailing macroeconomic conditions, introducing endogeneity and complicating causal inference.

Despite these challenges, the available evidence generally suggests that public investment multipliers exceed those associated with other types of government spending. Estimates of the additional output generated by one euro of public investment typically range from around 1.1 to 2.5 but can be as low as 0.8 or exceed 3.¹ Several studies, such as [Saccone et al. \(2022\)](#) and [Deleidi et al. \(2020\)](#), find output responses close to one on impact that increase over the medium term. One explanation is that public investment stimulates demand in the short run while raising productive capacity through the accumulation of public capital. Consistent with this mechanism, [Matvejevs and Tkacevs \(2025\)](#) show that increases in public investment crowd in private investment as firms adjust their capital stock towards its long-run relationship with public infrastructure.

Nevertheless, the empirical literature does not reach full consensus. Some studies find smaller effects or little difference between investment and consumption multipliers (e.g. [Haug and Sznajderska 2024](#); [Sabaj et al. 2023](#); [Boehm 2020](#)), while others report relatively modest multipliers in certain country groups (e.g. [Furceri and Li 2017](#); [Honda et al. 2020](#)).

A large part of the empirical literature identifies public investment shocks using structural vector autoregression (SVAR) models. In this framework, shocks to government investment are recovered by imposing identifying restrictions on the joint dynamics of fiscal variables and macroeconomic outcomes. Examples include [Alloza et al. \(2022\)](#), [Mallick \(2019\)](#), [Afonso and Aubyn \(2008\)](#), [Ilzetzi et al. \(2013\)](#), [Haug and Sznajderska \(2024\)](#), and [Ardanaz et al. \(2025\)](#). Alternative approaches include panel VAR models (e.g. [Brasili et al. 2023](#); [Afonso and Rodrigues 2024](#)) and identification strategies based on cyclically adjusted investment series (e.g. [Jalles et al. 2024](#); [Adarov et al. 2024](#)).

While these approaches attempt to address fiscal endogeneity, they remain vulnerable to the anticipation problem, as public investment projects are typically planned and announced well before expenditures occur. This concern has motivated alternative identification strategies that exploit

¹Appendix A summarizes public investment multipliers identified in the previous literature.

information external to the contemporaneous relationship between public investment and macroeconomic conditions. For example, [Kanazawa \(2021\)](#) extracts news about future public investment from stock returns of road pavement firms in Japan and uses these shocks as instruments for public investment in a local projection framework. More recently, [Clemens et al. \(2025\)](#) construct a narrative instrument for government investment based on official records in Germany and use it to identify investment shocks in a structural VAR.

A further approach to addressing anticipation, and the one most closely related to our source of identifying variation, relies on forecast errors to isolate unexpected changes in public investment. [Abiad et al. \(2016\)](#) construct public investment shocks using forecast errors from the IMF World Economic Outlook and find that increases in public investment raise output in the short to medium term.

However, their empirical strategy has several limitations. First, public and private investment, as well as the corresponding shocks, are measured as shares of GDP, introducing the possibility of denominator bias since fluctuations in GDP affect both the dependent and explanatory variables. Second, the unexpected component of public investment is constructed using only the forecast produced in October of the same year, without robustness checks based on alternative forecast vintages. Third, the specification does not account for the persistence of public investment shocks, implicitly assuming that forecast errors affect only contemporaneous spending. In practice, revisions to public investment plans often influence spending over several years, and ignoring this persistence may bias estimated dynamic responses and cumulative multipliers. Finally, and most crucially, the methodology in [Abiad et al. \(2016\)](#) is very shallow in its calculation of the multiplier. In particular, they interpret the elasticity of GDP for all years after the public investment shock to the shock itself as the public investment multiplier. Effectively, this amounts to assuming that despite the unexpected change in public investment in year t represented by the forecast error, the total public investment for all other years $t + h$ where $h = 1, 2, \dots$ remains constant. In [Section 4.1](#), we explicitly test it and show that it does not hold.

Our paper lies within the strand of the fiscal identification literature that exploits external information to isolate unexpected innovations in public investment. Like [Abiad et al. \(2016\)](#), we use forecast errors to distinguish unexpected changes in public investment from movements that were already anticipated. At the same time, our empirical implementation is an instrumental variable approach: rather than treating the forecast error itself as the fiscal shock whose dynamic

effects are traced directly, we use it as an instrument for realised public investment within a local projection framework. This allows us to account explicitly for the persistence of the investment response following the initial unexpected innovation and to estimate cumulative multipliers relative to the cumulative change in public investment. In this sense, our approach combines the forecast error identification strategy of [Abiad et al. \(2016\)](#) with the IV-LP framework. Furthermore, we construct public investment forecast errors in real monetary terms to avoid a potential denominator bias.

Another important insight emerging from the literature is that the magnitude of public investment multipliers depends on macroeconomic conditions and structural characteristics of the economy. Several studies find stronger effects during periods of economic slack. For example, [Auerbach and Gorodnichenko \(2012\)](#), [Elkhdari et al. \(2018\)](#), and [Petrović et al. \(2021\)](#) report larger output responses during periods of negative output gaps or weak economic growth. Macroeconomic uncertainty may also matter. Thus, [Gbohoui \(2021\)](#) finds that public investment has larger effects during periods of heightened uncertainty.

Pre-existing conditions also influence multiplier estimates. [Furceri and Li \(2017\)](#) and [Izquierdo et al. \(2019\)](#) find larger multipliers in economies with lower public debt, suggesting that fiscal space enhances the effectiveness of public investment. The existing stock of public capital also matters, for example, [Izquierdo et al. \(2019\)](#) report larger multipliers in countries with relatively low public capital stocks, where infrastructure gaps are more pronounced. Institutional and governance factors may further influence outcomes, as [Honda et al. \(2020\)](#) and [Abiad et al. \(2016\)](#) find larger effects in countries with stronger institutions or higher spending efficiency.

Finally, the literature highlights heterogeneity across country groups. Several studies focusing on emerging market and developing economies report smaller or more uncertain effects of public investment. For example, [Furceri and Li \(2017\)](#) and [Honda et al. \(2020\)](#) document modest multipliers in developing economies, while [Miyamoto et al. \(2020\)](#) find that public investment has statistically insignificant effects in low-income countries but larger impacts where governance is stronger. Similarly, [Eden and Kraay \(2014\)](#) estimate multipliers around 1.5 for IDA-eligible countries, although estimates vary depending on methodology. These findings suggest that institutional capacity and investment efficiency play an important role in shaping the macroeconomic impact of public infrastructure spending.

In view of the documented importance of these factors – the speed of economic growth, the size

of the existing public capital stock, and the public debt ratio – for the magnitude of the public investment multiplier, we repeat our analysis allowing the multiplier to vary depending on these conditions.

3 Data and public investment forecast errors

AMECO (2025) provides a real-time database of macroeconomic variables underlying the European Commission’s semiannual Economic Forecasts, including total and public investment. Each forecast vintage contains historical data, an estimate for the current year, and forecasts for the following two years. This structure allows us to calculate forecast errors across vintages. For public investment, we define the forecast error for a given year as the difference between its value reported in the following year and the value projected in an earlier forecast vintage. We interpret this difference as an unanticipated innovation to public investment. We construct analogous forecast errors for GDP, the GDP deflator, and total investment. For the public investment measure used in our empirical analysis, we combine forecasts and subsequently reported values of nominal public investment with the corresponding GDP deflator to construct forecast errors in real monetary terms. Since realised inflation differs from the expected inflation, care should be taken in obtaining the real values so as to convert each nominal value using the deflator for the respective period expected on the day the forecast about public investment is made. Appendix B explains this procedure in detail, as well as currency conversion for countries that switched to the euro between 2003 and 2023.

For the period prior to 2011, such forecast vintages are not available in AMECO. We, therefore, collect the corresponding data from archived European Commission Economic Forecast publications, which report the same variables. Specifically, we manually compile one-year-ahead forecasts, current year forecasts, and subsequently reported values, thereby extending the dataset in a manner consistent with the post-2011 AMECO vintages. For the state-dependent analysis, we additionally use unemployment data from AMECO and capital-stock data from the IMF Investment and Capital Stock Dataset. Our final sample comprises 23 European countries over the period 2002–2023.²

To construct the forecast errors, we use the European Commission’s autumn forecasts, which are typically published in October. Our baseline forecast error is constructed using the same-year forecast, while one-year-ahead forecasts are used as an alternative measure in the robustness

²The initial sample comprises 28 countries. Croatia, Slovakia, Luxembourg, and Cyprus are excluded due to large outliers in public investment and its forecast errors, while Ireland is excluded due to large outliers in GDP growth and its forecast errors.

analysis. Formally, for any variable X , let $X_{t|t}$ denote the European Commission’s forecast for year t published in the autumn of year t . We proxy the realised value of X_t by the estimate for year t reported in the autumn forecast of year $t + 1$, denoted by $X_{t|t+1}$.³ The same-year forecast error is, therefore, defined as

$$FE_{t|t} = X_{t|t+1} - X_{t|t}. \quad (1)$$

Appendix C contains summary statistics and distributions of these forecast errors by countries (also for countries excluded from the sample) and years.

