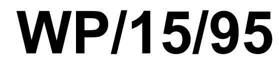
The Macroeconomic Effects of Public Investment: Evidence from Advanced Economies

INTERNATIONAL MONETARY FUND



IMF Working Paper

The Macroeconomic Effects of Public Investment: Evidence from Advanced Economies

by Abdul Abiad, Davide Furceri and Petia Topalova

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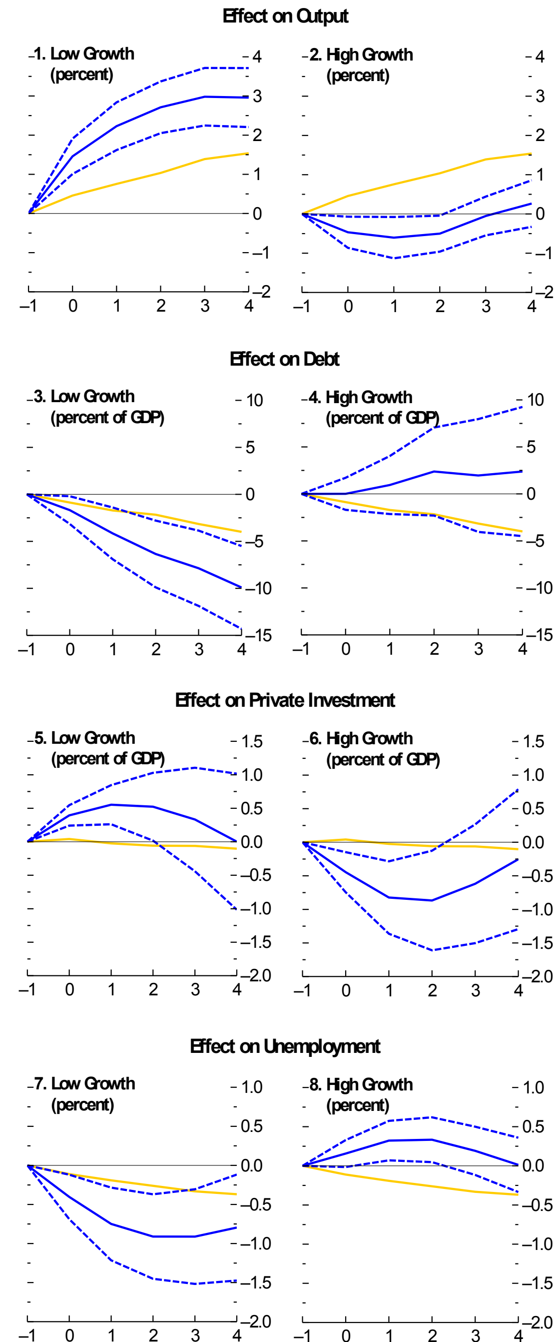
Perhaps surprisingly, higher public investment spending is not associated with an increase in the debt-to-GDP ratio. The point estimates in panel 2 of the figure show that higher public investment is typically followed by a *reduction* in the debt-to-GDP ratio, both in the short term (by about 0.9 percentage point of GDP) and in the medium term (by about 4 percentage points of GDP), but the decline in debt is statistically significant only in the short term. On average, in the advanced economies in our sample, the boost to GDP from higher government investment spending seems to be larger than the public debt taken to finance it.

There is no statistically significant effect on private investment as a share of GDP (panel 3). This result suggests the crowding in of private investment, as the level of private investment rises in tandem with the higher GDP as a result of the increase in public investment. Finally, an increase in public investment is found to reduce the unemployment rate by about 0.11 percent in the very short term and by about 0.35 percent over the medium term (panel 4).

The Role of Economic Slack

The macroeconomic effects of public investment shocks are very different across economic regimes (Figure 2). During periods of low growth, a public investment spending shock increases the level of output by about 1½ percent in the same year and by 3 percent in the medium term, but during periods of high growth the long-term effect is not statistically significantly different from zero. This finding is consistent with the growing literature on the effects of fiscal policy during recessions and expansions (see, among others, Auerbach and Gorodnichenko 2013a, 2014b; Blanchard and Leigh 2013; IMF 2013). As noted above, economic regimes are identified as periods of very low growth (recessions) and very high growth (significant expansions). Periods of very low (high)

Figure 2. The Effect of Public Investment in Advanced Economies: The Role of Economic Conditions
(Years on x-axis)

