CHAPTER 3

IS IT TIME FOR AN INFRASTRUCTURE PUSH? THE MACROECONOMIC EFFECTS OF PUBLIC INVESTMENT

This chapter finds that increased public infrastructure investment raises output in both the short and long term, particularly during periods of economic slack and when investment efficiency is high. This suggests that in countries with infrastructure needs, the time is right for an infrastructure push: borrowing costs are low and demand is weak in advanced economies, and there are infrastructure bottlenecks in many emerging market and developing economies. Debt-financed projects could have large output effects without increasing the debt-to-GDP ratio, if clearly identified infrastructure needs are met through efficient investment.

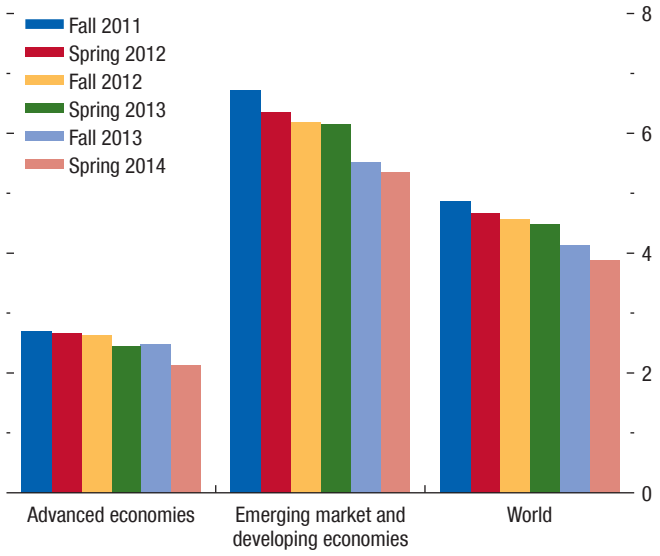
Five years after the global financial crisis, the global recovery continues but remains weak. In many advanced economies there is still substantial economic slack, and inflation remains too low in the euro area. Robust demand momentum has not yet taken hold, despite prolonged accommodative monetary policy, slowing in the pace of fiscal consolidation, and improvements in financial conditions. As noted in Chapter 1, there are now worries that demand will remain persistently weak—a possibility that has been described as "secular stagnation" (Summers 2013; Teulings and Baldwin 2014).

In emerging market economies the concerns are of a different nature. After a sharp rebound following the crisis, growth rates in the last few years have fallen not only below the postcrisis peak of 2010–11, but also below levels seen in the decade before the crisis. The persistent nature of the deceleration in output suggests that structural factors may be at work (Cubeddu and others 2014), and the serial disappointments in growth have led to a ratcheting down of medium-term growth forecasts (Figure 3.1). Although many factors are likely to be playing a role, one frequently expressed concern is inadequate infrastructure. In many emerging market economies, including Brazil, India, Russia, and South Africa, infrastructure bottlenecks are not just a medium-term worry but have been flagged as a constraint even on near-term growth. In low-income countries, deficiencies in the availability of infrastructure remain glaring and are often cited as an impediment to long-term development.[1]

Given these concerns and the current environment of low government borrowing costs—real interest rates are expected to remain lower than precrisis levels for the foreseeable future (see Chapter 3 of the April 2014 *World Economic Outlook*)—might this be a good time to increase public infrastructure investment? In

Figure 3.1. WEO Medium-Term Growth Projections
(Percent change)

Serial disappointments in emerging market growth rates have led to a ratcheting down of medium-term growth forecasts.



Source: IMF staff estimates.
Note: Economy groups are defined in Appendix 3.1. Medium-term growth projections are five-year-ahead growth forecasts.

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[1]See for example Calderón and Servén 2008; Foster and Briceño-Garmendia 2010; Fujita 2012; G20 Development Working Group 2011; and U.S. International Trade Commission 2009.

advanced economies an increase in infrastructure investment could provide a much-needed fillip to demand, and it is one of the few remaining policy levers available to support growth, given already accommodative monetary policy. In developing economies it could help address existing and nascent infrastructure bottlenecks. And in all economies it would help boost medium-term output, as higher infrastructure capital stocks expand productive capacity. As the Group of Twenty (G20) finance ministers and central bank governors stated in their communiqué from Sydney in February, higher infrastructure investment "is crucial for the global economy's transition to stronger growth."[2]

There are also arguments against such a push. Many advanced economies have little fiscal space available given still-high debt-to-GDP ratios and the need for further consolidation. Financing risks could increase with expected normalization of some key central banks' monetary policies. There are open questions about the size of the public investment multipliers and the long-term returns on public capital, both of which play a role in determining how public-debt-to-GDP ratios will evolve in response to higher public investment. Japan in the 1990s is often cited as a cautionary tale (Box 3.1). In all economies, but in developing economies in particular, inefficiencies in the public investment process are of concern: there is no shortage of anecdotes of increased government investment that produced few measurable benefits (see World Bank 1994; Pritchett 2000; Caselli 2005; and Warner 2014).

To assess appropriately the benefits and costs of increasing public investment in infrastructure, it is critical to determine what macroeconomic impact public investment will have. This chapter examines the following questions:

- How have public capital and investment evolved over time? How does infrastructure provision vary across groups of countries and types of infrastructure?
- What are the macroeconomic effects of public investment? To what extent does it raise output, both in the short and the long term? Does it increase the public-debt-to-GDP ratio if it is debt financed? How do these effects vary with key characteristics of the economy, such as the degree of economic slack, the efficiency of public investment, and the way the investment is financed?
- What do these findings suggest for infrastructure investment? Is this a good time to raise infrastructure investment? How do fiscal institutions and rules shape the evolution of public investment?

To address these questions, this chapter presents stylized facts on the provision of public and infrastructure capital. Since measures of infrastructure investment and the stock of infrastructure capital are not available for a wide range of countries, the evolution of public investment and the stock of public capital are used as proxy measures.[3] This is supplemented by physical measures of infrastructure, such as kilometers of roads and kilowatts of power generation capacity. The chapter then examines the historical evidence on the macroeconomic effects of public investment. Using a novel empirical strategy, the chapter offers new evidence on the effects of public investment changes on output and debt in advanced economies. It also presents evidence on their effects in emerging market and developing economies. To complement the empirical analysis, the chapter employs model simulations to explore additional issues, such as the role of monetary policy and the productivity of public capital. The chapter's main findings are as follows:

- The stock of public capital (a proxy for infrastructure capital) as a share of output has declined significantly over the past three decades across advanced, emerging market, and developing economies. In emerging market economies and low-income countries, infrastructure provision per capita is still a fraction of that in advanced economies. In some advanced economies, there are signs that aging infrastructure and insufficient maintenance and investment are affecting the quality of the existing infrastructure stock.
- Increased public investment raises output, both in the short term because of demand effects and in the long term as a result of supply effects. But these effects vary with a number of mediating factors, including (1) the degree of economic slack and monetary accommodation, (2) the efficiency of public investment, and (3) how public investment is financed. When there is economic slack and monetary accommodation, demand effects are stronger, and the public-debt-to-GDP ratio may actually decline. If the efficiency of the public investment process is relatively low—so that project selection

[2]The communiqué is available on the G20 website: https://www.g20.org/official_resources/library.

[3]Public capital and infrastructure capital are closely related: a significant component of the public capital stock in most countries consists of infrastructure, and the public sector was and continues to be its main provider. The two tend to be strongly correlated; see the stylized facts presented in the chapter.

and execution are poor and only a fraction of the amount invested is converted into productive public capital stock—increased public investment leads to more limited long-term output gains.

- 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 from advanced economies suggests that an increase in public investment that is debt financed could have larger output effects than one that is budget neutral, with both options delivering similar declines in the public-debt-to-GDP ratio. This should not, however, be interpreted as a blanket recommendation for a debt-financed public investment increase in all advanced economies, as adverse market reactions—which might occur in some countries with already-high debt-to-GDP ratios or where returns to infrastructure investment are uncertain—could raise financing costs and further increase debt pressure.
- Many emerging market and low-income economies have a pressing need for additional infrastructure to support economic development. But increasing public investment may lead to limited output gains, if efficiency in the investment process is not improved. Historically, there has been much wider variation in the macroeconomic response to public investment in emerging market and developing economies than in advanced economies. Model-based simulations suggest that public investment raises output in emerging market and developing economies, but at the cost of higher public-debt-to-GDP ratios, because of the general absence of economic slack and the relatively low efficiency of such investment. Thus, negative fiscal consequences should be carefully weighed against the broader social gains from increased public investment. For those emerging market and developing economies where infrastructure bottlenecks are constraining growth, the gains from alleviating these bottlenecks could be large.
- Increasing investment efficiency is critical 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. This could involve, among other reforms, better project appraisal and selection that identifies and targets infrastructure bottlenecks, including through centralized independent reviews, rigorous cost-benefit analysis, risk costing, and zero-based budgeting principles, and improved project execution.[4]
- Improvements in fiscal institutions and some fiscal rules could help protect public investment during periods of fiscal consolidation.

For many economies, given the large expected infrastructure investment needs over the coming years, facilitating increased private financing and provision of infrastructure will be very important—it is in fact one of the G20's top priorities.[5] The analysis of public versus private infrastructure provision is beyond the scope of this chapter, but as a burgeoning literature on the subject has noted, facilitating increased private financing and provision of infrastructure could help ease fiscal constraints, generate efficiency gains, and increase investment returns (see for example Chapter 3 of the October 2014 *Regional Economic Outlook: Sub-Saharan Africa;* European Investment Bank 2010; Arezki and others, forthcoming; OECD 2014; and World Bank, forthcoming). However, public-private partnerships can also be used to bypass spending controls, and governments can end up bearing most of the risk involved and facing potentially large fiscal costs over the medium to long term. Therefore, as the April 2014 *Fiscal Monitor* emphasizes, it is critical that countries maintain maximum standards of fiscal transparency when using public-private partnerships for infrastructure provision.[6]

The Economics of Infrastructure: A Primer

This section discusses the basic economics of infrastructure in order to set the stage for the remainder of the chapter. It discusses the role of infrastructure in the economy, how it differs from other types of capital, and the channels through which stepped-up infrastructure investment can affect economic activity, both in the short and long term.

Infrastructure refers to the basic structures that facilitate and support economic activity. In this chapter the term is used to denote what economists refer to

[4]A forthcoming IMF policy paper (IMF, forthcoming) explores the extent and sources of inefficiency in the planning and management of public investment projects and discusses policy options in these areas.

[5]See https://www.g20.org/g20_priorities/g20_2014_agenda/investment_and_infrastructure. For a discussion on financing future infrastructure needs, see World Economic Forum 2010 and McKinsey Global Institute 2013.

[6]For an in-depth discussion of the considerations that can guide public investment and public-private partnerships, see Hemming and others 2006; Akitoby, Hemming, and Schwartz 2007; and the April 2014 *Fiscal Monitor*.

as "core" infrastructure—roads and other transportation facilities, power generation and other utilities, and communications systems. Transport networks connect producers and consumers to markets, utilities provide essential inputs such as power and water for both production and consumption, and communications networks facilitate the exchange and dissemination of information and knowledge. As such, infrastructure is an indispensable input in an economy's production, one that is highly complementary to other, more conventional inputs such as labor and noninfrastructure capital. Indeed, it is hard to imagine any production process in any sector of the economy that does not rely on infrastructure. Conversely, inadequacies in infrastructure are quickly felt—in some countries, power outages, insufficient water supply, and decrepit or nonexistent roads adversely affect people's quality of life and present significant barriers to the operation of firms.

A few key characteristics distinguish infrastructure from other types of capital. First, infrastructure investments are often large, capital-intensive projects that tend to be "natural monopolies"—it is often more cost-effective for services to be provided by a single entity. Second, they tend to have significant up-front costs, but the benefits or returns accrue over very long periods of time, often many decades; this longevity (and the associated difficulty of ascertaining adequate returns over such a long horizon) can pose a challenge to private financing and provision. Third, infrastructure investments have the potential to generate positive externalities, so that the social return to a project can exceed the private returns it can generate for the operator.[7] This can lead to underprovision of needed investments. For these reasons, infrastructure has historically been provided by the public sector, public-private partnerships, or regulated private entities.

In deciding which infrastructure projects to undertake, governments must carefully weigh broader social returns against funding costs and fiscal consequences, recognizing that infrastructure projects are not undertaken primarily to boost revenues. Certain infrastructure projects may have a high social return, but costs might not be recouped through user charges and prices or through increased tax revenue from higher activity. Such situations generate a trade-off between positive social benefits on the one hand and negative fiscal consequences on the other.

[7]The benefits of constructing a new bridge, for example, spill over to the rest of the road network of which it is a part, and households and firms become more productive because of the improved transport network.

Increasing the flow of infrastructure services could be achieved by stepping up investment in new infrastructure projects (such as building new roads), but also by boosting operation and maintenance spending (such as filling potholes in existing roads), which reduces the rate of capital depreciation and extends the lifetime of installed infrastructure. Despite evidence of high rates of return, operations and maintenance spending is often neglected in favor of building new infrastructure (Rioja 2013), and is sometimes one of the first budget items to be pared back in times of fiscal pressure (Adam and Bevan 2014). But reducing maintenance expenditure is not equivalent to true fiscal savings from a longer-term perspective: potholes that are not filled today will have to be filled eventually, possibly at a higher cost.

An increase in public infrastructure investment affects the economy in two ways. In the short term it boosts aggregate demand through the short-term fiscal multiplier, similar to other government spending, and also by potentially crowding in private investment, given the highly complementary nature of infrastructure services. The size of the fiscal multiplier can vary with the state of the economy. Government investment also adds to the stock of public debt if the government borrows to finance additional spending. Whether debt rises as a share of GDP in the short term depends on the size of the fiscal multiplier and the elasticity of revenues to output. GDP may rise by more than debt initially, and the resulting higher tax revenue may offset some of the increased spending on public investment.

Over time, there is also a supply-side effect of public infrastructure investment as the productive capacity of the economy increases with a higher infrastructure capital stock. The efficiency of investment is central to determining how large this supply-side effect will be (see Box 3.2). Inefficiencies in the investment process, such as poor project selection, implementation, and monitoring, can result in only a fraction of public investment translating into productive infrastructure, limiting the long-term output gains.

The extent to which increases in public capital can raise potential output is a key factor in determining the evolution of the debt-to-GDP ratio over the medium and long term. In particular, if short-term multipliers, public investment efficiency, and the elasticity of output to public capital are sufficiently high, an increase in public investment can be "self-financing" in that it leads to a reduction in the debt-to-GDP ratio.[8]

[8]See Appendix 3.2 for further elaboration on this conceptual framework.

Public and Infrastructure Capital and Investment: Where Do We Stand?

This section documents how public and infrastructure capital and investment have evolved over the past four decades. Public capital and infrastructure capital are closely related: a significant component of the public capital stock in most countries consists of infrastructure, and the public sector was and continues to be its main provider.[9] However, there are differences: public capital can include noninfrastructure components (such as machinery and equipment, inventories, valuables, and land), and infrastructure can also be provided by the private sector or government-owned enterprises. Since measures of infrastructure investment and the stock of infrastructure capital are not available for a wide range of countries, the stylized facts here use the evolution of public investment and the stock of public capital as a proxy measure (Box 3.3 discusses issues with the measurement of the public capital stock).[10] This approach is supplemented by looking at physical measures of infrastructure, such as kilometers of roads and kilowatts of power generation capacity.

The stock of public capital, which reflects to a large extent the availability of infrastructure, has declined significantly as a share of output over the past three decades across advanced, emerging market, and developing economies (Figure 3.2). In advanced economies, this reflects primarily a trend decline in public investment from about 4 percent of GDP in the 1980s to 3 percent of GDP at present.[11]

In emerging market economies and low-income countries, sharply higher public investment in the late 1970s and early 1980s significantly raised public capital stocks, but since then public capital relative to GDP has also fallen.[12] Higher public investment rates in the past decade have stemmed the decline. Public capital stocks relative to GDP tend to be higher in developing economies than in advanced economies because of the higher investment rates and lower GDP levels in the former. However, when one adjusts for the efficiency of public investment (Box 3.2), which tends to be lower in developing economies, the estimated stock of public capital is significantly reduced (dashed lines in Figure 3.2; see also Dabla-Norris and others 2012; Gupta and others 2014; and Chapter 2 of the April 2014 *Fiscal Monitor*). And in per capita terms, these economies still have only a fraction of the public capital available in advanced economies (Figure 3.2, panel 5). The large variation in public capital stocks per person is mirrored by the availability of physical infrastructure per person (Figure 3.3).[13] Power generation capacity per person in emerging market economies is one-fifth the level in advanced economies, and in low-income countries it is only one-eighth the level in emerging markets. The discrepancy in road kilometers per person is similarly large.