For robustness, we also construct forecast errors based on one-year-ahead forecasts. Let $X_{t|t-1}$ denote the forecast for year t published in the autumn of year $t - 1$. The corresponding forecast error is defined as

$$FE_{t|t-1} = X_{t|t+1} - X_{t|t-1}. \quad (2)$$

An important feature of our construction is that public investment forecast errors are calculated in real monetary terms rather than as differences between forecast and realised public investment ratios to GDP. The latter measure does not allow for the capture of public investment deviations from expectations in isolation from other macroeconomic variables: the difference between the forecast and realised ratio may arise from an unexpected change in public investment, an unexpected change in GDP, or both. This is particularly relevant in our setting because GDP forecast errors may be correlated with subsequent economic activity, potentially introducing variation into the public investment shock that originates from the denominator (GDP) rather than from public investment. We, therefore, recover forecast and subsequently reported public investment in monetary terms and convert both into real terms using the corresponding GDP deflator (see Appendix B.1 for the details).

The interpretation of these forecast errors as unexpected innovations relies on the European Commission’s autumn forecasts providing a reasonable approximation of the information available to economic agents at the time. Since the forecasts used in our baseline specification are produced relatively late in the calendar year, they incorporate a substantial amount of information on

³We use the value reported in the autumn forecast of year $t + 1$, approximately ten months after the end of the reference year, as our measure of the realised value. We do not use later vintages because subsequent methodological and definitional revisions may introduce discrepancies unrelated to the original forecast error.

contemporaneous macroeconomic developments and fiscal execution. Consequently, the remaining difference between the forecast and the subsequently reported outcome is less likely to reflect developments that had been predictable when the forecast was produced. These forecast errors may arise from unforeseen changes in the scope or resource requirements of ongoing projects, or from differences between planned and actual expenditure timing. Although the aggregate data do not allow us to distinguish between these mechanisms, the persistent positive response of public investment documented in Section 4.1 suggests that the forecast errors do not merely capture spending brought forward from subsequent years.

All in all, we interpret $FE_{t|t}$ as the unexpected component of public investment relative to the information available at the time of the forecast. Importantly, unexpectedness alone does not guarantee that the forecast error is exogenous with respect to subsequent economic activity. The additional identifying assumption required for our instrumental-variable approach, as well as potential threats to this assumption, are discussed in Section 4.

4 Methodology

4.1 Persistence of public investment shocks

As discussed in Section 2, the study most closely related to our approach is [Abiad et al. \(2016\)](#), which uses public investment forecast errors directly in local projections. This approach identifies the output response to an unexpected innovation in public investment but does not explicitly account for the possibility that the initial innovation induces persistent changes in public investment in subsequent years. This distinction is important for the interpretation of the resulting multiplier. If an unexpected change in public investment affects not only contemporaneous expenditure but also its subsequent path, the relevant fiscal impulse extends beyond the initial forecast error. Estimating the public investment multiplier, therefore, requires accounting for the dynamic response of public investment itself.

To examine whether unexpected innovations to public investment are persistent, we estimate the following local projections for horizons $h = 0, \dots, H$:

$$g_{i,t+h} = \alpha_i^h + \lambda_t^h + \beta_h fe_{it} + \phi_y^h y_{i,t-1} + \phi_g^h g_{i,t-1} + \varepsilon_{i,t+h}, \quad (3)$$

where fe_{it} denotes the public investment forecast error and $g_{i,t+h}$ denotes the change in public

investment at horizon h , with both variables expressed in real terms and scaled by potential GDP as described below in Section 4.2. Country and year fixed effects are denoted by α_i^h and λ_t^h , respectively, while lagged GDP and public investment are included as controls. The coefficient β_h , therefore, traces the response of public investment at horizon h to an unexpected innovation in public investment.

Figure 1 shows that the response of public investment is persistent. An unexpected increase corresponding to one euro of public investment is associated with an approximately one-euro increase in public investment on impact. The response subsequently declines but remains positive, at around 0.4–0.5 euros, three to four years after the initial innovation. Thus, the forecast error does not merely predict a contemporaneous change in public investment; it is associated with a persistent change in its subsequent path.

This persistence has direct implications for the measurement of the public investment multiplier. If the initial forecast error induces additional public investment in subsequent years, comparing the cumulative output response only with the size of the initial innovation would understate the total fiscal impulse associated with that innovation. The denominator of the cumulative multiplier should, therefore, incorporate the cumulative response of public investment induced by the forecast error. Failing to account for this response would mechanically inflate the estimated multiplier. This consideration motivates the IV-LP specification presented in the following subsection, in which the cumulative change in public investment is instrumented by the initial forecast error.

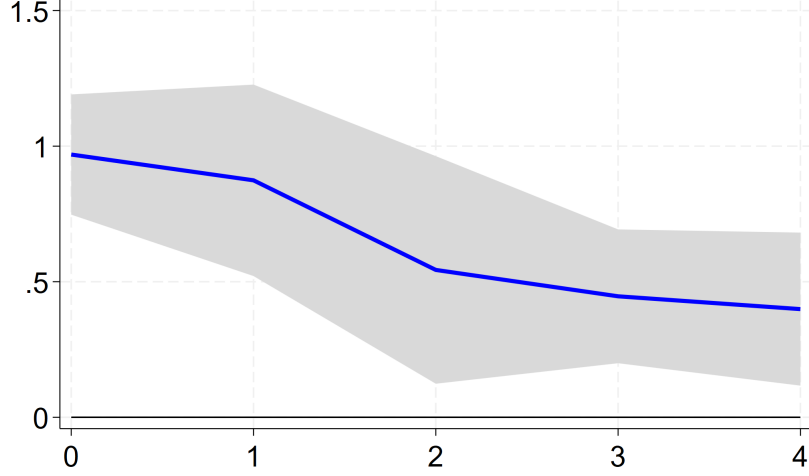
4.2 Dynamic and cumulative public investment multipliers

Following Ramey and Zubairy (2018) and related studies of fiscal multipliers, we estimate cumulative public investment multipliers directly using an instrumental-variable local projection (IV-LP) approach (Jordà, 2005). For each horizon $h = 0, \dots, H$, the second-stage equation is

$$\sum_{j=0}^h y_{i,t+j} = \alpha_h + \gamma_{i,h} + \theta_{t,h} + \beta_h \sum_{j=0}^h \hat{g}_{i,t+j} + \varphi_{y,h} y_{i,t-1} + \varphi_{g,h} g_{i,t-1} + \varepsilon_{i,t+h}. \quad (4)$$

where γ_i^h and θ_t^h denote country and year fixed effects, respectively, and lagged GDP and public investment are included as controls. The cumulative change in public investment is instrumented by the public investment forecast error using the first-stage equation

Figure 1: Dynamic response of total public investment to a public investment forecast error



Note: The figure reports the estimated coefficients β_h from Equation (3). The horizon on the X-axis is in years. Shaded areas denote 90% confidence intervals based on Driscoll–Kraay standard errors. The specification includes country and year fixed effects as well as lagged GDP and public investment as controls.

$$\sum_{j=0}^h g_{i,t+j} = \eta_h + \kappa_{i,h} + \chi_{t,h} + \delta_h f e_{it} + \rho_{y,h} y_{i,t-1} + \rho_{g,h} g_{i,t-1} + \nu_{i,t+h}. \quad (5)$$

where $f e_{it}$ denotes the public investment forecast error in year t , and κ_i^h and χ_t^h denote country and year fixed effects, respectively. The first-stage coefficient δ_h captures the cumulative response of public investment through horizon h to the initial forecast error.

The coefficient β_h in Equation (4) is the cumulative public investment multiplier at horizon h : it measures the cumulative change in output associated with one euro of cumulative additional public investment induced by the forecast error. Estimating the cumulative multiplier directly in a one-step IV-LP framework also allows its standard error to be obtained directly, rather than constructing the multiplier as a ratio of separately estimated impulse responses. To obtain the dynamic multiplier at horizon h , we replace the cumulative output response on the left-hand side of Equation (4) with $y_{i,t+h}$, while retaining the cumulative instrumented public investment response on the right-hand side.

The variables entering the estimation are expressed in real terms and scaled by potential GDP in the year preceding the public investment innovation. Specifically, we define

$$\begin{aligned}
y_{i,t+j} &= \frac{Y_{i,t+j} - Y_{i,t-1}}{Y_{i,t-1}^*}, \\
g_{i,t+j} &= \frac{G_{i,t+j} - G_{i,t-1}}{Y_{i,t-1}^*}, \\
fe_{it} &= \frac{FE_{it}}{Y_{i,t-1}^*},
\end{aligned} \tag{6}$$

where $Y_{i,t+j}$ denotes real GDP, $G_{i,t+j}$ denotes real public investment, FE_{it} denotes the forecast error in real public investment, and $Y_{i,t-1}^*$ denotes potential GDP. Thus, rather than using year-on-year changes, $y_{i,t+j}$ and $g_{i,t+j}$ are long differences relative to their respective values in the year preceding the public investment innovation.

Potential GDP is obtained by applying the Hodrick–Prescott filter to real GDP. Scaling by potential rather than actual GDP is particularly useful for the state-dependent analysis conducted below. When actual output is temporarily depressed during a recession, scaling an identical absolute change in GDP or public investment by actual GDP mechanically produces a larger relative change than when output is above potential. Using potential GDP as a common scaling variable reduces this mechanical dependence of the normalisation on the cyclical position of the economy.

The causal interpretation of β_h requires the public investment forecast error to satisfy the exclusion restriction: conditional on the controls and fixed effects, it should affect output only through the path of public investment. As discussed in Section 3, the use of late-year European Commission forecasts makes the forecast errors plausibly unanticipated. Unexpectedness, however, does not by itself guarantee exogeneity with respect to subsequent economic activity. Forecast errors could, for example, be correlated with unexpected macroeconomic developments or policy decisions that both affect the execution of public investment and independently influence output. An unforeseen improvement in economic conditions could simultaneously increase output while also allowing governments to execute more investment than initially projected, generating a positive correlation between the public investment forecast error and subsequent output even in the absence of a causal effect of public investment.

