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Revisiting Public Investment Multipliers

Nonlinear Effects of the Business Cycle, Fiscal Space, Efficiency, and Capital Stock

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Abstract

The paper examines the macroeconomic effects of public investment in emerging market and developing economies. To this end, the analysis develops a new measure of public investment shocks based on cyclically adjusted government investment. Estimations using local projections based on a large sample of 129 countries over 1980–2019 suggest that public investment can significantly boost economic growth: an increase in public investment by 1 percent of gross domestic product raises output by 1.1 percent after five years, on average. However, the effects are much larger when public investment spending is efficient and fiscal space is ample—reaching up to 1.6 percent over the same period. Public investment multipliers tend to be larger during recessions and in capital-scarce economies. The paper also finds that public investment can crowd in private investment, as well as boost productivity and potential output.

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Revisiting Public Investment Multipliers: Nonlinear Effects of the Business Cycle, Fiscal Space, Efficiency, and Capital Stock[1]

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1. Introduction

Public investment is often considered a powerful policy lever to foster economic growth. This is particularly the case in emerging market and developing economies (EMDEs), which face significant investment gaps to meet their sustainable development objectives in an environment where private investment has been in a broad-based and prolonged slump (World Bank 2024).[5] Public investment facilitates production; promotes the flows of capital, labor, goods and services; and provides the infrastructure needed to improve human capital and productivity. Given the non-excludable and non-rival nature of public goods and services, and substantial costs involved in the development and maintenance of public infrastructure, it often cannot be supplied effectively by the private sector.

That said, public infrastructure projects are generally costly and can lead to high budget deficits and unsustainable levels of public debt, particularly when the planning and execution of investment projects is weak (Adarov and Panizza 2024; Afonso and Alves 2023; Berg et al. 2012). Government spending may suffer from inefficiency, especially in countries with governance issues, corruption, and weak fiscal monitoring and accountability mechanisms, and in the worst cases, may yield infrastructure that is unproductive and costly to maintain (Chakraborty and Dabla-Norris 2011; Dabla-Norris et al. 2012; Pritchett 2000). In countries with weak institutions, public investment may also crowd out private investment, particularly when scaling up is sizeable and fast-paced (Aschauer 1989a; Cavallo and Daude 2011). Thus, the net macroeconomic effects of public investment can also be small or even negative.

In fact, the empirical estimates of public investment multipliers reported to date differ significantly. The estimates are sensitive to the sample of countries and timeline investigated, estimation methodology, incorporation of non-linear effects, and fiscal shock identification strategies (see Section 2 for discussion). Empirical work examining public investment multipliers in EMDEs is especially scarce. The main challenge in performing such research also rests in the difficulty of identifying changes in public spending that are uncorrelated with contemporaneous macroeconomic shocks, and that can thus be deemed as exogenous.

In light of these caveats, in this paper we aim to contribute to this literature in a number of ways. First, we use the data on public investment for a broad sample of 129 EMDEs over a long span of time (1980-2019). The large sample is helpful to better understand implications of public investment in EMDEs as a whole, as well as explore heterogeneity across country groups. Second, we bring together many of the methodological improvements in recent empirical research focusing on the role of initial conditions in determining the macroeconomic effects of public investment. These include: (i) prevailing business cycle conditions at the time of the shock; (ii) fiscal space; (iii) public investment efficiency; and (iv) the initial public capital stock level. While these themes have been touched upon in some earlier studies, no paper has yet brought them all together and

[5] Public investment in the context of the paper refers to general government gross fixed capital formation.

applied them to a broad sample of EMDEs. Our paper helps fill this gap in the literature. Third, we introduce a new approach to measuring public investment shocks based on the identification of the episodes of large changes in cyclically adjusted real public investment specific to each country. In contrast to many public investment shock identification frameworks, our approach relies on annual-frequency data on public investment that is publicly available and is easy to replicate.[6] Finally, in addition to the estimation of public investment multipliers, we examine the effects of public investment on private investment, productivity, and potential output, which helps to cast light on the long-run supply-side transmission channels of public investment.

Our local projections estimates, using the identified public investment shocks, suggest that public investment can stimulate economic growth. In particular, the scaling up of public investment equivalent to 1 percent of GDP leads to an increase in output of 1.1 percent after five years in EMDEs, on average. We also find that the size of the public investment multiplier depends on government efficiency and fiscal space. In countries with higher public investment efficiency and ample fiscal space, an increase in public investment equivalent to 1 percent of GDP can increase output by up to 1.6 percent over the horizon of five years.[7] By contrast, in countries with low public investment efficiency and high public debt, the output effects of public investment are smaller and not statistically significant. In line with the literature, we also find that public investment multipliers tend to be greater during recessions and in capital-scarce economies.

Our analysis also suggests that public investment can have significant crowding-in effects on private investment. In EMDEs, the scaling up of public investment by 1 percent of GDP leads to an increase in private investment by up to 2.2 percent over the horizon of five years, on average. Finally, the paper finds that public investment can boost productivity and potential output. In the EMDE sample with available data, a 1 percent of GDP increase in public investment can increase labor productivity by 1.9 percent and total factor productivity by 0.8 percent over five years. Potential output in response to public investment shocks increases by up to 1.1 percent over the same period. Thus, our analysis provides empirical support for both short-run demand and long-run supply-side transmission channels of public investment.

The rest of the paper is structured as follows. Section 2 provides a synthesis of the literature on public investment effects. Section 3 presents the new framework for the identification of public investment shocks and the estimation methodology. Section 4 discusses the empirical results. Section 5 outlines policy implications and concludes.

[6] See the comparative review of public investment shock identification strategies developed in the empirical literature in the methodology section.

[7] State-dependent public investment multipliers use the dynamics of public debt as a share of GDP to proxy fiscal space and public investment and infrastructure efficiency indexes in the estimations of multipliers conditional on public investment efficiency. In more technical terms, public investment efficiency is defined as the fraction of public investment that translates into effective public capital stock (Pritchett 2000), which, in turn, depends on the strength of institutions, quality of the design and implementation of public investment projects, and effectiveness of procurement systems, among other factors (see also Kim et al. 2020).

2. Synthesis of the literature

2.1. Theoretical foundations

The early literature examined the effects of government investment on economic growth in the context of the endogenous growth model in which public capital enters the production function as one of the productive inputs (Aschauer 1989a,b; Barro 1990; Barro and Sala-i-Martin 1992; Futagami, et al. 1993; Glomm and Ravikumar 1994; Turnovsky 1997). Subsequent studies built on this framework, incorporating features such as aid-funded public investment, infrastructure networks, and public debt accumulation to facilitate a more nuanced analysis of the transmission channels of public investment to growth (Adam and Bevan 2006; Agenor 2010; Berg et al. 2010, 2012). More recently, Chakraborty and Dabla-Norris (2011) studied the quality of public investment and distortionary effects of corruption within a general equilibrium growth model.

2.2. Transmission channels

Theoretical and empirical literature has identified multiple channels through which public investment influences economic growth:

- *Short-term aggregate demand effects.* Public investment has the potential to support economic activity by boosting aggregate demand in the short term. This positive impact, however, is at least partly offset by the associated fiscal effects on the real economy, because public investment in principle is funded via taxation, debt issuance, or reallocation of government expenditure. In addition, the multiplier effect is weakened by purchases of investment goods abroad and depends on the import intensity of investment ("leakage effect"). Rapid scaling up of public investment, depending on its funding source and efficiency, may fuel fiscal imbalances and thereby undermine growth prospects (Bom and Ligthart 2014a; Romp and de Haan 2005).

- *Long-run aggregate supply effects.* Public investment has the potential to directly increase the productive capacity of an economy by fostering enhanced productivity of private fixed capital and labor through the provision of public infrastructure. For instance, new roads and bridges can increase the overall competitiveness of an economy by enabling connectivity or reducing its cost (Aschauer 1989b; Romp and de Haan 2005; Straub 2011).

- *Crowding-in or crowding-out of private investment.* Public investment can crowd in private investment directly by requiring the use of private capital in the implementation of an investment project, for example, via public-private partnerships. Public investment can also enable infrastructure that raises returns on private capital—for instance, roads and communications infrastructure—thereby encouraging private sector investment (Aschauer 1989a, Eden and Kraay 2014). Public investment helps to reduce uncertainty and

risks associated with large private investment projects, especially infrastructure projects requiring massive upfront costs but longer payback periods (IMF 2021b). However, public investment may also crowd out private investment, especially when fiscal space is limited and additional fiscal stimulus raises sovereign risk and borrowing costs for the private sector (Abiad et al. 2016; Erenburg and Wohar 1995; Huidrom et al. 2020). The net effect on the private sector depends on the balance between these opposing factors, which, in turn, is influenced by fiscal space and the quality of public investment.

- *Efficiency and quality of public investment.* Scaling up of public investment may not necessarily result in an equivalent increase in the value of productive public capital (Pritchett 2000). Some resources are lost during the investment process because of weak governance, corruption, coordination issues, and poor design and implementation of investment projects. There may also be diminishing returns on additional public investment, though this depends on a country's circumstances and the merits of specific projects. In the worst case, low-quality investment may yield infrastructure that is unproductive and yet requires a continuous stream of fiscal resources for maintenance, thereby hurting long-term growth prospects (Chakraborty and Dabla-Norris 2011; Dabla-Norris et al. 2012). In part, this also relates to the composition of public investment: not all projects contribute equally to growth.[8]

- *Public capital maintenance costs.* More generally, depreciating public capital stocks require additional short- and long-run maintenance. The associated costs may lead to additional fiscal strains that undermine long-term positive growth effects. Meanwhile, inadequate or untimely maintenance of public capital could lead to even larger social and economic costs associated with infrastructure failures (Schwartz et al. 2020).[9] The strength of this channel is intertwined with the efficiency channel, as low-quality public investment is more likely to yield infrastructure that is prone to larger or more frequent upkeep costs.

- *Sustainability of economic growth.* Public investment—though not always the only solution—can also play an important role in delivering public goods or services that may not be privately profitable, such as public healthcare and education, water and energy transmission, and national security. This type of public investment can be instrumental for facilitating sustainable and inclusive growth through its positive effects on human capital development, social

[8] As a related matter, there are challenges associated with the measurement and valuation of public investment at a disaggregated level—that is, identifying infrastructure-related spending and composition of public investment by capital asset types (see also ADB 2017 and Fay et al. 2019). This hinders the assessment of the macroeconomic effects by individual categories of public investment and types of infrastructure, which are likely to be heterogeneous (see the meta-analysis in Foster et al. 2023).

