

“Crowding In” Effect of Public Investment on Private Investment Revisited

John Nana Francois

Maty Konte

Franz U Ruch



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Abstract

Current investment trends in emerging market and developing economies are not enough to meet the needs of their growing populations and will fall short of achieving the Sustainable Development Goals related to human and physical capital development. Public investment can play a critical role in addressing this shortfall, especially if it can crowd-in private investment. Using theory and panel data for 109 developing countries from 1980–2019, this paper investigates whether public investment crowds in or crowds out private investment. The paper also explores how the relationship changes across different groups of countries and under different institutional settings. The analysis uses changes in predicted disbursements on loans from official

creditors to developing country governments as an instrument for changes in public investment. The findings show that public investment is a complement to private investment, raising the marginal productivity of the latter. As a result, an extra dollar of public investment raises private investment by 1.6 dollars. The findings also reveal stronger evidence of crowding-in of private investment in low-income countries and Sub-Saharan Africa, where investment needs are greatest. Finally, the findings are embedded in a model with imperfect capital markets, which shows that public investment can be used as an effective vehicle to address underinvestment issues induced by capital market distortions.

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“Crowding In” Effect of Public Investment on Private Investment Revisited*

John Nana Francois[†]

Maty Konte[‡]

Franz U Ruch[§]

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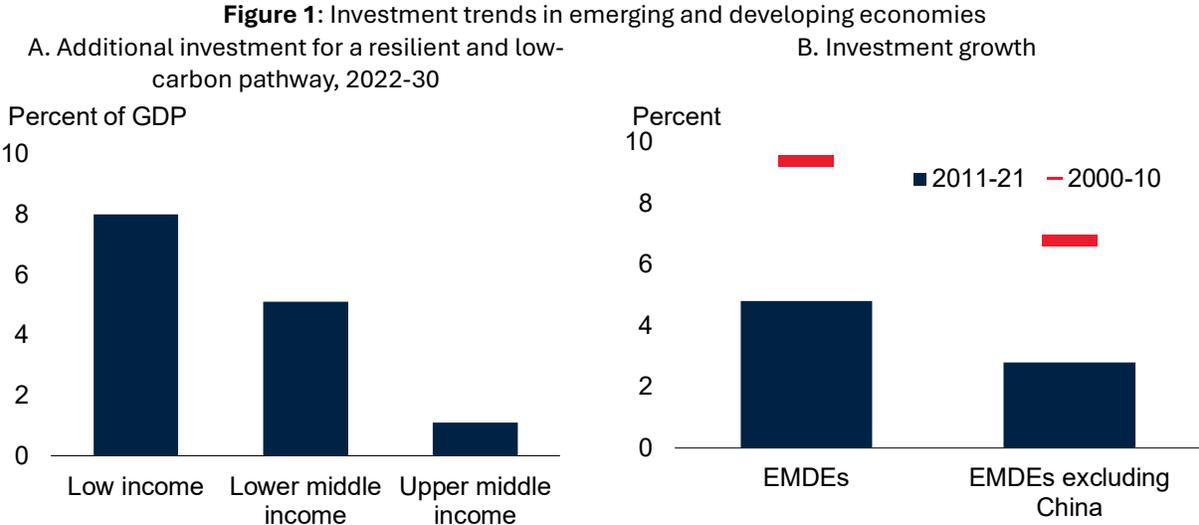
[†] Fiscal and Sustainable Growth Unit, Macroeconomic, Trade and Investment Department, World Bank. Email: jfrancois1@worldbank.org.

[‡] Economic and Market Research, International Finance Corporation. Email: mkonte@ifc.org

[§] Fiscal and Sustainable Growth Unit, Macroeconomic, Trade and Investment Department, World Bank. Email: fruch@worldbank.org.

1 Introduction

Current investment trends in emerging market and developing economies (EMDEs) are not enough to meet the needs of their growing populations. Existing infrastructure requires critical maintenance, and there are massive additional needs for transportation, clean water, and sanitation (Gaspar et al. 2019). The pandemic has only further increased these needs. Infrastructure gaps are estimated at about \$3 trillion (approximately 3.4 percent of 2030 world GDP) to achieve the Sustainable Development Goal related to human and physical capital development (Carapella et al. 2023). Moreover, to achieve significant cuts in greenhouse gas emissions, boost the clean energy transition, and limit the rise in global temperatures could require between 1 and 8 percent of GDP in additional investment per year, with higher needs in low-income countries (figure 1A; World Bank 2022).⁵



Source: World Bank.

Note: EMDEs = emerging market and developing economies.

A. Annual investment needs to build resilience to climate change and put countries on track to reduce emissions by 70 percent by 2050. Depending on availability, estimates include investment needs related to transport, energy, water, urban adaptations, industry, and landscape. In some Country Climate and Development Reports, especially those for low-income and lower-middle-income countries, estimated investments include development needs, especially those linked to closing the infrastructure gaps—such as solar mini grids to provide energy access—and cannot be considered entirely “additional” to pre-existing financing needs. B. Arithmetic annual averages. GDP-weighted averages for the period indicated.

Despite these large infrastructure needs, sluggish global investment growth continues. Between the decades of 2000-10 and 2011-21, fixed investment growth in EMDEs effectively halved from 9.4 to 4.8 percent (figure 1B). The slowdown in investment growth is geographically widespread, affecting all EMDE regions. Moreover, prevailing economic conditions, including rising global interest rates and high debt levels, have made borrowing

⁵ See also, for example, Gaspar et al. (2019); and IEA (2021).

more expensive and suggest sluggish investment growth will continue (Kose and Ohnsorge 2023).

Against this backdrop, this paper investigates the question of whether public investment, as a fiscal policy tool, can crowd-in private investment. We utilize data from a large panel of 109 EMDEs and employ an instrumental variable approach to identify the relationship between these two types of investment. The empirical setting is guided by a tractable model, where we show that the complementarity (substitutability) between public and private investment is sufficient to crowd-in (-out) private investment. Consequently, the parameter of interest we estimate captures, simultaneously, the structural relationship between public and private investment and the crowding-in (-out) of private investment by public investment. We extend the analysis to low-income countries (LICs) and Sub-Saharan Africa (SSA), two subgroups of countries where infrastructure needs are large given low levels of development and growing populations. Furthermore, we examine whether the effect of public investment on private investment varies by the level of corruption and financial development to understand the potential implications of factors that may impede or enhance the effectiveness of public investment in crowding-in private investment.

The relevance of public investment to spur private investment in EMDEs is critical. Yet, systematic evidence of the crowding-in effect of public investment on private investment in EMDEs remains scarce. The existing literature has focused on a limited number of low-income countries (Eden and Kraay 2014), high-income OECD countries (Boehm 2020) or U.S states, European countries, and Argentine provinces (Izquierdo et al. 2019). Expanding this to a large set of EMDEs will provide systematic and stronger evidence of the crowding-in effect of private investment in these countries, which can help drive policy strategies to address the weak outlook for investment growth.

Importantly, the existing literature studies the implication of the crowding-in effect of public investment under perfect capital markets. Capital market imperfections and distortions are, however, ubiquitous in developing countries. For example, access to financial markets, which is important for the growth of businesses and investment, is still a challenge in LICs and SSA. Moreover, structural conditions such as weak corruption control, asymmetric information, inaccessibility to financial markets, and market distortions induced by poorly designed tax systems can create imperfect capital markets that discourage private sector investment. Governments also tend to face lower interest rates than private agents (Eden and Kraay 2014). If public investment can crowd-in private investment, then governments can take advantage of the low interest rate they face relative to the private sector to help address underinvestment by the private sector.

In this paper, we move away from the assumption of perfect capital markets. In particular, because of the law of diminishing marginal returns on capital, more public investment may not always be desirable even if it crowds-in private investment. However, if capital market distortions exist (for example, distortionary taxes on firms' output), this can potentially

induce private sector underinvestment. A direct implication is that insofar as public investment resolves a market failure by crowding in private investment, it should be allowed a lower marginal rate of return compared to when capital markets are perfect (Ogura and Yohe, 1977).

Our key finding is that public investment crowds-in private investment in EMDEs in that a dollar increase in public investment raises private investment by about 1.6 dollars.⁶ This is because public and private investment are complements, which implies that an increase in public investment raises the marginal product of private investment and hence, crowds-in private investment.⁷ The evidence of crowding-in of private investment by public investment holds in LICs and SSA. Specifically, a dollar increase in public spending raises private investment by 1.5 and 1.4 dollars in LICs and SSA, respectively. Our estimated crowding-in effect in a smaller sample of 39 LICs is smaller than those estimated by Eden and Kraay (2014), who found that government investment raises private investment by approximately 2 dollars. Our results are, however, starkly different from findings in Boehm (2020), who provided evidence of crowding-out of private investment in OECD countries. We also find evidence that the crowding-in of private investment increases over longer horizons. More precisely, the crowding-in effects are visible for up to three years. Finally, we find that public investment is more effective in crowding-in private investment in countries with strong control of corruption control. Also, the crowding-in effect of public investment is greater than one and statistically significant in countries with lower financial development.

Our findings imply that in the short- to medium-term, public investment can be used as an effective vehicle to address underinvestment issues induced by capital market distortions. This is because institutional reforms that aim to resolve market distortions take time to implement. Consequently, while these reforms are the first best solution to solving market distortions, the reform process can be combined with increases in public investment to address private sector underinvestment. Our findings are also a warning to policy makers that cutting public investment may undermine private investment.

The rest of the paper proceeds as follows. Section 2 presents a simple theoretical model linking public investment to private investment. In section 3, we discuss the empirical strategy used to quantify the crowding-in effect and present summary statistics, stylized facts of our investment data and instrumental variable, and. Section 4 presents the main results. Section 5 presents sensitivity, validity, and robustness exercises. In section 6 we

⁶ Boehm (2020) provided evidence of crowding-out of private investment in OECD countries.

⁷ Specifically, public and private capital are Edgeworth complements in production in that an increase in public investment raises the marginal product of private investment and hence, the level of private investment. Real world examples of such complementary public investment include: the construction of a highway linking rural and urban centers, which increases productivity of private capital; safe public water delivery, which can induce higher private investment in sanitation; and reliable irrigation, which can improve private agricultural activities.

embed our results into a simple model to discuss the implications of estimates on the return of public investment under imperfect capital market conditions. Section 7 concludes.

2 Motivating the structural estimation: A simple model

Following the literature where public capital is productive, we consider that output in the economy is produced using the following technology,

$$Y_t = F(K_{p,t}K_{g,t}) \quad (2.1)$$

where K_p is private capital stock, K_g is public capital stock, $F(\cdot)$ is the production technology function, where $F_j > 0$ and $F_{jj} < 0$ where $j \in \{K_p, K_g\}$.⁸ Additionally, the cross-partial derivative $F_{K_p, K_g} \in \mathbb{R}$ captures the Edgeworth complementarity or substitutability between public and private investment. More precisely, when $F_{K_p, K_g} > 0$ then private and public capital are complements in the Edgeworth-Pareto sense. Here, an increase in the level of public capital raises the marginal product of private capital; hence, inducing an increase in private investment. In contrast, substitutability in the Edgeworth-Pareto ($F_{K_p, K_g} < 0$) sense yields the opposite effect. Finally, the case where $F_{K_p, K_g} = 0$, the two inputs are independent, in which case changes in public investment does not alter the marginal productivity of private investment.