Several features of our empirical strategy mitigate this concern. First, the baseline forecast is produced relatively late in the calendar year, when a substantial part of macroeconomic developments and budget execution for the reference year is already observable, narrowing the scope for within-year macroeconomic surprises to generate the forecast error. Second, year fixed effects absorb shocks common to the European economies in our sample. Third, as a robustness exercise, we

use forecast errors based on one-year-ahead forecasts and explicitly purge them of forecast errors in GDP growth and inflation, and their lags. Finally, we examine the robustness to excluding the global financial crisis and the Covid-19 period, during which unusually large macroeconomic and policy shocks were particularly likely. While these exercises cannot rule out all possible correlations between public investment forecast errors and unobserved determinants of output, they reduce the likelihood that such factors are driving our estimated multipliers.

4.3 Robustness specifications

We assess the robustness of the baseline estimates along several dimensions. The exercises are designed both to evaluate the sensitivity of the estimated multipliers to alternative modelling choices and, more importantly, to examine potential threats to the validity of the public investment forecast error as an instrument.

First, we examine whether the baseline current year public investment forecast error contains information related to broader macroeconomic developments. We construct three progressively purged versions of the forecast error. In the first specification, we remove the component associated with lagged GDP growth and inflation, thereby removing the component that could have been predicted using recent macroeconomic information available prior to the forecast error. In the second specification, we additionally control for contemporaneous forecast errors in GDP growth and GDP inflation. This removes variation in the public investment forecast error associated with unexpected macroeconomic developments occurring over the same period. Finally, in the third specification, we additionally control for the lagged public investment forecast error, thereby removing any component of the current forecast error that is predictable from the previous year's forecast error.

The three purging specifications can be represented by the following auxiliary regression:

$$FE_{it}^G = \alpha_i + \rho FE_{i,t-1}^G + \phi_\pi \pi_{i,t-1} + \phi_y \Delta y_{i,t-1} + \psi_y FE_{it}^Y + \psi_\pi FE_{it}^P + u_{it}, \quad (7)$$

where FE_{it}^G denotes the public investment forecast error, $\pi_{i,t-1}$ and $\Delta y_{i,t-1}$ denote lagged inflation and real GDP growth, respectively, and FE_{it}^Y and FE_{it}^P denote contemporaneous forecast errors in GDP growth and GDP inflation. The three purging strategies correspond to progressively adding these controls: the first includes only lagged inflation and GDP growth; the second adds the two macroeconomic forecast errors; and the third further incorporates the lagged public investment

forecast error. For each specification, the residual

$$\widetilde{FE}_{it}^G = \widehat{u}_{it} \quad (8)$$

is used as an alternative instrument in the IV-LP estimation. The resulting instrument therefore retains only the component of the public investment forecast error that is orthogonal to the information included in the respective purging specification.

Second, we construct an alternative instrument based on the European Commission’s one-year-ahead forecasts. As described in Section 3, the baseline forecast error compares the subsequently reported value of public investment with the forecast produced in the autumn of the same year. As an alternative, we use the forecast for year t produced in the autumn of year $t - 1$, so that the forecast error is given by Equation (2). Using forecasts made in the preceding year addresses a limitation of the baseline measure: the short interval induced by the use of the autumn forecast of the same year leaves relatively little time for unexpected investment decisions to translate into expenditure. However, the longer interval between the forecast and the subsequently reported outcome increases the scope for intervening macroeconomic developments to affect both public investment and economic activity. We, therefore, consider both the raw previous year forecast error and three purged versions constructed using the same sequence of auxiliary specifications described above. This allows us to assess whether the results are robust to using an earlier information set and how sensitive the resulting estimates are to removing variation associated with macroeconomic developments and persistence in forecast errors.

Third, we assess the role of common macroeconomic shocks by re-estimating the baseline model without year fixed effects. The baseline specification includes year fixed effects to absorb shocks that affect the European economies in the sample simultaneously. Comparing the baseline estimates with those obtained without year fixed effects, therefore, provides an indication of the extent to which common shocks influence the estimated multiplier.

Fourth, we examine whether the results are driven by exceptional macroeconomic episodes. We first exclude 2020–2021, which was affected by the Covid-19 pandemic, and then additionally exclude 2009–2010, which was strongly affected by the global financial crisis. These periods are particularly relevant from an identification perspective because unusually large and potentially correlated macroeconomic, fiscal, and policy surprises could simultaneously affect public investment

forecast errors and output.

Finally, we examine the sensitivity of the results to individual countries. We re-estimate the baseline specification repeatedly, excluding one country at a time from the sample. This exercise allows us to assess whether the estimated multiplier is disproportionately influenced by any particular country or by country-specific extreme observations.

The results of these robustness exercises are presented in Section 5.2.

4.4 State dependence

We extend the baseline specification to examine whether the public investment multiplier depends on the macroeconomic and fiscal conditions prevailing when the public investment innovation occurs. The use of exogenous forecast errors allows us to isolate unexpected public investment innovations within different states and thereby examine whether the output effects of such innovations vary with prevailing economic and fiscal conditions.

In this paper, we focus on three dimensions that may affect the transmission of public investment: the business cycle, which captures the degree of economic slack; public debt, which captures fiscal constraints; and the existing stock of public capital, which captures the potential scarcity of public infrastructure and hence the marginal productivity of additional public capital. Rather than dividing observations into discrete regimes, we follow [Auerbach and Gorodnichenko \(2017\)](#) and use a smooth transition function that allows the multiplier to vary continuously across states.

The transition function is defined as

$$F(z_{i,t-1}) = \frac{\exp(-\xi z_{i,t-1})}{1 + \exp(-\xi z_{i,t-1})}, \quad (9)$$

where $z_{i,t-1}$ is the state variable, standardised to have zero mean and unit variance. In the baseline specifications, the state variables are real GDP growth, the public-debt-to-GDP ratio, and the ratio of public to private capital. We use the output gap and the unemployment rate as alternative measures of the business cycle, and the public-capital-to-GDP ratio as an alternative measure of the relative abundance of public capital. Parameter ξ governs the smoothness of the transition between states and is set to 1.5, following the related literature.⁴

Function $F(\cdot)$ takes values between zero and one, with $F(0) = 0.5$. Given the specification in

⁴[Auerbach and Gorodnichenko \(2012\)](#) calibrate the transition parameter such that the economy spends approximately 20 per cent of the time in recession, consistent with the duration of U.S. recessions identified by the NBER.

Equation (9), $F(\cdot)$ is decreasing in $z_{i,t-1}$. Thus, higher values of $F(\cdot)$ correspond to lower GDP growth, lower public debt, or lower public capital, depending on the state variable considered. Effectively, such transition function interprets observations with values of $F(\cdot)$ close to one as being recessionary with a very high likelihood, whereas observations with values of $F(\cdot)$ close to zero are with higher likelihood interpreted as expansionary. Analogously, in specifications where we study, respectively, government indebtedness and sufficiency of public capital in the economy, higher values of $F(\cdot)$ imply a higher likelihood that the respective observations are in the state of low debt and low public capital observations, respectively.

To estimate state-dependent cumulative multipliers, we modify Equation (4) by interacting cumulative public investment with the transition weights:

$$\begin{aligned}
\sum_{j=0}^h y_{i,t+j} = & \alpha_h + \gamma_{i,h} + \theta_{t,h} \\
& + \beta_{A,h} F(z_{i,t-1}) \sum_{j=0}^h \hat{g}_{i,t+j} \\
& + \beta_{B,h} [1 - F(z_{i,t-1})] \sum_{j=0}^h \hat{g}_{i,t+j} \\
& + \Phi'_h X_{i,t-1} + \varepsilon_{i,t+h},
\end{aligned} \tag{10}$$

where $X_{i,t-1}$ contains the lagged controls included in the baseline specification. The coefficients $\beta_{A,h}$ and $\beta_{B,h}$ represent the cumulative public investment multipliers associated with the two limiting states. For example, when GDP growth is used as the transition variable, $\beta_{A,h}$ corresponds to the recessionary state and $\beta_{B,h}$ to the expansionary state. When public debt is used, they correspond to the low- and high-debt states, respectively, and when public capital is used, to the low- and high-public-capital states.

Because the state-dependent public investment terms in Equation (10) are endogenous, we instrument them using the corresponding interactions of the public investment forecast error with the transition weights, $fe_{it}F(z_{i,t-1})$ and $fe_{it}[1-F(z_{i,t-1})]$. The state variable is dated $t-1$, ensuring that the transition weights are predetermined with respect to the public investment innovation in year t .

5 Public investment multiplier

5.1 Baseline estimates

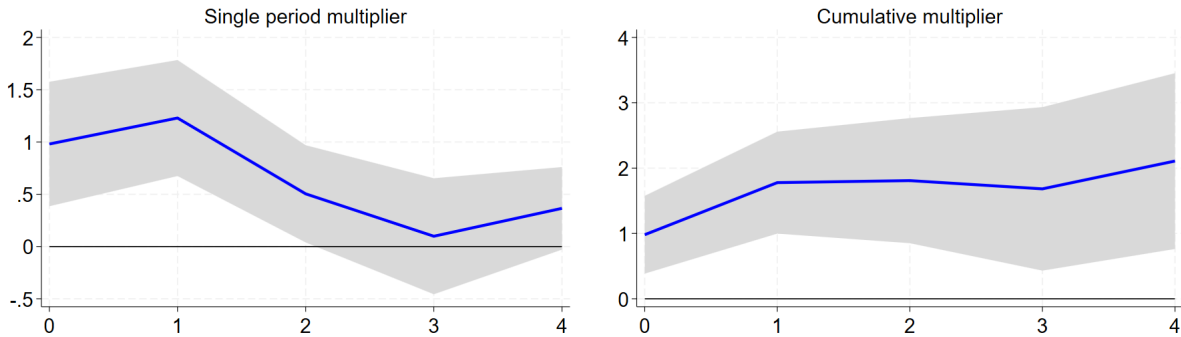
This section presents our baseline estimates of the single-period (or dynamic) and cumulative public investment multipliers obtained using the IV-LP estimation approach laid out in Section 4.2. Total public investment is instrumented using the EC public investment forecast error. All specifications include country and time fixed effects as well as lagged controls.