Even in some advanced economies, in which measures of the quantity of infrastructure appear high relative to those in the rest of the world, there are deficiencies in the quality of the existing infrastructure stock.[14] Business executives' assessment of the overall quality of infrastructure has been declining for the United States and Germany (Figure 3.4, panel 1), reflecting largely the perceived deterioration in the quality of roads and highways (panel 2). As the American Society of Civil Engineers (2013) notes, 32 percent of major roads in the United States are now in poor or mediocre condition, and the U.S. Federal Highway Administration estimates that between $124 billion and $146 billion annually in capital investment will be needed for substantial improvement in conditions and performance—considerably more than the current

[9]Over the past two decades, private participation in infrastructure via public-private partnerships has been on the rise. In the aggregate, however, public infrastructure investment still dwarfs private, as infrastructure investment via public-private partnerships is still less than a tenth of public investment in advanced economies and less than a quarter of public investment in emerging market and developing economies.

[10]Direct measures of public capital—more formally known as government nonfinancial assets—are available for a handful of economies only, and even these estimates are often based on different coverage and methods. As a result, the public capital series used here, taken from the April 2014 *Fiscal Monitor*, are constructed by cumulating government investment spending, assuming some initial value of public capital and depreciation rates (see the April 2014 *Fiscal Monitor* and Kamps 2006 for details).

[11]Although the decline in the stock of public capital in advanced economies may partially reflect an increasing role of the private sector in the provision of infrastructure (such as energy and telecommunications), the stock of private capital and the level of private investment as a share of output have also declined over the past three decades.

[12]Figure 3.12 shows the evolution of public capital stocks in emerging markets and in low-income countries separately. Both follow the same general pattern of rising in the late 1970s and early 1980s and declining thereafter, though the rise and decline have been sharper in low-income countries.

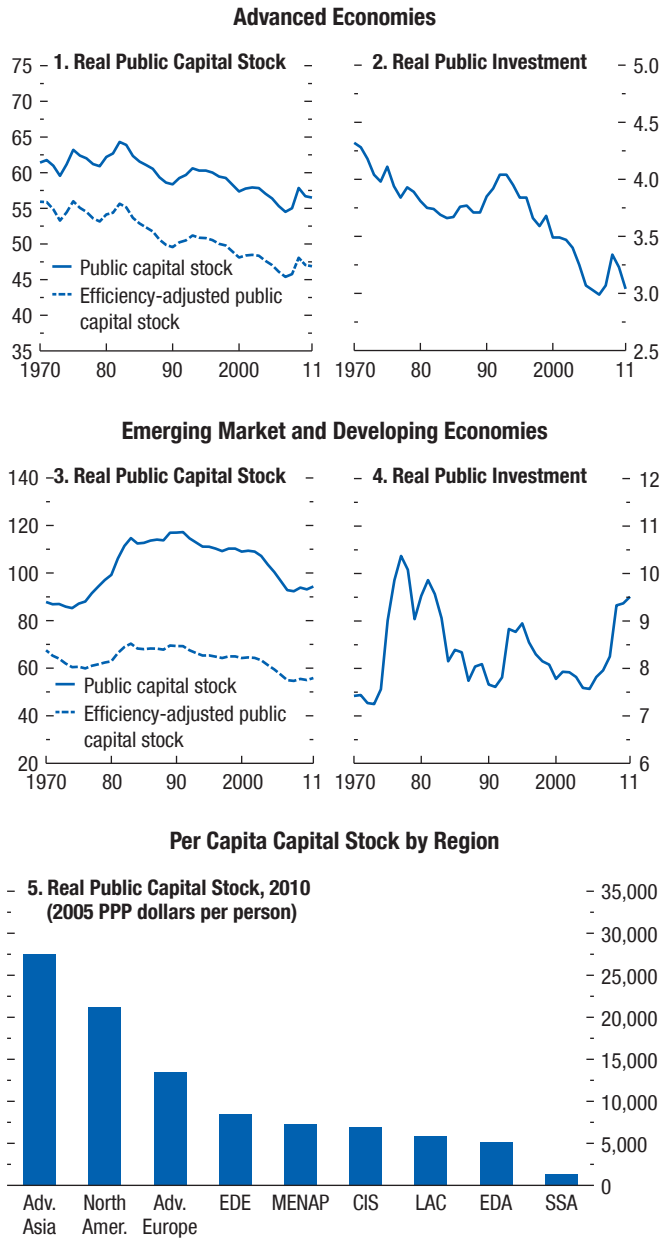
[13]Public capital stock per capita and physical infrastructure per capita (as measured by a synthetic index of power, roads, and telephones) are highly correlated. The cross-country correlation over the period 2005–11 is about 0.77, and a 1 percent higher stock of public capital per person corresponds to a 0.73 percent higher stock of infrastructure per person (Figure 3.3, panel 4).

[14]In addition, the evidence presented by Abiad and others (forthcoming) seems to suggest that the quantity of infrastructure in several advanced economies is also becoming increasingly inadequate.

Figure 3.2. Evolution of Public Capital Stock and Public Investment

(Percent of GDP, PPP weighted, unless noted otherwise)

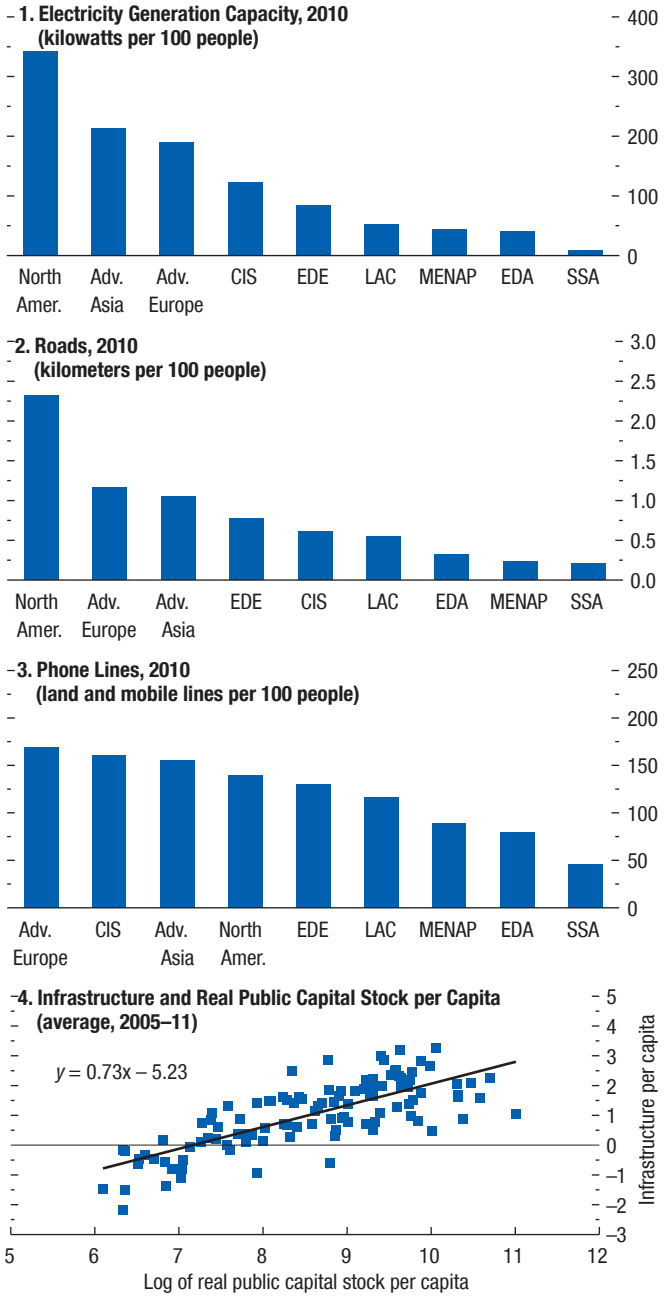
The stock of public capital has declined substantially as a share of output over the past three decades across advanced, emerging market, and developing economies. In per capita terms, non–advanced economies still have only a fraction of the public capital available in advanced economies.



Sources: IMF, Fiscal Monitor database; and IMF staff calculations.
Note: Adv. Asia = advanced Asia; Adv. Europe = advanced Europe; CIS = Commonwealth of Independent States; EDA = emerging and developing Asia; EDE = emerging and developing Europe; LAC = Latin America and the Caribbean; MENAP = Middle East; North Africa, Afghanistan, and Pakistan; North Amer. = North America; PPP = purchasing power parity; SSA = sub-Saharan Africa. Economy groups are defined in Appendix 3.1.

Figure 3.3. Physical Measures of Infrastructure

The large variation in public capital stocks per person is mirrored in the availability of physical infrastructure per person. Public capital stock per capita and physical infrastructure per capita are highly correlated.



Sources: IMF, Fiscal Monitor database; World Bank, World Development Indicators; and IMF staff calculations.
Note: Adv. Asia = advanced Asia; Adv. Europe = advanced Europe; CIS = Commonwealth of Independent States; EDA = emerging and developing Asia; EDE = emerging and developing Europe; LAC = Latin America and the Caribbean; MENAP = Middle East, North Africa, Afghanistan, and Pakistan; North Amer. = North America; SSA = sub-Saharan Africa. Economy groups are defined in Appendix 3.1. The infrastructure measure used in panel 4 is the principal component of electricity generation capacity, roads, and phone lines per capita.

$100 billion spent annually on capital improvements at all government levels.

Figure 3.4 also illustrates the heterogeneity of the state of infrastructure. Although the decline in the perceived quality of infrastructure in the United States and Germany is evident, a similar decline is not apparent in other Group of Seven economies—for example, in Canada, France, Japan, and the United Kingdom. Italy's infrastructure quality seems to be on the rise, albeit from relatively low levels. This heterogeneity should not be surprising and presents an important caveat: individual countries have differing infrastructure needs, and increased infrastructure investment should be considered only if there is a documented need and an economic payoff.

The Macroeconomic Effects of Public Investment

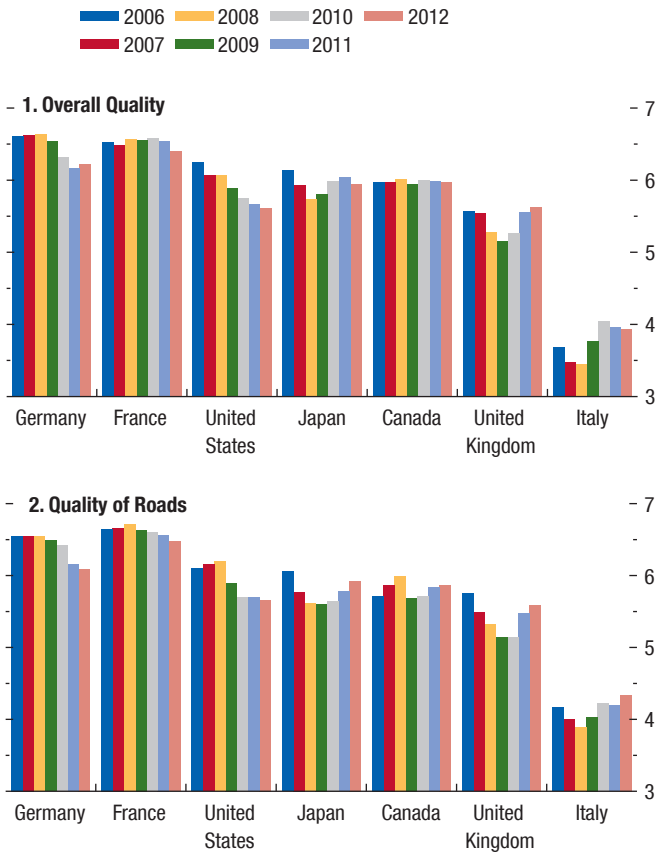
In order to assess the benefits and costs of additional public infrastructure investment properly, policymakers need a clear picture of the macroeconomic implications of such investment.

As discussed earlier in the chapter, an increase in public infrastructure investment affects output both in the short term, by boosting aggregate demand through the fiscal multiplier and potentially crowding in private investment, and in the long term, by expanding the productive capacity of the economy with a higher infrastructure stock. The macroeconomic response is shaped by various factors, including the degree of economic slack and monetary accommodation in the short term and efficiency of public investment in the long term. This section examines whether these theoretical predictions regarding the macroeconomic effects are borne out in the data. In contrast to the large body of literature that has focused on estimating the long-term elasticity of output to public and infrastructure capital using a production function approach,[15] the analysis here adopts a novel empirical strategy that allows estimation of both the short- and medium-term effects of public investment on a range of macroeconomic variables. Specifically, it isolates shocks to public investment that can plausibly be deemed exogenous to macroeconomic conditions and traces out the evolution of output, the public-debt-to-GDP ratio, and private investment in the aftermath of these shocks.

[15]See Romp and de Haan 2007; Straub 2011; and Bom and Ligthart, forthcoming, for a survey of the literature.

Figure 3.4. Quality of Infrastructure in G7 Economies
(Scale, 1–7; higher score indicates better infrastructure)

In some advanced economies, there are signs of deteriorating quality in the existing infrastructure stock.



Sources: World Economic Forum, Global Competitiveness Report survey; and IMF staff calculations.
Note: The G7 comprises Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States.

Since data on public infrastructure investment are not widely available, the empirical analysis examines the macroeconomic effects of total public investment, which may include investment in noninfrastructure items. To the extent that the productivity-enhancing effects of other public investments are lower than those for core infrastructure investment (see for example Bom and Ligthart, forthcoming), the estimates in the chapter present a lower bound on the long-term effects of public infrastructure investment.

The empirical analysis is complemented by model simulations for both advanced and developing economies, which helps identify the role of additional factors, such as monetary policy, investment efficiency, and productivity of public infrastructure capital.

An Empirical Exercise for Advanced Economies

The analysis begins by assessing the macroeconomic impact of public investment shocks in advanced economies, using the approach of Auerbach and Gorodnichenko (2012, 2013). In this approach, public investment shocks are identified as the forecast error of public investment spending relative to GDP. This procedure overcomes the problem of fiscal foresight (Forni and Gambetti 2010; Leeper, Richter, and Walker 2012; Leeper, Walker, and Yang 2013; Ben Zeev and Pappa 2014), because it aligns the economic agents' and the econometrician's information sets. Two econometric specifications are used. The first establishes whether these unanticipated shocks have significant effects on macroeconomic variables such as output, public-debt-to-GDP ratios, and private investment. The second is used to analyze whether these effects vary with the state of the economy, public investment efficiency, and the way higher public investment is financed (that is, whether it is debt financed or budget neutral).[16]

The analysis shows that public investment shocks have statistically significant and long-lasting effects on output (Figure 3.5, panel 1). An unanticipated 1 percentage point of GDP increase in investment spending increases the level of output by about 0.4 percent in the same year and by 1.5 percent four years after the shock. Using the sample average of government investment as a percentage of output (about 3 percent of GDP), this implies short- and medium-term investment spending multipliers of about 0.4 and 1.4, respectively. These multipliers are consistent with other estimates reported in the literature (see Coenen and others 2012 and literature cited therein).[17] The results are also robust to different time samples and when public investment shocks are isolated from other government spending shocks, as well as from unexpected changes in output.[18]

The point estimates in panel 2 of the figure show that higher public investment spending typically reduces 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. There is no statistically significant effect on private investment as a share of GDP (panel 3). The latter finding 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.

The macroeconomic effects of public investment shocks are very different across economic regimes (Figure 3.6, panels 1 through 4).[19] 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.[20] 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 these are not statistically significantly different from zero.[21]

In addition, the macroeconomic effects of public investment shocks are substantially stronger in coun-

[16]See Appendix 3.2 for details.

[17]These results are qualitatively similar if one estimates the impact of simple changes in public investment as a share of GDP instead of using forecast errors; see Appendix 3.2.

[18]A potential concern, for example, is that public investment shocks may respond to output growth surprises: public investment could be accelerated when unexpected growth provides funds, for example, or slowed when growth disappointments decrease revenues. In data from 17 advanced economies over the period 1985–2013, public investment innovations are only weakly correlated with output growth surprises (correlation –0.11). Moreover, purifying public investment shocks by removing the portion explained by growth surprises delivers results that are very similar to and not statistically significantly different from those reported in the baseline (see Appendix 3.2).

[19]Economic regimes are identified as periods of very low growth (recessions) and very high growth (significant expansions). Periods of very low (high) growth identified in this analysis 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.

[20]This finding is consistent with a growing literature that explores the effect of fiscal policy during recessions and expansions (see Auerbach and Gorodnichenko 2012; Blanchard and Leigh 2013; and IMF 2013 and the literature cited therein).

[21]One possibility is that these results are driven by the fact that these shocks occur in periods of economic recovery. However, no statistically significant correlation is found between the measure of investment spending shocks used and the economic regime. In particular, the correlation between investment spending shocks and the economic regime (or the change in the economic regime) is –0.01 (0.01).

tries with a high degree of public investment efficiency, both in the short and in the medium term (Figure 3.6, panels 5 through 8). 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 (about 9 percentage points four years after the shock) 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.

The output effects are larger when public investment shocks are debt financed than when they are budget neutral (Figure 3.6, panels 9 to 12).[22] 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.