Both private and public capital accumulation follows:

$$K_{i,t+1} = (1 - \delta)K_{i,t} + I_{i,t} \quad (2.2)$$

where the subscript $i = \{g, p\}$ represents the investment type and δ is the depreciation rate set to be the same for both types of capital for simplicity.

Assume a small open economy that faces an exogenously set interest rate of r^* . Government sets a fixed tax rate on firm's output. Given the latter, the firms problem (that is, the private sector) would be

$$\max_{K_p} (1 - \tau)F(K_{p,t}K_{g,t}) - (r^* + \delta)K_{p,t} \quad (2.3)$$

The first order condition for the above problem yields the after-tax marginal product of private capital,

⁸ Allowing public investment to be productive by entering the production function is standard in the literature (see, Aschauer, 1985; Baier and Glomm, 2001; Barro and Sala-i Martin, 1992; Francois et al., 2022; Gupta et al., 2009; Linnemann and Schabert, 2006; Turnovsky, 1997, for in a far from exhaustive list of analytical work on productive public capital). Importantly, there is ample evidence that public capital is indeed productive (see, for example, Baltagi and Pinnoi, 1995; Bom and Ligthart, 2008; Calderon et al., 2015; Eden and Kraay, 2014, among others), although the degree of productivity of public capital may vary across countries (see, for example, Calderon et al., 2015, in the case of infrastructure).

$$(1 - \tau)F_{K_p}(K_p, K_g) = r^* + \delta, \text{ which implies } F_{K_p}(K_p, K_g) = \frac{(r^* + \delta)}{1 - \tau} \quad (2.4)$$

It is worth mentioning that the presence of distortionary taxes in equation (2.4) highlights an important distinction between our study and that of Eden and Kraay (2014). In particular, Eden and Kraay (2014) assume that capital markets are perfect and hence, the marginal product of private and public capital are the same. They, however, acknowledge that the assumption that there are no capital market distortions inherently implies that: 1) government and private sector face the same interest rates and 2) there are no distortionary taxation. However, as discussed by the authors, these assumptions are strong in that governments do indeed face lower interest rates, are less credit constrained than the private sector, and need to raise revenues to repay debt-financed investment. An introduction of any of these two elements have important implications for the return of public investment, which will not be equal to the returns of private investment. Consequently, we relax this assumption and assume that capital markets are imperfect. This also implies that the marginal product of public and private capital is not equal. For now, we introduce distortionary taxes as the main source of distortions in our framework. We will discuss the implication of this for the returns of public investment in section 7.

Log-linearizing equation (2.4) around the steady state and applying some algebra (See annex A), we obtain,

$$\Delta k_{p,t} = -\frac{F_{K_p, K_g}}{F_{K_p, K_p}} \Delta k_{g,t} \quad (2.5)$$

where Δ is the first difference operator so that $\Delta k_{i,t} = k_{i,t} - k_{i,t-1}$ for $i \in \{g, p\}$. Now, from substituting equation (2.2) into (2.5), we arrive at

$$\Delta i_{p,t} = -\frac{F_{K_p, K_g}}{F_{K_p, K_p}} \Delta i_{g,t} = \alpha \cdot \Delta i_{g,t} \quad (2.6)$$

where $\alpha \equiv -\frac{F_{K_p, K_g}}{F_{K_p, K_p}}$ is the parameter of crowding-in ($\alpha > 0$) or crowding-out ($\alpha < 0$) of private investment following an increase in public investment. Notice that since $F_{K_p, K_p} < 0$, the sign of α is strictly governed by $F_{K_p, K_g} \in \mathbb{R}$. Here, $F_{K_p, K_g} > 0$ ($F_{K_p, K_g} < 0$) implies complementarity (substitutability), respectively, which means crowding-in (out) with $\alpha > 0$ ($\alpha < 0$).

In the empirical section that follows, we estimate the parameter in equation (2.6) to uncover the structural relationship between public and private investment and hence, the crowding-in effect of public investment.

3 Empirical strategy

Guided by the theoretical relation in equation (2.6), our empirical strategy is implemented using the local projections method á la Jordà (2005), which has been widely applied in the empirical literature that examines the impact of government spending shocks on macroeconomic outcomes. In panel form, the estimable equation is as given as:

$$\Delta I_{i,t+h}^p = \sum_{s=1}^l \rho_s^h \Delta I_{i,t-s}^p + \alpha^h \Delta I_{i,t}^g + \beta_i^h + \delta_t^h + \varepsilon_{i,t+h} \quad (3.1)$$

where $\Delta I_{i,t+h}^p \equiv \frac{I_{p,it+h} - I_{p,it-1}}{Y_{it-1}}$ and $\Delta I_{i,t-s}^g \equiv \frac{I_{g,it+h} - I_{g,it-1}}{Y_{it-1}}$. The subscripts i represents the country, t the year, and h the horizon, respectively. $I_{p,it}$ is private investment and $I_{g,it}$ is public investment and both are measured in constant local currency. We include a one lag term of private investment ($l = 1$) in our specification and it is captured by the parameter ρ^h for horizon $h \geq 0$. The parameter of interest is α^h , which captures simultaneously the structural relationship between private and public investment and the crowding-in (out) of private investment (that is, the contemporaneous and cumulative change over horizon h in private investment because of a change in government investment). Here, notice that the sign of the estimated value of α is governed by F_{k_p, k_g} as highlighted in our simple model in section 2. Hence, a positive (negative) value of α implies that public and private investment are Edgeworth complements (substitutes) and that public investment crowds-in (out) private investment. The parameters β_i^h and δ_t^h capture country- and year-effect for different horizons, respectively. The term ε_{t+h} represents the error term, which capture all other sources of variation in private investment changes h periods into the future. Finally, notice that equation (3.1) nests several scenarios. Specifically, when $h = 0$ and $l = 0$, the specification in (3.1) reduces to our baseline model in equation (2.1), and α captures the impact multiplier.

3.1 Data

We use the IMF's Investment and Capital Stock dataset which provides investment data for the general government and private sector. Investment data is based on gross fixed capital formation. The data is available for 109 economies. In line with equation (3.1), we convert nominal public and private investment in local currency to real using the domestic real GDP deflator. We take the annual changes in public and private investments, and then divide them by lagged real GDP from the IMF's World Economic Outlook (WEO). One limitation of this dataset is that when public investment data is not available, it is assumed to grow by the same rate as private investment. This affects observations further back in history where data is sparse. The instrumental variable should ameliorate any concerns about the correlation this assumption imposes.

Following Kraay (2014), we use predicted disbursements on loans by official creditors from the World Bank's Debtor Reporting System (DRS) as an instrument for changes in public investment. Official creditors include both multilateral institutions like the World Bank and African Development Bank, and bilateral creditors including sovereign governments like China, Japan, and the United States. This does not include official aid flows. The DRS provides comprehensive coverage of all individual external public and publicly guaranteed loans from all creditors and for all countries that borrow from the World Bank. It tracks the original amount of the loan, loan commitments, terms, disbursements, and repayments of all external loans. The data is confidential. The original amount of the loan as well as disbursements are recorded in the original denomination currency. Loans are generally tied to multi-year spending projects with disbursements linked to the stages of project implementation. See annex B for a discussion of the process of cleaning the data and some of its properties.

The key variable we need from the loan-level data are disbursement rates over the life of a loan defined as the amount dispersed in each year since the loan agreement as a ratio to the original loan amount. Figure 2 shows the average rate of disbursement over 1970-2021 based on the year in which the disbursement occurred. In the year of the loan, about 15 percent of the loan is disbursed to the debtor on average.⁹ This rate of disbursement declines over the life of the loan to 11 percent in the year after the loan is agreed. After five years about half the loan amount is disbursed. There is a difference in the rate of disbursement between multilateral and bilateral lenders. Multilateral lenders tend to disburse loans more evenly over several years, with disbursements averaging about 10 percent per year for the first five years of a loan. Bilateral lenders tend to disburse more upfront with less disbursed in later years. These rates of disbursement are below those found in Kraay (2014) despite only updating the data with an additional decade.

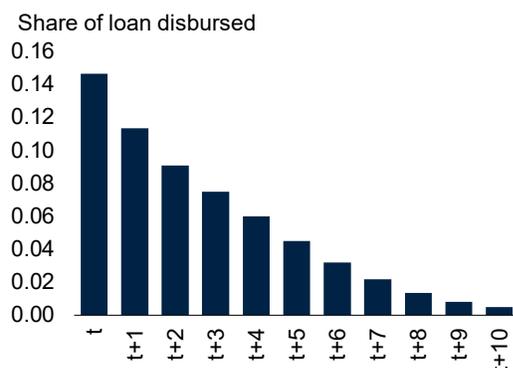
Average disbursement rates are then used to estimate predicted disbursements which is the instrumental variable. Predicted disbursements are calculated as in Kraay (2014) as the original loan amount multiplied by the average rate of disbursement over time across all other loans issued by the same creditor during the same decade and in the same region as the debtor. Regions are based on the World Bank's classification of region (for example, South Asia and Sub-Saharan Africa). For loans from regional multilateral organizations, that only loan to specific regions, the predicted disbursement is applied only to the creditor and decade. These loan-level predicted disbursements are then aggregated to the country-year

⁹ Disbursement rates have changed somewhat over the last half century. In the 1970s, average disbursements in the year of the loan agreement were 17 percent, and within five years was about two-thirds of the total loan. This dropped to less than 10 percent of the loan disburse in the year of the loan in the 1990s and about one-third within five years. By 2010-21, disbursements in the first year had increased back to 17 percent, as in earlier decades, with about half the loan disbursed within five years.

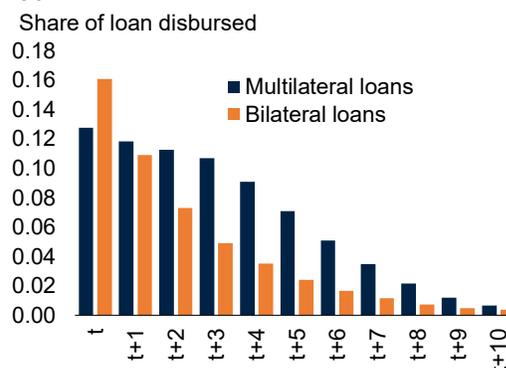
level. The benefit of this approach is that this instrument does not anticipate the future or respond to contemporaneous shocks.

Figure 2: Disbursement rates over the life of a loan

A. Average disbursement rate



B. Average disbursement rate, by creditor type



Source: Authors' calculations.

Note: Based on average disbursement rates for 73,994 loans (32,965 for multilateral and 41,029 for bilateral) in year of loan and subsequent years.

Since the predicted disbursements are in current US\$, to get our instrumental variable relative to GDP, we convert it to local currency using exchange rates from the World Bank's World Development Indicators, then deflate using the GDP deflator and again divide it by lagged real GDP. Before running regressions, we remove the 1st and 99th percentiles of each variable. After constructing our variables, we have observations between 1980 and 2019 for our regressions. Table 1 provides summary statistics of the main variables of interest.