Table 1: IV-LP Estimation results of the cumulative output response

Second stage	(0)	(1)	(2)	(3)	(4)
Instrumented Public investment	0.981**	1.778***	1.809***	1.683**	2.108**
L.Public investment	0.509**	1.189**	1.352	1.995	3.650
L.GDP	0.177***	0.249*	0.328	0.127	-0.379
First stage					
Public investment forecast error	0.897***	1.714***	2.177***	2.566***	2.896***
L.Public investment	0.025	-0.338**	-0.926***	-1.580***	-2.104***
L.GDP	0.018*	0.062**	0.138***	0.194***	0.222**
Diagnostic statistics					
R^2	0.725	0.723	0.687	0.659	0.658
Number of observations	385	362	338	314	290
Number of countries	23	23	23	23	23
Time fixed effects	Yes	Yes	Yes	Yes	Yes
SW Chi-sq stat (underid)	119.31***	64.64***	38.61***	28.80***	22.50***
SW F-stat (weak id)	112.72***	61.01***	36.40***	27.11***	21.15***

Note: IV-LP Estimation results of equation 4. Controls and time f.e. are included.

Figure 2: Public investment multipliers



Note: The horizon on the X-axis is in years. 90% confidence bands are constructed using Driscoll-Kraay standard errors. Controls and time f.e. are included

Table 1 reports the IV-LP estimates of the cumulative output response to instrumented public investment at horizons $h = 0, \dots, 4$. The coefficient on instrumented public investment at each

horizon represents the cumulative multiplier, that is, the change in output relative to the cumulative change in instrumented public investment induced by the forecast error, with both variables scaled by potential GDP in $t - 1$. The single-period and cumulative multipliers are displayed in Figure 2.

The estimated cumulative multiplier is positive and statistically significant at all horizons. On impact ($h = 0$), the multiplier is close to unity, implying that an additional euro of public investment raises output by approximately one euro contemporaneously. The cumulative multiplier increases to around 1.8 within the first two years and remains close to 2 thereafter, reaching 2.11 after five years. Thus, most of the cumulative output effect materialises relatively quickly, while the additional effects at longer horizons are comparatively modest. Although the point estimate remains relatively stable at longer horizons, the confidence intervals widen, reflecting greater uncertainty surrounding the medium-term multiplier.

The single-period multiplier peaks after one year and subsequently declines, becoming small at longer horizons. Together with the cumulative estimates, this pattern indicates that the output gains associated with the cumulative investment response are concentrated in the first few years following the initial innovation.

The first-stage results indicate that the public investment forecast error is a strong predictor of cumulative public investment at all horizons, with the Sanderson–Windmeijer F -statistics comfortably exceeding conventional weak-instrument thresholds throughout. The first-stage coefficient increases with the horizon, consistent with the persistent response of public investment documented in Section 4.1.

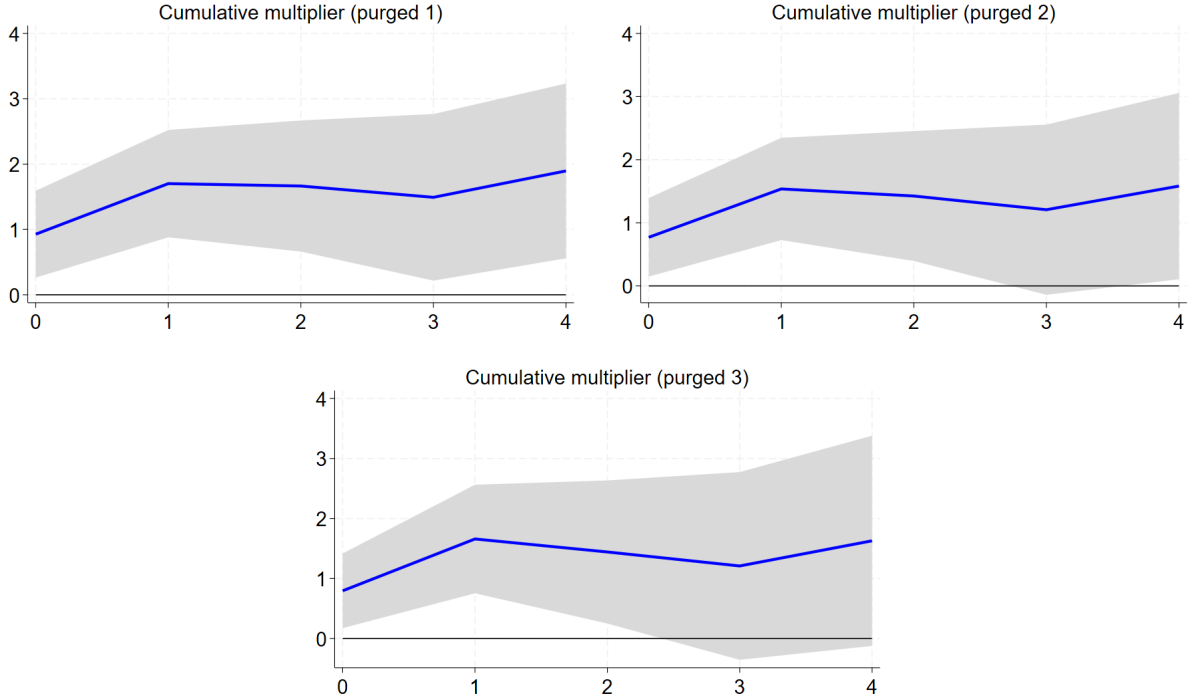
The magnitude and dynamic profile of our estimates are consistent with studies finding public investment multipliers close to unity on impact and larger effects over the medium term (including Saccone et al. 2022 and Deleidi et al. 2020 that find that the value is close to one on impact and rises further in the medium-term).

5.2 Robustness exercise

First, we examine whether the results are robust to purging the public investment forecast error of information related to macroeconomic developments. Figure 3 reports the cumulative multipliers obtained using three progressively purged versions of the forecast error (as described in Section 4.3).

The estimates are remarkably stable across the three specifications. The cumulative multiplier is close to unity on impact, rises to around 1.5–1.7 after one year, and remains positive thereafter.

Figure 3: Cumulative multipliers using purged forecast errors



Note: The horizon on the X-axis is in years. 90% confidence bands are constructed using Driscoll-Kraay standard errors. Controls and time f.e. are included

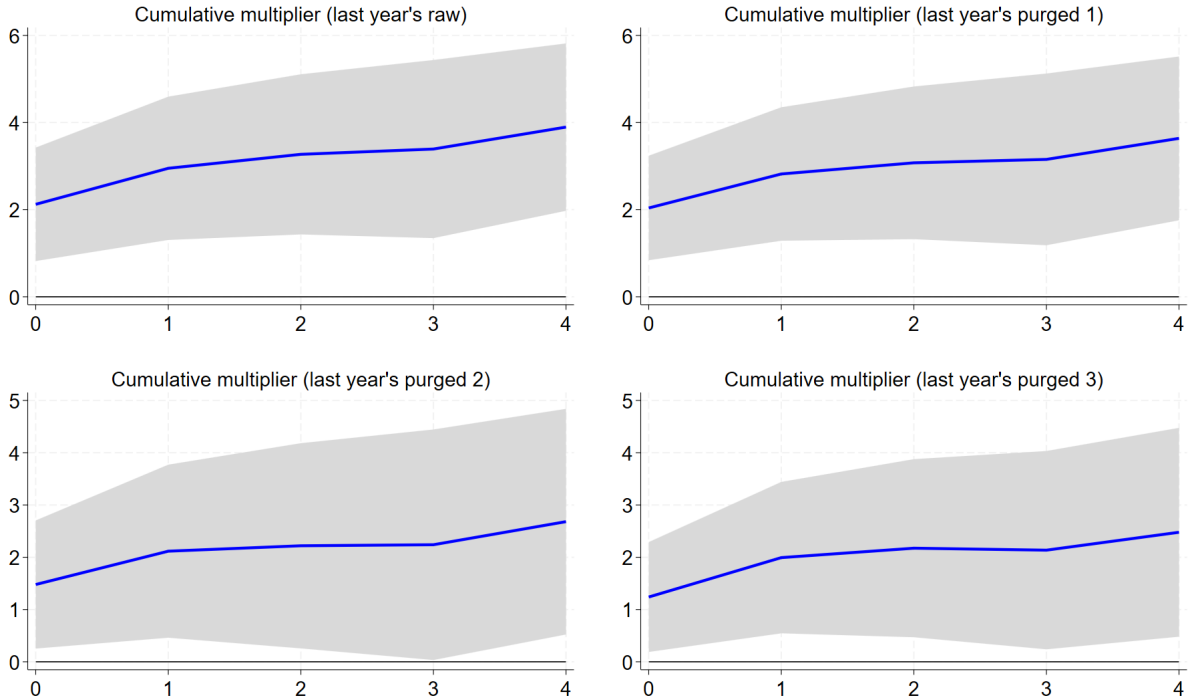
Although the point estimates are somewhat smaller and less precise than in the baseline specification, particularly at longer horizons, the qualitative dynamic pattern remains unchanged. Moreover, the second and third specifications produce very similar estimates, indicating that removing persistence in the public investment forecast error has little effect. Overall, the results suggest that the positive output response is not driven by variation in the instrument associated with observable macroeconomic conditions, contemporaneous macroeconomic surprises, or persistence in forecast errors.