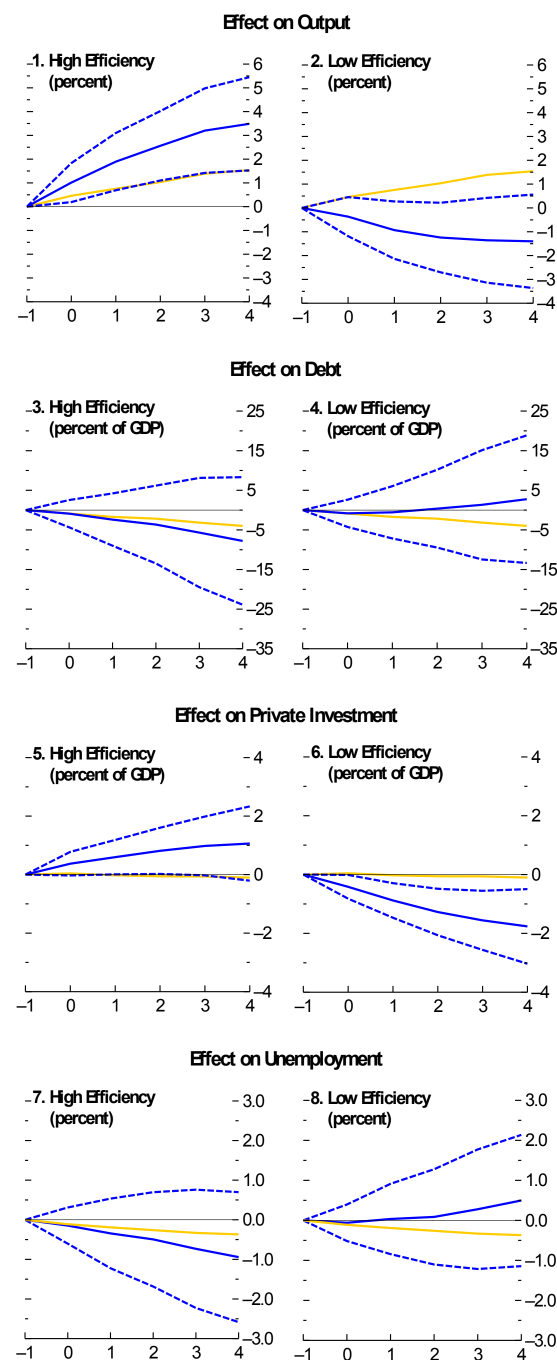


Source: IMF staff calculations.
Note: $t = 0$ is the year of the shock; dashed lines denote 90 percent confidence bands. Solid yellow lines represent baseline results.

growth identified also correspond to periods of large negative (positive) output gaps: during periods of very low (high) growth, the output gap varies between –0.4 and –7.2 (–1.1 and 8.5) percent of potential output, with an average output gap of –3.7 (3.5) percent. Using the output gap instead of growth rates to identify economic regimes gives qualitatively similar results. In particular, during periods of large negative output gaps, the short-term multiplier is 0.6 and is statistically significant, but when output gaps are large and positive, the output effect of public investment is 0.2 and not statistically significant.

Public investment shocks also bring about a reduction in the public-debt-to-GDP ratio during periods of low growth because of the much bigger boost in output. During periods of high growth, the point estimates suggest a rise in public debt, though the wide confidence intervals imply that the increase is not statistically significantly different from zero. The effects on private investment also differ based on the state of the economy. During low-growth periods, the increase in private investment outpaces the increase in GDP in the first few years, leading to a rise in private investment as a share of GDP. But during high-growth periods the opposite happens, suggesting the possibility of crowding out when there is less slack in the economy. Finally, public investment shocks reduce unemployment significantly during low growth periods, by about half a percentage point in the first year and by ¾ percentage point in the medium term, but do not have a material effect on unemployment rates during high-growth periods.

Figure 3. The Effect of Public Investment in Advanced Economies: The Role of Efficiency
(Years on x-axis)



Source: IMF staff calculations.
Note: $t = 0$ is the year of the shock; dashed lines denote 90 percent confidence bands. Solid yellow lines represent baseline results.

The Role of Investment Efficiency

The macroeconomic effects of public investment shocks are also substantially stronger in countries with a high degree of public investment efficiency, both in the short

and in the medium term (Figure 3).[9] In countries with high efficiency of public investment, a public investment spending shock increases the level of output by about 0.8 percent in the same year and by 2.6 percent four years after the shock. But in countries with low efficiency of public investment, the output effect is about 0.2 percent in the same year and about 0.7 percent in the medium term. As a result, although public investment shocks are found to lead to a significant medium-term reduction in the debt-to-GDP ratio in countries with high public investment efficiency, they tend to increase the debt-to-GDP ratio (albeit not in a statistically significant manner) in countries with low public investment efficiency. There is a greater boost to private investment when public investment efficiency is high, whereas private investment as a share of GDP falls when public investment efficiency is low. Finally, the effects on unemployment reduction are larger in countries with a high level of investment efficiency. No statistically significant correlation is found between the measure of investment spending shocks used here and the degree of investment efficiency. This suggests that the result that macroeconomic effects are larger in countries with higher investment efficiency is not driven by the fact that investment spending shocks tend to occur more frequently and to be larger in countries with higher degrees of public investment efficiency.[10]