[9] Governments may also have stronger incentives to spend on new investment projects rather than on maintenance as the former is more visible and attractive from an electoral perspective (De Haan and Klomp 2013).

inclusion, and environmental impacts (Foster et al. 2023; Mazzucato and Semieniuk 2017; Turnovsky 2015; Zachmann et al. 2012).

2.3. Main approaches to constructing public investment shocks

To gauge the extent to which public investment shocks impact economic growth, it is first necessary to identify changes in this spending that are independent of prevailing macroeconomic conditions. To date, the main methods deployed to tackle this identification challenge are the structural vector autoregression (SVAR) estimation with recursive identification, frameworks relying on instrumental variables, the narrative approach, and identification based on forecast errors:

- *SVAR with recursive identification of public spending shocks.* This approach employs recursive identification schemes and other parameter restrictions to pin down unexpected public spending shocks. Specifically, the Cholesky decomposition assumes that government spending does not respond to macroeconomic shocks in the same period (Blanchard and Perotti 2002). A drawback is that this rationale becomes less compelling at an annual frequency, yet availability of higher frequency data is often constrained, especially for EMDEs.

- *Official lending as an instrument for exogenous public spending.* This approach, pioneered by Kraay (2012, 2014), uses data on official creditor loan disbursements to identify public spending shocks in the recipient country based on the lag between loan approval and subsequent disbursements to identify a component insulated from contemporaneous macroeconomic developments. However, this framework is only applicable to countries that are recipients of official development assistance and requires the calculation of "predicted" disbursements for each loan.

- *Military spending as an instrument for exogenous public spending.* Building on the "natural experiment" framework proposed by Barro (1981), the narrative approach, developed in Ramey and Shapiro (1998), Ramey (2011a, b), and Ramey and Zubairy (2018), uses fluctuations in governments' military expenditures—assumed to be driven by external geopolitical factors as opposed to domestic macroeconomic conditions—to isolate exogenous changes in public spending. This approach, however, would not work well for EMDEs, in which military spending is typically less prone to fluctuation. More broadly, a pitfall of this method is that the resulting growth responses may be largely attributable to the military spending sub-component as opposed to more general fiscal stimulus.

- *Forecast errors in public spending as a proxy for fiscal shocks.* In more recent empirical research, Auerbach and Gorodnichenko (2012, 2013) use differences between actual public spending and the level predicted by professional forecasters to identify unanticipated public

spending shocks.[10] The methodology has the advantage of overcoming the issue of fiscal foresight, whereby anticipated fiscal policy changes may be incorporated into current economic decisions (Forni and Gambetti 2010; Leeper et al. 2012, 2013). However, this approach relies on the availability and quality of public spending forecast data. Additional caveats relate to the nature of fiscal projections: first, they may not be fully orthogonal to past macroeconomic trends; and second, they rely on subjective, heterogeneous assumptions about future macroeconomic developments.

2.4. Estimates of public investment multipliers

While the empirical work on total public spending multipliers across a broad range of countries is voluminous, the subset of the literature that distinguishes public investment multipliers is limited and primarily focuses on advanced economies. In general, there is an emerging consensus that public investment tends to have a positive growth impact in the medium term (Auerbach and Gorodnichenko 2013; Eden and Kraay 2014; Furceri and Li, 2017; Ilzetzki et al. 2013; Izquierdo et al. 2019; Leduc and Wilson 2012). However, there remains considerable variation in the estimates of the output elasticity to public investment; in a meta-analysis of 68 studies, Bom and Ligthart (2014b), report that the range is -1.7 to 2.0. In reviews of the literature, Gechert and Rannenberg (2018) and Vagliasindi and Gorgulu (2021) also report that public investment multiplier estimates range widely with an average of about 1.5. Appendix table B1 provides a comprehensive review of public investment multipliers in the literature over the past two decades.

Empirical work focusing on EMDEs has been especially scarce, given data constraints and methodological challenges in identifying spending shocks. Nevertheless, limited research on EMDEs also documents important growth impacts of public investment. For instance, Miyamoto et al. (2020) report an increase in output by 0.4 percent over 4 years for a sample of 39 EMDEs. Ilzetzki et al. 2013) estimate a public investment multiplier of 0.6 on impact, increasing to 1.6 in the longer run, for a panel of 24 developing countries. Furceri and Li (2017) report smaller magnitudes for a sample of 79 EMDEs: a 10-percent increase in public investment induces growth of 0.4 percent over four years. Smaller effects are reported in Warner (2014) using a sample of 124 EMDEs: a change in public investment equivalent to 1 percent of GDP is found to spur only meagre (0.1 percent) output growth in the short run with no significant effect in the long run. The observed wide range of estimates of government spending multipliers has prompted additional inquiry into the factors that may explain these differences—discussed in the following section.

[10] This approach was utilized recently in Abiad et al. (2016), Furceri and Li (2017), Honda et al. (2020), and Miyamoto et al. (2020) to estimate unconditional and state-dependent public spending multipliers.

2.5. Factors impacting the size of public investment multipliers

Macroeconomic conditions. In a synthesis review, Izquierdo et al. (2019) note that the position of economy in the business cycle, the degree of exchange rate flexibility, debt levels, the monetary policy stance, and openness to trade are important determinants of the size of multipliers. In this regard, the literature indicates that multipliers tend to be larger during recessions (Auerbach and Gorodnichenko 2012 and 2013; Honda et al. 2020; Riera-Crichton et al. 2015). Further, the output effects tend to be larger in supply-driven recessions compared to demand-driven recessions (Ghassibe and Zanetti 2022).[11] Multipliers are found to be larger during periods of monetary policy easing and elevated macroeconomic uncertainty, particularly when nominal interest rates are at very low levels, i.e. reach the "zero lower bound" (Christiano et al. 2011; Gbohoui 2021).

Country structural characteristics. Multipliers tend to be greater in countries with a fixed exchange rate regime, low levels of debt, and lower economic informality (Colombo et al. 2022; Honda et al. 2020; Huidrom et al. 2020). Financial development and economic development are also positively associated with the size of spending multipliers (Ilzetzki et al. 2013; Koh 2017).

Initial stock of public capital. Public investment multipliers are greater in countries with a lower level of initial public capital stock (Izquierdo et al. 2019). Excessive levels of public capital stock and investment may be detrimental for growth if resources are diverted away from more productive uses or crowd out private investment (Canning and Pedroni 2008; Devarajan et al. 1996). However, Honda et al. (2020) find that in low-income countries, output effects of public investment are greater in economies with higher initial capital stock, and conjecture that in low-income countries the private sector may not be responsive to fiscal policy shocks when the initial capital stock is too low.

Public investment efficiency. The quality of the public investment management process is important in order to reap the positive macroeconomic effects of public capital. The public investment management process encompasses multiple aspects, including project development, implementation, monitoring, and evaluation—the efficiency of which are generally difficult to quantify (Dabla-Norris et al. 2012). Gupta et al. (2014) compute "efficiency adjusted" public capital stocks and find that the growth effects of efficient public investment are higher. The positive effects of higher spending efficiency has been documented in other empirical research (Berg et al. 2013; Cavallo and Daude 2011; Furceri and Li 2017; Izquierdo et al. 2018; Leduc and Wilson 2012; Leeper et al. 2010; Miyamoto et al. 2020).

In sum, the literature is generally in agreement that public investment tends to have a positive impact on economic growth, particularly in the longer run. The wide dispersion of the magnitudes of public investment multipliers, however, motivated research that sought to reconcile this

[11] Ramey (2019) notes that these results may not be fully robust given their sensitivity to the sample composition and the methodology.

heterogeneity. Findings suggest that country-level characteristics—including public spending efficiency and capital scarcity—are relevant, as well as macroeconomic factors. Methodological and sample differences may also explain some variation in results across studies. That said, the evidence on the impact of public investment to growth in EMDEs is relatively meagre, owing in large part to associated data constraints. Thus, further research—including that provided in this paper—is needed to better inform how public investment can stimulate economic growth and mobilize private investment.

3. Methodology and data

3.1. Data and sample

The database used in the estimation of the macroeconomic effects of public investment draws from several sources. Public investment, private investment, and capital stock data are from the International Monetary Fund's Investment and Capital Stock Dataset (IMF 2021a). Public debt data are retrieved from the World Bank's Fiscal Space Database (Kose et al. 2022). Public investment efficiency data are obtained from several sources: IMF (2021b) Fiscal Monitor database, Devadas and Pennings (2018), and Dabla-Norris et al. (2012). Potential output data are sourced from Kilic Celik et al. (2023). GDP and inflation series are from the IMF's World Economic Outlook database. Labor productivity and total factor productivity data are from Penn World Table 10.01. The resulting dataset comprises up to 129 EMDEs, spanning the period 1980-2019 (see Appendix table A1 for the sample composition).[12]

3.2. A new approach to identify public investment shocks based on cyclically adjusted public spending

In this paper we apply a new approach to identify public investment shocks. The methodology builds on the work of Alesina et al. (1998), Alesina and Ardagna (2010), and related studies that assess the macroeconomic effects of changes in cyclically adjusted fiscal variables. Conceptually, the approach is consistent with the literature arguing that large and apparent scaling up of public investment tends to reflect exogenous decisions by the public authorities (Deleidi et al. 2020; Warner 2014). The shock identification framework involves four steps:

- First, we estimate output elasticities of public investment for each country in the sample by regressing the logarithm of real public investment on the logarithm of real GDP. Estimates are done using ordinary least squares for each country with at least 20 continuous observations of both variables.[13]

[12] The sample composition and time coverage are determined entirely by the data availability. In particular, the current version of the Investment and Capital Stock Dataset (IMF 2021a), providing consistent disaggregated series for public and private investment, covers the period 1960-2019.
[13] Countries with fewer than 20 continuous observations were not included in the sample going forward.

- Second, we obtain measures of potential output GDP^{pot} via a Hodrick-Prescott (HP) filter as the baseline estimate. We also use Baxter-King, Christiano-Fitzgerald Random Walk and the Hamilton (2018) filters as a robustness check.