Second, we replace the baseline instrument with the previous year's forecast errors, both in its raw form and using the three progressively purged versions described in Section 4.3. Figure 4 reports the resulting cumulative multipliers.

The raw previous year forecast error produces considerably larger multipliers than the baseline instrument: the cumulative multiplier is around 2 on impact and rises to almost 4 at $h = 4$. Progressively purging the instrument reduces the estimated multiplier, with the largest reduction occurring when contemporaneous GDP growth and inflation forecast errors are removed. Under

the most comprehensive purging specification, the cumulative multiplier ranges from around 1.3 on impact to approximately 2.5 at $h = 4$, considerably closer to the baseline estimates. At the same time, the dynamic profile remains similar across specifications, with the strongest increase occurring at short horizons. These results support the baseline finding of a positive and persistent output effect of public investment while illustrating why the shorter forecast horizon provides a cleaner source of identifying variation.

Figure 4: Cumulative multipliers using the previous year's forecast errors



Note: The horizon on the X-axis is in years. 90% confidence bands are constructed using Driscoll-Kraay standard errors. Controls and time f.e. are included

The auxiliary regressions underlying the most comprehensive purging specifications for both current year and last year forecast errors are reported in Table D.1 in Appendix D. The results reveal a marked difference between the forecast horizons. Observable macroeconomic variables and the lagged public investment forecast error explain only 4% of the within-country variation in the current year forecast error, compared with 36% for the previous year forecast error. In particular, the previous year forecast error exhibits strong persistence and is significantly associated with several macroeconomic variables and forecast errors. These findings support the use of the current year forecast error as our baseline instrument, as it is substantially less predictable from

past information and less strongly associated with broader macroeconomic developments than the previous year forecast error.

Third, we test whether the results are sensitive to the exclusion of time fixed effects. Figure D.1 in Appendix D shows that removing time fixed effects increases the estimated multipliers substantially, particularly at longer horizons. The cumulative multiplier reaches almost 4 at $h = 4$, compared with approximately 2.1 in the baseline specification. This pattern is consistent with common European macroeconomic shocks generating positive comovement between public investment and output while reinforcing the importance of controlling for such shocks in the baseline specification.

Fourth, we examine whether the results are driven by exceptional macroeconomic episodes by first excluding 2020–2021 and then additionally excluding 2009–2010. The resulting multiplier profiles remain close to the baseline estimates (Figure D.2 in Appendix D). This is reassuring from an identification perspective, as the baseline results do not appear to be driven by periods characterised by exceptionally large and potentially correlated fiscal and macroeconomic surprises.

Finally, we assess whether the baseline results are driven by individual countries by re-estimating the equation 4 while excluding one country at a time. Figure D.3 reports the resulting cumulative multiplier at $h = 4$. The estimates range from approximately 1.8 to 2.4 and remain close to the full-sample estimate of 2.11. Excluding Lithuania produces the lowest estimate, while excluding Romania produces the highest. Overall, the results indicate that the estimated cumulative multiplier is not driven by any single country.

Taken together, the robustness exercises support the baseline finding of a positive and persistent public investment multiplier, while also highlighting the importance of using a short forecast horizon and controlling for common macroeconomic shocks.

6 State-dependence of the public investment multiplier

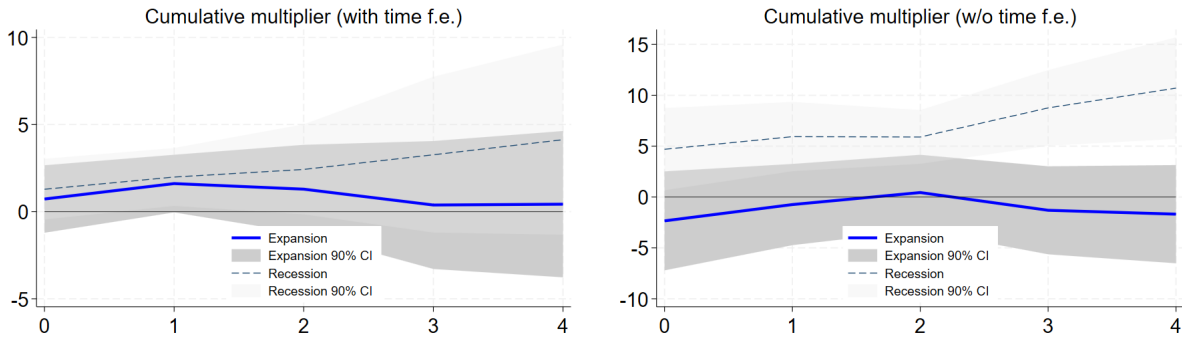
In this section, we present the state-dependent multiplier estimates based on the methodology described in Section 4.4. We focus on the three dimensions considered there: the state of the business cycle, the initial level of public debt, and the existing stock of public capital. For each dimension, we report estimates both with and without time fixed effects. Our preferred specifications include time fixed effects, which absorb common shocks affecting European economies simultaneously. However, specifications without time fixed effects provide a useful comparison because they also exploit

common time series variation in the state variables. This distinction is particularly relevant for the business cycle analysis, where synchronized European expansions and recessions constitute an important source of cyclical variation.

6.1 Recession vs expansion

First, we examine whether the effectiveness of public investment depends on the business cycle, distinguishing between recession and expansion episodes. Figure 5 indicates substantially larger output responses during recessions than during expansions. With time fixed effects, the cumulative multiplier during recessions rises steadily to around 3–4 at medium horizons, whereas the multiplier during expansions remains close to 1 and gradually declines over time. These figures, however, should be interpreted as the extreme rather than typical values of the multiplier for most severe contractions and expansions. As explained in Section 4.4, the transition function assigns a likelihood for each observation of the economy being in a contractionary or expansionary state. Therefore, these figures should be interpreted as the extremes to which the public investment multiplier moves in the states of high and low economic growth from the multiplier estimated by the baseline specification, which best describes a typical observation, i.e. such for which the GDP growth is at its average. This nuance of the correct interpretation applies to the rest of this section, too.

Figure 5: Cumulative multipliers for recession vs expansion



Note: The horizon on the X-axis is in years. 90% confidence bands are constructed using Driscoll-Kraay standard errors. Controls are included in all specifications. The left panel includes time fixed effects, while the right panel excludes them.

The difference between the two states is even more pronounced when time fixed effects are excluded. However, the inclusion of time fixed effects involves an important trade-off in this setting. While they absorb common European macroeconomic shocks that could otherwise confound the

estimated responses, they also absorb the common component of synchronized business-cycle fluctuations. Consequently, the specification with time fixed effects identifies state dependence primarily from cross-country differences in cyclical conditions within a given year, whereas the specification without them additionally exploits common time-series variation in the European business cycle.

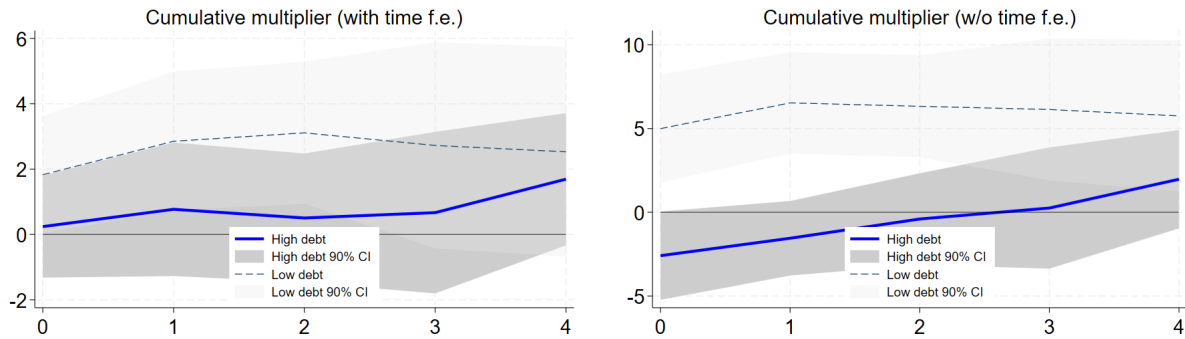
These findings are robust to using alternative measures of economic slack in the transition function, namely the output gap and the unemployment rate (see Figure D.4 in Appendix D).

Overall, these results are in line with [Auerbach and Gorodnichenko \(2012\)](#), [Elkhedari et al. \(2018\)](#), and [Petrović et al. \(2021\)](#), and suggest that the output effects of public investment are considerably stronger during downturns than during periods of economic expansion. This aligns perfectly with what basic economic theory predicts: the economy reacts to fiscal expansion in a Keynesian way in periods of economic slack due to available capacity, whereas in expansionary states spending and investment by the government crowds out that of the private sector.

6.2 High vs low public debt

Figure 6 indicates substantial differences in the public investment multiplier across levels of initial public debt. The cumulative multiplier is markedly larger when public debt is low than when it is high. With time fixed effects, the cumulative multiplier in the low debt state increases rapidly and remains around 3 over most horizons, while the high debt multiplier stays close to zero for several years and rises only modestly at longer horizons. The specification without time fixed effects yields the same qualitative pattern, although the divergence between the two states is larger.