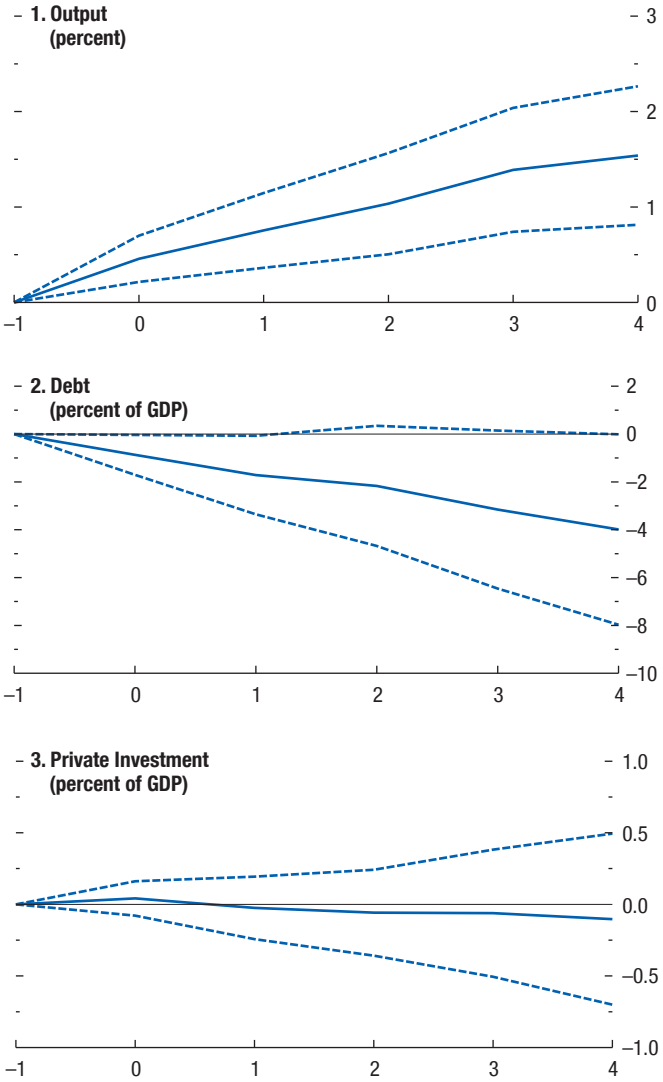
It is possible that increasing debt-financed public investment in countries with debt that is already high may increase sovereign risk and financing costs if the productivity of the investment is in doubt (possibly because of poor project selection), which in turn could lead to further debt accumulation, exacerbating debt sustainability concerns.[23] 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

[22]Budget-neutral public investment shocks are identified 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.

[23]Empirical evidence for emerging markets suggests that debt-financed public spending is associated with higher and more volatile sovereign risk spreads than tax-financed spending (Akitoby and Stratmann 2008). For further discussion of the links between public debt, public investment, and growth, see Ostry, Ghosh, and Espinoza 2014.

Figure 3.5. Effect of Public Investment in Advanced Economies
(Years on x-axis)

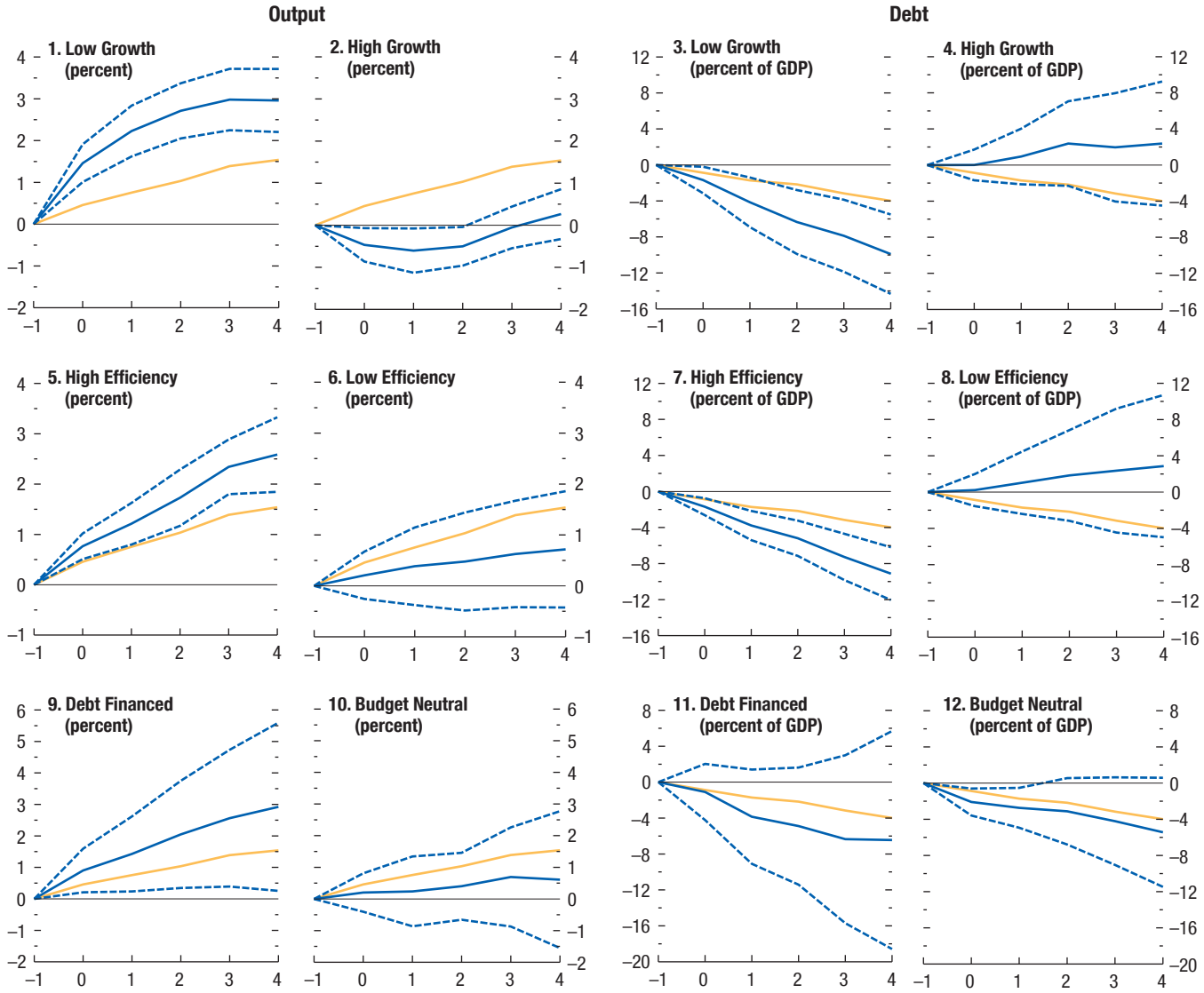
Public investment shocks have a statistically significant and long-lasting effect on output. They also typically reduce the debt-to-GDP ratio, though the decline in debt is statistically significant only in the short term. The level of private investment rises in tandem with GDP.



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

Figure 3.6. Effect of Public Investment in Advanced Economies: Role of Economic Conditions, Efficiency, and Mode of Financing
(Years on x-axis)

The effects of public investment on output and debt tend to be stronger when there is economic slack, when public investment efficiency is high, and when public investment is debt financed.



Source: IMF staff calculations.
Note: $t = 0$ is the year of the shock; dashed lines denote 90 percent confidence bands. Solid yellow lines represent the baseline result. See the text and Appendix 3.2 for the definition of high and low growth, high and low efficiency, and debt financed versus budget neutral. Shock represents an exogenous 1 percentage point of GDP increase in public investment spending.

interest rates. 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 historically, the effects of public investment differ materially according to the initial public-debt-to-GDP ratio. This may, however, be a result of lower debt-to-GDP ratios in advanced economies during most of the sample period.

An Empirical Exercise for Developing Economies

The empirical strategy used for the sample of advanced economies requires forecasts of public investment, which are not available over a long time span for economies that are not members of the Organisation for Economic Co-operation and Development. Given this data limitation, three different approaches are used that provide complementary evidence on the macroeconomic effects of public investment in developing economies.[24]

The first approach is to examine episodes of public investment booms and trace the evolution of key macroeconomic variables in the aftermath of large and sustained increases in public investment. The goal of this exercise is simply to establish the stylized facts about the macroeconomic conditions surrounding booms, rather than to estimate the causal effect of major pushes in infrastructure investments. Estimating the causal impact of booms is confounded by the fact that whether a country undergoes an investment boom and when a boom occurs are not exogenous to the country's macroeconomic conditions. For example, a shock that raises expected growth (for example, a sustained terms-of-trade boom or discovery of natural resources) may prompt governments to invest in infrastructure now, inducing a positive correlation between output and investment. Nevertheless, examining these large investment booms is a useful exercise for two reasons. First, a number of low-income countries have considerably stepped up government investment in recent years as a way to jump-start their economies in the face of weak external demand and infrastructure bottlenecks. Second, there are various theoretical reasons for such large investment drives to have different consequences relative to the average impact of public investment shocks that is picked up by the other two strategies.[25] This analysis follows Warner (2014) in identifying investment booms as a sustained and significant increase in the government investment ratio. Once the initial year of the investment boom is identified, the evolution of key macroeconomic variables is traced in the period following the start of the public investment push.

The historical experience with public investment booms paints a similar picture to the estimated macroeconomic impacts of public investment in advanced economies (Figure 3.7). About 120 public investment booms in the sample are identified, the vast majority of them in emerging market and developing economies. These booms are characterized by large and sustained increases in government investment spending: public investment as a share of GDP rises by about 7 percentage points of GDP in the first years of the boom. During this period, the level of output continuously increases, stabilizing after the fifth year at a level about 8 percent higher than in the year before the boom. This suggests a public investment multiplier of about 1–1.3.[26]

The analysis also traces the evolution of public debt after the beginning of a boom. The estimates' standard errors are large, but there is no evidence of an increase in the debt-to-GDP ratio in the aftermath of a boom. If anything, the negative point estimates suggest a relative decline in public debt as a share of output five years after the beginning of the boom. However, as shown in Appendix 3.2, the declining public debt ratio is driven by investment booms in commodity-exporting economies, in which stepped-up government investment could well have coincided with natural resource windfalls for public revenues.

The second approach to examining the macroeconomic consequences of public investment in developing countries is inspired by Corsetti, Meier, and Müller (2012). The empirical strategy relies on the idea that significant parts of government spending (investment in particular) are likely determined by past information and cannot easily respond to current economic conditions.[27] Thus, one can estimate a fiscal policy

[24]Details of these methodologies can be found in Appendix 3.2.

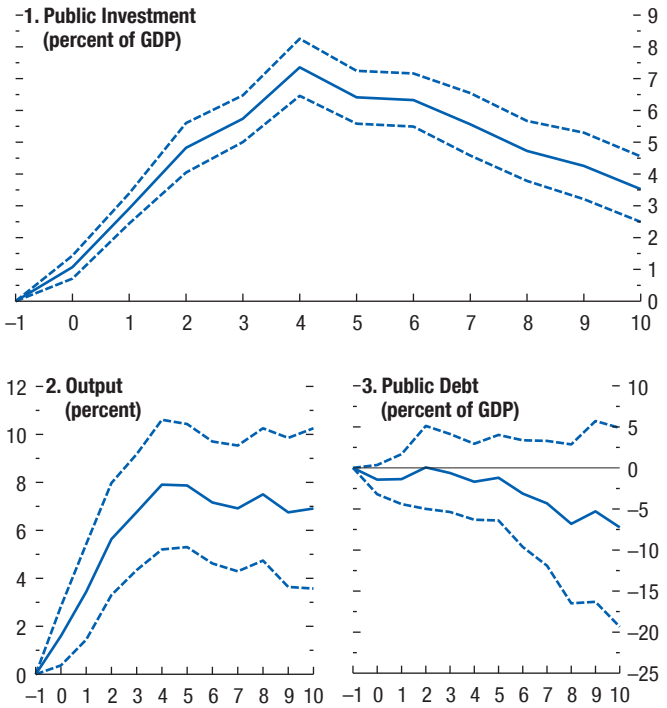
[25]Complementarities between different infrastructure projects and public and private investment may lead to disproportionate gains from coordinated pushes in infrastructure—the main hypothesis behind "big push" theories of development. On the other hand, large scaling up of public investment may result in the implementation of inframarginal projects and thus have lower-than-average impact (Warner 2014).

[26]These findings are somewhat different from those in the recent study by Warner (2014), who analyzes the growth impacts of public investment booms in a smaller set of low-income countries.

[27]In principle, this assumption can be violated for two reasons. First, public investment can automatically respond to cyclical conditions. This, however, should not pose a problem, because automatic stabilizers operate mostly via revenues and social spending. Second,

Figure 3.7. Output and Public Debt in the Aftermath of Public Investment Booms
(Years on x-axis)

Public investment booms in emerging market and developing economies are associated with higher output.



Source: IMF staff calculations.
Note: $t = 0$ is the beginning of a public investment boom; dashed lines denote 90 percent confidence bands. See Appendix 3.2 for a definition of public investment booms.

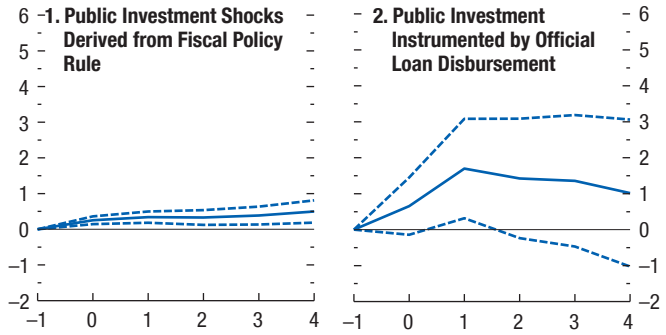
rule for public investment and from this obtain a series of exogenous shocks to public investment.[28] The estimated policy shocks are then used to trace the dynamic effects of public investment on output.

discretionary public investment spending can occur in response to output conditions. As discussed in Corsetti, Meier, and Müller 2012, the relevance of this concern relates to the precise definition of contemporaneous feedback effects. Although it is typically assumed in the literature that government spending does not react to changes in economic activity within a given quarter (Blanchard and Perotti 2002), whether it may respond in a period longer than a quarter is an open question. Recent evidence for advanced economies (Beetsma, Giuliodori, and Klaassen 2009; Born and Müller 2012), however, suggests that the restriction that government spending not respond to economic conditions within a year cannot be rejected.

[28]This identification strategy is very similar to the structure embedded in fiscal policy vector autoregression. The fiscal policy rule links the change in government investment to its lags, lagged growth, current and lagged public indebtedness, and expectations of the next year's growth.

Figure 3.8. Effect of Public Investment on Output in Emerging Market and Developing Economies
(Percent; years on x-axis)

Various empirical approaches suggest that public investment shocks in emerging market and developing economies have a positive effect on output, albeit with a much wider variation in responses than in advanced economies.



Sources: IMF staff calculations, drawing on Corsetti, Meier, and Müller 2012; Kraay 2012, forthcoming; and Eden and Kraay 2014.
Note: $t = 0$ is the year of the shock; dashed lines denote 90 percent confidence bands. Shock represents an exogenous 1 percentage point of GDP increase in public investment spending.

The third approach builds on recent work by Kraay (2012, forthcoming) and Eden and Kraay (2014) and applies primarily to low-income countries. In many of these countries, loans from official creditors such as the World Bank and other multilateral and bilateral aid agencies finance a significant fraction of government spending. The disbursements of these loans and the spending they finance are spread out over many years following the approval of the loans. Hence, part of the fluctuation in government investment is predetermined, as it reflects loan approvals in previous years. If one assumes that loan approval decisions made by creditors do not anticipate future macroeconomic shocks that affect output, this predetermined component of spending can be used as an instrument for total government investment to identify the causal impact of public investment on output.

These two approaches suggest that public investment may have a positive effect on output (Figure 3.8). The estimated effects are substantially smaller using the fiscal policy rule methodology, though they are more precisely estimated (panel 1). The contemporaneous effect of a 1 percentage point of GDP increase in public investment is a 0.25 percent increase in output, which gradually increases to about 0.5 percent four years after the shock. The Eden and Kraay (2014) methodology yields larger but much more imprecisely estimated

coefficients, with the effect of a public investment shock of about 1 percent four years after the shock (panel 2). The wide confidence bands preclude rejection of the null hypothesis that the two methodologies lead to identical estimates of the effect of public investment on output. The estimated medium-term multiplier is between 0.5 and 0.9, slightly lower than the multiplier estimated for advanced economies.

A Model-Based Approach

The empirical approaches in the preceding sections assess the short- and medium-term macroeconomic effects of public investment. But they 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 Chapter 3 of the April 2014 *World Economic Outlook*).[29] Therefore, to complement the empirical analysis, this section looks at the macroeconomic effects of public investment shocks using dynamic general-equilibrium models. An additional advantage of relying on model simulations is that in these models, public investment shocks are strictly exogenous and no identification assumptions are needed.

Simulations for advanced and emerging market economies use the IMF's Globally Integrated Monetary and Fiscal model.[30] Simulations for low-income countries are based on the model of Buffie and others (2012), which captures aspects pertinent to low-income countries, such as low public investment efficiency, absorptive capacity issues, and limited access to international and domestic borrowing (see Box 3.4).