- Third, we compute cyclically adjusted real public investment (CAPI) as follows:

$$CAPI = PI\left(\frac{GDP^{pot}}{real\ GDP}\right)^{\varepsilon_{PI}} \qquad (1)$$

  where PI is real public investment and ε_{PI} is the estimated elasticity of public investment.

- Fourth, for each country i we define public investment shocks ($shock_{i,t}$) as a measure taking the value of one when a country's first difference of CAPI exceeds its country-specific mean by one standard deviation:

$$shock_{i,t} = 1\ if\ \Delta CAPI_{it} > \overline{\Delta CAPI_i} + SDCAPI_i\ ,\ 0\ \text{otherwise} \qquad (2)$$

Focusing on country-level public investment adjustments greater than one standard deviation is in the spirit of Alesina and Ardagna (2010), who argue that focusing on large fiscal adjustments helps identification of changes in fiscal variables that are induced by discretionary policy, rather than influenced by the business cycle. Some examples of the episodes identified using this approach include the rapid scaling up of public investment in Poland in 2005-06 and 2018, in Brazil in 2007, and Morocco in 2008. In Poland, the episodes followed significant EU fund inflows and reforms as part of its EU integration. In Brazil, the episode followed the launch of the Growth Acceleration Program—a major infrastructure program including investment projects and policies to boost growth. In Morocco, the episode involved major public investment in infrastructure projects, such as the Green Morocco Plan to bolster the agricultural sector and the expansion of the Tanger Med port.

This approach to the identification of public investment shocks has several advantages. Given the focus only on large episodes of public investment increases, the results are more robust to imperfections in measuring the effect of the business cycle on fiscal variables, as small changes in cyclically adjusted public spending are excluded from the estimation. The proposed framework eschews certain limitations of existing identification methods that rely on data that are not publicly available (for instance, methods based on government spending forecast errors) or yield estimates for a limited set of countries (for instance, frameworks relying on narrative shock identification or quarterly-frequency data). As such, identification of disaggregated public investment shocks can be undertaken for a broad sample of countries with available annual data. The large sample, in turn, facilitates estimation of multipliers conditional on country characteristics.

In contrast to one-size-fits-all approaches, this framework accounts for heterogeneity across countries by considering the magnitude of public investment shocks within country-specific historical contexts. This is an important feature in the analysis of EMDEs, which may exhibit fiscal procyclicality (commodity exporters) or budgetary process-driven volatility of public spending (low-income countries). The approach can be expanded to allow for time-varying or state-dependent thresholds.

At the same time, a few caveats should be noted. First, issues related to endogeneity and fiscal foresight may persist, despite focusing on large cyclically adjusted public spending innovations to mitigate business cycle effects. Second, the methodology relies on measures of potential output, which are generally estimated with a certain degree of imprecision. Third, the measure of the public investment shock is a binary variable and does not yield an estimate of a multiplier directly from a regression. Rather, the output effects need to be interpreted in the context of the average change in public investment for the effective sample subject to the shock, rescaling to obtain the public investment multiplier value.

3.3. Methodological framework for the estimation of public investment multipliers

Responses of real GDP to public investment shocks are estimated using the local projections method proposed by Jordà (2005). This approach has a number of distinct advantages over other estimation frameworks, including VAR models.[14] First, it does not impose dynamic restrictions and obviates the need to estimate the equations for dependent variables other than the variable of interest, thereby economizing on the number of estimated parameters. Second, it is well-suited to estimating nonlinear effects of public investment conditional on country-characteristics (state-dependent multipliers). Third, it is relatively simple to deal with correlation in error terms—a likely complication in cross-country analysis. The following baseline specification is estimated:[15]

$$log(y_{i,t+k}) - log(y_{i,t-1}) = \alpha_i + \tau_t + \beta_k shock_{i,t} + \boldsymbol{\theta X_{i,t}} + \varepsilon_{i,t} \qquad (3)$$

in which k = 0,...,5 is the forecast horizon in years; $log(y_{i,t+k}) - log(y_{i,t-1})$ represents the cumulative change in real GDP (in percent) over the forecast horizon; α_i, τ_t are country and time fixed effects to account for time-invariant country heterogeneity and global factors (such as the world business cycle or oil price movements); $\boldsymbol{X_{i,t}}$ is a set of control variables including—as in Abiad et al. (2016) and Furceri and Li (2017)—two lags of the shocks and two lags of real GDP

[14] See Plagborg-Møller and Wolf (2021) for a discussion on the trade-offs between VARs and local projections.
[15] Similar local projections specifications have been widely used in empirical literature on public spending multipliers, for instance, Abiad et al. (2015); Furceri and Li (2017); Honda et al. (2020); Miyamoto et al. (2020).

growth.[16] To control for outliers, data points above the 99th percentile and below the 1st percentile are dropped in the estimations.

The coefficient β_k denotes the response of output in each period *k* to a public investment shock at *t* = 0 ($shock_{i,t}$, identified using the methodology described in the previous section). Specifically, it measures the average cumulative real GDP change in period *t+k* relative to period *t-1* (in percent), in response to the public investment shock for the effective sample—the sample of countries used in the estimation. To ease interpretation, the estimated coefficients are scaled by the average change in public investment as a percent of GDP for the effective sample that experienced the public investment shock, so that the impulse responses can be interpreted as the change in output (in percent) in response to a 1 percent of GDP increase in public investment.[17] The model is estimated for the broadest sample of countries available for robustness. For some exercises, however, the sample size is much smaller (for instance, for potential output, productivity estimations, and subgroups of EMDEs), and thus the results are not directly comparable and should be interpreted with caution.

Descriptive statistics summarizing average changes in output and public investment during public investment shock episodes are summarized in the Appendix table A3. Impulse response functions are obtained by plotting the estimated multipliers for *k* = 0,...,5, with 90-percent confidence bands computed using robust standard errors clustered at the country level.

To examine heterogeneity across country groups (for instance, categorized using income levels, commodity exporter status, degree of public spending efficiency) and discrete macroeconomic states (negative and positive economic growth periods), the model is estimated separately for each subsample. State-dependent multipliers, conditional on the values of continuous time-varying variables, are estimated using a local projections framework with a smooth transition function:[18]

$$log(y_{i,t+k}) - log(y_{i,t-1}) = \alpha_i + \tau_t + \beta_k^L F(z_{i,t}) shock_{i,t} + \beta_k^H (1 - F(z_{i,t})) shock_{i,t} + \boldsymbol{\theta X_{i,t}} + \varepsilon_{i,t} \quad (4)$$

with $F(z_{i,t}) = \frac{\exp(-\gamma z_{i,t})}{1+\exp(-\gamma z_{i,t})}, \quad \gamma > 0.$

[16] Among other robustness checks, the model is also estimated with additional control variables to examine the omitted variable bias, dropping lagged real GDP growth, and using the generalized method of moments (GMM) estimator to address possible bias arising from the lagged dependent variable.

[17] It is a standard approach in the empirical literature on spending multipliers to use an ex-post conversion using the average government spending ratio to GDP. As argued in Ramey and Zubairy (2016), this may however introduce a bias if government spending-to-GDP ratio varies significantly over the sample period.

[18] The same approach was used to estimate state-dependent public spending multipliers in Abiad et al. (2015), Furceri and Li (2017), Miyamoto et al. (2020), and Honda et al. (2020).

in which $z_{i,t}$ is the value of a conditioning variable, normalized to have zero mean and unit variance.[19] The coefficients β_k^L and β_k^H capture the output impact of public investment shocks at each horizon k for the state characterized by low values of a conditioning variable, $F(z_{i,t}) \approx 1$ when z goes to minus infinity; and the state characterized by high values of a conditioning variable, $1 - F(z_{i,t}) \approx 1$ when z goes to plus infinity.

This approach is equivalent to the smooth transition autoregressive model developed by Granger and Teräsvirta (1993). The advantage of this methodology is twofold. First, it permits a direct test of whether the effect of government spending varies across high and low levels of a given conditioning variable. Second, it allows the effect of government spending shocks to change smoothly between the levels of a conditioning variable by considering a continuum of states to estimate the impulse response functions, thus making the responses more stable and precise. To compute multipliers conditional on the public capital scarcity and fiscal space, equation 4 is estimated using the following conditioning variables for $F(z_{it})$: (i) Gross government debt as a share of GDP as a proxy for fiscal space; and (ii) Public capital stock as a share of GDP to examine the implications of capital scarcity. Variable definitions are reported in Appendix table A2.