Figure 6: Cumulative multipliers for high vs low public debt



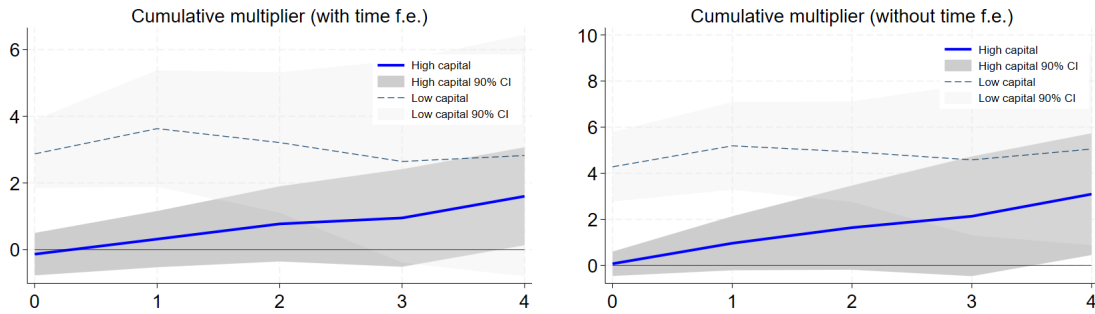
Note: The horizon on the X-axis is in years. 90% confidence bands are constructed using Driscoll-Kraay standard errors. Controls are included in all specifications. The left panel includes time fixed effects, while the right panel excludes them.

Overall, the results indicate that the output effects of public investment are considerably stronger when the initial level of public debt is low. This may reflect greater fiscal space, as additional borrowing is less likely to put upward pressure on borrowing costs and crowd out private investment when initial public debt is low. These results are consistent with the findings of [Furceri and Li \(2017\)](#) and [Ilzetzki et al. \(2013\)](#).

6.3 High vs low level of public capital

Figure 7 provides evidence that the output effects of public investment are state-dependent with respect to the existing stock of public capital. The cumulative multiplier is substantially larger in low-capital states than in high-capital states. When time-fixed effects are included, the multiplier in the low-capital regime is already high on impact, increases in the first year, and then remains persistently elevated, whereas in the high-capital regime it is initially close to zero and rises only gradually at longer horizons. However, the estimates in the high-capital regime are imprecisely estimated, and the increase in the cumulative multiplier at longer horizons should, therefore, be interpreted cautiously. The specification without time fixed effects yields the same conclusion. These findings are consistent with diminishing marginal returns to public capital, implying that additional investment has stronger growth effects when it alleviates existing infrastructure shortages rather than adding to an already relatively abundant capital stock. Similar findings were provided by [Izquierdo et al. \(2019\)](#).

Figure 7: Cumulative multipliers for high vs low level of public capital



Note: The horizon on the X-axis is in years. 90% confidence bands are constructed using Driscoll-Kraay standard errors. Controls are included in all specifications. The left panel includes time fixed effects, while the right panel excludes them.

7 Conclusion

This paper provides new evidence on the macroeconomic effects of public investment in European economies. Identifying these effects is challenging because public investment projects are typically anticipated well before expenditure takes place and because investment decisions may themselves respond to macroeconomic conditions. To address these challenges, we construct a novel dataset of European Commission public investment forecast errors for 23 European countries over 2002–2023 and use these forecast errors as instruments for public investment within an IV-LP framework. In contrast to approaches based on forecast errors in public investment ratios to GDP, we construct the forecast errors in real monetary terms, thereby isolating unexpected changes in public investment from the variation of the public investment to GDP ratio arising mechanically from changes of GDP in the denominator. Furthermore, we explicitly account for the persistence of investment spending by relating the cumulative output response to the total cumulative change in public investment induced by the forecast error.

The results indicate sizeable macroeconomic effects of public investment. The cumulative multiplier is close to 1 on impact, rises to around 1.8 within the first two years, and reaches approximately 2.1 over the five-year horizon. The corresponding dynamic estimates indicate that most of the output response occurs during the first two to three years following the initial innovation.

A range of robustness exercises supports the main findings. The results remain qualitatively similar when the baseline forecast error is purged of variation associated with lagged macroeconomic conditions, contemporaneous GDP growth and inflation forecast errors, and persistence in public investment forecast errors. Using forecast errors based on forecasts made one year earlier also produces positive multipliers, although these forecast errors are considerably more predictable from macroeconomic information and yield larger estimates unless they are purged of such information. This emphasises the importance of the endogeneity issue and the usefulness of instrumenting public investment with its forecast errors to resolve it.

The results are also robust to excluding the global financial crisis and the Covid-19 period and to excluding individual countries from the sample. By contrast, omitting time-fixed effects produces substantially larger multiplier estimates, highlighting the importance of controlling for common European macroeconomic shocks.

The state-dependent estimates further indicate that the multiplier is larger during economic

downturns, when initial public debt is low and when the existing stock of public capital is relatively small.

These findings have implications for the design of fiscal and public investment policies in Europe. The larger multipliers estimated during downturns suggest that preserving the capacity to undertake public investment when economic activity is weak can strengthen the stabilising role of fiscal policy. At the same time, the finding that multipliers are larger at lower levels of public debt points to an important interaction between public investment policy and fiscal sustainability. Maintaining fiscal space in normal times may allow governments to support productive investment during downturns without generating substantial increases in borrowing costs and associated crowding-out effects, while improving the resulting economic benefit of public investment. These results, therefore, highlight the potential output costs of fiscal consolidation that falls disproportionately on public investment, while also underscoring the importance of preserving incentives for prudent fiscal policy and debt sustainability. Larger multipliers where public capital is relatively scarce support investment frameworks that identify infrastructure gaps and prioritise investment where the existing public capital stock is relatively limited.

The findings also contribute to the debate on a fiscal golden rule, under which borrowing is permitted to finance public investment. The estimated multipliers capture the output effects of unexpected public investment changes under the financing arrangements prevailing in the sample; they do not separately identify the effects of debt-financed investment or of adopting a golden rule. Nevertheless, the sizable output effects provide an argument for protecting productive investment within fiscal frameworks. The smaller estimated multipliers at higher levels of public debt caution against treating investment expenditure as an unconditional justification for additional borrowing. Taken together, these findings are consistent with investment provisions that preserve flexibility while remaining subject to a credible debt sustainability framework and rigorous assessment of project quality.

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Appendix

A Public investment multiplier estimates

Table A.1: Public investment multipliers in the previous literature

Study	Multiplier	Sample	Methodology
Abiad et al. (2016)	0.4 (year 0) – 1.4 (year 4)	17 OECD economies; 1985–2013	LPs using forecast errors
Auerbach and Gorodnichenko (2012)	2.12 (peak over 20 quarters)	United States; 1947–2008	SVAR using forecast errors
Bom and Ligthart (2014)	0.08 (short run) – 0.12 (long run)	68 studies; 1983–2008	Meta-regression analysis
Deleidi et al. (2020)	0.9–1.2 (year 0) – 1.9–3.4 (year 6)	11 euro area countries; 1970–2016	LPs
Demetriades and Mamuneas (2000)	0.36–2.06 short run – 0.36–1.97 long run	12 OECD countries; 1972–91	Simultaneous equations system
Eden and Kraay (2014)	1.5 (year 1)	39 low-income countries (IDA borrowers)	2SLS using Kraay (2014)
Elkhadari et al. (2018)	0.3 (year 1) – 1.2 (year 5)	Algeria; 2008–15	SVAR using Blanchard and Perotti (2002)
Furceri and Li (2017)	0.2 (year 1) – 0.4 (year 4)	79 EMDEs; 1990–2013	LPs using forecast errors
Gbohoui (2021)	0.55 (year 0) – 0.07 (year 2)	Advanced economies; 1996–2019	LPs using forecast errors
Gechert and Rannenberg (2018)	0.6	98 studies	Meta-regression analysis
Honda et al. (2020)	0.1 (year 1) – 0.2 (year 2)	42 low-income countries; 1995–2017	LPs using forecast errors
Ilzetzi et al. (2013)	0.4 (q0) – 1.5 (q20) / 0.6 (q0) – 1.6 (q20)	High income countries; 1985–2013 / Developing countries; 1985–2013	SVAR using Blanchard and Perotti (2002)
Izquierdo et al. (2019)	0.2 – 1.4 after two years	31 European countries; U.S. states; Argentine provinces	Local projections using Blanchard and Perotti (2002) and forecast errors
Minea and Mustea (2015)	0.53 (year 1) – 1.18 (year 10)	Mediterranean countries; 1980–2012	PVAR
Miyamoto et al. (2020)	0.2 (year 0) – 1.2 (year 4)	17 advanced economies; 39 EMDEs	LPs using forecast errors
Petrović et al. (2021)	0.7 – 0.8 (after one year)	10 Central and Eastern European countries	LPs and SVAR using Blanchard and Perotti (2002)
Rafiq and Zeufack (2012)	2.7 in recessions; 2.0 in expansions (year 1)	Malaysia; 1981–2004	SVAR using Blanchard and Perotti (2002)
Warner (2014)	0.14 (year 0)	124 EMDEs; 1960–2011	OLS

B Data

B.1 Deflation

AMECO does not provide the deflator for public investment. One of the options to transform the nominal values into real would be to use the deflator for "Real total expenditure of general government". We do not use it for two reasons: a) the composition of goods and services between government consumption and investment is vastly different, b) this measure is absent in vintages prior to 2011. The latter implies there would have been a break in how we compute the real values.

Instead, we use the deflator of GDP throughout. We favour it as opposed to any other deflator, like that of private consumption, because the manner in which government investment differs from government consumption and other major categories of GDP is a large share of capital goods in its composition. A deflator of specifically investment goods is also absent in vintages before 2011.