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 (forthcoming) 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 (Table 3.1). In particular, they suggest that the elasticity of core infrastructure installed by a national government is 0.17. This is the estimated elasticity that is assumed in the simulations in this chapter.[31]

Table 3.1. Elasticity of Output to Public Capital

	All Public Capital	Core Infrastructure Capital
Installed by National Government	0.122	0.170
Installed by Subnational Government	0.145	0.193

Source: Bom and Ligthart, forthcoming.

Model simulations for advanced economies

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 (see Chapter 1). 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.[32] 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 per-

[29]Japan's experience with public investment in the 1990s is perhaps the most relevant historical example; for details, see Box 3.1.

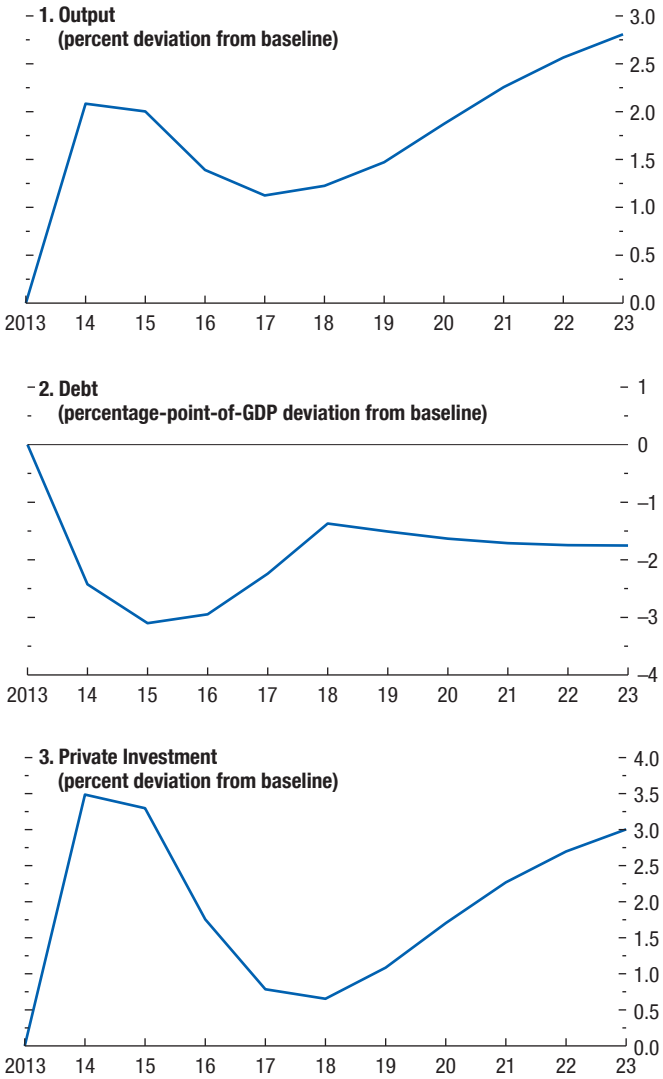
[30]For a detailed description of the model, see Kumhof and Laxton 2007 and Kumhof, Muir, and Mursula 2010.

[31]Panels 5 and 6 of Figure 3.10 illustrate how different assumptions regarding the elasticity of output to public capital affect the results.

[32]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.

Figure 3.9. Model Simulations: Effect of Public Investment in Advanced Economies in the Current Scenario

When monetary policy in advanced economies is accommodative, public investment shocks have a substantial short-term effect on output, bringing about a decline in the public-debt-to-GDP ratio.



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

cent over the long term because of the resulting higher stock of public capital (Figure 3.9, panel 1). Similarly, private investment increases both in the short and in the long term (Figure 3.9, 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.[33]

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 3.10, panels 1 and 2). These results are broadly consistent with the empirical evidence in the previous subsections.

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 3.10, 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.

Model simulations for developing economies

Are the macroeconomic effects of public investment in emerging market economies and low-income countries similar to those in advanced economies? As previously illustrated, a central factor currently at work in advanced economies (but currently not present in developing economies) is substantial economic slack and very accommodative monetary

[33]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.

policy. Another important difference between these two groups is that public investment efficiency in advanced economies is typically higher than that in emerging market and low-income economies (Box 3.2). Because of these two factors, a public investment shock of similar size leads to considerably lower long-term output effects in emerging market economies and low-income countries than in advanced economies (Figure 3.11 and Box 3.4). This phenomenon also has implications for public debt dynamics. The model simulations suggest that increased public investment may be self-financing under current conditions in advanced economies (in the sense that the public-debt-to-GDP ratio does not rise), but higher public investment would mean a higher public-debt-to-GDP ratio in emerging market economies and low-income countries.

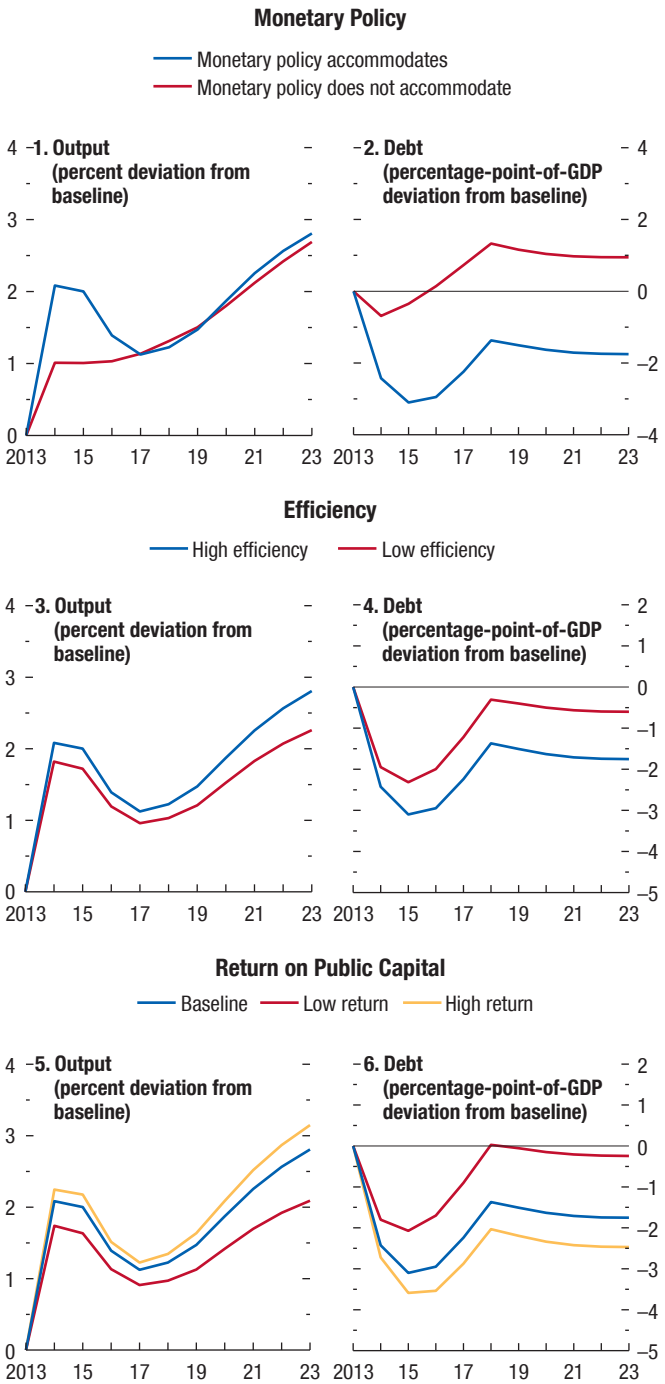
Summary and Policy Implications

Is now a good time for an infrastructure push? This chapter documents a substantial decline in public capital as a share of output over the past three decades across advanced, emerging market, and developing economies. It also notes that, in per capita terms, infrastructure provision in emerging market economies and low-income countries is still only a fraction of what it is in advanced economies. As for the macroeconomic impact of increased public investment, the chapter finds that such investment raises output in both the short and long term. It also finds that these effects vary with a number of mediating factors, and these are fundamental to teasing out the chapter's policy implications.

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 from advanced economies suggests that an increase in public investment that is debt financed would have larger output effects than an increase that is budget neutral, with both options delivering similar declines in the debt-to-GDP ratio. Current conditions present an opportunity to increase public investment, for those economies where the aforementioned conditions hold. The increased public investment would provide a much-needed boost to demand in the short term and would also help raise potential output in the long term. These conclusions should not, however, be interpreted as a

Figure 3.10. Model Simulations: Effect of Public Investment in Advanced Economies—Role of Monetary Policy, Efficiency, and Return on Public Capital

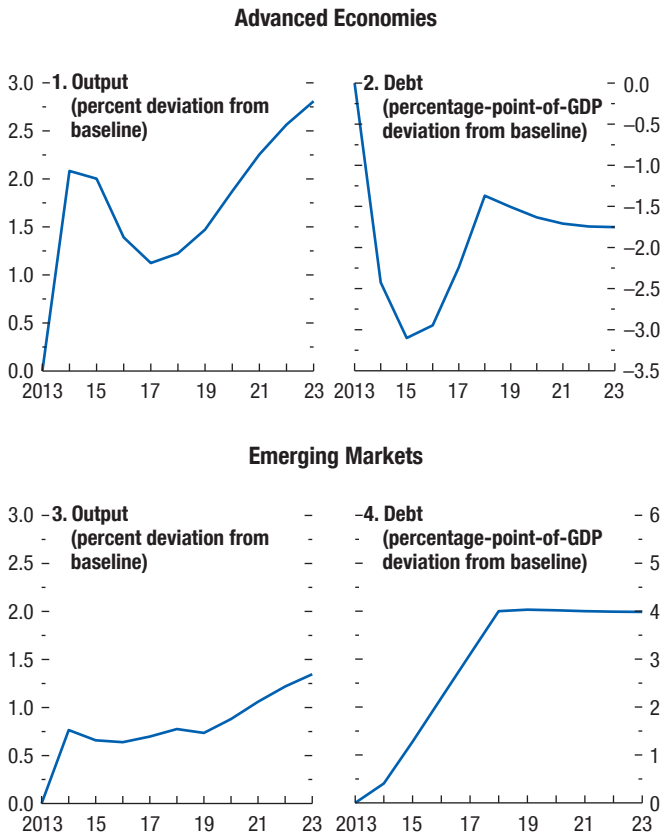
If monetary policy is not accommodative, the short-run output impact of public investment shocks is smaller. Differences in public investment efficiency and return on public capital will also shape the macroeconomic response.



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

Figure 3.11. Model Simulations: Effect of Public Investment in Advanced Economies and Emerging Markets

The response of output to public investment shocks is smaller in emerging market economies, because the lack of slack implies an immediate monetary policy response, and because public investment efficiency is relatively lower.



Source: IMF staff estimates.
Note: Economy groups are defined in Appendix 3.1. Shock represents an exogenous 1 percentage point of GDP increase in public investment spending.

blanket recommendation for a debt-financed public investment increase across all economies. Adverse market reactions—which could occur in some countries with already-high debt-to-GDP ratios or where returns to infrastructure investment are uncertain—could raise financing costs and further increase debt pressure.

But if infrastructure needs are indeed pressing and investment may be self-financing for some economies—in the sense that the public-debt-to-GDP ratio may not rise as a result of investment—why is public investment in advanced economies at a three-decade low? The reason is that in practice, public investment decisions frequently are not guided by economic rationale. This can cut both ways—inefficient and unproductive projects are often pursued by politicians and line ministries when they should not be, and some productive projects (and importantly, maintenance) are forgone when they should be given priority. Regarding the latter, Box 3.5 illustrates how improvements in fiscal institutions and some fiscal rules seem to help preserve public investment during periods of fiscal consolidation.

For many emerging market economies and low-income countries, there is a pressing need for additional infrastructure to support economic development. But increasing public investment may lead to limited output gains, if efficiency in the investment process is not improved. Historically, there has been much wider variation in the macroeconomic effects of public investment, and the empirical estimates of the macroeconomic effects of public investment are as a result much less precise. Model-based simulations suggest that public investment does raise output in both the short and long term, but at the cost of rising public-debt-to-GDP ratios because of the general absence of economic slack and the relatively low efficiency of such investment. Thus, negative fiscal consequences should be carefully weighed against the broader social gains from increased public investment. For those emerging market and developing economies where infrastructure bottlenecks are constraining growth, the gains from alleviating these bottlenecks could be large.

Increasing investment efficiency is critical to mitigating the possible trade-off between higher output and higher public debt. 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 (Box 3.2). Improvement could involve, among other reforms, better project appraisal and selection that identifies and targets infrastructure bottlenecks, including through centralized independent reviews, rigorous cost-benefit analysis, risk costing, and zero-based budgeting principles. As the April 2014 *Fiscal Monitor* notes, only half of the increase in government investment in emerging market and developing economies during 1980–2012 translated into productive capital; it also finds that reducing all inefficiencies in public investment by 2030 would provide the same boost to the capital stock as increasing government investment by 5 percentage points of GDP in emerging market economies and by 14 percentage points of GDP in low-income countries.

Appendix 3.1. Data Sources and Country Groupings

Country Groups

The members of the economy groupings used in the chapter's analyses are shown in Table 3.2. These include 36 advanced economies, as listed in Table B of the Statistical Appendix, 94 emerging market economies, and 59 low-income developing countries. The latter two groups comprise the 153 economies categorized as a single group under the term "emerging market and developing economies" in Table E of the Statistical Appendix.

Data Sources

The primary data sources for this chapter are the *World Economic Outlook* (WEO), the Organisation for Economic Co-operation and Development (OECD), and the April 2014 *Fiscal Monitor*. All data sources used in the analysis are listed in Table 3.3. For indicators with multiple sources, the sources are listed in the order in which they are spliced (which entails extending the level of a primary series using the growth rate of a secondary series).

Appendix 3.2. The Macroeconomic Effects of Public Investment

Conceptual Framework

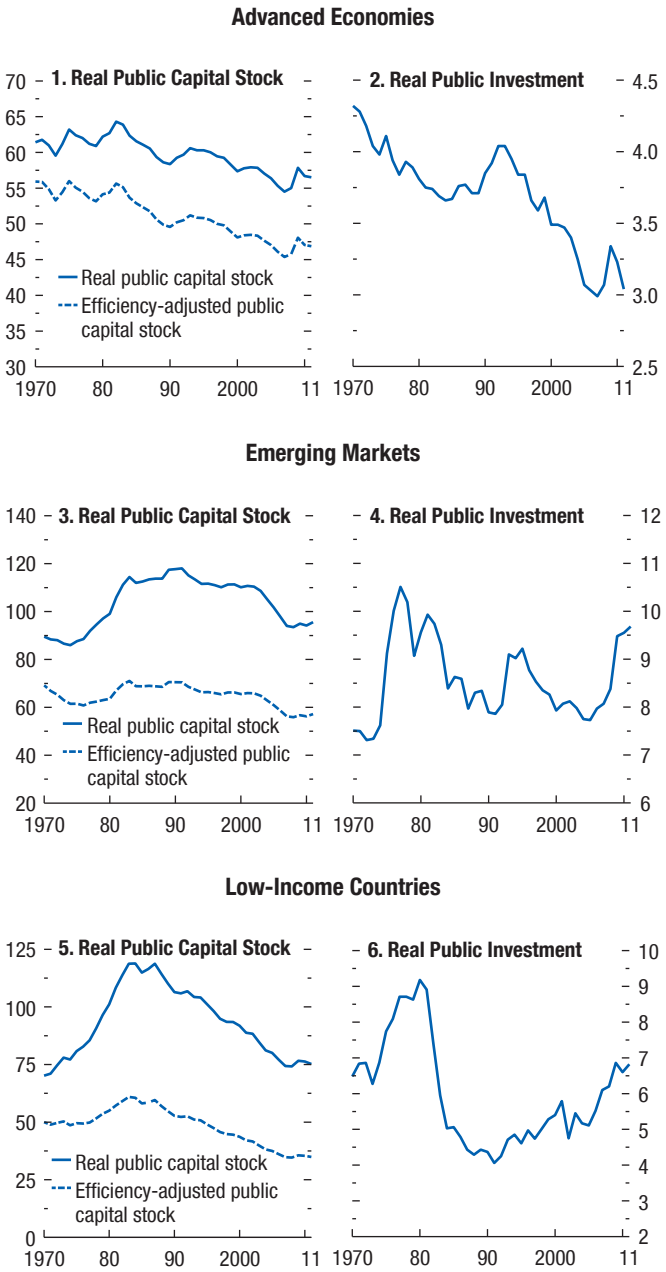
What are the effects of public investment on output and the debt-to-GDP ratio? Following Delong and Summers (2012), this section presents a highly stylized framework for assessing the effect of public investment on output and the debt-to-GDP ratio and for evaluating under which conditions an increase in public investment is self-financing.