Table 1: Summary statistics

	Mean	Median	Standard deviation	Minimum	Maximum	Interquartile range	Skewness	Kurtosis	Number of observations
Change in private investment to GDP	0.74	0.63	4.11	-34.72	62.77	2.78	1.44	38.02	3737
Change in public investment to GDP	0.27	0.19	2.43	-42.52	29.81	1.41	-0.85	50.31	3737
Predicted loan disbursements to GDP	0.07	0.00	2.30	-33.18	46.20	0.39	6.40	213.70	3774
Predicted multi. loan disbursements to GDP	0.05	0.00	0.45	-7.68	6.54	0.22	1.41	58.36	3756

Source: Authors' calculations.

Note: Multi. = multilateral. All variables are as a ratio to GDP. "Change" refers to the annual change as described in equation (3.1).

3.2 Identification

A primary challenge with estimating the effect of public investment on private is the issue of endogeneity of government investment. This issue occurs because public investment is a fiscal policy tool often used to help stimulate the economy during economic downturns. There is a strong possibility that during economic downturns where private investment is low, governments may increase public investment to stimulate the economy. Consequently, an estimated negative relationship between public and private investment is likely to be driven by the negative shock to the economy. This means that there will be a negative correlation between the error term and public investment, thereby, inducing a downward biased OLS estimate of α . On the other hand, if government investment is procyclical (that is, increases during economic booms), which is historically the case for several developing countries, then during good times such as booms in commodity prices, government investment will rise (Galeano et al., 2021). Procyclicality would create an upward bias on the OLS estimate of α . Additionally, and perhaps a more critical issue of endogeneity is measurement errors in investment data. The presence of measurement errors in the independent variable can lead to attenuation bias. This may imply a positive relationship between the error term and public investment, inducing an upward bias in the OLS estimate of the crowding-in parameter. Generally, this endogeneity issue that causes government investment to be contemporaneously correlated to the error term, ε_{it} , will render the OLS estimation inconsistent.

Evidently, failure to address the issue of endogeneity can lead to inaccurately estimating the size, and potentially the sign of α . The natural strategy to employ to address the endogeneity is an instrumental variable estimation. We, therefore, utilize the identification strategy of Kraay (2012) and Kraay (2014). While focusing on the output multiplier and government spending, these studies exploit two conditions: (1) The studies argue that a significant fraction of government spending in developing economies is financed by loans from official creditors, and (2) these loans typically disburse over a period of many years following the initial approval of the loan. Kraay (2014), therefore, constructs a measure of predicted disbursements on loans from official creditors that reflects only fluctuations in loan approval decisions made in previous years, but not the current year. We update the instrumental variable using the same unique loan-level dataset from 1980 to 2021 (extended it from 2010) on about 79,000 individual loans from official creditors to governments in developing countries.

The key identifying assumption is that loan approval decisions in a given year do not anticipate shocks to private investment or output in subsequent years. Given this identifying assumption, subsequent predicted disbursements are uncorrelated with contemporaneous macroeconomic shocks, and are a valid instrument for changes in government investment.¹⁰

¹⁰ As discussed in Kraay (2012, 2014), conditional on the identifying assumption that loan approvals do not respond to future shocks to growth, our choice of instrument will be uncorrelated the error term for all $h \geq 0$.

Moreover, in countries where official creditor financing of government investment is large, predicted disbursements will also be a strong instrument for changes in government investment.¹¹ We, therefore, employ the predicted disbursements on loans from official creditors to identify the exogenous component of government investment.

There are several challenges associated with using predicted disbursements as an instrument for public investment. First, as described in Kraay (2014), for the first-stage regression, predicted disbursements are correlated with overall government spending, which comprise investment and non-investment spending. Hence, if one is regressing private investment on public investment and using predicted disbursements as an instrument, it may be the case that non-investment government spending affects private investment, and if the latter is not controlled for, could lead to a violation of the exclusion restriction. However, controlling for non-investment government spending in the first-stage regression can be problematic as non-investment government spending might be correlated with the error-term in the first-stage regression. Second, it may be that predicted loan disbursements acts as a signal to private investors that the involvement of multilateral creditors may lower policy uncertainty. We attempt to address these challenges by employing an instrument-free estimator in section 6.3.

In our preferred specification of equation (3.1), we also control for the lagged private investment. This empirical strategy is guided by two arguments in Kraay (2012). First, although loan commitments are made before subsequent shocks are realized, the shocks may be persistent and possibly predictable. Second, if loan commitments are correlated with contemporaneous macroeconomic shocks, they will also be correlate with future shocks, which will violate the exclusion restriction. Consequently, including the lagged dependent variable in the regression helps address this possibility and improves the credibility of our identifying assumption.

4 Main results

Based on the two-stage least squares (2SLS) regression, using predicted disbursement as the instrumental variable, the coefficient on public investment is 1.6 (in the case of $h=0$) and is statistically significant at the 5% level of significance (table 2; panel B).¹² The cumulative impact of public investment on private investment rises to a peak of 2.4 after two years. The estimates have two economic meanings, as highlighted in section 2. Specifically, recall that a positive coefficient on public investment in the private investment equation means that government investment is an Edgeworth-Pareto complement to private investment, suggesting that an increase in public investment raises the marginal product of private investment. Additionally, the estimated positive coefficient implies the crowding-in of private investment following an increase in public investment. In particular, the results

¹¹ Total disbursements average 77 percent of public investment and 2.8 percent of GDP for country-year pairs.

¹² In annex C we look at the impact of alternative censoring rules applied to the loan-level data.

suggest that an extra dollar increase in government investment crowds-in private investment by approximately 1.8 dollars after one-year and by 2.1 after four-years.

Table 2: The response of private investment to government investment

	Baseline (1)	Cumulative Multipliers (horizon h in years)				
		h=0 (2)	h=1 (3)	h=2 (4)	h=3 (5)	h=4 (6)
Panel A: OLS						
Change in government investment	-0.041 (0.057)	-0.069 (0.051)	0.169** (0.081)	0.165* (0.097)	0.211** (0.099)	0.297*** (0.097)
Panel B: 2SLS						
Change in government investment	1.843** (0.821) [0.706, 5.06]	1.623** (0.698) [0.60, 4.36]	2.394** (0.944) [0.71, 5.57]	2.239*** (0.829) [0.43, 4.44]	2.067** (0.881) [0.22, 4.20]	1.351 (1.149) [-1.24, 4.03]
Panel C: First-stage estimates						
Change in predicted disb.	0.212*** (0.070)	0.231*** (0.072)	0.212*** (0.072)	0.230*** (0.073)	0.255*** (0.071)	0.252*** (0.074)
Observations	3,437	3,349	3,242	3,136	3,029	2,922
F-statistic	9.340	10.32	9.268	10.03	12.83	11.63
KP Underid stat	0.00454	0.00295	0.00457	0.00326	0.00115	0.00175
No. of countries	109	109	109	109	109	109

Notes: *** p < 0.01, ** p < 0.05, * p < 0.1. Dependent variable is change in private investment to lagged GDP. Robust standard errors in parentheses are Driscoll-Kraay standard errors to control for the presence of error cross-sectional dependence a' la Boehm (2020). All estimations include country-fixed effects and year effects. "Baseline" specification does not include the lagged dependent while all the estimations in columns (2)-(6) include one year lag of the dependent variable. "KP" is Kleibergen and Paap underidentification test.

The 2SLS effective F-statistic lies between 9.3 and 12.8. The effective *F*-statistic follows Olea and Pflueger (2013) and has recently been advocated by Andrews et al. (2019) as the more reliable metric of first stage strength in the presence of heteroskedastic residuals.¹³ Similar to the standard rule-of-thumb value for the standard *F*-statistic, in a just-identified model, the yardstick value for the effective *F*-statistic is 10 (Andrews et al. 2019). A well-documented issue of using instrumental variables is that when they turn out weak, the estimated coefficient of interest can be biased and unreliable; a possibility here with some *F*-statistics below the benchmark. Hence, the Andersen-Rubin instrument consistent 95 percent confidence intervals for the baseline 2SLS are 0.73 to 5.19 and for h=0 is 0.6 to 4.36 (and slightly smaller for Driscoll-Kraay standard errors). Indeed, Eden and Kraay (2014), who focus on 39 LICs countries, acknowledge that although their reported weak-instrument

¹³ This statistic coincides with the conventional *F*-statistic when residuals are homoskedastic.

consistent confidence interval does not contain zero, their weak instrument intervals are extremely large. Specifically, the estimated response of private investment to an increase in public investment can range from as low as 0.18 to as high as 9.85 with a point estimate of about 2 in Eden and Kraay (2014). Furthermore, our point estimates are smaller than the ones estimated in Eden and Kraay (2014).

Evidently, the 2SLS estimates are larger over all horizons than that of the ordinary least squares (OLS) estimates. As we can observe for the full sample, the OLS estimate is -0.04 (in the baseline regression, which excluded a lagged dependent), and it is statistically insignificant (table 2; panel A). The cumulative response rises over the horizon (h), with the multiplier becoming significant at two-years ahead ($h = 1$) at 0.17 and also at five-years ahead ($h = 4$) at 0.3. Recall, however, that the OLS estimates are likely to be biased (downward) because of the negative correlation between changes in public investment and the error term.

4.1 Crowding-in in countries with significant investment needs

Investment needs in low-income countries, several of which are in Sub-Saharan Africa (SSA) as well as IDA countries, remain large and are fundamental to ensuring poverty reduction and sustainable development. For example, according to Rozenberg and Fay (2019), the SSA region has the highest infrastructure gap of any EMDE region, estimated at about 9 percent of GDP per year. This is almost four times the size of current infrastructure investment spending (Kasyanenko et al., 2023). Several examples of this underinvestment across many sectors are available. In the power sector, one-half of the population in SSA had access to electricity in 2021 compared with closer to nine-in-ten worldwide. In telecommunications, about one-third of the population is using the internet compared to about two thirds globally. In agriculture, which is a source of employment for about two-thirds of the population, productivity is low (Kasyanenko et al., 2023; Fuglie et al., 2019). Hence, we re-estimate the relationship between public and private investment separately for subgroups, including low-income countries, International Development Association (IDA) members, and Sub-Saharan African countries.

The results for the subsample analysis are presented in table 3. We find evidence of crowding-in in all three subgroups. The impact multipliers ($h=0$) in LICs and SSA are smaller than in all EMDEs but cumulative multipliers at longer horizons are higher. In LICs, there is evidence that public investment also crowds-in private investment with an additional dollar of public investment associated with up to 1.5 dollars in private investment after one year ($h = 0$), rising to peak at 2.5 after three years ($h = 2$). The impact multiplier, which can be directly compared, is lower than that estimated by Eden and Kraay (2014) which is equal to 2. The effective F-statistic is consistently above the 10 benchmark threshold. Crowding-in may be even larger in IDA countries at 2.1 dollars for each additional dollar of public investment after

one year and up to 3.5 after five years. However, the F-statistic is below the 10 threshold between 5 and 6.7. In SSA, the impact multiplier is 1.5, slightly lower than in the overall sample but not statistically significantly different. The cumulative multiplier rises to 3.1 after three years suggesting a strong complementarity between public and private investment in this region. The effective F-statistics remain above 10 across all horizons suggesting a relevant instrument.