4. Empirical results

4.1. Stylized facts about public investment

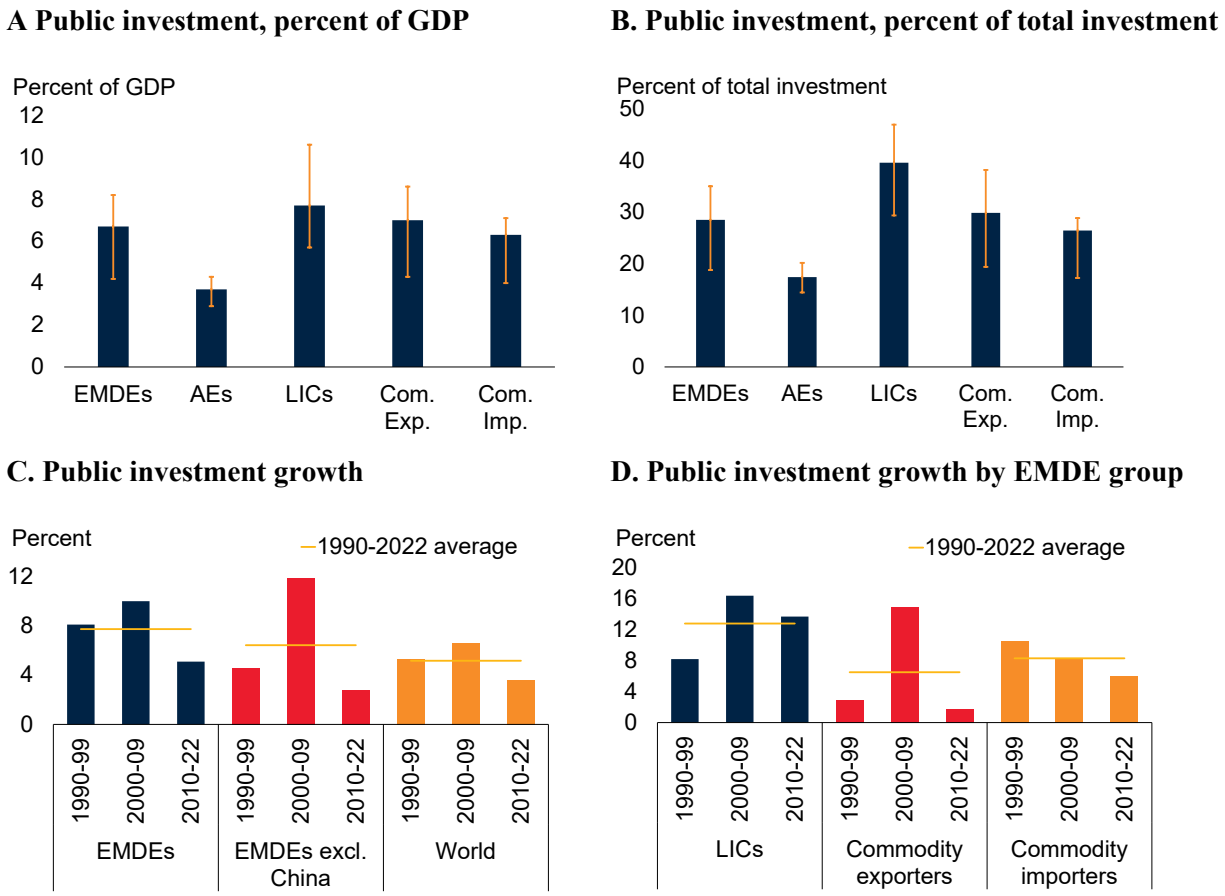
Before examining the estimated unconditional and state-dependent public investment multipliers, in this section we provide several key observations about public investment patterns in EMDEs. Public investment tends to play a greater role in EMDEs than in advanced economies. Over the past decade, public investment comprised about 7 percent of GDP, on average, versus about 4 percent of GDP in advanced economies (figure 1.A). Public investment amounted to almost 30 percent of total investment in EMDEs, with a greater share in low-income countries (about 40 percent). By contrast, in advanced economies public investment comprised less than a fifth of total investment in the past decade (figure 1.B).

This pattern is consistent with the fact that the private sector tends to be weaker in EMDEs than in advanced economies, and often lacks the capacity to invest in large infrastructure projects. EMDEs thus tend to rely more on the public sector to deliver necessary infrastructure. In addition, creditors often see EMDE governments as more creditworthy than local private investors, given their power

[19] The weights assigned to each regime vary between 0 and 1 according to the weighting function so that $F(z_{i,t})$ can be interpreted as the probability of being in a given economic state. Following the literature that uses a similar approach, (Abiad et al. 2015 and Furceri and Li 2017), the parameter is set to 1.5, while the results do not change materially when other values are used.

to tax, their ownership of significant assets that can serve as collateral, and their capacity to pool the resources needed to execute large-scale projects (Martinez et al. 2023).

Figure 1. Public investment in EMDEs



Sources: Haver Analytics; IMF Investment and Capital Stock Dataset (IMF 2021a); WDI (database); World Bank.
Note: AEs = advanced economies; EMDEs = emerging market and developing economies; Com. Exp. = commodity-exporting EMDEs; Com. Imp. = commodity-importing EMDEs; LICs = low-income countries.
A.B. Bars show means and whiskers show interquartile ranges for 2010-22 by group. Sample includes up to 36 advanced economies and 126 EMDEs.
C.D. Average annual public investment growth calculated with countries' real public investment in constant international dollars as weights. Sample includes up to 162 economies, of which 126 are EMDEs, 23 are LICs, 76 are commodity exporting EMDEs, and 50 are commodity-importing EMDEs.

Over the past three decades, public investment patterns in EMDEs have evolved notably. In the 1990s, public investment in EMDEs was growing at a rapid pace largely on account of robust growth in China. This was followed by exceptionally high public investment growth in the 2000s which witnessed a period of macroeconomic stability, rapid economic integration, and reduction of poverty, amid elevated commodity prices. The latter also resulted in accelerated public investment growth in commodity-exporting EMDEs (figures 1.C and 1.D).

However, public investment growth plunged after the global financial crisis. Average annual public investment growth in EMDEs halved, dropping from 10 percent in the 2000s to 5 percent in the 2010s—the slowest average pace over the past three decades (figure 1.C). This slowdown was associated with multiple factors: weaker economic growth in EMDEs in the aftermath of the global financial crisis; the worsening of the global macroeconomic environment resulting in the slowdown of trade and capital flows; heightened economic uncertainty; geopolitical tensions; tight financial conditions; elevated debt levels, eroding fiscal space; and commodity price volatility. In particular, public investment growth in commodity-exporting EMDEs—which was much higher than that in other EMDEs through the 2000s—slumped as global commodity prices declined, adversely affecting these countries' public finances (figure 1.D). The COVID-19 recession further worsened the macroeconomic backdrop. Government expenditures to contain the pandemic and provide support to vulnerable population groups and the private sector were prioritized, resulting in cutbacks and delays in public investment spending.

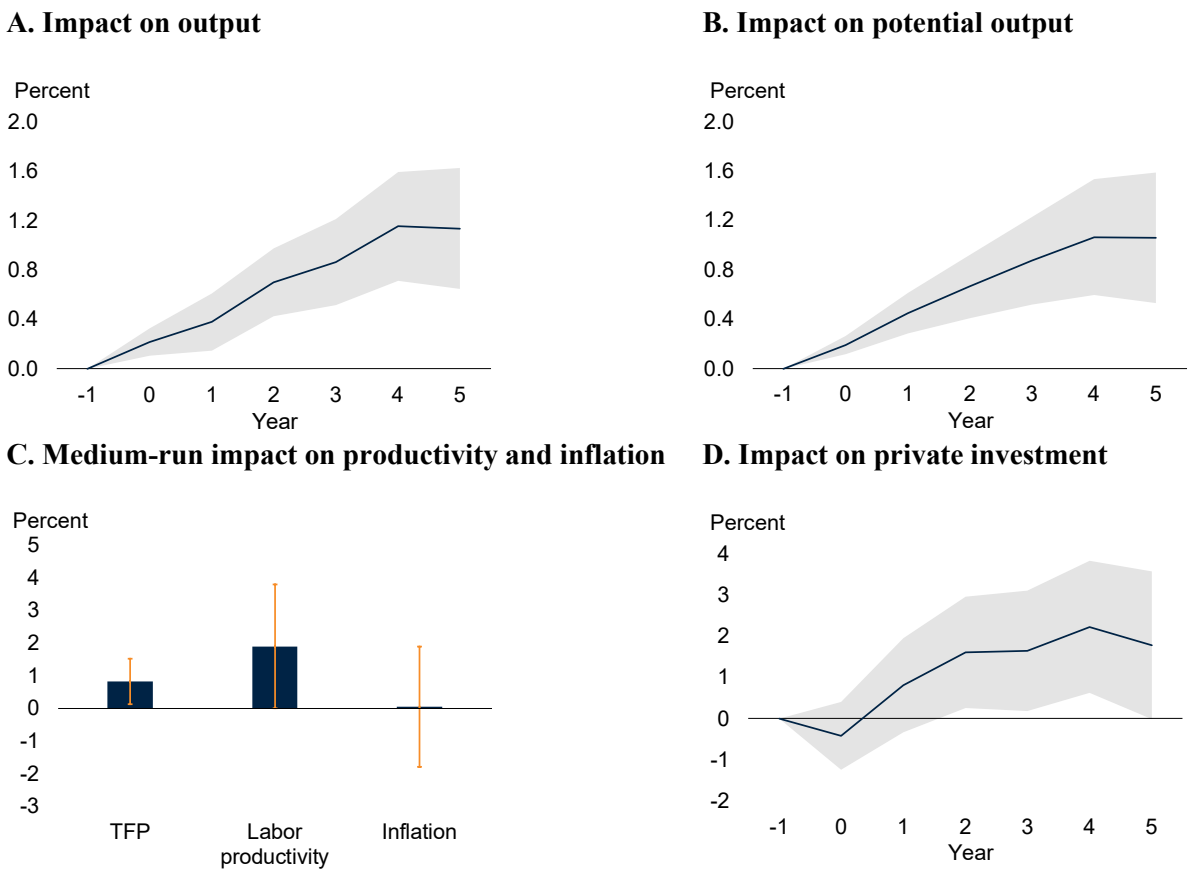
4.2. Baseline unconditional public investment multipliers

The estimations using the new methodological framework outlined in section 3 suggest that public investment shocks lead to positive output responses that remain highly statistically significant at the horizon of five years (Figure 2.A). In particular, an increase in public investment equivalent to 1 percent of GDP is associated with a gradual increase in output from 0.4 percent after one year, reaching 1.1 after five years. The output effects of public investment tend to be smaller in the short run but increase over the long term as the supply-side effects on productivity and productive capacity fully manifest themselves, consistent with the literature (Leduc and Wilson 2012; Ramey 2021). In the short run, offsetting fiscal effects, the impact of leakage through imports, possible transitory crowding out of private investment, private sector capacity constraints, and the time needed to adjust consumption and production may dampen the effects of public investment.[20] The estimated effects are broadly in line with public investment multipliers reported in past empirical work (see section 2 and Appendix B).

A noteworthy aspect of the results is the high degree of heterogeneity across EMDEs. In higher-income EMDEs, positive public investment shocks lead to a strong and persistent impacts on output. In low-income countries, however, the effects on output are characterized by a wide dispersion, which translates to much lower statistical significance of public investment multipliers. Small sample size may play a part, but this could also be the result of lower efficiency in their public investment. That said, the average effect tends to be larger in low-income countries than in higher-income EMDEs, reaching up to 1.7 percent over the horizon of five years after a public investment shock equivalent to 1 percent of GDP. Public investment effects are slightly lower in commodity-exporting EMDEs than in other EMDEs (Appendix figure A1).

[20] Similar results are reported in recent empirical studies (for instance, Abiad et al. 2016; Furceri and Li 2017; Ilzetzki et al. 2013).