The Role of Financing: Debt-financed vs. Budget-neutral Public Investment

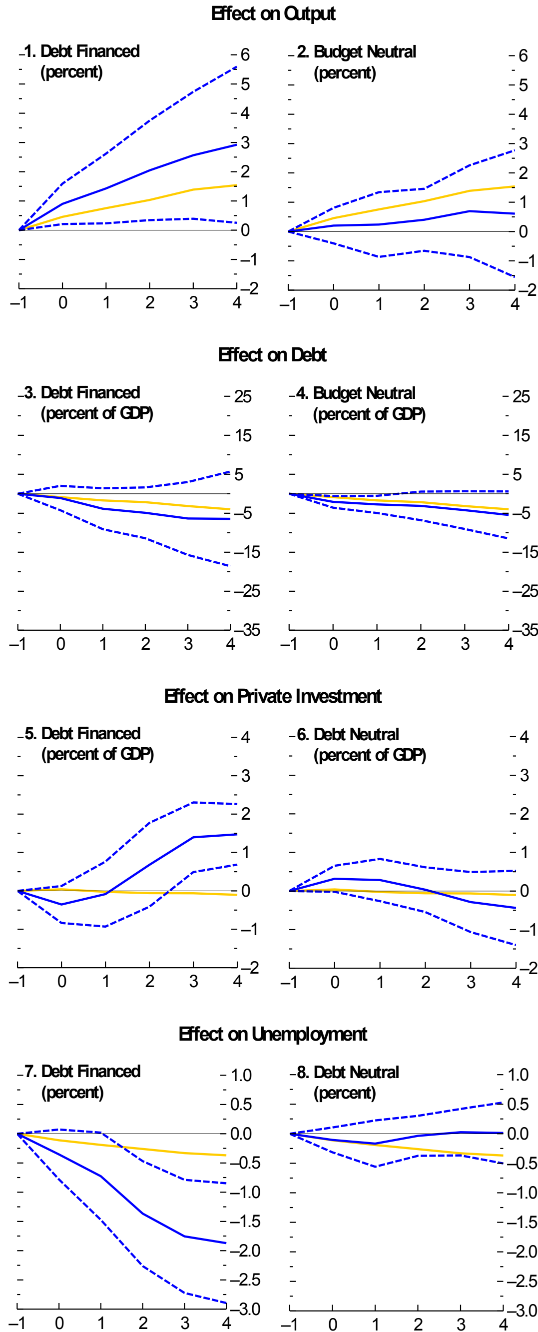
[9] Berg et al. (forthcoming) reconsider the macroeconomic implications of investment efficiency, noting that countries with lower efficiency of public investment would tend to have lower capital stock, which would push up public capital's rates of return. In our analysis, this channel is likely subdued as we focus on a set of advanced economies, with relatively little variation in the public capital stock.

[10] In particular, the correlation between investment spending shocks and the degree of efficiency is –0.11.

The macroeconomic effects of public investment also vary depending on how it is financed. Government projects financed through debt issuance have stronger expansionary effects than budget-neutral projects that are financed by raising taxes or cutting other spending. Budget-neutral public investment shocks are identified in the data as those in which the difference between the shocks to other components of the government budget and public investment shocks is greater than or equal to zero. We find that the output effects of public investment tend to be larger when public investment shocks are debt-financed than when they are budget-neutral (Figure 4). In particular, although a debt-financed public investment shock of 1 percentage point of GDP increases the level of output by about 0.9 percent in the same year and by 2.9 percent four years after the shock, the short- and medium-term output effects of a budget-neutral public investment shock are not statistically significantly different from zero. The larger short- and medium-term output multipliers for debt-financed shocks imply that the reduction in the debt-to-GDP ratio is similar in the two types of shocks. The short-term effects on private investment are similar to those in the baseline regardless of how public investment is financed, but private investment is boosted as a share of GDP in the medium-term when public investment is debt-financed, possibly because of the larger output multipliers. Finally, and in line with the differing effects on output, the effects of public investment on unemployment are bigger when it is debt-financed than when it is budget-neutral.