Table 3: The response of private investment to government investment

	Cumulative Multipliers (horizon h in years)				
	(1)	(2)	(3)	(4)	(5)
Low-income countries					
	<i>h=0</i>	<i>h=1</i>	<i>h=2</i>	<i>h=3</i>	<i>h=4</i>
Change in government investment	1.511*** (0.532)	1.664** (0.776)	2.540** (1.019)	2.341** (1.062)	1.283 (1.106)
Observations	722	699	677	654	631
F-statistic	12.38	11.04	11.26	12.75	12.23
KP Underid stat	0.00324	0.00511	0.00481	0.00343	0.00384
IDA countries					
Change in government investment	2.120* (1.113)	3.441* (1.762)	3.067** (1.516)	3.478** (1.650)	2.583 (1.894)
Observations	1,479	1,432	1,387	1,341	1,296
F-statistic	5.912	4.999	5.932	6.679	6.041
KP Underid stat	0.0165	0.0263	0.0157	0.0108	0.0148
Sub-Saharan Africa					
Change in government investment	1.446** (0.625)	2.191** (0.937)	2.997** (1.222)	3.054** (1.191)	1.543 (1.291)
Observations	1,363	1,321	1,280	1,239	1,197
F-statistic	12.26	10.84	10.83	12.46	10.76
KP Underid stat	0.00147	0.00251	0.00242	0.00131	0.00238

Notes: *** p < 0.01, ** p < 0.05, * p < 0.1. Dependent variable is change in private investment to lagged GDP. Robust standard errors in parentheses are Driscoll-Kraay standard errors to control for the presence of error cross-sectional dependence a la Boehm (2020). All estimations include country and year effects and one year lagged dependent variable. "KP" is Kleibergen and Paap underidentification test.

4.2 Crowding-in and the role of corruption control

It may be the case that the effectiveness of public investment and the ability to crowd-in private investment is affected by the level of corruption. There exists a well-established literature that provides evidence of the negative impact of corruption on the business environment, investment efficiency, infrastructure, and public service delivery (for example, Mauro 1995; Davis 2004; Barr et al. 1995; Beekman et al. 2014; and Kaufmann et al. 2002).

Poor governance spurs rent-seeking behaviors and diverts public funds to unintended activities, lowering the effectiveness of public investment.

Table 4: The response of private investment to government investment, corruption of control

	(1)	(2)	(3)	(4)	(5)
	Cumulative Multipliers (horizon h in years)				
	h=0	h=1	h=2	h=3	h=4
	Higher control of corruption				
Change in government investment	0.870*	2.519**	2.514**	2.272**	1.450
	(0.484)	(1.094)	(1.074)	(1.122)	(1.307)
Observations	1,955	1,902	1,849	1,795	1,742
F-statistic	11.67	10.80	11.06	13.53	13.05
KP Underid stat	0.00171	0.00263	0.00232	0.000934	0.00112
No. of countries	93	93	93	93	93
	Lower control of corruption				
Change in government investment	4.764	1.661	1.686	1.965	2.005
	(4.312)	(3.069)	(3.010)	(2.449)	(3.164)
Observations	1,394	1,340	1,287	1,234	1,180
F-statistic	1.580	1.378	1.658	2.049	1.617
KP Underid stat	0.196	0.225	0.183	0.140	0.186
No. of countries	70	70	70	70	70

Notes: *** p < 0.01, ** p < 0.05, * p < 0.1. Dependent variable is change in private investment to lagged GDP. Robust standard errors in parentheses are Driscoll-Kraay standard errors to control for the presence of error cross-sectional dependence a ´ la Boehm (2020). All estimations include country-fixed effects and year effects and one year lagged dependent variable. “KP” is Kleibergen and Paap underidentification test.

To examine for the impact of corruption on the ability to crowd-in private investment, we divide the sample (that is, country-year pairs) into those above (high corruption control) and below (low corruption control) the median outcome for corruption control from the Worldwide Governance Indicators (Kaufmann et al. 2011). The control of corruption indicator measures perceptions of the extent to which public power is exercised for private gain.

We find that the crowding-in effect of public investment on private investment is only statistically significant in the high control of corruption group, with the cumulative impact increasing up to four years ahead (table 4). When control of corruption is weak, the estimated coefficient across the different horizons, while generally smaller in magnitude, is

not statistically significant, further emphasizing the importance of good governance in fostering private investment.

4.3 Crowding-in and financial development

An important factor in driving investment, particularly, private investment is financial development. A well-developed financial sector promotes investment because it reduces liquidity constraints, facilitating access to financial resources to businesses, reduces information asymmetry that increases the cost of sending and borrowing and ensures an efficient allocation of financial resources (Allen and Ndikumana, 2000). Moreover, financial development plays a critical role in pooling savings and allocating capital to productive investment (Svirydzenka, 2016). Consequently, the accumulation of capital depends on financial development. Yet, financial development may be undermined and be less relevant if there are large inefficiencies in the financial system because of the misallocation of capital or if there is little to no access to financial markets and institutions. Furthermore, the marginal returns to growth from further financial development diminish at high levels of financial development—that is, there is a significant, bell-shaped, relationship between financial development and growth (Sahay et al., 2015). These non-linear relationships may be present for the impact of public investment on private investment.

Using the IMF's financial development database, we find that countries with low levels of financial development tend to have high crowding-in. We again divide the sample into those above and below the median level of financial development across time. The results are reported in table 5. The estimated effect of public investment on private investment is positive and statistically significant for the low levels of financial development (below median). When financial development is low, the cumulative effect of public investment on private investment increases and reaches a value of 3.2 after two years. The crowding-in effect turns insignificant after five years. For the high levels of financial development, the crowding-in effect is not statistically significant, and the estimated coefficients are generally lower than those obtained with the low level of financial development sample.

We find similar results when using the Chinn and Ito (2006) measure of capital account openness (See annex D). We divide the sample between those above and below the median level of capital account openness. Economies with more restrictive capital account openness have positive and significant crowding-in of private investment. The effect is large, with a peak multiplier of about 4.1 in year three ($h=2$).

These findings could be explained by the fact that countries with low levels of financial development often face higher borrowing costs and, thus, a lower return on investment, which makes private investment less profitable. Therefore, more public investment could increase the incentive to invest as it may increase the expected return on investment and alleviate the risk of investing in countries with a low level of financial development. It is worth noting that these results do not provide evidence that there is a statistical difference

between crowding-in for economies with low and high levels of financial development. We only find that there is clear evidence of crowding-in when financial development is low.

Table 5: The response of private investment to government investment, financial development

	(1)	(2)	(3)	(4)	(5)
	Cumulative Multipliers (horizon h in years)				
	h=0	h=1	h=2	h=3	h=4
	Below Median				
Change in government investment	2.799*	3.189*	3.007**	2.768*	1.217
	(1.498)	(1.730)	(1.370)	(1.516)	(2.084)
Observations	1,640	1,601	1,570	1,533	1,496
F-statistic	4.719	4.213	4.686	5.629	4.829
KP Underid stat	0.0248	0.0335	0.0244	0.0134	0.0215
No. of countries	82	82	82	82	82
	Above Median				
Change in government investment	0.269	0.878	1.130	0.702	0.318
	(0.635)	(1.167)	(1.487)	(1.413)	(1.687)
Observations	1,658	1,593	1,522	1,456	1,390
F-statistic	6.267	5.523	5.308	5.567	5.167
KP Underid stat	0.0183	0.0264	0.0292	0.0258	0.0316
No. of countries	80	80	78	77	75

Notes: *** p < 0.01, ** p < 0.05, * p < 0.1. Dependent variable is change in private investment to lagged GDP. Robust standard errors in parentheses are Driscoll-Kraay standard errors to control for the presence of error cross-sectional dependence a' la Boehm (2020). All estimations include country and year effects and one year lagged dependent variable. "KP" is Kleibergen and Paap underidentification test.

5 Robustness and validity of the instrument

In this section we conduct a battery of robustness exercises by re-estimating our empirical model with alternative instruments in bilateral and multilateral loans. We also use alternative model specifications to check for the robustness of our main findings. Finally, we use an alternative estimator in *kinky* least squares to test the robustness and validity of our results.¹⁴

¹⁴ In annex D we look at the impact of alternative censoring rules on our main instrumental variable.

5.1 Alternative instruments

Table 6 presents the results for the case of alternative instrumental variable, where we employ multilateral and bilateral loans. The results show that a dollar increase in public investment increases private investment by about 2 dollars on impact in the case where predicted disbursements from multilateral creditors is used as instrument for public investment (Panel A, Table 6).

Table 6: The response of private investment to government investment, alternative instruments

	(1)	(2)	(3)	(4)	(5)
	Cumulative Multipliers (horizon h in years)				
	h=0	h=1	h=2	h=3	h=4
	Panel A: Multilateral N = 109				
Change in government investment	2.146** (0.860)	2.045** (0.802)	2.476** (1.216)	1.708 (1.365)	1.622 (1.493)
Observations	3,429	3,344	3,237	3,131	3,024
F-statistic	7.405	7.501	6.976	7.118	8.106
KP Underid stat	0.0110	0.00998	0.0128	0.0119	0.00733
	Panel B: Bilateral N = 109				
Change in government investment	1.593 (1.076)	1.280 (0.883)	2.356 (1.698)	2.983* (1.786)	2.490 (1.640)
Observations	3,404	3,317	3,211	3,106	3,000
F-statistic	5.185	6.048	5.094	5.928	7.929
KP Underid stat	0.0267	0.0163	0.0264	0.0165	0.00637

Notes: *** p < 0.01, ** p < 0.05, * p < 0.1. Dependent variable is change in private investment to lagged GDP. Robust standard errors in parentheses are Driscoll-Kraay standard errors to control for the presence of error cross-sectional dependence a la Boehm (2020). All estimations include country and year fixed effects and one year lagged dependent variable. "KP" is Kleibergen and Paap underidentification test.

Moreover, the crowding-in effect after one year of the public investment shock (h=1) is about 2.5 and is statistically significant at the 5 percent level. Albeit slightly larger than the crowding-in effect from our main results, the evidence of crowding-in of private investment by public investment is consistent with the main results in the previous section. For longer horizons, however, the multiplier is statistically not different from zero. In the case of using predicted disbursements from bilateral loans only one horizon estimate (h = 2) is found to be statistically significant, and the effective F-statistics are lower still. Our results are somewhat in line with Kraay (2014) who finds a greater strength of identification from

multilateral loans than bilateral based on the logic that multilateral loans are a greater part of the loan-level dataset sample and are disbursed more slowly.

5.2 Accounting for global shocks

The globalization of finance over the last several decades and the existence of a global financial cycle suggest that investment across countries may be subject to common global shocks (Miranda-Agrippino and Rey, 2022; Kose et al., 2009). While time fixed effects control for common shocks in the main results, as an alternative we include cross-sectional averages of public and private investment in our regressions. Based on guidance from Chudik et al. (2017) we include three lags of the cross-sectional averages. The multipliers presented in table 7 are consistent with the multiplier estimated in our main results, where time effect was used to account for common shocks. Specifically, we find a baseline estimate of 1.6, which rises to 2.3 after three years.