Figure 2. Macroeconomic impacts of public investment in EMDEs



Source: Authors' estimates.
Note: Responses of variables (cumulative change in year t relative to year t = -1, in percent) to a public investment shock equivalent to 1 percent of GDP; t = 0 is the year of the shock. Shaded areas denote 90-percent confidence bands, based on standard errors clustered at the country level.
A. Response of real GDP to a public investment shock.
B. Response of real potential GDP to a public investment shock.
C. Responses of total factor productivity (TFP), labor productivity, and consumer price index to a public investment shock after five years based on local projections. Bars indicate the point estimates, whiskers indicate 90-percent confidence intervals.
D. Response of real private investment to a public investment shock.

The analysis suggests that potential output also increases steadily in response to public investment. In a sample of EMDEs with the available data, a 1 percent of GDP rise in public investment leads to an increase in potential output peaking at about 1.1 percent over five years (Figure 2.B).[21] This effect is associated with a concurrent boost in productivity—by up to 0.8 percent for total factor productivity and 1.9 percent for labor productivity over the medium term (Figure 2.C). The impact of public investment surges on output does not lead to a corresponding increase in inflation. These

[21] The sample size for the exercises with potential output and productivity is smaller because of data availability, and is not directly comparable to the baseline results, which use the full EMDE sample.

findings support the hypothesis that public investment can increase output through both short-term aggregate demand and longer-run aggregate supply channels, thereby boosting potential output (Ramey 2021).

An important impact of public investment occurs via the crowding-in effect on private investment. An increase in public investment equivalent to 1 percent of GDP induces an increase in private investment by up to 2.2 percent at the horizon of five years (Figure 2.D). The estimates also suggest a possible crowding-out effect on impact; however, the effect is small, not statistically significant from zero, and is reversed within a year. The crowding-in effect on private investment is in line with the estimates reported in the literature (see, for instance, Eden and Kraay 2014; Furceri and Li 2017). In this regard, the results provide empirical support for policies to mitigate the slowdown of private investment through a scaling up of public investment. This effect could operate through several transmission channels. An increase in public capital can raise the return on private capital by facilitating connectivity (for instance, roads and bridges), thereby facilitating private sector investment (Aschauer 1989b; Eden and Kraay 2014). Public investment reduces uncertainty and risks associated with private investment in large infrastructure projects and may also directly crowd in private investment via public-private partnerships (IMF 2021b).

4.3. State-dependent public investment multipliers

The role of the business cycle. Public investment multipliers, on average, are greater in magnitude during recessions than during expansions. A 1 percent of GDP increase in public investment yields an increase in output by 1.1 percent in times of expansion after five years. An equivalent public investment shock in recessions leads to an increase in output by up to 1.6 percent over the same period. However, the estimates during recessions are characterized by notable heterogeneity across countries, resulting in wider confidence bands (figure 3). These results are consistent with the empirical literature reporting larger government spending multipliers in recessions.[22]

The position of an economy in the business cycle may affect the size of the multiplier for several reasons. In expansions, public spending stimulus may be less effective, because if the economy is operating close to full capacity, an additional increase in public spending is less likely to crowd in private sector resources.[23] In contrast, economic slack during recessions enables public investment to mobilize unused private sector capacity (Batini et al. 2014). Public spending during recessions may also help mitigate unemployment and improve market confidence and is less likely to be

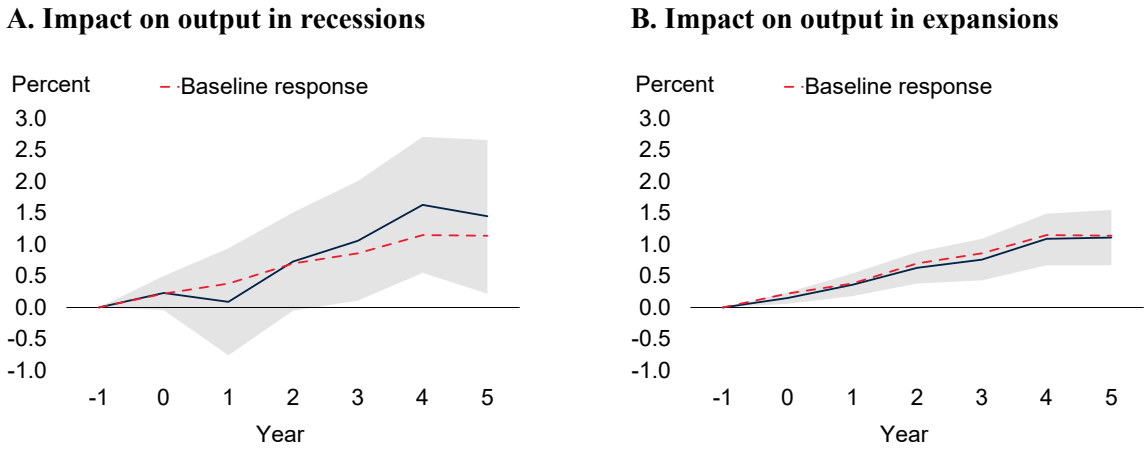
[22] Larger public investment multipliers in recessions are reported in Auerbach and Gorodnichenko (2012 and 2013); Caggiano et al. (2015); Furceri and Li (2017); Honda et al. (2020); Riera-Crichton et al. (2015). That said, such estimates may not be fully robust, with significant heterogeneity across countries (Ramey 2019).

[23] That said, during expansions public investment also has a positive effect on output in EMDEs. This is in line with the view that EMDEs often have underutilized capacity because of infrastructure gaps, limited access to finance constraining the ability of the private sector to expand production capacity, and unused available labor resources, which can be engaged in expansions through public investment.

accompanied by increasing inflation and interest rates (Auerbach and Gorodnichenko 2012; Ghassibe and Zanetti 2022).

In practice, however, EMDEs often have limited fiscal resources for public investment projects during recessions and crises. In fact, public investment tends to contract during economic distress. "Shovel-ready" investment projects may help revive economic activity and crowd in private investment during economic downturns as long as they are well-planned and executed, and do not undermine fiscal sustainability; such projects and conditions, however, may not always be present.

Figure 3. Effects of public investment on output conditional on the business cycle



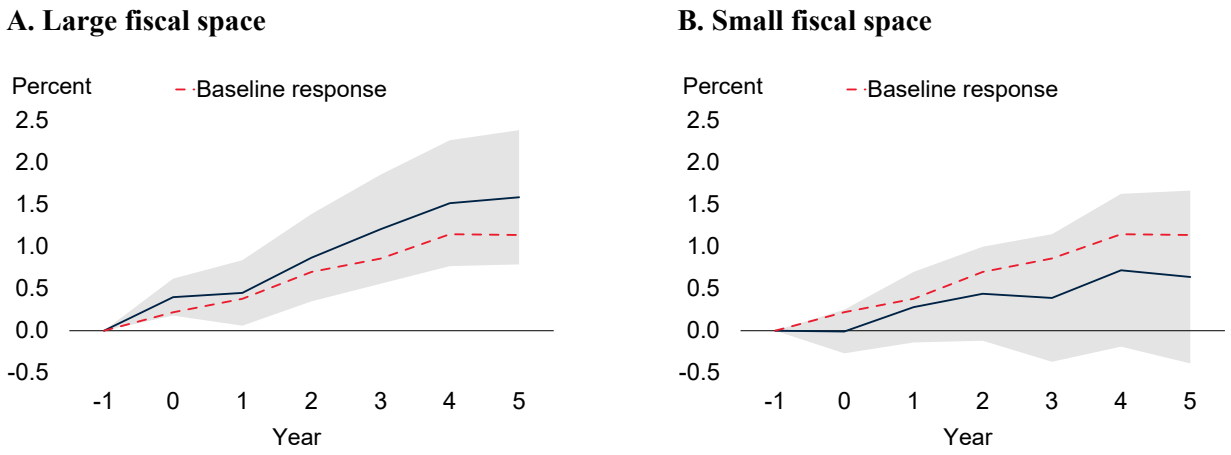
Source: Authors' estimates.
Note: Responses of real GDP (cumulative change in year *t* relative to year *t* = -1, in percent) to a public investment shock equivalent to 1 percent of GDP in recessions and expansions, defined as periods of negative and positive real GDP growth, respectively. Dashed lines indicate the baseline unconditional responses. Shaded area denotes 90 percent confidence bands, based on standard errors clustered at the country level.

Implications of fiscal space. EMDEs with larger fiscal space, as measured by public-debt-to-GDP ratios, experience much stronger positive impacts of public investment: output increases by up to 1.6 percent five years after a public investment shock equivalent to 1 percent of GDP. Conversely, public investment in countries with high and rising debt (implying limited fiscal space) appears to be ineffective: the estimated public investment multipliers are lower and not statistically significant (figure 4).[24] While changes in public-debt-to-GDP ratios only partly reflect fiscal space dynamics, these results nevertheless imply that the effect of public investment on output in

[24] These results thus are in line with the literature, arguing that in countries with high debt, public spending multipliers can be insignificant or even negative (Huidrom et al. 2020; Ilzetzki et al. 2013).

countries with large fiscal space is up to 1 percentage point higher than in countries with small fiscal space, on average.[25]

Figure 4. Effects of public investment on output conditional on fiscal space



Source: Authors' estimates.
Note: Responses of real GDP (cumulative change in year t relative to year t = -1, in percent) to a public investment shock equivalent to 1 percent of GDP, conditional on fiscal space. t = 0 is the year of the shock. High-efficiency and low-efficiency samples are based on the top and bottom quartiles of the IMF (2021b) public infrastructure efficiency index, which ranges from 0 to 100 (the values above 81 and below 47, respectively).