In the short term, an increase in public investment boosts aggregate demand through the short-term fiscal multiplier. This increase in government spending will also affect the debt-to-GDP ratio, which may increase or decrease depending on the size of the fiscal multiplier and on the elasticity of revenues to output. More formally, in the short term (one year), an increase in public investment as a share of potential GDP (Δi) leads to a change in the debt-to-potential-GDP ratio (Δd) given by

$$\Delta d = (1 - \mu\tau)\Delta i, \qquad (3.1)$$

in which μ is the fiscal multiplier and τ is the marginal tax rate.

Figure 3.12. Evolution of Public Capital Stock and Public Investment
(Percent of GDP, purchasing-power-parity weighted)



Sources: IMF, Fiscal Monitor database; and IMF staff calculations.
Note: Economy groups are defined in the text.

Table 3.2. Economy Group Composition

Advanced Economies		
Australia	Hong Kong SAR	Norway
Austria	Iceland	Portugal
Belgium	Ireland	San Marino
Canada	Israel	Singapore
Cyprus	Italy	Slovak Republic
Czech Republic	Japan	Slovenia
Denmark	Korea	Spain
Estonia	Latvia	Sweden
Finland	Luxembourg	Switzerland
France	Malta	Taiwan Province of China
Germany	Netherlands	United Kingdom
Greece	New Zealand	United States
Emerging Market Economies		
Albania	Grenada	Philippines
Algeria	Guatemala	Poland
Angola	Guyana	Qatar
Antigua and Barbuda	Hungary	Romania
Argentina	India	Russia
Armenia	Indonesia	Samoa
Azerbaijan	Iran	Saudi Arabia
The Bahamas	Iraq	Serbia
Bahrain	Jamaica	Seychelles
Barbados	Jordan	South Africa
Belarus	Kazakhstan	Sri Lanka
Belize	Kosovo	St. Kitts and Nevis
Bosnia and Herzegovina	Kuwait	St. Lucia
Botswana	Lebanon	St. Vincent and the Grenadines
Brazil	Libya	Suriname
Brunei Darussalam	Lithuania	Swaziland
Bulgaria	FYR Macedonia	Syria
Cabo Verde	Malaysia	Thailand
Chile	Maldives	Timor-Leste
China	Marshall Islands	Tonga
Colombia	Mauritius	Trinidad and Tobago
Costa Rica	Mexico	Tunisia
Croatia	Micronesia	Turkey
Dominica	Montenegro	Turkmenistan
Dominican Republic	Morocco	Tuvalu
Ecuador	Namibia	Ukraine
Egypt	Oman	United Arab Emirates
El Salvador	Pakistan	Uruguay
Equatorial Guinea	Palau	Vanuatu
Fiji	Panama	Venezuela
Gabon	Paraguay	
Georgia	Peru	
Low-Income Developing Countries		
Afghanistan	Guinea	Niger
Bangladesh	Guinea-Bissau	Nigeria
Benin	Haiti	Papua New Guinea
Bhutan	Honduras	Rwanda
Bolivia	Kenya	São Tomé and Príncipe
Burkina Faso	Kiribati	Senegal
Burundi	Kyrgyz Republic	Sierra Leone
Cambodia	Lao P.D.R.	Solomon Islands
Cameroon	Lesotho	South Sudan
Central African Republic	Liberia	Sudan
Chad	Madagascar	Tajikistan
Comoros	Malawi	Tanzania
Democratic Republic of the Congo	Mali	Togo
Republic of Congo	Mauritania	Uganda
Côte d'Ivoire	Moldova	Uzbekistan
Djibouti	Mongolia	Vietnam
Eritrea	Mozambique	Yemen
Ethiopia	Myanmar	Zambia
The Gambia	Nepal	Zimbabwe
Ghana	Nicaragua	

Table 3.3. Data Sources

Indicator	Source
Electricity Generation Capacity	Calderón, Moral-Benito, and Servén 2014; Canning 2007; World Bank, World Development Indicators Database
General Government Gross Debt	Abbas and others 2010; IMF, World Economic Outlook Database
Gross Domestic Product (constant prices)	IMF, World Economic Outlook Database; World Bank, World Development Indicators Database
Gross Domestic Product (current prices)	IMF, World Economic Outlook Database; World Bank, World Development Indicators Database
Gross Domestic Product Forecast (constant prices)	IMF, World Economic Outlook Database
Overall Quality of Infrastructure	World Economic Forum, *Global Competitiveness Report*
Population	IMF, World Economic Outlook Database; World Bank, World Development Indicators Database
Predicted Disbursement of Loans	Kraay, forthcoming
Private Gross Fixed Capital Formation (PPP-adjusted, 2005 U.S. dollars)	IMF, Fiscal Monitor Database (April 2014)
Public Gross Fixed Capital Formation (PPP-adjusted, 2005 U.S. dollars)	IMF, Fiscal Monitor Database (April 2014)
Quality of Roads	World Economic Forum, *Global Competitiveness Report*
Real Public Capital Stock (PPP-adjusted, 2005 U.S. dollars)	IMF, Fiscal Monitor Database (April 2014)
Roads	Calderón, Moral-Benito, and Servén 2014; World Bank, World Development Indicators Database; International Road Federation, World Road Statistics
Telephone Lines	Calderón, Moral-Benito, and Servén 2014; World Bank, World Development Indicators Database
Trade-Weighted Terms of Trade	April 2013 *World Economic Outlook,* Chapter 4
OECD countries	
Gross Domestic Product (constant prices)	OECD Statistics and Projections Database
Gross Domestic Product Forecast (constant prices)	OECD Statistics and Projections Database
Government Spending (constant prices)	OECD Statistics and Projections Database
Government Spending Forecast (constant prices)	OECD Statistics and Projections Database
Government Fiscal Balance	OECD Statistics and Projections Database
Government Fiscal Balance Forecast	OECD Statistics and Projections Database
Private Consumption (constant prices)	OECD Statistics and Projections Database
Private Consumption Forecast (constant prices)	OECD Statistics and Projections Database
Private Gross Fixed Capital Formation (constant prices)	OECD Statistics and Projections Database
Private Gross Fixed Capital Formation Forecast (constant prices)	OECD Statistics and Projections Database
Public Gross Fixed Capital Formation (constant prices)	OECD Statistics and Projections Database
Public Gross Fixed Capital Formation Forecast (constant prices)	OECD Statistics and Projections Database
General Government Gross Debt	IMF, World Economic Outlook Database

Note: OECD = Organisation for Economic Co-operation and Development; PPP = purchasing power parity.

Over time, the short-term increase in public investment will affect the debt-to-GDP ratio by affecting its annual debt-financing burden, which is equal to the difference between the real government borrowing rate (r) and the GDP growth rate (g) times the initial change in the debt-to-GDP ratio:

$$(r - g)\Delta d = (r - g)(1 - \mu\tau)\Delta i. \tag{3.2}$$

Whether this additional financing burden will lead to an increase in the debt-to-GDP ratio in the long term will depend on the parameters of equation (3.2) but also crucially on the elasticity of output to public capital. In particular, in the long term, an increase in public investment will lead to an increase in potential output (Y), which will generate long-term future tax dividends:

$$\tau\Delta Y = \tau\varepsilon y_0\Delta i, \tag{3.3}$$

in which ε is the long-term elasticity of output to public capital and y_0 is the initial output-to-public-capital

ratio.[34] Equations (3.2) and (3.3) imply together that if short-term multipliers and the elasticity of output to public capital are sufficiently large, such that

$$(r - g)(1 - \mu\tau) - \tau\varepsilon y_o \leq 0,$$

then at the margin, an increase in public investment will be self-financing.

Empirical Analysis for Advanced Economies

Baseline approach

The analysis in this section assesses the macroeconomic impact of public investment shocks, applying the statistical approach used by Auerbach and Gorodnichenko (2012, 2013). In this approach, shocks are identified as unanticipated changes in public investment; public investment forecasts are used to compute unanticipated innovations. This procedure overcomes the problem of fiscal foresight (see Forni and Gambetti 2010; Leeper, Richter, and Walker 2012; Leeper, Walker, and Yang 2013; and Ben Zeev and Pappa 2014), because it aligns the economic agents' and the econometrician's information sets.[35]

Two econometric specifications are used, first to establish the macroeconomic impact of public investment shocks and then to determine whether the effects vary with the state of the economy and with the degree of public investment efficiency. In the first specification, the *average* response of real GDP, the debt-to-GDP ratio, and private investment as a share of GDP are estimated. The statistical method follows the approach proposed by Jordà (2005) to estimate impulse-response functions. This approach has been advocated by Stock and Watson (2007) and Auerbach and Gorodnichencko (2013), among others, as a flexible alternative that does not impose the dynamic restrictions embedded in vector autoregression (autoregressive distributed-lag) specifications and is particularly suited to estimating nonlinearities in the dynamic response. The first regression specification is estimated as follows:

$$y_{i,t+k} - y_{i,t} = \alpha_i^k + \gamma_t^k + \beta^k FE_{i,t} + \varepsilon_{i,t}^k, \qquad (3.4)$$

in which y is the log of output (debt-to-GDP ratio and private-investment-to-output ratio); α_i are country fixed effects, included to take account of differences in countries' growth rates; γ_t are time fixed effects, included to take account of global shocks such as shifts in oil prices or the global business cycle; and *FE* is the forecast error of public investment as a share of GDP, computed as the difference between actual and forecast series.

In the second specification, the response is allowed to vary with the state of the economy and with the degree of public investment efficiency. The second regression specification is estimated as follows:

$$y_{i,t+k} - y_{i,t} = \alpha_i^k + \gamma_t^k + \beta_1^k G(z_{it}) FE_{i,t} + \beta_2^k (1 - G(z_{it})) FE_{i,t} + \varepsilon_{i,t}^k, \qquad (3.5)$$

with

$$G(z_{it}) = \frac{\exp(-\gamma z_{it})}{1 + \exp(-\gamma z_{it})}, \ \gamma > 0,$$

in which z is an indicator of the state of the economy (or degree of public investment efficiency) normalized to have zero mean and unit variance. The indicator of the state of the economy considered in the analysis is GDP growth,[36] and the measure of investment efficiency is from the World Economic Forum's *Global Competitiveness Report* and was also used in the April 2014 *Fiscal Monitor*.

Equations (3.4) and (3.5) are estimated for each k = 0, . . . , 4. Impulse-response functions are computed using the estimated coefficients β^k, and the confidence bands associated with the estimated impulse-response functions are obtained using the estimated standard errors of the coefficients β^k, based on clustered robust standard errors.

The macroeconomic series used in the analysis come from the OECD's Statistics and Projections database, which covers an unbalanced sample of 17 OECD economies (Australia, Belgium, Canada, Denmark, Finland, France, Germany, Iceland, Japan, Korea, Netherlands, New Zealand, Norway, Sweden, Switzerland, United Kingdom, United States) over the period

[34]For simplicity of formulation, the depreciation rate is assumed to be zero.

[35]Leeper, Richter, and Walker (2012) demonstrate the potentially serious econometric problems that result from fiscal foresight. They show that when agents foresee changes in fiscal policy, the resulting time series have nonfundamental representations.

[36]As in Auerbach and Gorodnichenko 2013, γ = 1.5 is used for the analysis of recessions and expansions, γ = 1.0 for the role of public investment efficiency. The results do not qualitatively change for different values of gamma greater than zero. Similar results are obtained when the output gap is used to identify the state of the economy. The main reasons for identifying the state of economy using GDP growth instead of the output gap are that the latter is unobservable and its estimates are highly uncertain and subject to substantial and frequent revisions.

1985–2013. The forecasts of investment spending used in the analysis are those reported in the fall issue of the OECD's *Economic Outlook* for the same year.[37] As a robustness check, the forecasts of the spring issue of the same year and the fall issue of the previous year are alternatively used. The results show that the response functions are almost identical and not statistically significantly different from that reported in the baseline (Table 3.4, columns 2 and 3).

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. Inspection of the data, however, shows that the public investment innovations identified are only weakly correlated (about –0.11) with output growth surprises. Moreover, 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 3.4, column 4).

[37]The macroeconomic series from the OECD's Statistics and Projections database are available for a much longer period relative to *World Economic Outlook* forecasts. See Vogel 2007 and Lenain 2002 for an assessment of OECD forecasts and a comparison with forecasts prepared by the private sector. The size of the shock varies between –4.6 and 1.2 percentage points of GDP, with an average (median) of about –0.3 (–0.1) percentage point of GDP.

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, the measure of public investment shocks has been regressed on the forecast errors of other components of government spending, private investment, and private consumption. The results, presented in column (5) of Table 3.4, show that the response functions 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:

$$y_{i,t+k} - y_{i,t} = \alpha_i^k + \gamma_t^k + \beta^{k+} D_{it} FE_{i,t} + \beta^{k-}(1 - D_{it}) FE_{i,t} + \varepsilon_{i,t}^k, \quad (3.6)$$

with

$D_{it} = 1$ if $FE_{it} > 0$, and 0 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 3.4, columns 6 and 7).

Table 3.4. Effect of Public Investment on Output in Advanced Economies: Robustness Checks

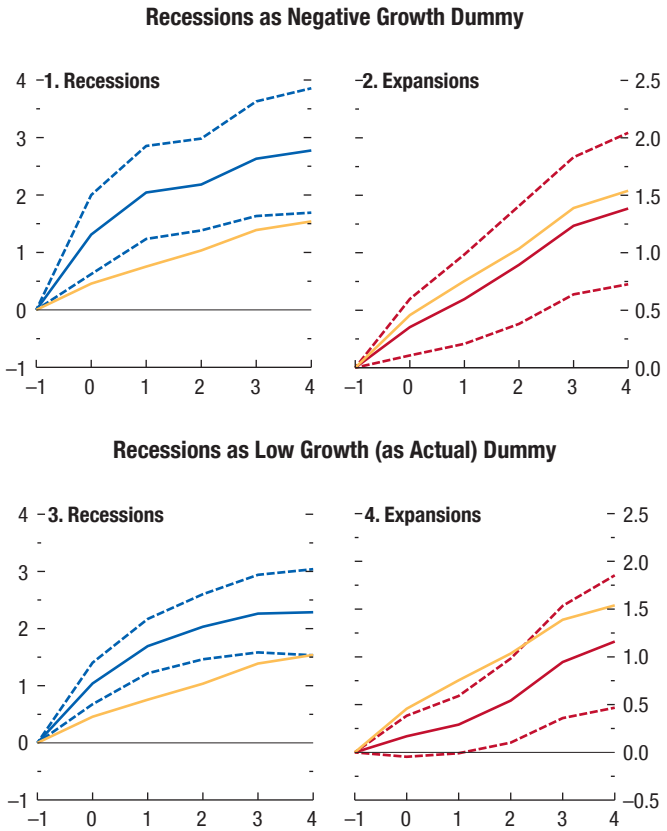
	Baseline	April Forecast	Previous October Forecast	Purging Public Investment Forecast Errors of Forecast Errors in: Growth	Purging Public Investment Forecast Errors of Forecast Errors in: Demand Components[1]	Positive Shocks	Negative Shocks
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Impact of Public Investment Shock on Output at k =							
0	0.457	0.264	0.332	0.418	0.502	1.013	0.316
	(0.147)	(0.160)	(0.118)	(0.147)	(0.143)	(0.447)	(0.181)
1	0.755	0.581	0.697	0.702	0.844	1.240	0.584
	(0.238)	(0.216)	(0.216)	(0.241)	(0.264)	(0.619)	(0.309)
2	1.035	0.966	1.004	0.993	1.241	1.576	0.888
	(0.322)	(0.270)	(0.288)	(0.323)	(0.339)	(0.763)	(0.431)
3	1.389	1.099	1.124	1.354	1.625	1.706	1.242
	(0.394)	(0.349)	(0.330)	(0.393)	(0.405)	(0.754)	(0.547)
4	1.539	1.318	1.219	1.507	1.864	1.459	1.393
	(0.441)	(0.402)	(0.383)	(0.439)	(0.489)	(0.715)	(0.617)

Source: IMF staff calculations.

Note: $k = 0$ is the year of the public investment shock, measured by the public investment forecast error. Standard errors (in parentheses) are corrected for heteroscedasticity and clustered at the country level. The sample includes 17 Organisation for Economic Co-operation and Development economies for the 1985–2013 period. All regressions include a full set of country and year fixed effects.

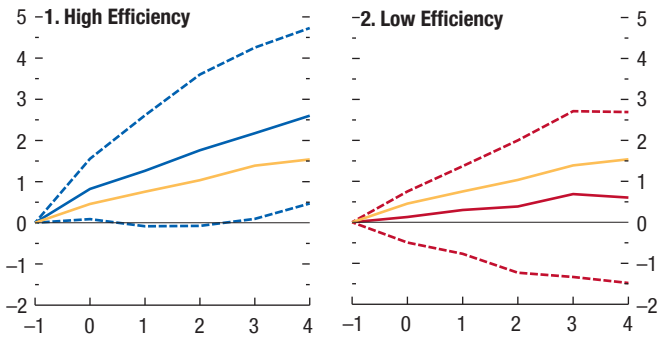
[1]Demand components include private consumption, investment, and government consumption.