Table 7: The response of private investment to government investment, cross sectional dependence

	(1)	(2)	(3)	(4)	(5)	(6)
	Baseline	h=0	h=1	h=2	h=3	h=4
Change in government investment	1.558** (0.623)	1.581** (0.658)	2.237*** (0.863)	2.373*** (0.782)	2.300*** (0.815)	1.420 (1.092)
Observations	3,245	3,223	3,116	3,010	2,903	2,796
F-statistic	13.61	10.78	10.05	10.67	13.98	12.90
KP Underid stat	0.00115	0.00259	0.00359	0.00267	0.000847	0.00122
No. of countries	109	109	109	109	109	109

Notes: *** p < 0.01, ** p < 0.05, * p < 0.1. Dependent variable is change in private investment to lagged GDP. Robust standard errors in parentheses are Driscoll-Kraay standard errors to control for the presence of error cross-sectional dependence á la Boehm (2020). All estimations include country and year fixed-effects and one year lag of the dependent variable. “KP” is Kleibergen and Paap underidentification test.

5.3 Exogeneity of the instrument

So far, we have estimated the effect of public investment on private investment using instrumental variable approach. Nonetheless, our results above rely on the assumption that our selected instrument satisfies the exclusion restriction for all endogeneity correlation between the error term and public investment. Importantly, the associated F-statistics for the IV are often marginally greater than the rule of thumb of 10 and in several cases smaller than 10. This suggests a weak instruments problem and challenges the assumption that our IV strictly satisfies the exclusion restrictions. At a more intuitive level, we are recycling an instrumental variable from Kraay (2014), where the instrument was used to identify the exogenous shocks in government spending. In our case, we are regressing private investment on public investment (a subcomponent of public spending) and are using

predicted disbursements as an instrument. It may, however, be the case that non-investment government spending affects private investment, and if it is not controlled for, could lead to a violation of the exclusion restriction. The challenge, however, is that non-investment government spending is in itself endogenous, which raises other empirical roadblocks including searching for another instrument. In this section, with appropriate assumptions, we apply a novel instrument-free estimator in kinky least squares (KLS) developed by Kiviet (2013, 2020, 2022) as both an alternative estimator for robustness checks of our results and to formally test the exclusion restriction.

Our IV estimates produce a crowding-in effect of private investment that are larger than the OLS estimates. This suggests the presence of a combination of measurement errors and potential countercyclicality of public investment might be the dominant endogeneity issues in our case.¹⁵ In fact, the issue of measurement errors is likely the dominant endogeneity issue given that historically there has been evidence of the procyclicality of public investment in developing countries, although there are cases where countercyclicality of public investment is observed (see, for example, Galeano et al., 2021), which will instead bias the OLS estimates upward. Furthermore, economic theory often predicts the crowding-in of private investment by productive government investment (Berg et al., 2019). In this sense, an empirical estimate of a negative or near-zero effect from the OLS estimator will be at odds with predictions from standard economic theory. This suggests that the true impact of public investment on private investment is positive, and that the OLS estimate may be biased downwards. Consequently, it is not unreasonable to assume a prior negative correlation between the error term and public investment governed by the presence of measurement errors. To what degree measurement errors can explain the large difference between the OLS and IV estimates, however, remains an open question.

The KLS allows us to check the validity of our instrument as well as the crowding-in effect for different degrees (or sizes) of the negative correlation between the error term and the endogenous variable. More precisely, for identification of the regression coefficients, the KLS can restrict the admissible correlation of the regressor with the error term within plausible bounds. Here, no instruments are needed. Rather, the bias of the OLS estimator is analytically corrected for all values on a grid of endogeneity correlations (Kripfganz and Kiviet, 2021). Consequently, for a narrow and plausible range of a postulated endogeneity correlations, the KLS confidence intervals are—as a general rule—narrower than those from 2SLS (Kripfganz and Kiviet, 2021). The latter point is especially true if there is the possibility of weak instruments, which might be the case for our IV given the F-statistics reported. Finally, and perhaps more importantly, the KLS approach enables testing of any potential exclusion restrictions, which is not possible under a just-identified model when the 2SLS estimator is applied.

¹⁵ Edén and Kraay (2014) allude to similar sources of endogeneity.

The KLS estimator is given by:

$$\beta_{KLS} = \beta_{OLS} - \text{Bias Correction}(\rho),$$

where β_{OLS} is the standard OLS estimator, which is inconsistent when ρ defined as the correlation coefficient between public investment and the error term is not equal to zero. The bias correction is analytically described in Kiviet (2020, 2022); Kripfganz and Kiviet (2021).¹⁶ The KLS estimator requires specifying admissible correlation values of the regressor (public investment) with the error term within plausible bounds. Hence, to estimate β_{KLS} , we postulate values for ρ . Under our reasonable assumption of the presence of measurement error, we specify ρ to lie between $[-0.7, 0.1]$. We include a low positive correlation coefficient (that is, 0.1) to allow for the case that government investment is procyclical. Notice that the interval allows us to conduct sensitivity analysis on the degree or severity of measurement errors.

We re-estimate equation (3.1) in Jorda (2005) projection form using the KLS approach. Figures 3 and 4 present the KLS estimates of the crowding-in effect of public investment and the test for the exclusion restriction for correlation coefficients under our assumption of $\rho \in [-0.7, 0.1]$, respectively. We report estimates for each horizon. To elucidate the results, we present our finding diagrammatically.

As shown in figure 3, the KLS estimates show a positive and statistically significant impact of public investment on private investment for a wide range of our specified coefficient of correlation for all horizons. For example, in panel A, the KLS reports a positive and statistically significant impact of public investment at the 5% level of significance for $\rho \in [-0.7, -0.1]$, although the effect declines with larger ρ values. In panel E, the positive impact of public investment on private investment holds in the KLS estimates for ρ up to about 0.03. In all cases, we notice that the KLS estimate overlaps with the IV and for longer horizons ($h > 0$), the KLS point estimates coincide with the IV point estimates. Turning to test of exclusion restriction in figure 4, we observe that only for large negative endogeneity correlations (that is, around $\rho < -0.5$ in the case of panel A) do we not reject the null hypothesis that the instruments are validly excluded from the model at the 5% level. Nonetheless, the validity of instruments tends to hold for smaller negative endogeneity correlation in the case of longer horizons and even for smaller positive endogeneity correlation (panel F). In summary, while challenges of weak instrument are present in our model, there is conditional evidence that our instrument is valid for reasonable assumptions of the direction and degree of endogeneity, particularly over longer horizons.

¹⁶ See Kripfganz and Kiviet (2021) and Kiviet (2020, 2022) for detailed discussion on the analytics of the bias correction term.

Figure 3: Estimates of crowding-in across estimators and horizons

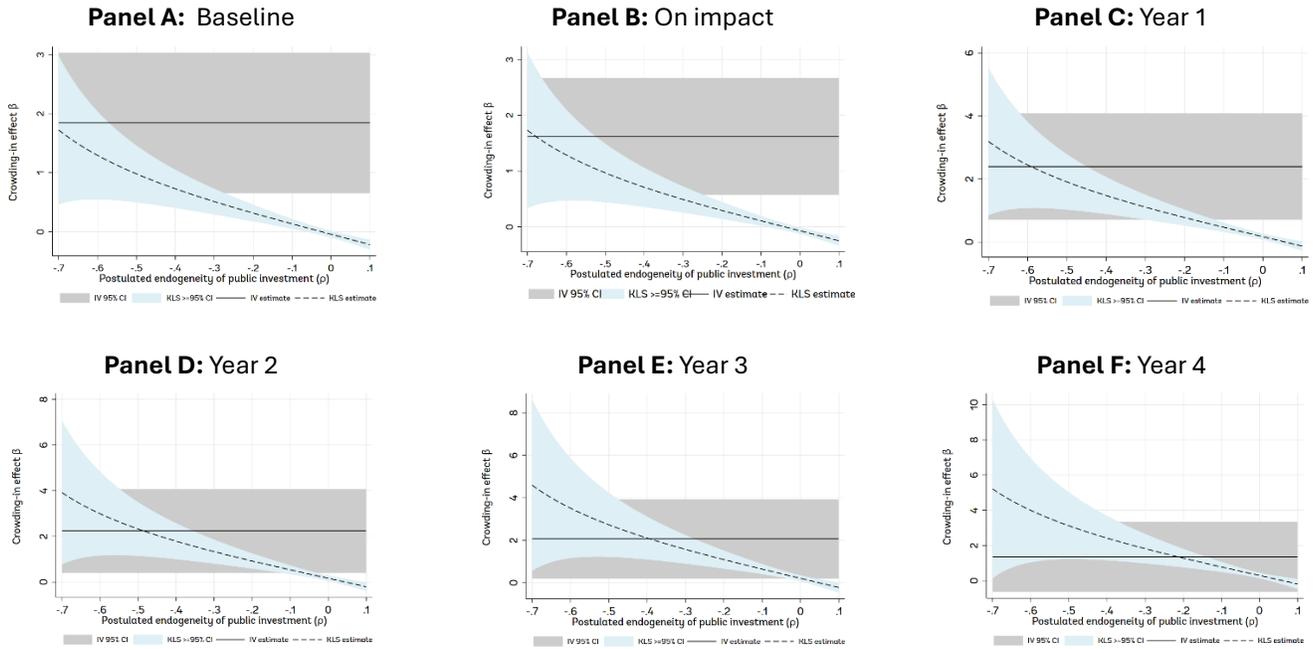
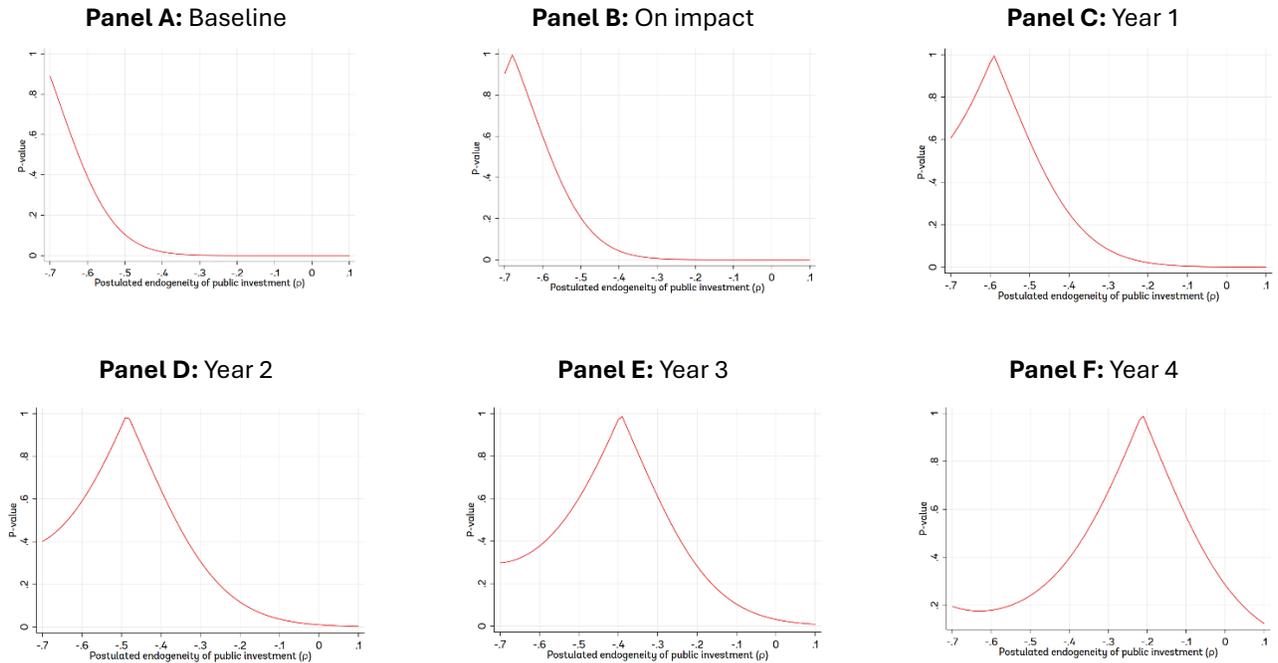