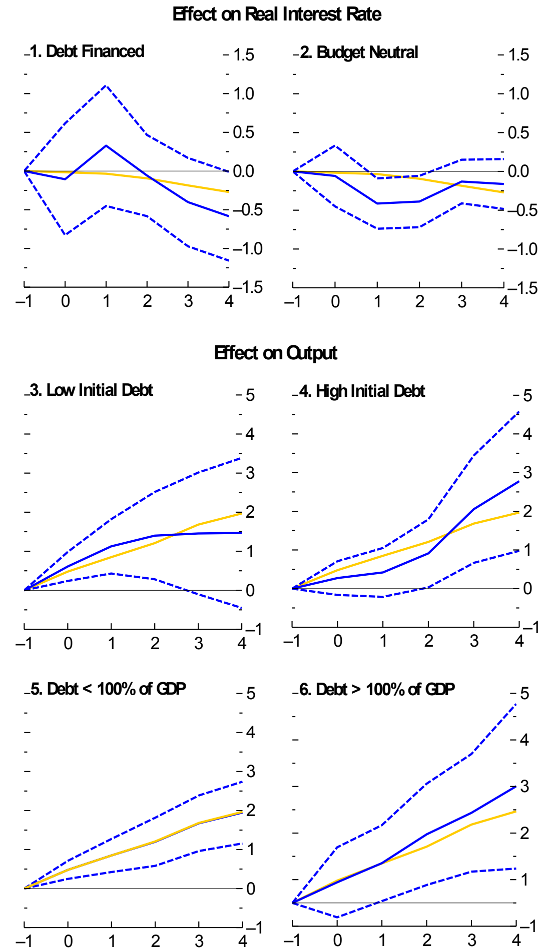
It is possible that increasing debt-financed public investment in countries where debt is already high may increase sovereign risk and financing costs if the productivity of the investment is in doubt (e.g., because of poor project selection or implementation), exacerbating debt sustainability concerns. We thus examine whether public investment shocks are associated with subsequent changes in real interest rates. Within the sample of 17 advanced economies employed in the estimation, the empirical evidence suggests that historically, debt-financed public investment shocks have not led to increases in funding costs, as proxied by sovereign real interest rates (Figure 5, panels 1 and 2).

Figure 4. The Effect of Public Investment in Advanced Economies: The Role of Mode of Financing
(Years on x-axis)



Source: IMF staff calculations.
Note: t = 0 is the year of the shock; dashed lines denote 90 percent confidence bands. Solid yellow lines represent baseline results.

Figure 5. Effect of Public Investment in Advanced Economies: The Role of Mode of Financing
(Percent; years on x-axis)



Source: IMF staff calculations.
Note: t = 0 is the year of the shock; dashed lines denote 90 percent confidence bands. Solid yellow lines represent baseline results.

Moreover, an examination of whether the effects of public investment shocks on debt and output depend on the initial level of public debt yields no evidence that the effects of public investment differ materially according to the initial public-debt-to-GDP ratio

(Figure 5, panels 3 and 4). This may, in principle, reflect the fact that debt-to-GDP ratios in advanced economies were moderate during most of the sample period. However, even when we focus on country-periods of very high-debt (namely, when the debt-to-GDP ratio exceeds 100 percent of GDP – the 90th percentile of the debt-to-GDP distribution in the sample), we do not find any evidence of non-linear effects of the initial level of public debt (Figure 5, panels 5 and 6).

B. Robustness Checks

Our findings are robust to alternative measures of public investment shocks, estimation periods, and country samples. As a first robustness check, we use the forecasts of the spring issue of the same year and the fall issue of the previous year instead of the October forecast to compute government investment forecast errors. The results in columns 2 and 3 of Table 1 show that the response functions of real output are almost identical and not statistically significantly different from that reported in the baseline (Table 1, column 1).

As an additional robustness check, we assess whether the effects of public investment on output have changed over time. The results show that this is not the case. There has been no statistically significant change in the public investment multiplier over time in our sample of advanced economies, even though the point estimates of the output effect of public investment are somewhat larger in the post-2000 period.