Figure 3.13. 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.

Figure 3.14. 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.

The results presented in this 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 3.13). Although these results may be driven simply by the fact that these shocks occur in periods of economic recovery, no statistically significant correlation is found between the measure of investment spending shocks used in this study and the state of the economy. In particular, the correlation between investment spending shocks and the state of the economy (change in the state of economy) is –0.01 (0.01). Similarly, 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.[38] Finally, these results are also robust to different measures of public investment efficiency, such as the one presented in Box 3.3 (Figure 3.14).

Alternative approach

As an alternative approach, the dynamic macroeconomic impact of changes in public investment (as a share of GDP) is estimated. The results, depicted in panel 1 of Figure 3.15, show that changes in public investment have statistically significant and long-lasting effects on output. In particular, a 1 percentage point of GDP increase in investment spending increases the level of output by about 1.2 percent in the same year and by 1.3 percent after four years. If the sample period average response of government spending to output (about 3 percentage points of GDP) is used,

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

the short- and medium-term investment spending multipliers are about 1.2 and 1.3, respectively.

A 1 percentage point of GDP increase in investment spending is found to reduce the debt-to-GDP ratio in the short term (by about 1.2 percentage points of GDP), but the medium-term effect is surrounded by large uncertainty and not statistically significantly different from zero (Figure 3.15, panel 2). There is no statistically significant effect on private investment as a share of GDP (Figure 3.15, panel 3).

The results are qualitatively similar when changes in public investment are instrumented with fiscal-spending-based consolidations and expansions identified using the narrative approach (Chapter 3 of the April 2011 *World Economic Outlook*).[39]

Empirical Analysis for Developing Economies

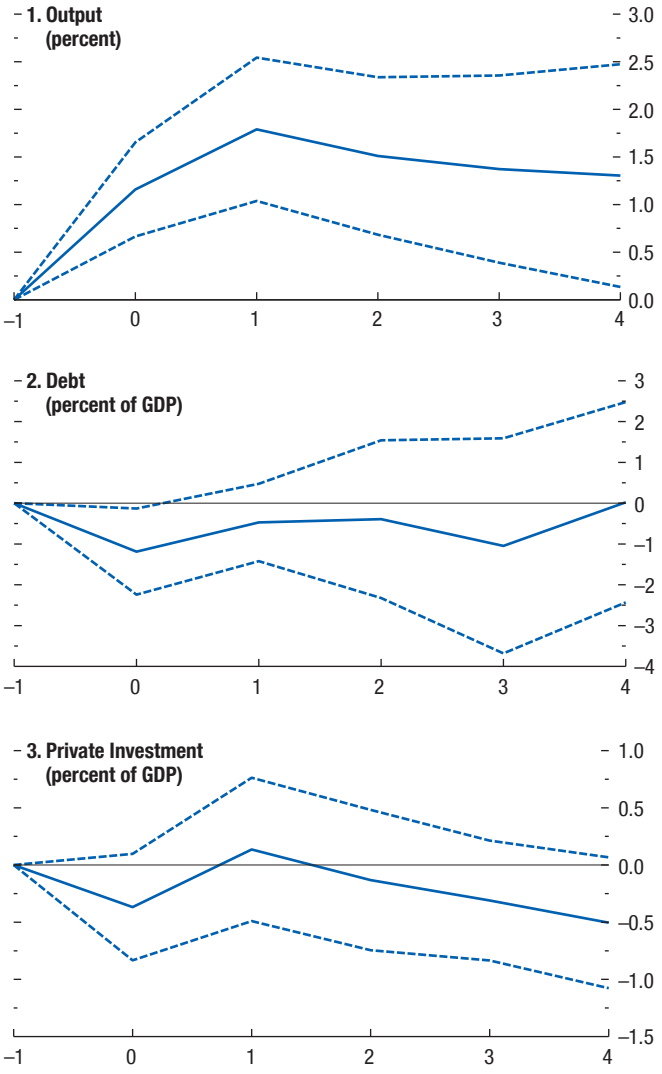
The empirical strategy that is applied for the sample of advanced economies requires forecasts of public investment, which are not available over a long time span for non-OECD economies. Given these data limitations, three different approaches are undertaken that provide complementary evidence on the macroeconomic effects of public investment in developing economies.

First approach: Investment booms

The first approach employed here is to examine episodes of public investment booms and trace the evolution of key macroeconomic variables in the aftermath of large and sustained increases in public investment. Investment booms are identified, following Warner (2014), as a sustained and significant increase in the government investment ratio. Using historical series of real public investment as a share of GDP from the April 2014 *Fiscal Monitor,* the beginning of a boom is identified as the point at which

- The difference between the five-year-forward average public-investment-to-GDP ratio and the five-year-backward average public-investment-to-GDP ratio exceeds the 80th percentile of such differences for a particular country for at least three consecutive years. This ensures that (1) this is a relatively large change in investment for the specific country and (2) the increase in investment is sustained over a period of time.
- The difference between the five-year-forward average public-investment-to-GDP ratio and five-year-backward average public-investment-to-GDP ratio exceeds a certain absolute threshold, which is set

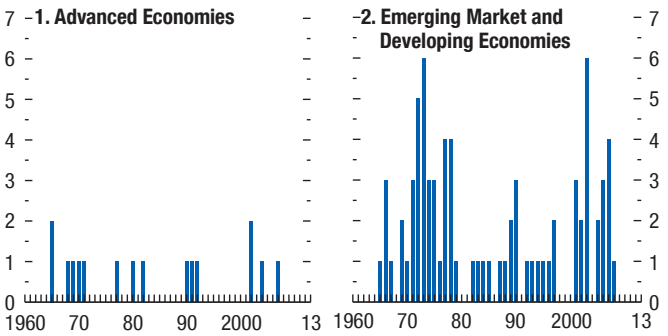
Figure 3.15. Effect of Changes in Public Investment in Advanced Economies
(Years on x-axis)



Source: IMF staff estimates.
Note: $t = 0$ is the year of the shock; dashed lines denote 90 percent confidence bands. Shock represents a 1 percentage point of GDP increase in public investment spending.

[39]These narrative measures are identified as those motivated by reasons unrelated to economic activity and are found to have statistically significant effects on public investment. Compared with the approach described in the previous section, this approach has one major shortcoming, in that the vast majority of the identified exogenous shocks are positive (that is, fiscal consolidations) and are motivated by debt reduction and therefore may be endogenous to debt-to-GDP ratios. In particular, out of 206 episodes, 161 are fiscal consolidations, and only 45 are fiscal expansions.

Figure 3.16. Distribution of Public Investment Booms over Time
(Number of countries)



Source: IMF staff calculations.

at 3 percentage points of GDP for non–advanced economies and 1 percentage point of GDP for advanced economies, where public investment ratios are significantly lower (see Figure 3.2).

Figure 3.16 presents the distribution of the beginning of public investment booms identified by this statistical procedure across time and for advanced and emerging market and developing economies. The vast majority of booms studied took place in emerging market and developing economies, with only a handful in advanced economies. Public investment booms are concentrated in the 1970s, when there was also a substantial buildup in the public capital stock in emerging market and developing economies, as well as in the mid-2000s, when public investment rates picked up again in this group of countries (see Figure 3.2).

Once the initial year of the investment boom has been identified, the evolution of key macroeconomic variables in the period following the public investment push is traced, using the estimation equation

$$y_{i,t+k} - y_{i,t} = \alpha_i^k + \gamma_t^k + \beta^k \, Boom_{i,t} + \varepsilon_{i,t}^k, \qquad (3.7)$$

in which y is the log of real output (the evolution of public investment as a share of GDP is also examined, as well as the debt-to-GDP ratio); α_i are country fixed effects, to account for different growth rates and levels of public investment across countries; γ_t are time fixed effects that control for global shocks such as shifts in commodity prices and global recessions; and $Boom_{i,t}$ is an indicator variable that equals one in the year the boom begins and zero otherwise. Separate regressions are estimated for each $k = \{0,9\}$. The coefficients β^k trace the impulse-response function of the level of the dependent variable of interest at time $t + k$ to a public investment boom that began at time t.

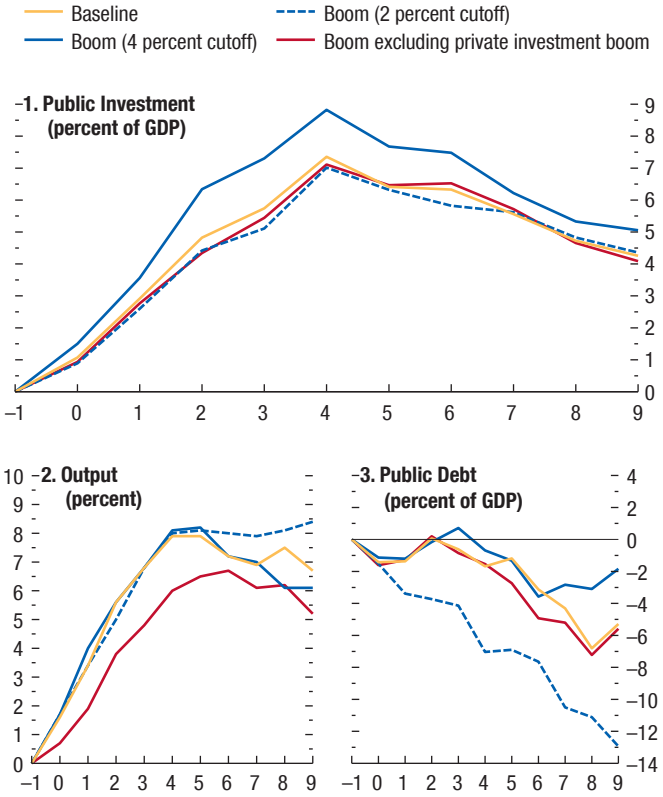
Estimating the causal impact of booms is confounded by the fact that whether a country undergoes an investment boom and when a boom occurs are not exogenous to the country's macroeconomic conditions. For example, anticipation of high growth in the future (such as from a sustained terms-of-trade boom or discovery of natural resources) may prompt governments to invest in infrastructure now, leading to overestimation of the causal impact of investment. Alternatively, public investment may be ratcheted up during times of economic slack in the hope of providing a boost to growth, which could potentially bias the estimated impact downward. The goal of this exercise is simply to establish the stylized facts around public investment booms, without claiming that the patterns observed are caused by the boom.

Figure 3.17 depicts the evolution of public investment, output, and public debt in the 10 years following the beginning of a boom using the study's baseline definition of a boom (as described earlier and presented in Figure 3.7), as well as several robustness checks. Namely, the sensitivity of the patterns to using alternative cutoffs for the absolute change in public investment in identifying the booms is examined. Although the baseline is built on an absolute difference between the five-year-forward and five-year-backward moving average of at least 3 percent for emerging market and developing economies and 1 percent for advanced economies, uniform cutoffs of 2 percent and 4 percent are also considered. Using a 2 percent cutoff for defining a boom increases the number of booms identified to 134; with the 4 percent cutoff, 89 booms are identified.

Given the poor availability of data on the breakdown of total investment into public and private, some of the data on real government investment that are used are imputed from the total investment series, potentially conflating the roles of the public and private sectors. As an additional robustness check, the series on public and private investment for each of the 122 booms identified in the baseline are examined, and booms prior to and during which there is a high degree of comovement between the public and private investment series are excluded.[40] This procedure

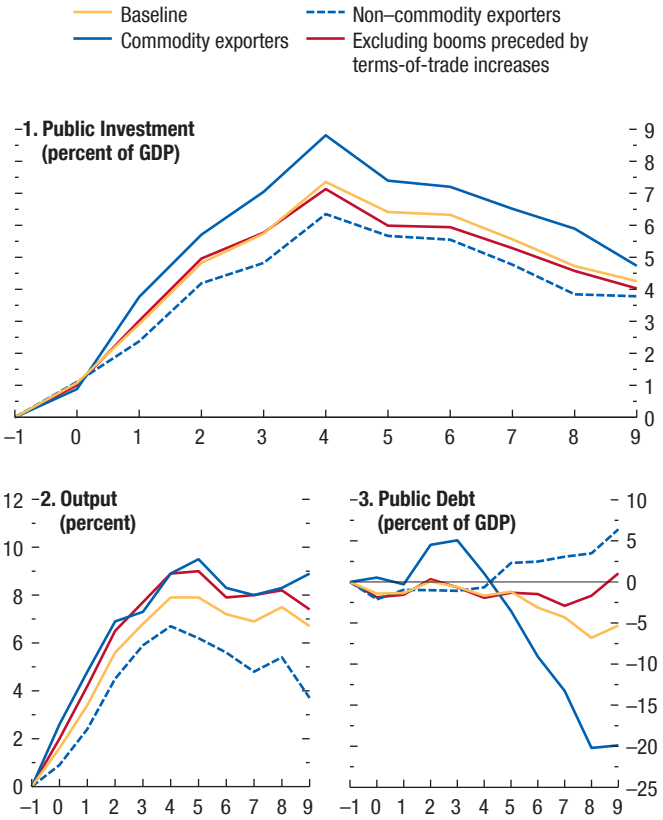
[40] This methodology constitutes a rather conservative method of defining public investment booms, as it likely excludes cases in which the patterns in total investment reflect primarily the behavior of public investment and cases in which there is strong complemen-

Figure 3.17. Output and Public Debt in the Aftermath of Public Investment Booms: Robustness Checks
(Years on x-axis)



Source: IMF staff calculations.
Note: $t = 0$ is the beginning of a public investment boom. See text for a definition of public investment booms.

Figure 3.18. Output and Public Debt in the Aftermath of Public Investment Booms: Role of Natural Resources
(Years on x-axis)



Source: IMF staff calculations.
Note: $t = 0$ is the beginning of a public investment boom. See text for a definition of public investment booms.

reduces the number of booms to 101. The red lines in Figure 3.17 depict the evolution of the macroeconomic variables following the 101 booms identified in this manner. Across all these alternative definitions of a boom, the same patterns are observed: there is a sustained increase in the level of output in the years following the beginning of a public investment boom, with no evidence of a rise in public indebtedness.

Finally, the extent to which these findings might simply reflect the experience of economies that benefit from favorable terms-of-trade shocks or natural resource discoveries and ratchet up public investment in response to these growth-enhancing events is examined. The sample of economies is split into commodity (including fuel) exporters and non–commodity exporters. The investment booms identified in the sample of commodity exporters are clearly larger in magnitude and are associated with a larger increase in output (Figure 3.18). Perhaps not surprisingly, this is precisely the set of countries that drive the negative point estimates on the evolution of the public-debt-to-GDP ratio following booms. In the non–commodity exporters, public investment booms are followed by a small and statistically nonsignificant increase in public debt. Finally, zeroing in on booms that are not coincidental to or preceded by favorable terms of trade yields results very similar to the baseline (red lines in Figure 3.18). Booms associated with favorable terms of trade are defined as those for which the five-year average (that is, from $t - 4$ to t, in which t is the beginning of the boom) of the deviation of the trade-weighted terms of trade from their long-term historical average exceeds the 80th percentile.

tarity between public and private investment. On the latter, see Eden and Kraay 2014.

Second approach: Exogenous public investment shocks

The second approach is inspired by Perotti (1999) and Corsetti, Meier, and Müller (2012). The empirical strategy relies on the idea that significant portions of government spending (and especially investment) are likely determined by past information and cannot easily respond to current economic conditions. Thus, a fiscal policy rule can be estimated for public investment and a series of exogenous shocks to public investment obtained from the residuals of this estimation. The policy shocks are then used to trace the dynamic effects of public investment on output.

The first step of this approach consists of estimating an annual time series of public investment innovations. The change in public investment (as a share of GDP) is assumed to follow a simple rule that relates it to its own lag, current and past debt-to-GDP ratios, past output growth, and expectations about current economic activity (proxied by the *World Economic Outlook* growth forecasts):[41]

$$\Delta i_{i,t} = \alpha_i + \gamma_t + \beta \Delta i_{i,t-1} + \delta_0 d_{i,t} + \delta_1 d_{i,t-1} + \theta g_{i,t-1} + \mu E_{i,t-1}(g_{i,t}) + \varepsilon_{i,t}, \quad (3.8)$$

in which $i_{i,t}$ denotes public investment as a share of GDP; α_i and γ_t indicate country and time fixed effects, respectively; d is the debt-to-GDP ratio; g denotes output growth; $E(g)$ denotes expectation about current economic activity; and ε represents the measure of public investment shocks.

The identifying assumption is that there is no two-way contemporaneous interdependence between change in investment and output growth. In principle, this assumption can be violated in two ways. First, public investment can *automatically* respond to cyclical conditions. This, however, should not pose a problem, because automatic stabilizers operate mostly through revenues and social spending. Second, discretionary public investment spending can occur in response to output conditions. As Corsetti, Meier, and Müller (2012) discuss, the relevance of this concern relates to the precise definition of contemporaneous feedback effects. Although it is typically assumed in the literature that government spending does not react to changes in economic activity within a given quarter (Blanchard and Perotti 2002), whether it might respond in a period longer than a quarter is an open question. Recent evidence for advanced economies (Beetsma, Giuliodori, and Klaassen 2009; Born and Müller 2012), however, suggests that the restriction that government spending not respond to economic conditions within one year cannot be rejected.