Figure 4: P-values for the KLS exclusion restrictions test of Predicted Disbursement



Notes: The null hypothesis here is that the instruments are validly excluded from the model. The peak of the graphs are the points where the KLS point estimate coincides with the IV-point estimate. The baseline result represents the model specification where no lags of private investment was controlled for. In the rest of the specification (Panels B-F), we use the Jorda (2005) LPM specification where the horizon is set to 4 years. These specifications in the lag term of private investment. All regressions presented in the figure controls for country-fixed and year effects.

6 Implication of the results

In the previous sections we have presented evidence of crowding-in of private investment through public investment. This section provides insights into the implication of the results of complementarity between private and public investment on optimal return to public investment. The section also sheds light on whether based on our results in table 2, public investment can help drive private investment in a situation in which market imperfection induces underinvestment in the private sector. In line with Ogura and Yohe (1977), we lay out a model in which the life of any publicly provided project is T periods is considered. The economy-wide intertemporal welfare function, which the government maximizes, over the lifetime of such projects is then given by

$$U(C_1, \dots, C_T) \quad (6.1)$$

where C_i is consumption in period i . The economy's aggregate resource constraint is given by

$$F(K_p, K_g) = C_t + I_{p,t} + I_{g,t} + R_{t-1}^* D_{t-1} - D_t + \bar{G} \quad (6.2)$$

where $R^* = 1 + r^*$, \bar{G} is a fixed level of government consumption, and D_t is foreign debt. The government is aware of the private agents' reactions given in equation (2.4) by $F_{K_p}(K_{p,t}, K_{g,t}) = \frac{r^* + \delta}{1 - \tau}$ as it maximizes its welfare function. More precisely, the policy objective of the government is to choose the stream of government investment that will induce the correct path of private investment that coincides with equation (2.4). Substituting $I_{i,t}$ in equation (2.2) into equation (6.2), the government problem is to choose $C_t, K_{p,t}, K_{g,t}$ and D_t to maximize equation (6.1) subject to (6.2), and (2.4), so that the following Lagrangian emerges:

$$V = U(C_1, \dots, C_T) + \sum_{t=1}^T \lambda_t \left(F(K_{p,t}, K_{g,t}) - C_t - (K_{p,t+1} - (1 - \delta)K_{p,t}) - (K_{g,t+1} - (1 - \delta)K_{g,t}) - R_{t-1}^* D_{t-1} + D_t \right) + \sum_{t=1}^T \mu_t F_{K_p}(K_{p,t}, K_{g,t}) \quad (6.3)$$

The appropriate first order conditions (FOC) are as follows:

FOC for consumption:

$$V_{C_t} = U_t - \lambda_t = 0 \quad (6.4)$$

FOC for private capital:

$$V_{K_{p,t+1}} = \lambda_{t+1} F_{K_p} - \lambda_t + (1 - \delta)\lambda_{t+1} + \mu_{t+1} F_{K_p, K_p} = 0 \quad (6.5)$$

FOC for public capital:

$$V_{K_g,t+1} = \lambda_{t+1}F_{K_g} - \lambda_t + (1 - \delta)\lambda_{t+1} + \mu_{t+1}F_{K_g,K_p} = 0 \quad (6.6)$$

FOC for foreign debt:

$$V_{D_t} = \lambda_t - \lambda_{t+1}R_t^* = 0 \quad (6.7)$$

Combining the system of equations from equations (6.4) to (6.7) and apply some algebra (See annex E), we can derive the marginal return of government investment as¹⁷

$$F_{K_g} = (r^* + \delta) + \frac{F_{K_p,K_g}}{F_{K_p,K_p}} \left[\frac{r^* + \delta}{1 - \tau} - (r^* + \delta) \right] \quad (6.8)$$

There are several observations from the equation describing the optimal marginal return to public capital. First, it is evident that an assumption that the marginal return to public capital is equal to the marginal return to private capital is stringent and is a special case of equation (6.8). Specifically, this scenario only arises when public and private investment are perfect substitutes so that F_{K_g,K_p} is equal to F_{K_p,K_p} . Second, in the presence capital market distortions like distortionary taxes captured by $\tau > 0$, we observe that the term in the square bracket is greater than zero.¹⁸ Here, the question of misallocation of resource and the power of the government to effectively intervene with its own investment decision arise. More precisely, in this case, the economy provides too much current consumption at the expense of too little investment for the future. That is, it is cheaper to borrow to finance consumption than borrow to invest due to the wedge created by τ . Thus, depending on the sign of F_{K_p,K_g} in equation (6.8), we can answer the question of how much power the government can marshal to optimally counterbalance the underinvestment with increases in government investment (Ogura and Yohe, 1977). Given the benefit of hindsight and uncovering that public and private investment are Edgeworth complements in our empirical estimation in the previous Section, we focus on the complementarity case to answer this question.

Notice that for any degree of Edgeworth complementarity (i.e., $F_{K_p,K_g} > 0$), an increase in public investment will induce a rise in private investment by increasing its marginal product; see equation (2.6). Consequently, public investment becomes an effective tool to help counterbalance the private sector underinvestment induced by the imperfect risk spreading in the capital market. This, however, has an implication for the optimal marginal return to public capital. That is, the last term in equation (6.8) is negative (i.e., $\frac{F_{K_p,K_g}}{F_{K_p,K_p}} \left[\frac{r^* + \delta}{1 - \tau} - (r^* + \delta) \right] < 0$) suggesting that in the case where capital market distortions exists and private investment is discouraged, public investments that crowd-in private investment should be

¹⁷ For exposition purposes, we provide the details of the derivation of equation (7.8) in Annex B.

¹⁸ Notice that in our case distortionary taxes were used to demonstrate the implications of capital market distortions in our framework. However, even in the absence of distortionary taxes, other imperfect capital market conditions, such as access to debt with lower interest rates by governments, can drive a similar wedge between the rates faced by private agents versus the government.

at lower rates of return compared to the scenario where capital markets are perfect and there are no distortions ($\tau = 0$), where $F_{K_g} = r^* + \delta$.

The contrasting conclusion is straightforward in that in the case where market “distortions” encourage extra incentives for private investment. For example, consider the scenario where the government provides subsidies to firms (i.e., $\tau < 0$) and public and private investment are Edgeworth complements. In this case, the last term in equation (6.8) is positive (i.e., $\frac{F_{K_p, K_g}}{F_{K_p, K_p}} \left[\frac{r^* + \delta}{1 - \tau} - (r^* + \delta) \right] > 0$). In this case, the marginal return of public investment should be expected to be higher than when markets have no distortions. Finally, it is worth mentioning that these conclusions are not intended to discount the role of how the correction of capital market distortions can be the first best solution in addressing underinvestment. Instead, it highlights that the latter, which takes effective regulations and reforms to correct, can be carried out in conjunction with increased public investment. Indeed, our results in section 4.2 show that policy reforms along the line of better corruption control can also enhance the crowding-in effect of public investment on private investment.

7 Conclusion

Developing countries face a widening investment gap estimated at \$3 trillion per year to achieve the Sustainable Development Goals. Yet, private investment growth remains weak in the post-pandemic high interest rate environment. This paper estimates the effect of public investment on private investment in a large panel of 109 developing countries over the period 1980-2019. In our setup, the parameter of interest simultaneously captures the crowding-in (-out) of private investment by public investment and complementarity (substitutability) between public and private investment. To identify the impact, we update and extend predicted loan disbursements from official loans as an instrumental variable à la Kraay (2014).

We document the following results: First, we find that public investment is an *Edgeworth complement* to private investment in that an increase in the former raises the marginal productivity of private investment. Second, the complementarity implies crowding-in of private investment by public investment such that an extra dollar of public investment raises private investment by 1.6 dollars. Over time, the cumulative multiplier rises to a peak of 2.4 dollars. This crowding-in effect holds true for low-income countries and Sub-Saharan Africa—economies where investment needs are largest. We find that the cumulative effect of crowding-in is larger in these subgroups over time than for all EMDEs. Moreover, we find evidence that public investment is more effective in crowding-in private investment in countries with strong corruption control. Third, when we embed our empirical results into a model with capital market distortions, we demonstrate that public investment should be allowed a lower rate of return than under perfect capital markets. From a policy perspective, our results suggest that public investment, in conjunction with policy efforts and regulations

to correct capital market distortions, can be used to address underinvestment induced by imperfect capital markets. Nonetheless, any scale-up in investment would be more effective in an environment where corruption is well-controlled.

References

- Allen, D. S. and L. Ndikumana. 2000. Financial intermediation and economic growth in Southern Africa. *Journal of African Economies* 9(2), 132–160.
- Andrews, I., J. H. Stock, and L. Sun. 2019. Weak instruments in instrumental variables regression: Theory and practice. *Annual Review of Economics* 11, 727–753.
- Aschauer, D. A.. 1985. Fiscal policy and aggregate demand. *The American Economic Review* 75(1), 117–127.
- Auerbach, A. J. and Y. Gorodnichenko. 2012. Measuring the output responses to fiscal policy. *American Economic Journal: Economic Policy* 4(2), 1–27.
- Baier, S. L. and G. Glomm. 2001. Long-run growth and welfare effects of public policies with distortionary taxation. *Journal of Economic Dynamics and Control* 25(12), 2007–2042.
- Baltagi, B. H. and N. Pinnoi. 1995. Public capital stock and state productivity growth: Further evidence from an error components model. *Empirical Economics* 20, 351–359.
- Barr, A., M. Lindelow, and P. Serneels. 1995. Corruption in public service delivery: An experimental analysis. *Journal of Economic Behavior Organization* 72, 225–239.
- Barro, R. J. and X. Sala-i Martin. 1992. Public finance in models of economic growth. *The Review of Economic Studies* 59(4), 645–661.
- Beekman, G., E. Bulte, and E. Nillesen. 2014. Corruption, investments and contributions to public goods: Experimental evidence from rural Liberia. *Journal of Public Economics* 115, 37–47.
- Ben Zeev, N., V. A. Ramey, and S. Zubairy. 2023. Do government spending multipliers depend on the sign of the shock? In *AEA Papers and Proceedings*, Volume 113, pp. 382–387. American Economic Association.
- Berg, A., E. F. Buffie, C. Pattillo, R. Portillo, A. F. Presbitero, and L.-F. Zanna. 2019. Some misconceptions about public investment efficiency and growth. *Economica* 86(342), 409–430.
- Boehm, C. E.. 2020. Government consumption and investment: Does the composition of purchases affect the multiplier? *Journal of Monetary Economics* 115, 80–93.
- Bom, P. R. and J. Ligthart. 2008. How productive is public capital? a meta-analysis. Technical report, CESifo.
- Calderon, C., E. Moral-Benito, and L. Serven. 2015. Is infrastructure capital productive? a dynamic heterogeneous approach. *Journal of Applied Econometrics* 30(2), 177–198.