To compute the forecast errors in real terms correctly, we must account for difference between the expected and realised change in the GDP deflator (henceforth we use "inflation" to denote the change in the GDP deflator). The difference in the nominal value of the forecast and realised public investment may originate from the difference between the expected and realised inflation; similarly, a difference between the expected and realised GDP deflator can increase or decrease the forecast error compared to the difference in the nominal values. To control for that, we compute real values of public investment with the deflators for a certain period using deflators contained in the same vintage from which the respective nominal value is taken. Only then do we proceed with comparing the values of public investment, already in real terms, across different vintages for the forecast error computation. In other words, the same-year forecast errors (used in the baseline specification and all additional parts of the analysis) are obtained as

$$FE_{t|t} = X_{t|t+1} - X_{t|t} = \frac{V_{t|t+1}}{P_{t|t+1}} - \frac{V_{t|t}}{P_{t|t}} \quad (11)$$

and the one-year-ahead forecast errors, used only for robustness tests, are obtained as

$$FE_{t|t-1} = X_{t|t+1} - X_{t|t-1} = \frac{V_{t|t+1}}{P_{t|t+1}} - \frac{V_{t|t-1}}{P_{t|t-1}} \quad (12)$$

where V denotes the nominal value of public investment and P – the GDP deflator.

B.2 Currency conversion

A number of countries have switched from their national currency to the euro during the sample period. Since the nominal figures of public investment are provided in the units of national currency, for countries that switched to euro, we convert all figures provided in the national currency units (until and excluding the year provided in Column 2 of Table B.1) to euro using the official exchange rate (Column 3 of Table B.1).

Table B.1: Currency conversion for countries that switched to euro during the sample period

Country	Year	Exchange rate
Croatia	2023	7.5345
Estonia	2011	15.64485
Latvia	2014	0.702804
Lithuania	2015	3.4528
Malta	2008	0.4293
Slovakia	2009	30.126
Slovenia	2007	239.64

B.3 Public investment definition change after 2013

Observations of public investment forecast errors for 2013 are excluded from the analysis because their construction requires comparing AMECO vintages that straddle a change in the underlying national accounts methodology. In particular, Regulation (EU) No 549/2013 introduced the European System of Accounts 2010 (henceforth ESA 2010), which replaced ESA 95 and broadened the definition of gross fixed capital formation, notably by capitalising research and development expenditure and recognising military weapons systems as fixed assets ([European Parliament & Council of the European Union \(2013\)](#)). The 2013 and 2014 AMECO vintages, therefore, rely on different accounting frameworks. As a result, due to the introduction of ESA 2010, the historical data for public investment starting from the 2014 vintage is different to prior vintages. Therefore, the cross-vintage difference between 2013 and 2014 cannot be cleanly interpreted as a pure forecast error. To ensure that all forecast errors that we subsequently use as instruments capture the difference between the forecast and realised values rather than methodological breaks in the underlying series, the computed public investment forecast-error observations for 2013 are excluded from the analysis.

When we repeat the analysis using one-year-ahead forecast errors, as given by formula 2, in the robustness tests, this change of the regulation affects the computed forecast errors for both 2012 and 2013. Hence, we exclude the public investment forecast-error observations for both of these years.

C Summary statistics

Table C.1: Summary statistics of public investment forecast errors by country

Country	min	p10	mean	median	p90	max
Austria	-0.1192	-0.0510	0.0089	0.0224	0.0717	0.0994
Belgium	-0.0712	-0.0525	0.0029	0.0010	0.0588	0.1072
Bulgaria	-0.3777	-0.3388	-0.1171	-0.1023	0.0887	0.2389
Croatia	-0.6599	-0.2410	0.2043	-0.1213	0.7886	2.7464
Cyprus	-0.2213	-0.1499	0.0922	-0.0068	0.3334	1.0876
Czechia	-0.1799	-0.1428	-0.0159	-0.0120	0.1245	0.2000
Denmark	-0.0867	-0.0731	0.0044	0.0048	0.0869	0.1216
Estonia	-0.1923	-0.1836	-0.0093	-0.0261	0.0960	0.3702
Finland	-0.1450	-0.0919	0.0000	0.0026	0.0854	0.1380
France	-0.1068	-0.0797	-0.0159	-0.0095	0.0302	0.0642
Germany	-0.0553	-0.0499	-0.0096	-0.0109	0.0278	0.0565
Greece	-0.3958	-0.2838	-0.0334	-0.0142	0.1694	0.2416
Hungary	-0.3819	-0.1371	0.0140	-0.0033	0.2135	0.2618
Ireland	-0.1542	-0.1468	-0.0025	-0.0074	0.0892	0.3292
Italy	-0.1078	-0.0782	-0.0041	-0.0084	0.0566	0.1375
Latvia	-0.2433	-0.1959	-0.0100	0.0049	0.1487	0.3105
Lithuania	-0.2136	-0.1659	-0.0195	-0.0294	0.1045	0.2268
Luxembourg	-0.8155	-0.1177	0.0837	-0.0308	0.0482	3.1023
Malta	-0.3108	-0.2541	-0.0381	-0.0849	0.2124	0.2430
Netherlands	-0.0725	-0.0539	-0.0004	-0.0045	0.0589	0.0840
Poland	-0.2038	-0.1168	-0.0247	-0.0074	0.0793	0.1446
Portugal	-0.1952	-0.1777	0.0002	-0.0424	0.1406	0.4404
Romania	-0.2382	-0.1685	-0.0115	-0.0398	0.1689	0.2040
Slovakia	-0.2068	-0.1354	0.0373	-0.0002	0.2755	0.4831
Slovenia	-0.1510	-0.0963	0.0161	0.0108	0.1502	0.2198
Spain	-0.0994	-0.0679	-0.0089	-0.0088	0.0647	0.1074
Sweden	-0.0536	-0.0343	0.0216	0.0094	0.0542	0.2698
United Kingdom	-0.1129	-0.0823	0.0163	0.0115	0.1198	0.1867

Table C.2: Summary statistics of public investment forecast errors by year

Year	min	p10	median	mean	p90	max
2002	-0.0976	-0.0787	-0.0082	0.0116	0.1249	0.2698
2003	-0.0536	-0.0381	0.0188	0.0238	0.0801	0.1126
2004	-0.2433	-0.1192	0.0253	0.0352	0.2001	0.3485
2005	-0.1606	-0.1089	-0.0087	-0.0096	0.0790	0.2024
2006	-0.1129	-0.0585	0.0240	0.0458	0.1399	0.3702
2007	-0.1168	-0.0831	0.0010	0.0073	0.0925	0.1760
2008	-0.1449	-0.0628	-0.0070	0.0002	0.1075	0.1414
2009	-0.2546	-0.1644	-0.0209	-0.0107	0.0939	0.2995
2010	-0.1923	-0.1623	-0.0301	-0.0034	0.1968	0.4404
2011	-0.3958	-0.1495	-0.0360	-0.0454	0.0642	0.2653
2012	-0.2136	-0.1687	-0.0168	-0.0306	0.0510	0.1657
2014	-0.1790	-0.0618	-0.0033	0.0335	0.1815	0.2394
2015	-0.1510	-0.0517	0.0008	0.0485	0.2257	0.4831
2016	-0.3819	-0.2049	-0.0295	-0.0616	0.0579	0.1708
2017	-0.3777	-0.0638	-0.0028	-0.0041	0.0819	0.2416
2018	-0.1475	-0.0709	0.0160	0.0121	0.1126	0.1375
2019	-0.3044	-0.1092	-0.0081	-0.0260	0.0407	0.1583
2020	-0.1023	-0.0663	0.0133	0.0004	0.0593	0.0789
2021	-0.3045	-0.1438	-0.0480	-0.0540	0.0489	0.1678
2022	-0.2815	-0.2089	-0.0472	-0.0571	0.0389	0.1010