The second step consists of estimating the impact of these innovations ($\hat{e}_{i,t}$) on macroeconomic outcomes, as described in equation (3.4). Since estimating the public investment rule requires forecasts of the next year's growth, the estimation sample is restricted to the post-1990 period, when such forecasts become available for emerging market and developing economies. The results are based on a sample of 77 emerging market economies and 51 low-income countries.

In the baseline specification, the top and bottom 1 percent of shocks are trimmed from the public investment shock series. Including the entire sample leads to smaller and statistically nonsignificant point estimates of the effect of public investment on output. Trimming the top and bottom 5 percent of shocks yields larger and more statistically significant point estimates (Table 3.5).

Third approach: Instrumental variables

The third strategy builds on recent work by Kraay (2012, forthcoming) and Eden and Kraay (2014). In many low-income countries, loans from official creditors (such as the World Bank and other multilateral and bilateral aid agencies) finance a significant fraction of government spending. The disbursements of these loans and the spending they finance are spread out over many years following the approval of the loans. Hence, part of the fluctuation in government investment is predetermined, because the fluctuation reflects loan approval decisions made in previous years. If it is assumed that loan approval decisions by creditors do not anticipate future macroeconomic shocks that matter for output, this predetermined component of spending can be used as an instrument for total government investment to identify the causal impact of public investment on output.

Kraay's (forthcoming) series on predicted disbursements of loans (excluding loans approved in the current year) is employed as the instrument for public investment.[42] Using loan-level data from the Debtor

[41]The growth forecasts used in the analysis are those reported in the spring issue of the *World Economic Outlook* for the same year. As a robustness check, the forecasts of the fall issue of the same year and the spring issue of the previous year are alternatively used.

[42]Kraay (forthcoming) employs the predicted disbursements of official loans as an instrument for total government spending, whereas Eden and Kraay (2014) use it as an instrument for public investment, to tease out the short-term multiplier of public investment in a set of 52 low-income countries. The work discussed in this appendix builds on these studies by examining both the short- and

Table 3.5. Effect of Public Investment on Output in Emerging Market and Developing Economies: Public Investment Shocks Derived from a Fiscal Policy Rule

	Baseline[1]		Full Sample		Top and Bottom 5 Percent of Shocks Trimmed	
k	Coefficient	SE	Coefficient	SE	Coefficient	SE
	(1)	(2)	(3)	(4)	(5)	(6)
–1	0	0	0	0	0	0
0	0.252	(0.066)	0.144	(0.074)	0.324	(0.100)
1	0.340	(0.096)	0.193	(0.086)	0.571	(0.142)
2	0.331	(0.126)	0.187	(0.100)	0.567	(0.191)
3	0.384	(0.152)	0.225	(0.119)	0.728	(0.238)
4	0.497	(0.189)	0.239	(0.174)	1.010	(0.313)

Note: Columns (1), (3), and (5) present the estimated coefficients on the public investment shock from a series of regression estimates for each *k* in {0,4}. Standard errors (SEs) of the estimated coefficients, which are shown in columns (2), (4), and (6), are corrected for heteroscedasticity and clustered at the country level. There are 128 economies in the sample, with data from 1990–2013. All regressions include a full set of country and year fixed effects. $k = 0$ is the year of the shock.

[1]In the baseline specification, the top and bottom 1 percent of public investment shocks are trimmed.

Reporting System database maintained by the World Bank, Kraay (forthcoming) constructs loan-level predicted disbursements by applying to each initial loan commitment the average disbursement profile across all other loans issued by the same creditor in the same decade to all countries in the same geographical region as the actual borrower. These predicted loan-level disbursements of previously approved loans are then aggregated at the country-year level.[43] These series are available for the 1970–2010 period.

Because the identification strategy requires a strong correlation between public investment and predicted disbursements of loans, the sample is restricted to countries where disbursements from official creditors constitute an important source of financing. Namely, following Kraay (forthcoming), only countries whose disbursements of loans from official creditors equal on average at least 1 percent of GDP over 1970–2010 are included. This results in a regression sample covering 95 countries for which data on both public investment and official creditors' loan disbursements are available.

The following series of regressions is then estimated using two-stage least squares:

$$y_{i,t+k} - y_{i,t} = \alpha_i^k + \gamma_t^k + \beta^k X_{i,t} + \varepsilon_{i,t}^k, \qquad (3.9)$$

in which y is the log of real output; α_i are country fixed effects; γ_t are time fixed effects; and $X_{i,t}$ is the change in public investment as a share of GDP, instrumented with the change in predicted disbursements of previously approved loans. Equations are estimated for each $k = \{0,4\}$. The coefficients β^k trace the impulse-response function of the level of output at time $t + k$ to a change in public investment at time t.

Table 3.6 reports the estimated coefficients β^k based on equation (3.9). Panel 1 presents the first-stage regression results, and panel 2 reports the two-stage least-squares estimates of the response of output to change in public investment instrumented by the change in predicted loan disbursements. The results from three different samples are presented: all economies for which there are data, in column (1); only countries in which disbursements of loans from official creditors average at least 10 percent of total government spending, in column (2); and only countries eligible for support from the World Bank's International Development Agency, in column (3).

Across all three samples of economies, the effects of public investment on output are rather imprecisely estimated. The estimated coefficient is statistically significant at conventional levels only for the year following the change in investment. This could be a result of the rather weak first stage—the *F*-statistics are smaller than 10 in all three samples (Staiger and Stock 1997)—or could simply reflect the wide variety of experiences with public investment in developing economies.

medium-term effects of public investment on output and studying these effects in a larger sample of countries.

[43]See Kraay, forthcoming, for details on the data and construction of the instrument.

Table 3.6. Effect of Public Investment on Output in Emerging Market and Developing Economies: Public Investment Instrumented by Predicted Official Loan Disbursement

	Baseline	High-Disbursement Countries	IDA
	(1)	(2)	(3)
1. First Stage: Dependent Variable—Change in Public Investment as Percent of GDP			
Change in Predicted Disbursements	0.146	0.170	0.122
	(0.063)	(0.070)	(0.063)
First-Stage *F*-Statistic	3.705	5.344	7.217
Number of Observations	3,245	2,294	1,864
Number of Countries	95	66	58
2. Two-Stage Least Squares: Dependent Variable—Output Growth			
Impact of Change in Public Investment on Output at k =			
0	0.655	0.716	0.765
	(0.484)	(0.418)	(0.641)
1	1.700	1.691	1.801
	(0.841)	(0.748)	(1.146)
2	1.425	1.570	1.396
	(1.009)	(0.912)	(1.329)
3	1.359	1.700	1.156
	(1.112)	(1.017)	(1.534)
4	1.018	1.548	0.438
	(1.243)	(1.112)	(1.675)

Source: IMF staff calculations.

Note: $k = 0$ is the year of the change in public investment instrumented by the change in predicted loan disbursement. Panel (1) reports ordinary least-squares estimates of the first-stage regression of change in public investment on change in predicted loan disbursements. Panel (2) shows the two-stage least-squares estimates of the effect of change in public investment on real output from a series of regressions estimated for each k in {0,4}. Standard errors (in parentheses) are corrected for heteroscedasticity and clustered at the country level. Data are from 1970–2010. All regressions include a full set of country and year fixed effects. Results from three different samples are presented in columns (1), (2), and (3)—respectively, the full set of countries, only countries where disbursements of loans from official creditors average at least 10 percent of total government spending, and only countries eligible for International Development Association (IDA) support.

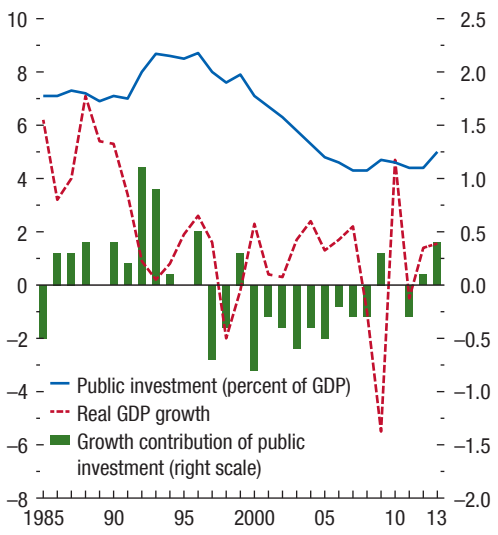
Box 3.1. Public Investment in Japan during the Lost Decade

Public investment in Japan is sometimes criticized as having contributed to the country's large debt increase and for failing to stimulate growth during the so-called Lost Decade. But there is reason for skepticism about such claims. To shed light on this debate, this box revisits Japan's experience with public investment.

It is true that Japan briskly increased public investment in the early 1990s, but the increase was unwound after just a few years to finance higher social security spending for a rapidly aging population. In particular, after the bursting of the bubble economy in the early 1990s, the government increased public investment spending by 1½ percent of GDP, with such spending reaching a peak of 8.6 percent in 1996. After that, the ratio of public investment to GDP steadily declined, picking up only recently in the aftermath of the global financial crisis, the 2011 earthquake, and the start of Abenomics (Figure 3.1.1). In the 20 years after 1992, the last year in which Japan recorded a fiscal surplus, social spending increased by 10.6 percent of GDP, and public investment declined by 2.3 percent of GDP.

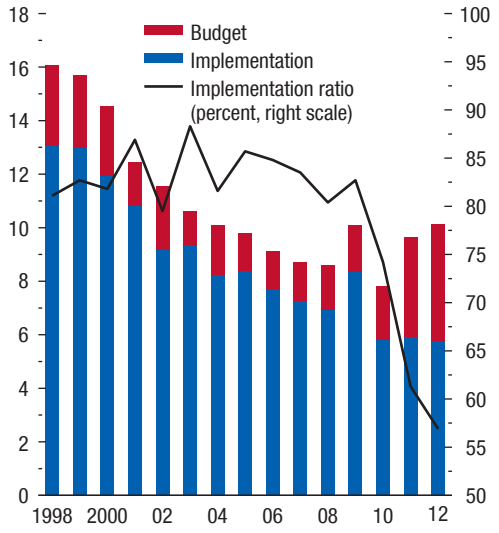
The author of this box is Ikuo Saito.

Figure 3.1.1. Japan: Public Investment and Growth
(Percent, unless noted otherwise)



Source: Economic and Social Research Institute, Japan.

Figure 3.1.2. Japan: Budget and Implementation of Public Investment
(Trillions of yen)



Source: Ministry of Finance, Japan.
Note: Budgeted amounts include carryover from previous years.

Not only was there this decline in investment throughout the late 1990s and the first decade of the 2000s, which has perhaps been less well remembered than the fast rise in the early 1990s, but announcements of investment plans have regularly exceeded their implementation. The ratio of public investment plans to actual implementation was 80–85 percent between 1998 and 2009, after which it dropped as resources for many planned projects shifted to recovery from a series of earthquakes that culminated with the historic 2011 event (Figure 3.1.2). This partial implementation may also help explain the gap between the perceived and actual growth of public investment.

However, the perception that the ability of public investment to stimulate activity has been on a declining trend is more accurate (see, for example, Auerbach and Gorodnichenko 2014). According to a macroeconomic model of the Japanese economy produced by the Economic and Social Research Institute—an arm of Japan's Cabinet Office—the short-term public investment multiplier declined from 1.31 in 1998 to

Box 3.1 *(continued)*

1.14 in 2011. Potential reasons for this decline include balance sheet adjustments (in the wake of the global financial crisis) that may have reduced the public investment multiplier, a lack of coordination between fiscal and monetary policies, reduced availability of highly productive projects, and cross subsidization among projects (Syed, Kang, and Tokuoka 2009).[1]

In sum, the frequent claim that Japan's public investment has been wasted does not fully withstand careful examination. It is true that Japan's public investment has recently faced greater challenges, as indicated by a lower multiplier effect since 1998. But given the great burst of activity in the early 1990s, the actual decline in the volume of public investment relative to GDP since the late 1990s, combined with the sharply reduced implementation of projects after 2009, may have combined to produce a misleadingly heightened perception that Japan's investment has been ineffective.

[1]Because projects with different profitability rates are tracked within the same account, a less productive infrastructure project can sometimes be cross subsidized by a more lucrative project.

Box 3.2. Improving the Efficiency of Public Investment

To be efficient, public investment must meet two conditions: it must be allocated to projects with the highest ratio of benefits to costs, and its aggregate level must align with fiscal sustainability. Efficiency entails not only the proper allocation of investment to sectors, but also the production of public assets at the lowest possible cost. When public investment is inefficient, higher levels of spending may simply lead to larger budget deficits, without increasing the quantity or quality of roads, schools, and other public assets that can help support economic growth.

One method for assessing the efficiency of public investment is to estimate "efficiency frontiers."[1] If a country has higher-quality infrastructure than other countries with a similar or greater level of capital stock, it is on the efficiency frontier. The further a country is from the efficiency frontier, the lower its efficiency score. Applying this approach, Albino-War and others (forthcoming) find that, on average, emerging market and developing economies are 10–20 percent less efficient than advanced economies (Figure 3.2.1).[2] The averages mask substantial differences within each group, however, indicating a global potential for improvement.

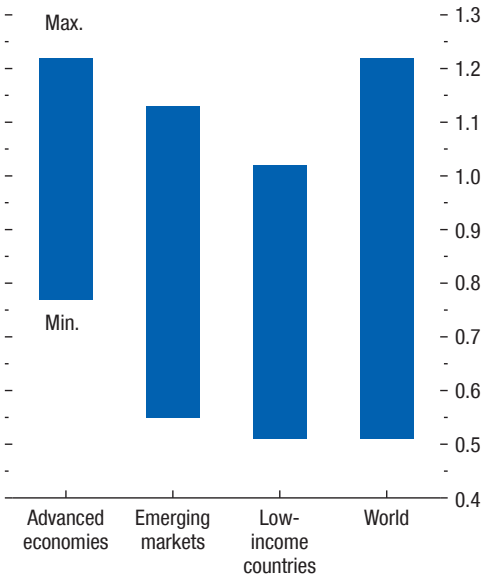
Examining the quality of public investment management can help identify the underlying causes of these inefficiencies. For example, the Public Investment Management Index assigns country scores for the four phases of public investment management: project appraisal, selection and budgeting, implementation, and ex post evaluation (Dabla-Norris and others 2012). These scores indicate that emerging market economies generally perform better than low-income countries (Figure 3.2.2).

But problems are evident in advanced economies as well. Common challenges include weak strategic guidance, budget planning, and project appraisal (including a failure to undertake cost-benefit analysis systematically); poor project selection and budgeting because of rigidities in the sectoral allocation of investment and fragmented decision making regarding capital and current budgets and investment; completion delays and cost overruns from overly optimistic cost estimates and inadequate cost controls; and a lack of interim and ex post project evaluation.

Well-designed institutional arrangements for public investment decision making and management can help improve the efficiency of public investment (IMF, forthcoming). For example, project appraisal can be strengthened by instituting a centralized, independent review process to ensure robust estimates of the costs, benefits, and risks of potential projects, as has been done in Australia, Chile, Korea, and Norway.

Both project appraisal and project selection can be strengthened by preparing investment budgets from a zero base, as in the United Kingdom, to ensure that

Figure 3.2.1. Public Efficiency Measured by Efficiency Frontiers
(Efficiency scores, infrastructure quality)



Sources: Albino-War and others, forthcoming; Dabla-Norris and others 2012; and IMF staff calculations.

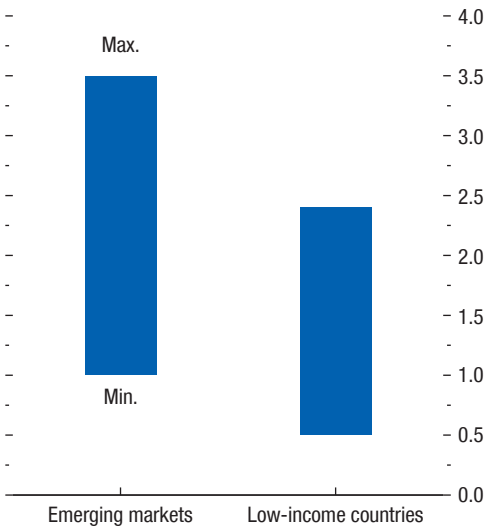
The authors of this box are Carlos Mulas Granados, Bahrom Shukurov, and SeokHyun Yoon.

[1]Estimation of the efficiency frontier involves comparing an indicator of public infrastructure quantity (the input) to an indicator of public infrastructure quality (the output). Quantity is the sum of past public investment, adjusted for depreciation, per capita. Quality is the "overall quality of infrastructure" indicator from the World Economic Forum's *Global Competitiveness Report*.

[2]As a proxy for the private sector's provision of infrastructure, the estimates include GDP per capita as an input. The results are not greatly affected by adding this control (the correlation coefficient of the efficiency scores with and without GDP per capita as an input is 0.89).