- Carapella, P.M., Mogue, M.T., Pico-Mejia, J.C. and Soto, M., 2023. How to Assess Spending Needs of the Sustainable Development Goals: The Third Edition of the IMF SDG Costing Tool (No. 2023/005). Washington, DC: International Monetary Fund.
- Chinn, M.D. and Ito, H., 2006. What matters for financial development? Capital controls, institutions, and interactions. *Journal of Development Economics*, 81(1), pp.163-192.
- Chudik, A., K. Mohaddes, M. H. Pesaran, and M. Raissi. 2017. Is there a debt-threshold effect on output growth? *Review of Economics and Statistics* 99(1), 135–150.
- Davis, J.. 2004. Corruption in public service delivery: Experience from south asia’s water and sanitation sector. *World Development* 32, 53–71.
- Eden, M. and A. Kraay. 2014. ““crowding in” and the returns to government investment in low-income countries.” *World Bank Policy Research Working Paper* 6781.
- Fiorito, R. and T. Kollintzas. 2004. Public goods, merit goods, and the relation between private and government consumption. *European Economic Review* 48(6), 1367–1398.
- Francois, J.N., N. Ahmad, A. Keinsley, and A. Nti-Addae. 2022. Heterogeneity in the long-run remittance-output relationship: Theory and new evidence. *Economic Modelling* 10, 105793.
- Fuglie, K., M. Gautam, A. Goyal, and W. F. Maloney. 2019. *Harvesting prosperity: Technology and productivity growth in agriculture*. World Bank Publications.
- Galeano, L., A. Izquierdo, J. P. Puig, C. A. Vegh, and G. Vuletin. 2021. Can automatic government spending be procyclical? Technical report, National Bureau of Economic Research, Inc.
- Gaspar, V., M. D. Amaglobeli, M. M. Garcia-Escribano, D. Prady, and M. Soto. 2019. *Fiscal policy and development: Human, social, and physical investments for the SDGs*. International Monetary Fund.
- Gbohoui, W.. 2021. *Uncertainty and public investment multipliers: the role of economic confidence*. International Monetary Fund.
- Gupta, S., C. A. Pattillo, and S. Wagh. 2009. Effect of remittances on poverty and financial development in Sub-Saharan Africa. *World development* 37(1), 104–115.
- IEA. 2021. Financing clean energy transitions in emerging and developing economies. World Energy Investment 2021 Special Report in collaboration with the World
- Izquierdo, M. A., M. R. Lama, J. P. Medina, J. Puig, D. Riera-Crichton, C. Vegh, and G. J. Vuletin. 2019. *Is the public investment multiplier higher in developing countries? An empirical exploration*. International Monetary Fund.

- Jorda, O.. 2005. Estimation and inference of impulse responses by local projections. *American Economic Review* 95(1), 161–182.
- Kasyanenko, S., P. G. Kenworthy, F. U. Ruch, E. T. Vashakmadze, D. L. Vorisek, and C. M. Wheeler. 2023. Investment in emerging market and developing economy regions: Trends, prospects, and policy options. Technical report, The World Bank.
- Kaufmann, D., A. Kraay, E. Lora, and L. Pritchett. 2002. Growth without governance [with comments]. *Economia* 3(1), 169–229.
- Kaufmann, D., A. Kraay, and M. Mastruzzi. 2011. The worldwide governance indicators: methodology and analytical issues. *Hague Journal on the Rule of Law* 3(2), 220–246.
- Kiviet, J. F.. 2013. Identification and inference in a simultaneous equation under alternative information sets and sampling schemes. *The Econometrics Journal* 16(1), S24–S59.
- Kiviet, J. F.. 2020. Testing the impossible: identifying exclusion restrictions. *Journal of Econometrics* 218(2), 294–316.
- Kiviet, J. F.. 2022. Instrument-free inference under confined regressor endogeneity and mild regularity. *Econometrics and Statistics*.
- Kose, M. A. and F. Ohnsorge. 2023. Falling long-term growth prospects.
- Kose, M. A., E. Prasad, K. Rogoff, and S.-J. Wei. 2009. Financial globalization: A reappraisal. *IMF Staff papers* 56(1), 8–62.
- Kraay, A.. 2012. How large is the government spending multiplier? evidence from world bank lending. *The Quarterly Journal of Economics* 127(2), 829–887.
- Kraay, A.. 2014. Government spending multipliers in developing countries: evidence from lending by official creditors. *American Economic Journal: Macroeconomics* 6(4), 170–208.
- Kripfganz, S. and J. F. Kiviet. 2021. kinkyreg: Instrument-free inference for linear regression models with endogenous regressors. *The Stata Journal* 21(3), 772–813.
- Linnemann, L. and A. Schabert. 2006. Productive government expenditure in monetary business cycle models. *Scottish Journal of Political Economy* 53(1), 28–46.
- Mauro, P.. 1995. Corruption and growth. *The Quarterly Journal of Economics* 110, 681–712.
- Miranda-Agrippino, S. and H. Rey. 2022. The global financial cycle. In *Handbook of International Economics*, Volume 6, pp. 1–43. Elsevier.
- Miyamoto, W., T. L. Nguyen, and D. Sergeyev. 2018. Government spending multipliers under the zero lower bound: Evidence from Japan. *American Economic Journal: Macroeconomics* 10(3), 247–277.

- Miyamoto, W., T. L. Nguyen, and V. Sheremirov. 2019. The effects of government spending on real exchange rates: Evidence from military spending panel data. *Journal of International Economics* 116, 144–157.
- Ogura, S. and G. Yohe. 1977. The complementarity of public and private capital and the optimal rate of return to government investment. *The Quarterly Journal of Economics*, 651–662.
- Olea, J. L. M. and C. Pflueger. 2013. A robust test for weak instruments. *Journal of Business & Economic Statistics* 31(3), 358–369.
- Ramey, V. A. and S. Zubairy. 2018. Government spending multipliers in good times and in bad: evidence from us historical data. *Journal of Political Economy* 126(2), 850–901.
- Rozenberg, J. and M. Fay. 2019. *Beyond the gap: How countries can afford the infrastructure they need while protecting the planet*. World Bank Publications.
- Sahay, M. R., M. Cihak, M. P. M. N’Diaye, M. A. Barajas, M. D. B. A. Pena, R. Bi, M. Gao, M. A. J. Kyobe, L. Nguyen, C. Saborowski, et al.. 2015. *Rethinking financial deepening: Stability and growth in emerging markets*. International Monetary Fund.
- Svirydzenka, K.. 2016. *Introducing a new broad-based index of financial development*. International Monetary Fund.
- Turnovsky, S. J.. 1997. Fiscal policy in a growing economy with public capital. *Macroeconomic Dynamics* 1(3), 615–639.
- World Bank. 2022. *Climate and Development: An Agenda for Action—Emerging Insights from World Bank Group 2021-22 Country Climate and Development Reports*. Washington, DC: World Bank.

Annex A: Deriving the main equation

Recall that the first order condition for private capital is,

$$F_{K_p}(K_p, K_g) = \frac{(r^* + \delta)}{1 - \tau} \quad (\text{A.1})$$

Log-linearizing around the steady state yields the following

$$F_{K_p, K_p}(K_p, t - K_p) = -F_{K_p, K_g}(K_g, t - K_g) \quad (\text{A.2})$$

where variables without time t subscripts are the steady state value for the corresponding variable. Dating Eq. (A.2) back by one period and subtracting the resulting equation from Eq. (A.2) yields,

$$\Delta K_{p,t} = \alpha \Delta K_{g,t} \quad (\text{A.3})$$

where $\alpha = \frac{F_{K_p, K_g}}{F_{K_p, K_p}}$ and $\Delta K_{i,t} = K_{i,t} - K_{i,t-1}$ for $i \in \{p, g\}$ so that Δ is the first difference operator. Now using the private and public capital accumulation equation in Eq. (2), we obtain

$$\Delta I_{i,t} = \Delta K_{i,t+1} - (1 - \delta) \Delta K_{i,t} \quad (\text{A.4})$$

We can then substitute $\Delta K_{i,t+1}$ into the $t + 1$ version of Eq. (A.3) such that we have

$$\Delta I_{p,t} + (1 - \delta) \Delta K_{p,t} = \alpha (\Delta I_{g,t} + (1 - \delta) \Delta K_{g,t}) \quad (\text{A.5})$$

Applying some algebra and using the relation in Eq.(A.3) we obtain the main estimation equation as

$$\Delta I_{p,t} = \alpha \Delta I_{g,t}, \quad (\text{A.6})$$

where α is simultaneously governs the crowding-in (out) of private investment following an increase in government investment as well as the structural relationship between government and private investment.

Annex B: Loan-level data for the instrumental variable

The dataset was retrieved in November 2023 and includes 78,903 loan-level observations for loans agreed between January 1970 to December 2021. Since we are interested in the impact of general government investment, we exclude loans to central banks and local governments. This leaves 75,555 observations.¹⁹ Next, we follow the same censoring rules as applied by Kraay (2014). First, we remove creditors that have less than 50 loans in total which is 950 observations from 116 creditors (average of about eight loans per creditor). Second, we drop loans for which we do not have exchange rates to convert original currency denomination to US\$; a total of 330 observations. Third, the instrumental variable is based on the disbursement profiles of loans defined as the fraction of the original loan that is dispersed in the year of the agreement and subsequent years. Sometimes the total amount disbursed on loans can exceed the original amount of the agreed loan as additional commitments are made because of renegotiation, rescheduling, or consolidation of loans. We, therefore, drop loans that have total disbursements that exceed five times the original amount of the loan (145 observations); This is likely because the loan amount was increased after the agreement and so not recorded in the original amount of the loan. Finally, we drop 138 loans which are large relative to a country's GDP (above 10 percent of GDP) but with very low disbursement rates (less than 10 percent of the original loan amount).