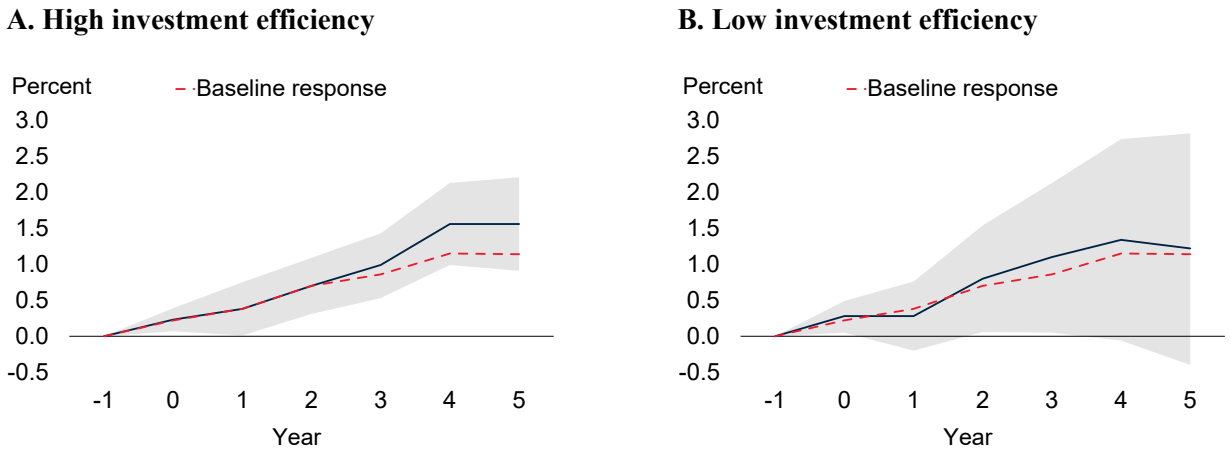
Fiscal space influences the output effects of public investment through two channels. The first is associated with the effects on private sector, as additional public spending in countries with weak fiscal positions may lead to lower disposable income of liquidity-constrained households, as well as increased tax burdens for the private sector in the future (which may also be anticipated). The second channel relates to the interest rate effect, as scaling up of government expenditures in countries with high levels of debt may lead to higher international interest rate spreads, on account of higher sovereign risk and inflation, thus increasing borrowing costs for the private sector (Blanchard 1990; Huidrom et al. 2020; Sutherland 1997).

Infrastructure investment projects, given their large upfront costs and long time horizons, are often financed by borrowing rather than from current government revenues. Larger fiscal space implies that the sovereign has more capacity to service its borrowing and therefore is more creditworthy, allowing it to finance such investment at a lower interest rate.

[25] The high-debt and low-debt states are defined using the smooth transition function that reflects the historical dynamics of public-debt-to-GDP ratios on a country-by-country basis. For a median EMDE, a low-debt state over the sample period corresponds to about 30 percent of GDP and a high-debt state corresponds to about 80 percent of GDP for EMDEs that experienced a public investment shock.

Implications of public investment efficiency. The efficiency of public investment plays a crucial role in driving its growth effects.[26] The estimates suggest a greater effect on GDP in response to public investment shocks in EMDEs with the highest efficiency, culminating in an increase in output of about 1.6 percent after five years—one-half percentage point higher than the effect of public investment in EMDEs with the lowest efficiency (figure 5). In countries with the lowest efficiency, the effects of public investment are lower and not statistically significant (albeit still positive).

Figure 5. Effects of public investment on output conditional on public investment efficiency



Source: Authors' estimates.
Note: Responses of real GDP (cumulative change in year t relative to year t = -1, in percent) to a public investment shock equivalent to 1 percent of GDP, conditional on fiscal space. t = 0 is the year of the shock. Dashed line indicates the baseline unconditional response. Shaded area denotes 90 percent confidence bands, based on standard errors clustered at the country level. High-efficiency and low-efficiency samples are based on the top and bottom quartiles of the IMF (2021b) public infrastructure efficiency index, which ranges from 0 to 100 (the values above 81 and below 47, respectively).

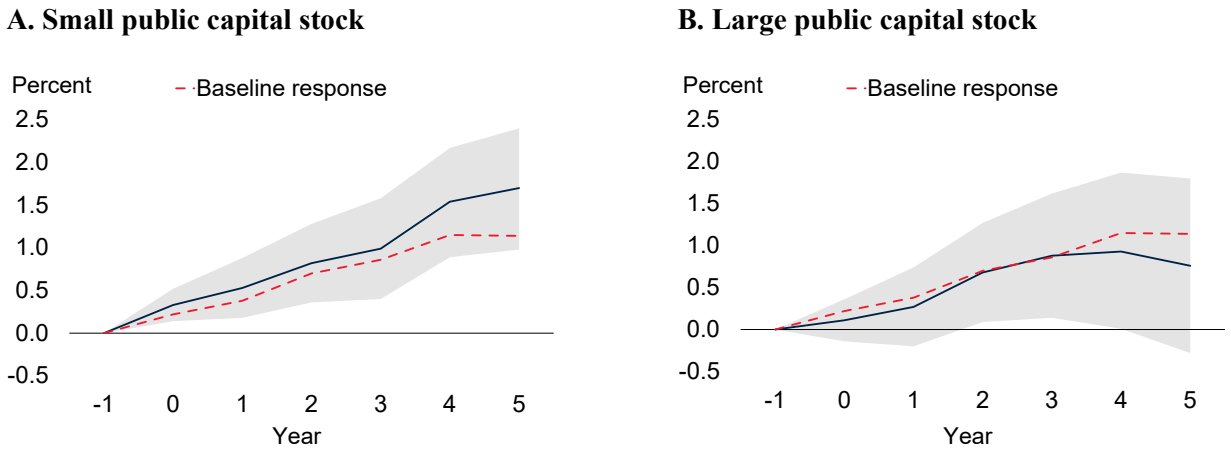
These results are consistent with empirical studies using other samples and methods and provide support for the argument that low public investment efficiency is problematic.[27] Poor design, evaluation, and implementation of investment projects, including issues with corruption and governance, can deplete valuable fiscal resources without necessarily increasing the quantity or quality of public infrastructure that supports growth (Dabla-Norris et al. 2012; IMF 2014; Pritchett

[26] The analysis uses the IMF (2021b) public infrastructure efficiency index, which is a cross-sectional index available for 120 countries (including 93 EMDEs), produced using the data envelopment analysis. The index ranges from 0 to 100, with higher values indicating better efficiency. The model was also estimated using the Devadas and Pennings (2018) infrastructure efficiency index and the Dabla-Norris et al. (2012) public investment management index. Estimations using alternative measures also suggest statistically insignificant and lower output effects of public investment in low-efficiency economies (see the results in the robustness section).
[27] See, for instance, Cavallo and Daude (2011); Furceri and Li (2017); IMF (2014); Izquierdo et al. (2019); Leduc and Wilson (2012); and Leeper et al. (2010).

2000). Therefore, well-designed public investment management processes are essential to ensure the effectiveness of public investment.

Initial public capital stock. The impact of public investment on output also varies with the initial level of the public capital stock (figure 6). The magnitude and statistical significance of the public investment multiplier tends to decrease with the level of public capital stock relative to GDP, consistent with expectations of diminishing marginal returns to capital. Specifically, a 1 percent of GDP increase in public investment is associated with a 1.7 percent increase in GDP after five years in capital-scarce countries. This contrasts with 0.9 percent (not statistically significant in the medium term) when the public-capital-stock-to-GDP ratio is high. Similar results are found in empirical studies using other samples and methods (for instance, Izquierdo et al. 2019).

Figure 6. Effects of public investment on output conditional on public capital stock



Source: Authors' estimates.
Note: Responses of real GDP (cumulative change in year t relative to year t = -1, in percent) to a public investment shock equivalent to 1 percent of GDP, conditional on fiscal space. t = 0 is the year of the shock. Dashed line indicates the baseline unconditional response. Shaded area denotes 90 percent confidence bands, based on standard errors clustered at the country level. Small public capital stock and large public capital stock responses are based on local projections with the smooth transition function that uses public-capital-stock-to-GDP ratio as the conditioning variable to capture historically lowest and highest capital stock ratios of a given country in public investment shock years (the values of public capital stock of 68 and 113 percent of GDP for a median EMDE, respectively).

4.4. Robustness checks

A range of robustness checks were carried out, and results were corroborative of baseline findings. These included testing alternatives for public investment shock identification, sensitivity checks to the choice of statistical filters, robustness checks to the sample period, and model specifications (selected results are reported in Table 1):

Table 1. Selected additional results and robustness checks

Model	Public investment multiplier	
	t = 1	t = 5
Baseline specification	0.4***	1.1***
IV (2SLS) estimation using public investment shocks to instrument public investment	0.4***	1.0***
GMM estimation	0.5**	0.8**
Dropping country fixed effects	0.4***	1.5***
Dropping lagged real GDP growth variable	0.3**	1.1***
Pre-global financial crisis period only (1980-2007)	0.3*	0.9***
Additional control variables: two lags of inflation and trade-to-GDP ratio	0.4**	1.1***
Alternative fiscal space specification		
Large increase in debt-to-GDP ratio (upper quartile = above 3.7)	0.3	0.7
Large decrease in debt-to-GDP ratio (lower quartile = below -3.2)	0.5*	1.4***
Alternative public investment efficiency measures		
Low efficiency: Dabla-Norris et al. (2012) PIMI below the sample mean	0.1	0.9
High efficiency: Dabla-Norris et al. (2012) PIMI above the sample mean	0.4***	1.2***
Low efficiency: Bottom quartile of Devadas and Pennings (2018) Infrastructure Efficiency index	0.2	0.3
High efficiency: Top quartile of Devadas and Pennings (2018) Infrastructure Efficiency index	0.2*	1.0***
Low efficiency: Bottom quartile of CPIA Public Sector Management and Institutions index	0.3	0.6
High efficiency: Top quartile of CPIA Public Sector Management and Institutions index	0.4**	1.1***

Source: Authors' estimates.
Note: 2SLS = two-stage least squares; CPIA = Country Policy and Institutional Assessment; GMM = generalized method of moments; IV = instrumental variables approach; PIMI = Public Investment Management Index. The table shows responses of real GDP (cumulative change in year *t* relative to year *t* = -1, in percent) to a public investment shock equivalent to 1 percent of GDP; *t* = 0 is the year of the shock. ***, **, and * indicate statistical significance at the 1, 5, and 10 percent levels, respectively.

Sensitivity checks for public investment shock parameterization and statistical filters. Given that the identification of public investment shocks may be sensitive to the choice of the statistical filters or the cut-off level to isolate large changes in public investment, alternative threshold levels and filters were explored, including the Baxter-King, Christiano-Fitzgerald, and Hamilton filters. The results are not statistically different from the baseline results. Our focus only on large changes in cyclically adjusted public investment also mitigates concerns regarding the imprecision in the estimation of potential output. Using higher threshold levels to identify public investment shocks would come at the cost of a lower number of shock episodes, resulting in less precise estimates.