Table 1. Effect of Public Investment on Output in Advanced Economies: Robustness

						Purging forecast errors for forecast errors in:				
	Baseline	April forecast	Previous October Forecast	Pre 2000	Post 2000	Growth	Demand components 1/	Positive Shocks	Negative Shocks	Trimmed top and bottom 1% of shocks
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Impact of public investment shock on output at k=										
0	0.457	0.264	0.332	0.401	0.581	0.418	0.502	1.013	0.316	0.466
	(0.147)	(0.160)	(0.118)	(0.198)	(0.209)	(0.147)	(0.143)	(0.447)	(0.181)	(0.138)
1	0.755	0.581	0.697	0.582	0.948	0.702	0.844	1.240	0.584	0.740
	(0.238)	(0.216)	(0.216)	(0.301)	(0.387)	(0.241)	(0.264)	(0.619)	(0.309)	(0.232)
2	1.035	0.966	1.004	0.753	1.223	0.993	1.241	1.576	0.888	1.058
	(0.322)	(0.270)	(0.288)	(0.414)	(0.489)	(0.323)	(0.339)	(0.763)	(0.431)	(0.302)
3	1.389	1.099	1.124	1.036	1.569	1.354	1.625	1.706	1.242	1.492
	(0.394)	(0.349)	(0.330)	(0.526)	(0.575)	(0.393)	(0.405)	(0.754)	(0.547)	(0.358)
4	1.539	1.318	1.219	1.135	1.642	1.507	1.864	1.459	1.393	1.747
	(0.441)	(0.402)	(0.383)	(0.590)	(0.796)	(0.439)	(0.489)	(0.715)	(0.617)	(0.405)

Note: k=0 is the year of the public investment shock, measured by the public investment forecast error. Standard errors (in parentheses below the ceofficients) are corrected for heteroskedasticity and clustered at the country level. Sample includes 17 OECD economies for the 1985-2013 period. All regressions include a full set of country and year fixed effects.

1/ Demand components include private consumption, investment and government consumption.

A problem in the identification of public investment shocks is that they may be endogenous to output growth surprises. Indeed, whereas automatic stabilizers operate mostly via revenues and social spending, discretionary public investment spending can occur in response to output conditions. To ensure that our findings do not capture this potential reverse relationship between output and investment, we separate public investment shocks from output growth innovations.[11] The results obtained by separating public investment shocks from output growth innovations are almost identical and not statistically significantly different from those reported in the baseline (Table 1, column 6).

Another possible problem in identifying public investment shocks is a potential systematic bias in the forecasts concerning economic variables other than public investment, with the result that the forecast errors for public investment are correlated with those for other macroeconomic variables. To address this concern, we regress the measure of public investment shocks on the forecast errors of other components of government spending, private investment, and private consumption, and use the residuals from this regression as our measure of public investment shocks. The results, presented in column 7 of Table 1, show that the response functions of output are almost identical and not statistically significantly different from that reported in the baseline.

Whether public investment has a different macroeconomic impact depending on whether the public investment shocks are positive or negative is also assessed, using the following econometric specification:

$$y_{i,t+k} - y_{i,t} = \alpha_i^k + \gamma_t^k + \beta^{k+} D_{it} FE_{i,t}^k + \beta^{k-}(1 - D_{it}) FE_{i,t}^k + \varepsilon_{i,t}^k, \quad (7)$$

with

$$D_{it} = 1 \ \ if \ \ FE_{it} > 0, \quad \text{and} \quad 0 \ \text{otherwise.}$$

The results of this exercise show that although the output effect is typically larger for positive investment shocks than for negative ones, the difference is not statistically significant (Table 1, columns 8 and 9).

Finally, we examine whether our findings are sensitive to the trimming of public investment shocks from outliers and to sample changes. Column 10 of Table 1 contains the impulse response of output when the public investment forecast errors have been trimmed from the top and bottom 1 percent of values. Our findings are also robust to changes in the sample of countries considered. Results (available upon request) demonstrate that the impact of public investment on output ranges from 0.4 to 0.57 at time k=0, and from 1.3 to 1.9 at time k=4, when each one of the 17 economies in our baseline sample are excluded from the estimation one at a time.

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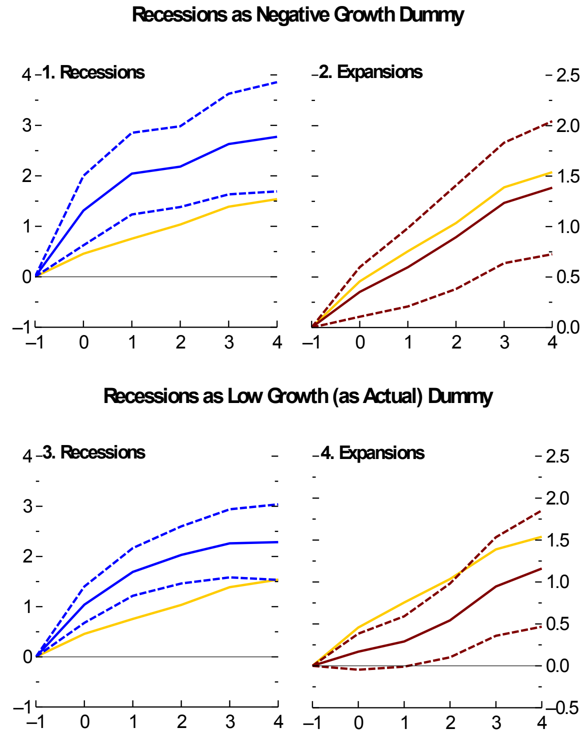
[11] Namely, we regress public investment forecast errors on growth forecast errors and use the residuals from this regression as our measure of public investment shocks.