Figure C.1: Distribution of public investment forecast errors by country

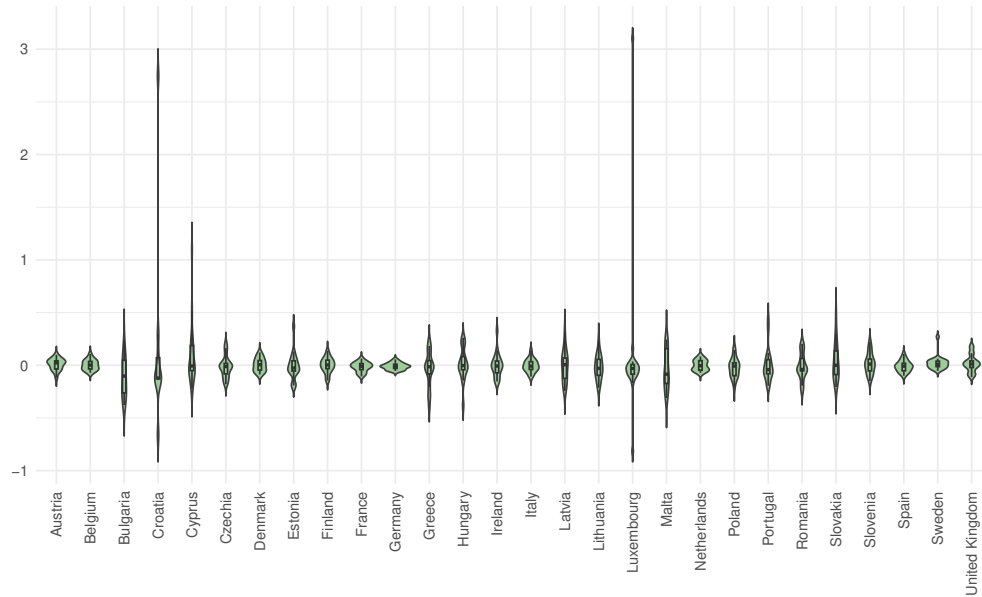
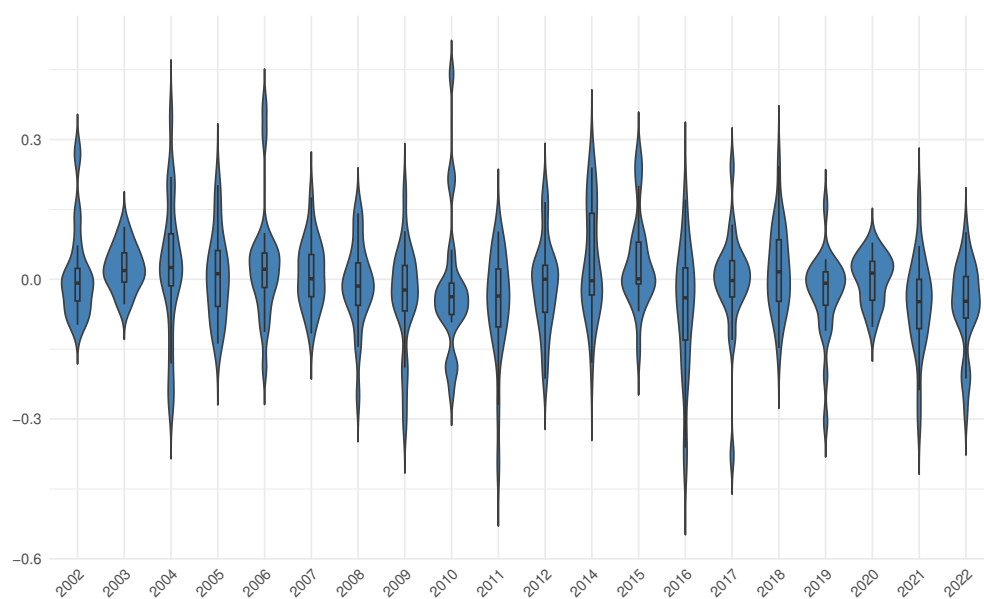


Figure C.2: Distribution of public investment forecast errors by year (all countries)



The forecast-error observations for the year 2013 are excluded because of the definition change of public investment, which prohibits comparing data from vintages before 2013 and after 2014. For more details, see Appendix [B.3](#).

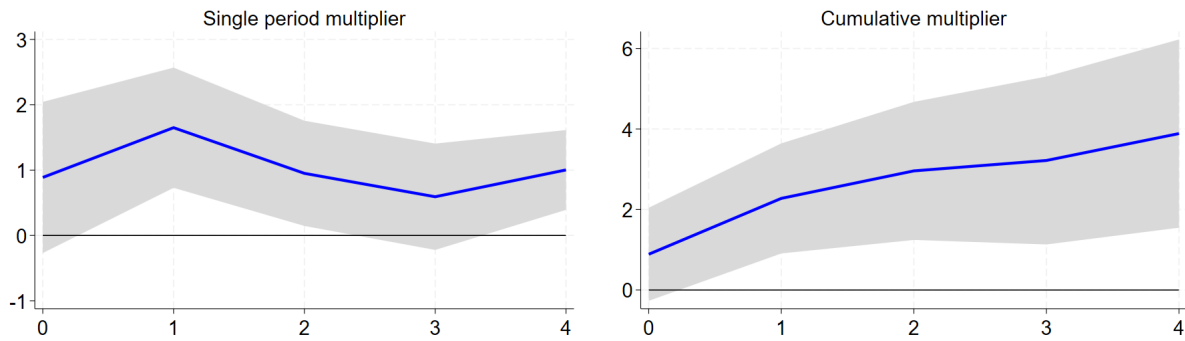
D Robustness analysis

Table D.1: Auxiliary regressions used to purge public investment forecast errors

	Public investment forecast error	
	Current-year forecast error	Previous-year forecast error
Lagged public investment forecast error	-0.103* (0.052)	0.893*** (0.075)
Lagged inflation	-1.521 (1.221)	-4.269** (1.785)
Lagged GDP growth	1.678*** (0.581)	1.899** (0.836)
GDP growth forecast error	2.513 (1.542)	2.615*** (0.807)
Inflation forecast error	-1.137 (1.939)	-2.446* (1.401)
Country fixed effects	Yes	Yes
Time fixed effects	No	No
Observations	364	364
Countries	23	23
Within R^2	0.037	0.356
F -statistic	2.58	37.12
p -value	0.026	0.000

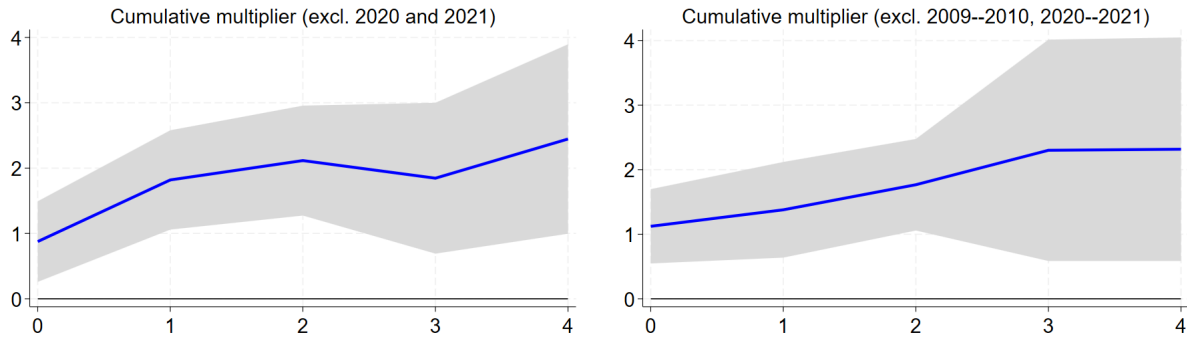
Note: The dependent variable is the public investment forecast error based on the current year forecast in column (1) and on the previous year forecast in column (2). Standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Figure D.1: Public investment multipliers excluding time fixed effects



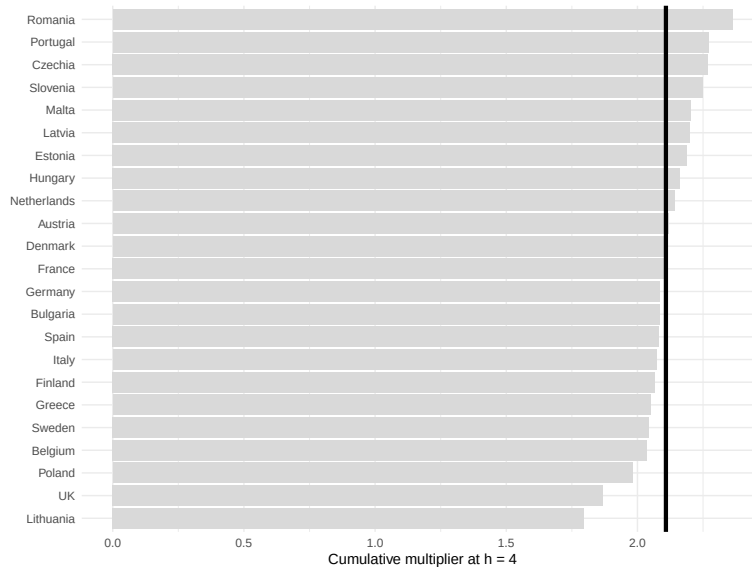
Note: The horizon on the X-axis is in years. 90% confidence bands are constructed using Driscoll-Kraay standard errors. Controls are included, time fixed effects are excluded.

Figure D.2: Public investment multipliers excluding crisis years



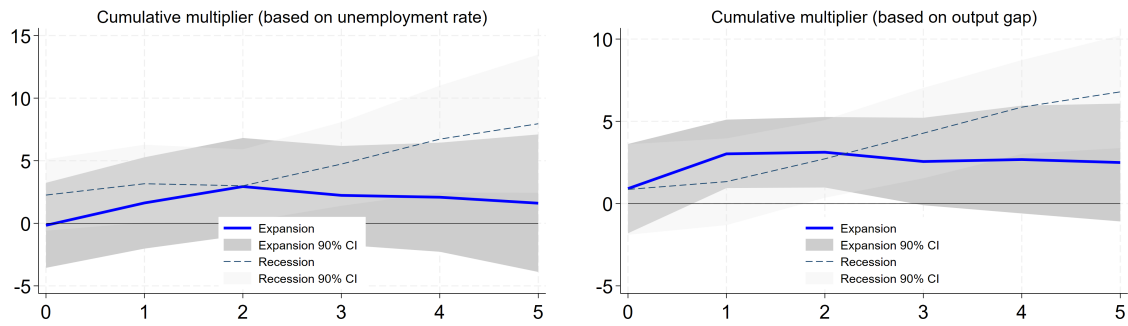
Note: The horizon on the X-axis is in years. 90% confidence bands are constructed using Driscoll-Kraay standard errors. Controls and time f.e. are included

Figure D.3: Public investment multipliers excluding leaving one country out



Note: Each bar reports the estimated cumulative public investment multiplier at $h = 4$ after excluding the indicated country from the sample. The vertical line denotes the corresponding full-sample estimate (2.11).

Figure D.4: Cumulative multipliers for recessions vs expansion (w/o time f.e.)



Note: The horizon on the X-axis is in years. 90% confidence bands are constructed using Driscoll-Kraay standard errors. Controls and time f.e. are included