After cleaning the data, we are left with 73,993 loan-level observations covering 122 emerging and developing economies.²⁰ There are an average of 606 loans per country with a maximum of 3,172 loans and minimum of 21. Most of these loans, about 55 percent, are bilateral between governments and the rest from multilateral organizations. Table B1 provides a breakdown of the total amount of loans provided, as well as the main creditors across decades. Total loans disbursed amounted to over \$2.4 trillion in 2015 prices. Multilateral loans make up the largest share of this total, about 60 percent, however, this is because of the growing role of multilateral loans in recent decades. In the 1970s, a little over one-quarter of loans were from multilateral organizations. The largest three creditors among multilaterals are the World Bank (including IBRD and IDA), the Asian Development Bank, and the Inter-American Development Bank. Among bilateral creditors the largest in the last decade were China, Japan, and France. China has rapidly increased its loan portfolio in recent decades to become the biggest bilateral lender. In contrast, the United States significantly decreased bilateral loans, instead shifting to grants and official aid.

¹⁹ There were 9,506 loans in the 1970s, 20,989 in the 1980s, 17,659 in the 1990s, 12,231 in the 2000s, and 15,170 from 2010-21.

Table B1: Official lending

	1970-79	1980-89	1990-99	2000-09	2010-21
Disbursements by Multilateral Creditors (Constant 2015 US\$ billions)					
International Bank for Reconstruction and Development	13.4	76.7	104.0	102.0	165.0
International Development Association	19.9	43.3	81.3	87.9	144.0
Asian Development Bank	0.9	6.8	26.9	36.1	84.6
Inter-American Development Bank	1.7	6.7	24.8	43.9	58.9
ASDB Soft Window	1.2	4.4	12.0	19.5	27.2
European Investment Bank	0.2	0.4	2.7	8.8	19.3
Development Bank of Latin America and the Caribbean (CAF)	0.0	0.2	2.5	10.4	16.5
African Dev. Bank	0.5	3.4	8.2	6.0	15.3
Islamic Dev. Bank	0.1	0.7	1.1	3.1	13.1
African Dev. Fund	0.0	0.6	1.6	4.8	8.4
Other multilateral	7.7	17.9	20.0	33.5	56.7
Total multilateral	45.6	161.0	285.0	356.0	609.0
Disbursements by Bilateral Creditors (Constant 2015 US\$ billions)					
China	3.7	2.8	1.9	12.7	117.0
Japan	10.6	35.0	78.4	50.2	74.9
France	6.5	12.2	15.2	10.4	27.8
Russian Federation	0.0	0.2	5.1	5.5	20.0
Germany, Fed.Rep. Of	13.5	15.6	26.1	6.5	16.5
Saudi Arabia	6.5	9.4	1.7	1.7	9.1
India	0.4	0.4	0.4	2.0	8.9
Korea, Republic Of	0.0	0.0	1.8	1.3	7.0
Kuwait	2.6	4.6	4.1	4.1	6.6
United Arab Emirates	2.3	1.7	0.6	1.0	5.7
United States	29.7	48.1	22.8	2.5	4.2
Other bilateral	37.2	72.9	43.9	17.0	24.3
Total bilateral	113.0	203.0	202.0	115.0	322.0

Annex C: Robustness to censoring rules on loan data and clustering of standard errors

The loan data used to create the instrumental variable is subject to several censoring rules including on creditors with few loans, on the fraction of total disbursement to the original amount of the loan, and on loans that are large relative to a country's GDP but with low disbursement rates. To account for the arbitrariness of some of the choices, in this section we look at the robustness of our main results to changes in these choices. Table C1 shows the results for some of these changes. First, with regards to the disbursement rates the main instrumental variable follows Kraay (2012) and does not use loans where total disbursements are greater than five times the loan amount. If we instead restrict this to only two times, our results do not differ much from the main results in the paper. Next, in the main instrumental variable we exclude creditors that have fewer than 50 loans from our sample. Here we shift to fewer than 200 loans. Again, while the F-statistics are somewhat lower the main regressions still reflect the crowding in of private investment over most horizons. Finally, we look at loans that are larger than 4 percent of GDP (in the main results we choose 10 percent) and have a disbursement rate below 25 percent (10 percent). In this case the estimated crowding-in is lower than in the main results of this paper but not statistically different.

Table C1: The response of private investment to government investment, alternative instruments

	Includes lagged dependent variable					
	(1)	(2)	(3)	(4)	(5)	(6)
	Cumulative Multipliers (horizon h in years)					
	Baseline	h=0	h=1	h=2	h=3	h=4
	Total disbursements to loan >2					
Change in government investment	1.719** (0.762)	1.450** (0.602)	2.165** (0.874)	2.118** (0.878)	2.160** (0.853)	1.563* (0.925)
Observations	3,437	3,349	3,242	3,136	3,029	2,922
F-statistic	9.359	11.71	10.93	11.47	14.48	13.78
KP Underid stat	0.00517	0.00233	0.00315	0.00251	0.000916	0.00111
	Creditors with total loans > 200					
Change in government investment	2.387* (1.283)	1.967** (0.957)	3.307** (1.369)	2.910** (1.176)	2.134* (1.180)	1.367 (1.392)
Observations	3,436	3,349	3,242	3,136	3,029	2,922
F-statistic	5.066	6.706	6.165	6.504	8.314	7.820
KP Underid stat	0.0279	0.0121	0.0158	0.0131	0.00547	0.00669
	Disb. < 4% of GDP and share disb. < 25%					
Change in government investment	1.713*** (0.658)	1.559** (0.617)	2.226** (0.873)	1.850** (0.849)	2.050** (0.955)	1.077 (1.165)
Observations	3,437	3,349	3,242	3,136	3,029	2,922
F-statistic	13.42	11.19	10.48	10.81	12.91	12.38
KP Underid stat	0.00101	0.00190	0.00258	0.00216	0.000928	0.00111

Notes: *** p < 0.01, ** p < 0.05, * p < 0.1. Dependent variable is change in private investment to lagged GDP. Robust standard errors in parentheses are Driscoll-Kraay standard errors to control for the presence of error cross-sectional dependence a' la Boehm (2020). All estimations include country-fixed effects and year effects. "KP" is Kleibergen and Paap underidentification test. "Baseline" specification does not include the lagged dependent.

Next, in table C2 we show the main results in table 2 based on clustering at the country level of the standard errors.

Table C2: The response of private investment to government investment with standard clustering treatment

	(1)	(2)	(3)	(4)	(5)	(6)
	Baseline	h=0	h=1	h=2	h=3	h=4
Panel A: OLS						
Change in government investment	-0.041 (0.057)	-0.069 (0.059)	0.169* (0.100)	0.165 (0.108)	0.211 (0.133)	0.297** (0.123)
Panel B: 2SLS						
Change in government investment	1.843** (0.854)	1.464** (0.673)	2.040* (1.106)	1.906 (1.174)	1.722* (0.999)	0.981 (0.961)
Observations	3,437	3,349	3,242	3,136	3,029	2,922
F-statistic	6.313	8.721	7.517	7.982	9.855	9.166
KP Underid stat	0.0147	0.00496	0.00788	0.00661	0.00285	0.00388
No. of countries	109	109	109	109	109	109

Notes: *** p < 0.01, ** p < 0.05, * p < 0.1. Dependent variable is change in private investment to lagged GDP. Robust standard errors in parentheses are clustered at the country level. All estimations include country-fixed effects and year effects. "KP" is Kleibergen and Paap underidentification test.

Annex D: Financial development using Chinn-Ito index

Table D1: The response of private investment to government investment, Chinn-Ito Index

	(1)	(2)	(3)	(4)	(5)	(6)
	Baseline	h=0	h=1	h=2	h=3	h=4
	Less financially open (Below Median)					
Change in public investment	2.101*	1.992*	3.293**	4.058**	2.864*	3.108*
	(1.099)	(1.095)	(1.478)	(1.813)	(1.494)	(1.827)
Observations	1,668	1,616	1,562	1,510	1,458	1,405
F-statistic	8.665	7.445	6.710	7.525	9.014	8.389
KP Underid stat	0.00421	0.00802	0.0113	0.00736	0.00409	0.00521
No. of countries	80	79	79	79	79	79
	More financially open (Below Median)					
Change in public investment	1.326	1.111	0.829	-0.366	1.047	-0.929
	(1.070)	(0.858)	(1.266)	(1.415)	(1.543)	(1.592)
Observations	1,769	1,733	1,680	1,626	1,571	1,517
F-statistic	2.942	3.845	3.213	3.221	4.298	3.793
KP Underid stat	0.0855	0.0485	0.0705	0.0698	0.0382	0.0500
No. of countries	80	80	80	80	80	80

Notes: *** p < 0.01, ** p < 0.05, * p < 0.1. Dependent variable is change in private investment to lagged GDP. Robust standard errors in parentheses are Driscoll-Kraay standard errors to control for the presence of error cross-sectional dependence a la Boehm (2020). All estimations include country-fixed effects and year effects. "KP" is Kleibergen and Paap underidentification test. "Baseline" specification does not include the lagged dependent.

Annex E: Deriving equation 7.8

The appropriate first order conditions are as follows:

$$V_{C_t} = U_t - \lambda_t = 0 \quad (B.1)$$

$$V_{k_p,t+1} = \lambda_{t+1}F_{k_p} - \lambda_t + (1 - \delta)\lambda_{t+1} + \mu_{t+1}F_{k_g,k_p} = 0 \quad (B.2)$$

$$V_{k_g,t+1} = \lambda_{t+1}F_{k_g} - \lambda_t + (1 - \delta)\lambda_{t+1} + \mu_{t+1}F_{k_g,k_p} = 0 \quad (B.3)$$

$$V_{D_t} = \lambda_t - \lambda_{t+1}R_t^F = 0 \quad (B.4)$$

where $R^F = 1 + r^F$. Equation (A.1) captures the marginal utility of consumption. Eq. (A.2) and (A.3) are the first order conditions for private and public investment, respectively. We can combine Equation A. 1 and A. 4 to arrive at

$$U_{t+1}/U_t = 1/R_t^F \quad (B.5)$$

Equation (A.5) is the consumption Euler equation which requires that investment proceed until the intertemporal marginal rate of substitution equals the return to the riskless bonds. So that the economic agent is indifferent between consuming one more unit today on the one hand and investing that unit and consuming in the future on the other.

Now, substituting Eq. (A.1) into equations (A.2) and (A.3) yields

$$\mu_{t+1}F_{k_p,k_p} = U_t - U_{t+1}F_{k_p} - (1 - \delta)U_{t+1} \quad (B.6)$$

$$\mu_{t+1}F_{k_g,k_p} = U_t - U_{t+1}F_{k_p} - (1 - \delta)U_{t+1} \quad (B.7)$$

Combining equations (A.6) and (A.7) we obtain,

$$F_{k_p,k_g} \left(U_t - U_{t+1}F_{k_p} - (1 - \delta)U_{t+1} \right) = F_{k_p,k_p} \left(U_t - U_{t+1}F_{k_g} - (1 - \delta)U_{t+1} \right) \quad (B.8)$$

Using Eq. (B.5) and the fact that $F_{k_p} = \frac{r^* + \delta}{1 - \tau}$ and applying some algebra yields,

$$F_{K_g} = (r^* + \delta) + \frac{F_{K_p,K_g}}{F_{K_p,K_p}} \left[\frac{r^* + \delta}{1 - \tau} - (r^* + \delta) \right] \quad (B.9)$$

Equation (10) is the marginal return on government investment.