The results presented in the previous section show that the short-term effects of investment spending shocks are larger in recessions than in expansions. This finding is robust to different specifications (interacting the shock with a recession dummy instead of a transition function of the state of the economy) and definitions of recessions (recessions defined as periods of negative growth or when growth is below the 2013 OECD average GDP growth) (Figure 6). Similarly, the finding that public investment shocks lead to larger output effects in countries with higher degree of public investment efficiency is robust to different measures. In Figure 7, we use the public investment efficiency frontier estimated by Albino-War et al (2014), which captures the efficiency with which a country can convert public investment into physical infrastructure stocks.

Figure 6. Effect of Public Investment Shocks on Output, Recessions versus Expansions: Robustness Checks
(Percent; years on x-axis)

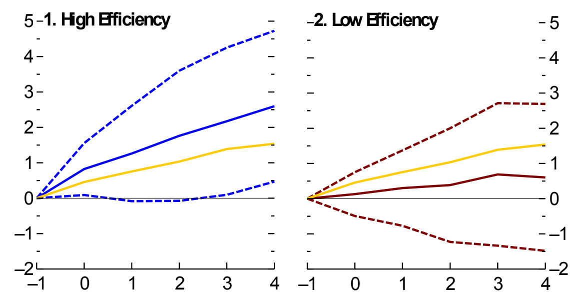


Source: IMF staff calculations.
Note: $t = 0$ is the year of the shock; dashed lines denote 90 percent confidence bands. Blue lines represent recessions; red lines represent expansions; yellow lines represent the baseline. Shock represents an exogenous 1 percentage point of GDP increase in public investment spending.

V. MODEL SIMULATIONS

The empirical approaches in the preceding sections assessed the short- and medium-term macroeconomic effects of public investment. But those approaches are not well suited to estimating the effects of public investment shocks over longer periods (for example, more than 10 years), nor can they fully address issues that are relevant today but have little historical precedent, such as the zero floor on nominal interest rates in many advanced economies and the current environment of very low real interest rates (see Blanchard et al 2014).[12] Therefore, to complement the empirical analysis, this section looks at the macroeconomic effects of public investment

Figure 7. Effect of Public Investment Shocks on Output, High versus Low Efficiency: Robustness Checks
(Percent; years on x-axis)



Source: IMF staff calculations.
Note: $t = 0$ is the year of the shock; dashed lines denote 90 percent confidence bands. Blue lines represent high efficiency; red lines represent low efficiency; yellow lines represent the baseline. Shock represents an exogenous 1 percentage point of GDP increase in public investment spending.

[12] In our sample, Japan in the 1990s is the only example where public investment shocks have occurred at zero lower bound on nominal interest rates. In the model simulations the steady-state short-term real interest rate is set at 1 percent.

shocks using a dynamic stochastic general-equilibrium model.

The analysis uses the IMF's Globally Integrated Monetary and Fiscal model (see Kumhof and Laxton 2007; Kumhof, Muir, and Mursula 2010; Coenen and others 2012; for a detailed description of the model). The main advantage of using such a structural model is that public investment shocks are strictly exogenous and no identification assumptions are needed. Moreover, the model presents some attractive features particularly relevant for the assessment of the impact of fiscal shocks. First, it has a highly detailed fiscal policy block. Second, it incorporates some empirically relevant channels that shape the transmission of fiscal shocks (for example, it specifies that a significant share of households is liquidity constrained). Third, the model captures the effect of automatic stabilizers on both the tax and spending side.

A critical input in the model-based analysis is the elasticity of output to public capital. There is now a substantial literature, triggered by the seminal contributions of Aschauer (1989), that estimates the long-term elasticity of output to public capital. A cursory reading of the literature reveals estimates ranging widely, from large and positive to slightly negative. However, a recent meta-analysis by Bom and Ligthart (2014) of 68 of these studies shows that much of the variation in estimates can be attributed to differences in research design, including how public infrastructure capital is defined, what output measure is used, whether capital is installed at the national level or by state and local governments, the econometric specification and sample coverage, and whether endogeneity and nonstationarity are properly addressed. Controlling for these factors, Bom and Ligthart come up with a much narrower range for the estimated output elasticity of public capital. In particular, they suggest that the elasticity of output with respect to core infrastructure installed by a national government is 0.17. This is the estimated elasticity that is assumed in the baseline simulations.