Sensitivity to country fixed effects. A possible bias from estimating the baseline model using country fixed effects stems from the fact that the error term may have a non-zero expected value on account of the interaction between fixed effects and country-specific developments (Teulings and Zubanov 2014). Estimates excluding country fixed effects are similar to the baseline results.

Omitted variables and the choice of estimator. The baseline model was estimated with additional variables, introduced to control for inflation and trade openness. The results indicate no

large differences relative to the baseline. As an additional check, the model was estimated dropping the lagged dependent variable. Results are also robust to using generalized method of moments as the estimator. As an alternative, the identified public investment shocks were also used as an instrument for a change in public investment as a share of GDP, in two-stage least squares (2SLS) estimation, yielding very similar results.

Sensitivity to the sample period and the sample composition. In order to examine whether the effects of public investment may have changed in the aftermath of the global financial crisis, the multipliers were estimated also for the pre-2007 period, with the findings confirming the baseline results. As a sensitivity check, the estimations were also carried out using the same common sample of countries across all empirical exercises, however this results in less reliable estimates on account of a much smaller sample, with larger error bands.

5. Conclusion and policy implications

In this paper, we contribute to the literature by introducing a new methodology to identify public investment shocks that can be easily replicated and extended by other researchers going forward. We use the identified public investment shocks to examine the macroeconomic implications of public investment for EMDEs using a broader sample than employed in the earlier literature, which allows a more granular analysis of cross-country heterogeneity and non-linear effects associated with prevailing macroeconomic conditions and country structural characteristics.

The estimation results confirm the findings of previous research and expand the empirical evidence to a broad sample of EMDEs. Inter alia, our paper provides new insights into the heterogeneity of public investment multipliers across country groups and helps to cast light on the factors that explain the varying growth effects of public investment. In this regard, a particularly noteworthy aspect of our results is that the positive effects of public investment on economic growth can be significantly bolstered under certain conditions that are feasible to achieve with robust policy interventions. In particular, fiscal space and public spending efficiency are crucial for bolstering the positive effects of public investment. While the scaling up of public investment by 1 percent of GDP on average raises output by 1.1 percent after 5 years, in countries with ample fiscal space and high public investment efficiency, the effects are much higher—reaching 1.6 percent over the same period. These results help inform policy debates on the macroeconomic effects of public spending, particularly in the context of developing economies, which generally have larger infrastructure gaps and unmet funding needs to address the Sustainable Development Goals.

The positive effects of public investment reflect both the beneficial aggregate demand and supply impacts, including through boosting the productive capacity of the economy and crowding in of private investment. The latter is especially important for EMDEs, given the prolonged weakness in private investment growth they have experienced over the past decade and their massive private capital mobilization needs to address investment gaps.

Furthermore, the results suggest that in countries with low fiscal space, public investment multipliers tend to be lower and statistically insignificant. Thus, limited fiscal space not only impedes the ability of a government to scale up public investment, but also undermines its effectiveness. This underscores the importance of boosting fiscal space during good times to help provide room for maneuvering during recessions. If public debt ratios do not decrease during times of economic expansion, countries may be unable to avail themselves of countercyclical spending increases to help dig themselves out of recessions. As the paper also shows, the scaling up of public investment is especially effective during recessions. Redoubled policy efforts to boost fiscal space—such as reforms to improve tax collection efficiency, enhance fiscal frameworks, and curtail unproductive expenditures—are particularly important in light of the significant debt accumulated over the past decade.

Finally, our results accentuate the large payoffs that countries could realize by strengthening public investment efficiency. Policy interventions that can improve the efficiency of public investment range from broad structural reforms to improve the quality of institutions—tackling corruption, poor governance, and limited capacity of fiscal administration—to policies that focus more narrowly on enhancing public investment project management frameworks, such as planning, allocation, implementation, and monitoring of public investment projects. Low-income countries that face particularly deep structural challenges, vast infrastructure gaps, and limited fiscal resources, have much lower capacity to undertake such reforms on their own. Therefore, extensive coordinated support from the global community, including both financial support and technical assistance, is imperative to help these countries address their pressing development needs.

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APPENDIX A

Table A1. Sample composition

Albania	Costa Rica	Lao PDR	Romania
Algeria	Côte d'Ivoire	Lebanon	Russian Federation
Angola	Djibouti	Lesotho	Rwanda
Antigua and Barbuda	Dominica	Liberia	São Tomé and Príncipe
Argentina	Dominican Republic	Libya	Saudi Arabia
Armenia	Ecuador	Madagascar	Senegal
Azerbaijan	Egypt, Arab Rep.	Malawi	Serbia
Bahamas, The	El Salvador	Malaysia	Seychelles
Bahrain	Equatorial Guinea	Maldives	Sierra Leone
Bangladesh	Eritrea	Mali	South Africa
Barbados	Eswatini	Mauritania	Sri Lanka
Belize	Ethiopia	Mauritius	St. Kitts and Nevis
Benin	Fiji	Mexico	St. Lucia
Bhutan	Gabon	Moldova	St. Vincent and the
Bolivia	Gambia, The	Mongolia	Grenadines
Bosnia and Herzegovina	Georgia	Montenegro	Sudan
Botswana	Ghana	Morocco	Syrian Arab Republic
Brazil	Grenada	Mozambique	Tajikistan
Brunei Darussalam	Guatemala	Myanmar	Tanzania
Bulgaria	Guinea	Namibia	Thailand
Burkina Faso	Guinea-Bissau	Nepal	Togo
Burundi	Guyana	Nicaragua	Tunisia
Cabo Verde	Haiti	Niger	Uganda
Cambodia	Honduras	Nigeria	Ukraine
Cameroon	Hungary	North Macedonia	United Arab Emirates
Central African Republic	India	Oman	Uruguay
Chad	Indonesia	Pakistan	Uzbekistan
Chile	Iran, Islamic Rep.	Panama	Viet Nam
China	Iraq	Papua New Guinea	Yemen, Rep.
Colombia	Jordan	Paraguay	Zambia
Comoros	Kazakhstan	Peru	
Congo, Dem. Rep.	Kenya	Philippines	
Congo, Rep.	Kuwait	Poland	

Source: Authors.

Table A2. Definitions of data used and sources

Variable	Definition	Source
Real public investment	General government investment (gross fixed capital formation) in billions of national currency deflated using the GDP deflator	Investment and Capital Stock Dataset (IMF 2021a)
Real private investment	Private investment (gross fixed capital formation), in billions of national currency deflated using the GDP deflator	Investment and Capital Stock Dataset (IMF 2021a)
Real GDP	Gross domestic product, in billions of national currency deflated using the GDP deflator	IMF World Economic Outlook Database
Potential GDP	Index derived from real potential output growth estimated using the production function approach	Potential growth database (Kilic Celik et al. 2023)
Inflation	Growth rate of consumer price index, in percent	IMF World Economic Outlook Database
Labor productivity	Real GDP per average annual hours worked by persons engaged	Penn World Table 10.01
Total factor productivity	Total factor productivity in constant national prices (2017 = 1)	Penn World Table 10.01
Public debt	General government debt, percent of GDP	World Bank's Fiscal Space Database (Kose et al. 2022)
Public infrastructure efficiency index (IMF 2021b)	Public infrastructure efficiency index constructed based on the data envelopment analysis using the volume and quality of infrastructure as output, and public capital stock and per capita GDP as input variables	IMF (2021b)
Public infrastructure efficiency index (Devadas and Pennings 2018)	Infrastructure efficiency index constructed as a weighted average of the quality of electricity, water, and road infrastructure	Devadas and Pennings (2018)
Public investment management index (PIMI)	Index based on country performance scores in public investment project appraisal, selection, implementation, and evaluation	Dabla-Norris et al. (2012)
Public capital stock	General government capital stock, percent of GDP	Investment and Capital Stock Dataset (IMF 2021a)

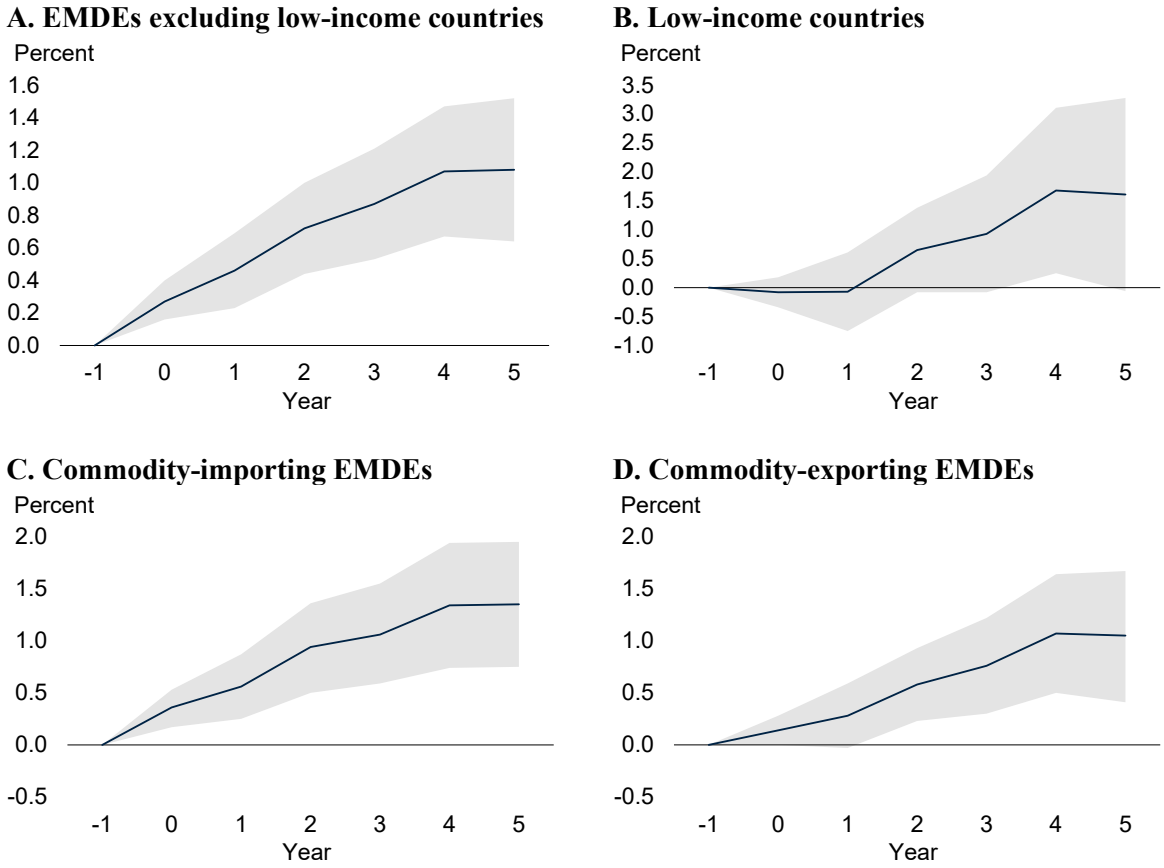
Source: Authors.