Since the global financial crisis, policy rates in the largest advanced economies have been near zero and are expected to remain at this level in the near term because of still-large output gaps. The effects of public investment shocks under these conditions are examined through a simulation of the macroeconomic response of output, the public-debt-to-GDP ratio, and private investment to a 1 percent of GDP increase in public investment, assuming that monetary policy rates stay close to zero for two years. There are two main reasons to assume that policy rates stay near zero for two years. First, such an assumption is in line with market expectations about policy rates for most large advanced economies. Second, in the model, the only way the central bank can stabilize output and inflation is by cutting nominal interest rates. When the option of cutting interest rates is removed for a longer period—for example, three or more years—the model generates unstable macroeconomic dynamics, which complicates the computation of simulation results.

The results of this simulation suggest that a 1 percent of GDP permanent increase in public investment increases output by about 2 percent in the same year. Output declines in the third year after the shock as monetary policy normalizes, then increases to 2.5 percent over the long term because of the resulting higher stock of public capital (Figure 8, panel 1). These results are consistent with recent papers that have used theoretical models to analyze the effect of fiscal stimulus in a liquidity trap. Hall (2009) finds a short- term output multiplies close to 1.7 at a zero nominal interest rate. Christiano et al (2011) and

Eggerston (2011) find even stronger effect at the zero lower bound, with multipliers ranging between 2 and 2.5.

Similarly, the permanent increase in public investment boosts private investment both in the short and in the long term (Figure 8, panel 3). The large output effects imply that the debt-to-GDP ratio declines, by about 3 percentage points of GDP three years after the shock, after which it increases somewhat, stabilizing at about 1.5 percentage points of GDP below the baseline five years after the shock.[13]

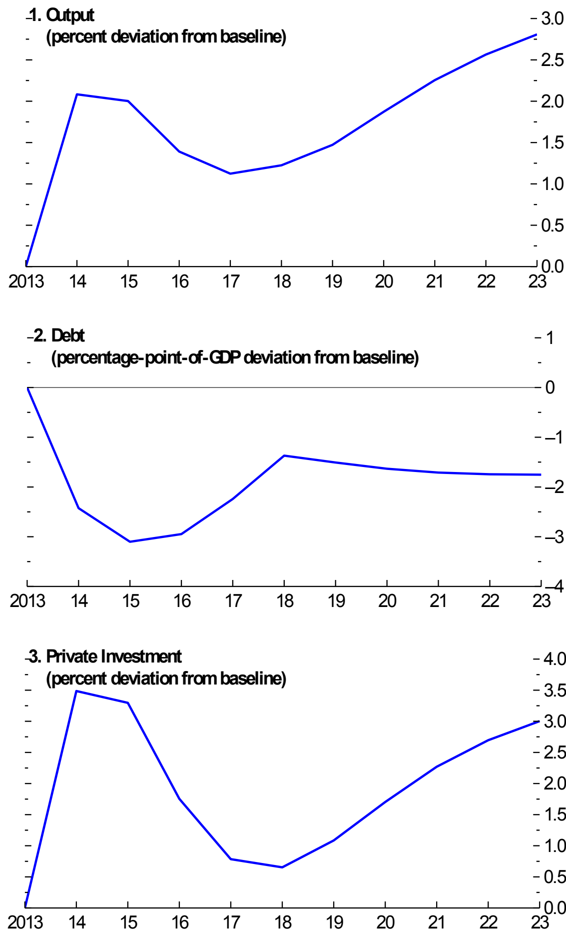
How different would the results be under normal conditions of less slack and an immediate monetary policy response to the increase in public investment? In this case, the short-term output effects would be much smaller. As a result, the debt-to-GDP ratio would eventually rise, stabilizing at a level 1.5 percentage points of GDP higher than the baseline (Figure 9, panels 1 and 2). These results are broadly consistent with the empirical evidence in the previous section.

These simulations implicitly assume that public investment is fully efficient, that is, that each dollar invested translates into productive public capital. However, it is likely that in countries with a lower degree of investment efficiency, the resulting output effects are smaller. The simulations presented in Figure 8, panels 3 and 4, confirm and quantify these results. In countries with a lower degree of investment efficiency, a 1 percentage point of GDP increase in public investment increases output by about 2.2 percent in the long term, compared with about 2.8 percent in countries where public investment is fully efficient. As a result, in countries with a low degree of investment efficiency, the debt-to-GDP ratio would decline less than in countries with full investment efficiency.

Finally, the simulations presented in panels 5 and 6 of Figure 9 illustrate how different assumptions regarding the long-term return of public investment (elasticity of output to public capital affect) affect the results. In particular, they show that the higher the return on public capital and the productivity of investment, the larger the long-term output effect of increases in public investment, and the decline in the debt-to-GDP ratio.