Table A3. Summary statistics for public investment shocks

Variable	Value
Number of economies	129
Public investment shock = 1	
Number of observations	557
Mean real GDP growth (percent)	4.48
Mean public investment (percent of GDP)	8.11
Mean change in public-investment-to-GDP ratio (percentage points)	2.68
Public investment shock = 0	
Number of observations	3804
Mean real GDP growth (percent)	3.79
Mean public investment (percent of GDP)	6.76
Mean change in public-investment-to-GDP ratio (percentage points)	-0.43

Source: Authors.
Note: Summary statistics for the sample of 129 EMDEs used in the estimation of public investment multipliers, differentiating between periods with and without public investment shocks.

Figure A1. Impact of public investment on real GDP by EMDE country groups



Source: Authors' estimates.
Note: EMDEs = emerging market and developing economies; LICs = low-income countries. Responses of real GDP (cumulative change in year t relative to year t = -1, in percent) to a public investment shock equivalent to 1 percent of GDP; t = 0 is the year of the shock. Shaded areas denote 90 percent confidence bands, based on standard errors clustered at the country level.

APPENDIX B

Table B1. Output effects of public investment: Summary of the literature

Study	Public investment multiplier	Sample	Methodology	Notes
Abiad et al. (2016)	0.4 (year 0) – 1.4 (year 4)	17 OECD economies; 1985-2013	Local projections with forecast error shocks	Output growth in response to a 1 percent of GDP increase in public investment. Larger multipliers in low-growth episodes and in countries with high spending efficiency.
Auerbach and Gorodnichenko (2012)	2.12 (peak response over 20 quarters)	the United States; 1947-2008	SVAR with forecast error shocks	Cumulative output effect in dollars in response to a 1 dollar increase in public investment. Larger multipliers in recessions that in expansion.
Barry et al. (2018)	0.16 (quarter 1) – 1.10 (quarter 12)	Cameroon; 1999 -2015	SVAR with Blanchard and Perotti (2002) identification	Cumulative change in output in percent in response to a 1 percent increase in public investment. Statistically insignificant for most of the forecast horizon and in the longer run.
Bom and Ligthart (2014b)	0.08 (short run) – 0.12 (long run)	68 studies over 1983–2008	Meta-regression analysis	Meta-regression estimates of output elasticity of public capital based on studies utilizing a production-function approach. Impact on output growth in response to a 1 percent increase in public capital.
David (2017)	0.1 (quarter 0) – 2.1 (quarter 20)	Paraguay; 1998-2015	SVAR with Blanchard and Perotti (2002) identification	Output growth in percent, in response to a 1 percent increase in public investment. Larger multipliers for public investment than for public consumption.
Deleidi et al. (2020)	[0.9 – 1.2] in year 0; [1.9 – 3.4] in year 6	11 euro area countries; 1970-2016	Local projections	Output growth in response to a 1 percent increase in public investment. Smaller multipliers in the pre-2007 period. The ranges of individual country estimates are in parentheses.
Demetriades and Mamuneas (2000)	[0.36 – 2.06] in the short run; [0.36 – 1.97] in the long run	12 OECD countries; 1972-91	Simultaneous equations system	Output elasticities. Impact on output of a 1 percent increase in public capital. The ranges of individual country estimates are in parentheses.
Eden and Kraay (2014)	1.5 (year 1)	39 low-income countries (IDA borrowers)	2SLS with Kraay (2012) identification	Output increase in dollars in response to a 1 dollar increase in public investment. Lower multiplier using OLS (0.2).
Elkhdari et al. (2018)	0.3 (year 1) – 1.2 (year 5)	Algeria; 2008-15	SVAR with Blanchard and Perotti (2002) identification	Output growth in response to a 1 percent increase in capital expenditures. Larger multipliers during periods with negative output gaps.
	0.5 (year 1) – 1.8 (year 5)	9 MENA countries; 2000-15		
Espinoza and Senhadji (2011)	0.2-0.3 in the short term; 0.6-1.1 in the long term	Gulf Cooperation Council countries; 1975-2009	Panel models	Output growth in response to a 15 percent increase in capital expenditures. Larger multipliers for public investment than for public consumption.
Furceri and Li (2017)	0.2 (year 1) – 0.4 (year 4)	79 EMDEs; 1990-2013	Local projections with forecast error shocks	Output growth in response to a 10 percent increase in public investment. Larger multipliers during economic slack, in closed economies, in countries with fixed exchange rates, lower public debt, and higher investment efficiency.

Table B1 (continued)

Study	Public investment multiplier	Sample	Methodology	Notes
Gbohoui (2021)	0.55 (year 0) – 0.07 (year 2)	Advanced economies; 1996- 2019	Local projections with forecast error shocks	Output growth in response to a 1 percent of GDP increase in public investment. Larger multipliers during heightened uncertainty.
	0.22 (year 0) – 0.56 (year 2)	EMDEs; 1990-2019		
Gechert and Rannenberg (2018)	0.6	98 empirical studies	Meta-regression analysis	Output growth in response to a 1 percent of GDP increase in public investment. Larger multipliers during economic downturns.
Gonzales-Garcia et al. (2013)	0.12 (year 0) – 0.44 (after 4 years)	Eastern Caribbean Currency Union; 1994-2009	SVAR with Blanchard and Perotti (2002) identification	Cumulative output growth in response to a 1 percent of GDP increase in public investment. Larger multipliers for public investment than for public consumption (the latter are not statistically significant).
Honda et al. (2020)	0.1 (year 1) – 0.2 (year 2)	42 low-income countries; 1995-2017	Local projections with forecast error shocks	Output growth in response to a 1 percent of GDP increase in public investment. Larger multipliers in recessions, under a fixed exchange rate regime, in countries with better institutions.
Ilzetzki et al. (2013)	0.4 (quarter 0) – 1.5 (quarter 20)	High income countries; 1985–2013	SVAR with Blanchard and Perotti (2002) identification	Cumulative output response to public investment shocks. Larger multipliers in countries with fixed exchange rates, closed economies, countries with low debt (not stat. significant in high-debt sample).
	0.6 (quarter 0) – 1.6 (quarter 20)	Developing countries; 1985–2013		
IMF (2014)	0.4 (year 0) – 1.5 (year 4)	Advanced economies; 1985–2013	Local projections with forecast error shocks	Output response to a 1 percent of GDP increase in public investment. Larger multipliers during low growth and in countries with higher spending efficiency.
	(a) 0.3 in year 0 – 0.5 in year 4; (b) 0.5 in year 0 – 0.9 in year 4	Developing economies; 1990–2013	Local projections with shocks based on Corsetti et al. (2013) and Kraay (2012)	Output response to a1e percent of GDP increase in public investment. Shock identification: (a) Corsetti et al. (2013) approach based on fiscal rules; (b) Kraay (2012) methodology based on official development assistance.
Izquierdo et al. (2019)	0.2 – 1.4 after two years	31 European countries; U.S. states; Argentine provinces	Local projections with Blanchard and Perotti (2002), forecast error, and IV identification	Output growth in response to a 1 percent increase in public investment. Larger multipliers in countries with low public capital stock; statistically insignificant multipliers in countries with low spending efficiency.
Jong-A-Pin and de Haan (2008)	Ranging from about -2.5 to 2.5	21 OECD countries over 1960-2001	VAR	Output elasticity of public capital at the horizon of 20 years. Output growth in response to a 1 percent increase in public capital.
Minea and Mustea (2015)	0.53 (year 1) – 1.18 (year 10)	Mediterranean countries; 1980-2012	PVAR	Cumulative output growth in response to a 1 percent increase in public investment. Heterogeneous multipliers across country groups within the sample: larger in Asian, smaller in African countries.

Table B1 (continued)

Study	Public investment multiplier	Sample	Methodology	Notes
Miyamoto et al. (2020)	0.2 (year 0) – 1.2 (year 4)	17 advanced economies	Local projections with forecast error shocks	Output growth in response to a 1 percent of GDP increase in public investment. Statistically insignificant in low-income countries. Larger multipliers in countries with better governance.
	0.2 (year 0) – 0.5 (year 4)	39 EMDEs		
Petrović et al. (2021)	0.7 – 0.8 (after one year)	10 Central and Eastern European countries;	Local projections and SVAR with Blanchard and Perotti (2002) identification	Cumulative output growth in percent in response to a 1 percent increase in public investment. Larger multipliers in low-growth periods.
Puig (2014)	1.03 over two years	Argentina; 1993-2012	SVAR	Increase in output in dollars in response to a 1 dollar increase in public investment. Greater impact of public investment than public consumption.
Rafiq and Zeufack (2012)	2.7 in recessions; 2.0 in expansions (year 1)	Malaysia; 1981-2004	SVAR with Blanchard and Perotti (2002) identification	Output growth in response to a 1 percent increase in public investment. Greater impact of public investment than public consumption.
Warner (2014)	0.14 (year 0)	124 EMDEs; 1960-2011	OLS	Output per capita growth in response to a 1 percent increase in public investment. Insignificant impact in the long run.

Source: Authors.
Note: 2SLS = two-stage least squares; EMDEs = emerging market and developing economies; IDA = International Development Association; IV = instrumental variables approach; MNA = Middle East and North Africa; OECD = Organisation for Economic Co-operation and Development; OLS = ordinary least squares; PVAR = panel vector autoregression; SVAR = structural vector autoregression; VAR = vector autoregression.