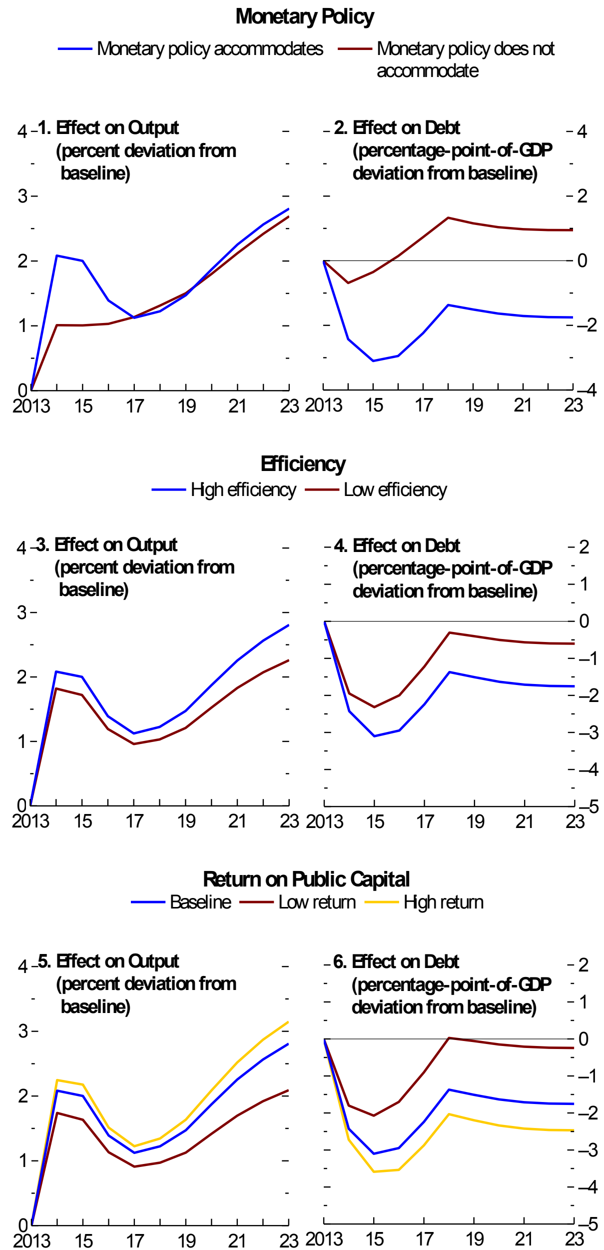
[13] The public investment shock is debt financed for the first five years. The debt-to-GDP ratio is stabilized and general transfers adjust to satisfy the fiscal rule afterward. The model needs to include a fiscal rule to ensure that it generates stable macroeconomic dynamics. Note, however, that given the large output effects, general transfers end up at a level higher than what prevailed in the absence of the shock.

Figure 8. Model Simulations: Effect of Public Investment in Advanced Economies in the Current Scenario



Source: IMF staff estimates.
Note: Shock represents an exogenous 1 percentage point of GDP increase in public investment spending.

Figure 9. Model Simulations: Effect of Public Investment in Advanced Economies: The Role of Monetary Policy, Efficiency, and Return on Public Capital



Source: IMF staff estimates.
Note: Shock represents an exogenous 1 percentage point of GDP increase in public investment spending.

VI. CONCLUSIONS AND POLICY IMPLICATIONS

We examine the macroeconomic impact of increased public investment, and find that such investment raises output in both the short and long term, crowds in private investment, and reduces unemployment, with limited effect on the public debt ratio. We also find that these effects vary with a number of mediating factors. The effects of public investment are particularly strong when there is slack in the economy and monetary accommodation. In such cases, the boost to output from higher government investment may exceed the debt issued to finance the investment. Government projects are more effective in boosting output in countries with higher efficiency of public investment. Finally, the mode of financing investment matters. We find suggestive evidence that debt-financed projects have larger expansionary effects than budget-neutral investments financed by raising taxes or cutting other government spending.

Our findings suggest that for economies with clearly identified infrastructure needs and efficient public investment processes and where there is economic slack and monetary accommodation, there is a strong case for increasing public infrastructure investment. Moreover, evidence suggests that increasing public infrastructure investment will be particularly effective in providing a fillip to aggregate demand and expanding productive capacity in the long run, without raising the debt-to-GDP ratio, if it is debt financed.

Finally, our results show how critical increasing investment efficiency is to mitigating the possible trade-off between higher output and higher public-debt-to-GDP ratios. Thus a key priority in many economies, particularly in those with relatively low efficiency of public investment, should be to raise the quality of infrastructure investment by improving the public investment process.

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