Box 3.2 *(continued)*

Figure 3.2.2. Public Investment Management Index Scores in Emerging Markets and Low-Income Countries



Sources: Albino-War and others, forthcoming; Dabla-Norris and others 2012; and IMF staff calculations.
Note: The Public Investment Management Index is an index of public investment efficiency composed of 17 indicators grouped into four stages of the public investment management cycle: project appraisal, selection, implementation, and evaluation. See Dabla- Norris and others 2012 for details.

new capital expenditure targets those sectors with the highest returns rather than those that have previously benefited from substantial investment. Planning current and capital expenditure within a medium-term budget framework can also ensure that investments are sustainable and that maintenance spending is fully taken into account, as is done, for example, in Australia, Chile, Ethiopia, Ireland, and Korea.

Project implementation can be improved by providing for explicit contingencies within the budget in anticipation of cost overruns and to avoid overcommitting the budget to new projects, as in Denmark and the United Kingdom. Finally, project evaluation can be strengthened by undertaking more systematic assessments of whether projects are on time, are within budget, and deliver their expected outputs, as is done, for example, in Chile and Korea.

Box 3.3. Fiscal Balance Sheets: The Significance of Nonfinancial Assets and Their Measurement

What assets constitute the stock of public capital in various economies? Answering this question requires data on the stock of nonfinancial assets within the framework of a balance sheet that covers all levels of government or the public sector.[1]

In a macroeconomic statistics balance sheet, a distinction is made between nonfinancial assets, financial assets, liabilities, and net worth. The standard breakdown of nonfinancial assets as applied in the analytical framework for government finance statistics is shown in Table 3.3.1.

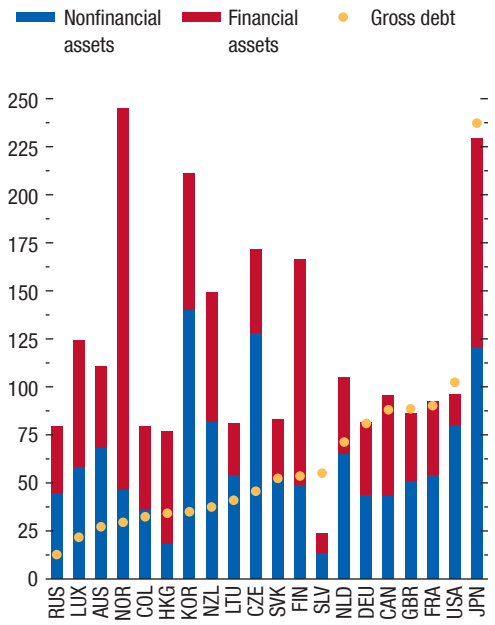
A recent IMF working paper (Bova and others 2013) looks at the size, composition, and management of government-owned nonfinancial assets across 32 advanced and emerging market economies. It finds that nonfinancial assets comprise mainly structures (such as roads and buildings) and, when valued, land and subsoil assets. These assets have increased in value over time, primarily because of higher property and commodity prices, and in large part are owned by subnational governments. However, their levels as a percentage of GDP differ widely across countries (Figure 3.3.1).

Although data compilation is often a first step toward more effective asset management, the availability of internationally comparable data on nonfinancial assets is limited, and some countries report only subcategories. Moreover, some countries report data only for the central government rather than for general government or the public sector. Achieving a full, global picture of governments' balance sheets will require broader data coverage and the resolution of differences in accounting methods.

The authors of this box are Rob Dippelsman, Gary Jones, Kara Rideout, and Florina Tanase.

[1]The IMF's *Government Finance Statistics Manual 2001* (GFSM 2001) and its update, the *Government Finance Statistics Manual 2014* (GFSM 2014), provide guidance on compiling such information.

Figure 3.3.1. General Government Assets and Liabilities, 2012
(Percent of GDP)



Sources: IMF, *Government Finance Statistics Yearbook;* Organisation for Economic Co-operation and Development; and IMF staff calculations.
Note: Data labels in the figure use International Organization for Standardization country codes.

Table 3.3.1. Summary Classification of Nonfinancial Assets

61	Nonfinancial assets		
611	Fixed assets	612	Inventories
6111	Buildings and structures	613	Valuables
61111	Dwellings	614	Nonproduced assets
61112	Buildings other than dwellings	6141	Land
61113	Other structures	6142	Mineral and energy resources
61114	Land improvements	6143	Other naturally occurring assets
6112	Machinery and equipment	61431	Noncultivated biological resources
61121	Transport equipment	61432	Water resources
61122	Machinery and equipment other than transport equipment	61433	Other natural resources
6113	Other fixed assets	6144	Intangible nonproduced assets
61131	Cultivated biological resources	61441	Contracts, leases, and licenses
61132	Intellectual property products	61442	Goodwill and marketing assets
6114	Weapons systems		

Source: IMF, *Government Finance Statistics Manual 2001*.

Box 3.4. The Macroeconomic Effects of Scaling Up Public Investment in Developing Economies

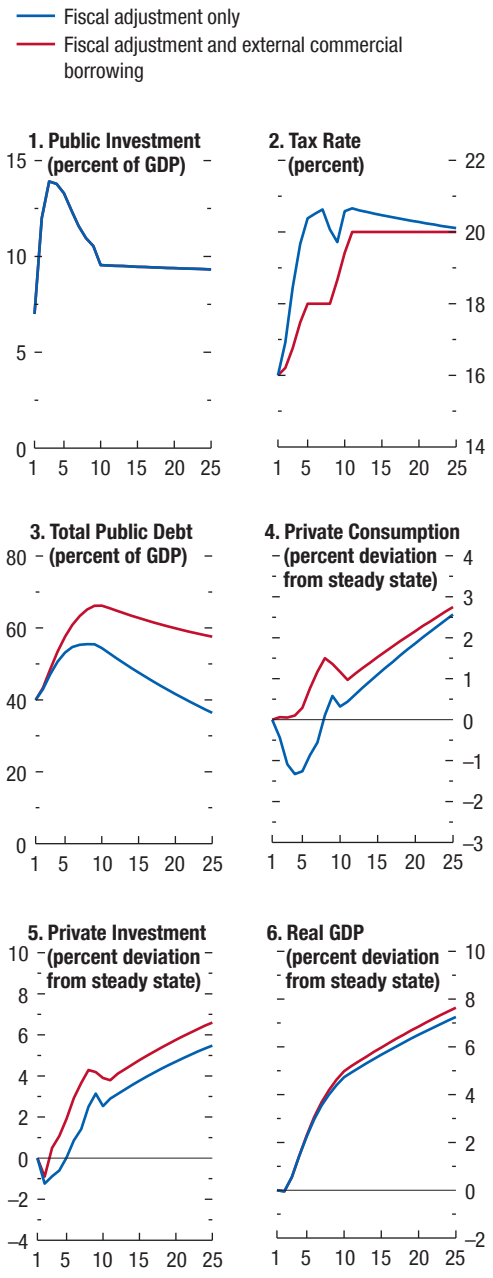
Scaling up public investment can spur economic advancement in developing economies, but it can also involve some major macroeconomic challenges and trade-offs regarding growth and debt sustainability. This box discusses some of these benefits and challenges, paying particular attention to some factors that shape the effects on growth and debt sustainability. The effects of investment depend not only on the rate of return of public capital (relative to the cost of funding), but also on the type of financing, the efficiency of public investment, the response of the private sector, and the authorities' ability to implement fiscal adjustment and manage debt. To illustrate the discussion, the box uses the Debt, Investment, and Growth model developed by Buffie and others (2012), which is calibrated to capture aspects pertinent to low-income countries, such as low public investment efficiency, limited absorptive capacity, and limited access to international and domestic borrowing.[1]

Figure 3.4.1 presents the macroeconomic effect of scaling up public investment in low-income countries. In particular, it assumes that the public-investment-to-GDP ratio increases from the current level of about 7 percent of GDP to 14 percent of GDP in about three years and then stabilizes at about 9 percent of GDP. The results of the simulation show that such an increase can generate substantially greater output over the long term (by about 7 percent after 25 years), but it can also raise the debt-to-GDP ratio in the short to medium term, even though part of the scaling up is financed with concessional loans and grants (blue lines in the figure). In the absence of nonconcessional external borrowing, taxes must increase sharply in the short to medium term, leading to a crowding out of private investment and consumption. The more ambitious and front-loaded the increase in public investment, the larger the increase in taxes and its associated effects tend to be.

The author of this box is Felipe Zanna.

[1]The Debt, Investment, and Growth model is a real, dynamic, open economy framework with several production sectors that use public capital as an input; it allows for different financing strategies (external concessional, external commercial, domestic) and various fiscal rules that respond to debt paths. In the model, efficiency is set to 0.5—that is, 1 dollar of public investment can translate into 0.5 dollar of public capital—a ratio in line with estimates in Pritchett 2000. See also Dabla-Norris and others 2012. The return to public capital is calibrated to 25 percent, which is close to values provided by Foster and Briceño-Garmendia (2010) and Dalgaard and Hansen (2005).

Figure 3.4.1. Role of Type of Financing in Scaling Up Public Investment in Low-Income Countries
(Years on x-axis)



Source: IMF staff estimates.

Box 3.4 *(continued)*

Nonconcessional external borrowing can help bridge financing gaps and smooth difficult macroeconomic adjustments in the short to medium term. With more borrowing, debt-to-GDP ratios can be expected to increase for some time, but this additional financing can help ease the fiscal adjustment and prevent the crowding out of private consumption and investment (Figure 3.4.1). These gains from additional nonconcessional debt should, however, be balanced against the risks associated with this type of financing. Policymakers may put off necessary tax increases and expenditure cuts while continuing to borrow on nonconcessional terms, thus potentially saddling the country with a high ratio of debt to GDP.

Resource-rich developing economies may have additional resources to finance investment increases, but they also face additional challenges. Natural resources provide a valuable opportunity to invest those resources domestically to speed up development (see Collier and others 2010 and van der Ploeg and Venables 2011). Resource-rich economies should design mechanisms to prevent boom-bust cycles. They can do so by incorporating in their plans the implications of the volatility of resource prices and the exhaustibility of reserves, as well as by establishing a resource fund.[2] Such economies should also be cautious about borrowing in advance (before resource revenues materialize) to start investment programs.[3]

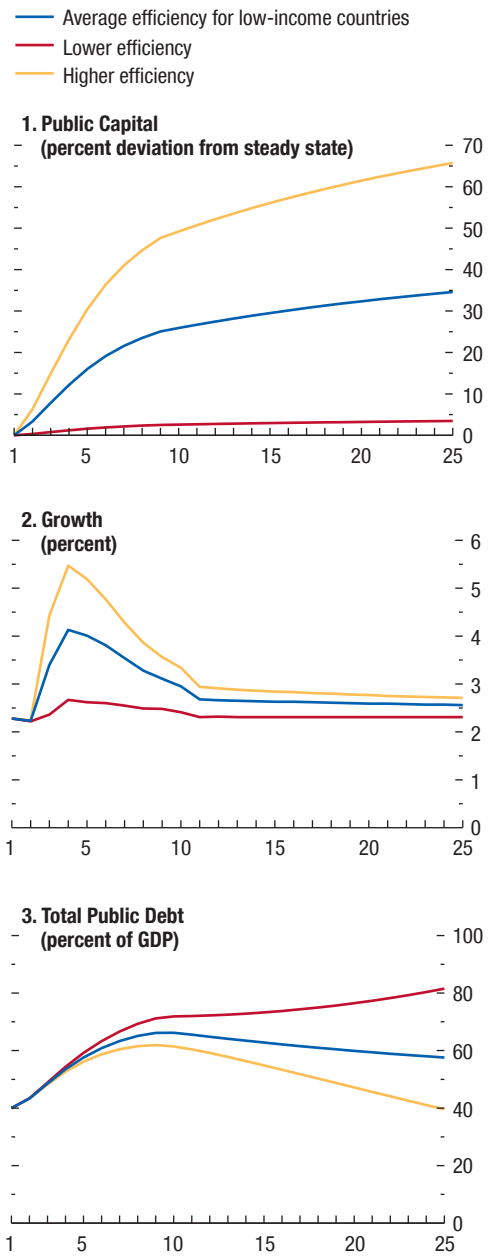
The macroeconomic effect of increasing public investment hinges on countries' structural characteristics, especially the efficiency of such investment. In particular, in countries with high investment efficiency, more public investment may lead to significant growth effects and a decline in the debt-to-GDP ratio in the long term (after 25 years). In countries with low investment efficiency, however, it may lead to low growth dividends and unsustainable debt dynamics (Figure 3.4.2).

Overall, reaping the growth and development benefits of greater public investment while minimizing the risks to debt sustainability in developing economies will require policymakers to improve public investment efficiency, debt management capacity, and fiscal flexibility.

[2]A resource fund works as a fiscal buffer mechanism that saves resource revenues in boom times that can be drawn down to support investment spending during periods of low resource revenues. See Berg and others 2013 and Melina, Yang, and Zanna 2014.

[3]In the 1970s era of soaring commodity prices, many developing economies used their natural resources as collateral for loans to undertake ambitious projects. When prices plummeted in the 1980s, these economies suffered debt crises (Gelb 1988; Manzano and Rigobón 2007).

Figure 3.4.2. Role of Improving Public Investment Efficiency in Low-Income Countries
(Years on x-axis)



Source: IMF staff estimates.

Box 3.5. Fiscal Institutions, Rules, and Public Investment

Budget institutions affect fiscal policy outcomes and shape the composition of the budget, including the share of resources devoted to investment spending. For example, stronger planning institutions have been associated with smaller cuts in public investment over the past four years (Figure 3.5.1, panel 1, and IMF 2014).

Budget rules also affect public investment spending, especially in the case of the so-called golden rule of public finance. This rule calls for excluding net investment spending from the budget balance against which implicit or explicit fiscal discipline targets are applied. The idea behind the rule is that a government, like a private company, should not attribute to one year the full cost of projects expected to generate gains over several years.

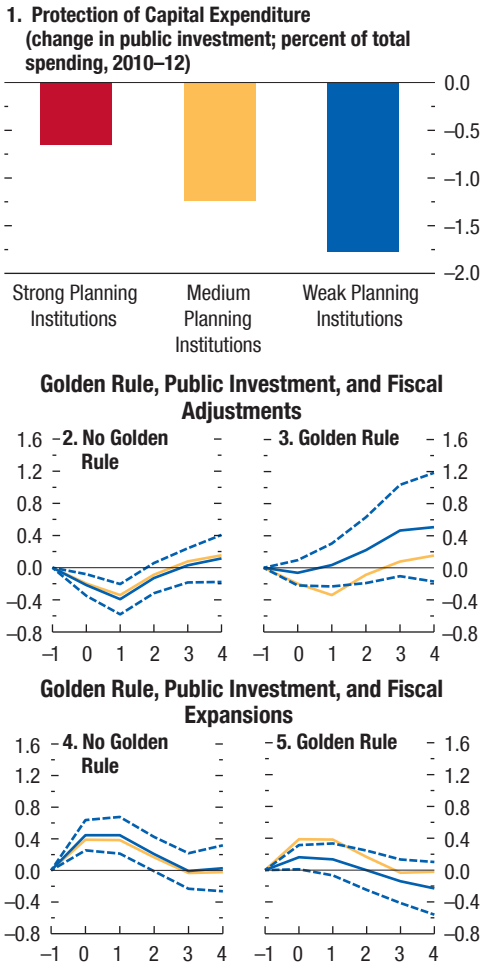
Several arguments have been advanced in favor of the golden rule.[1] First, financing investment out of current revenue may conflict with other spending objectives of policy authorities or with institutional or political constraints. Under such conditions, amending the budget constraint with a golden rule may allow a rise in productive investment, which adds to the stock of public capital and raises output. Second, the golden rule takes into account that borrowing to finance productive public investment could pay for itself over the longer term, both through user fees and through higher tax revenues resulting from higher output. Third, spreading the costs of public investment over time promotes intergenerational equity, shifting part of the cost of investment to future beneficiaries. Finally, if public investment is productive, a balanced current budget is consistent with a positive, steady-state ratio of public debt to GDP and with optimal fiscal policy.

The golden rule can also entail significant budgetary and economic development risks (see for example Balassone and Franco 2000 and Buiter 2001). First, in the presence of excess demand, public investment should be part of the fiscal adjustment required to bring domestic absorption into line with resource availability. Second, investments carry no guarantee of success, and even public investments that significantly boost economic growth may not reduce budgetary pressures if the tax base is limited or tax enforcement is weak. Third, freeing public investment from fiscal constraints may

The authors of this box are Davide Furceri and Carlos Mulas Granados.

[1]See for example Fitoussi and Creel 2002 and Blanchard and Giavazzi 2004.

Figure 3.5.1. Fiscal Policies and Public Investment



Source: IMF staff calculations.
Note: Panel 1 presents averages of scores on four dimensions: clear and transparent medium-term fiscal objectives, medium-term budget frameworks, performance orientation of the budget, and intergovernmental fiscal arrangements. Countries are categorized into one of three groups (strong, medium, weak) based on their average score in each of these four subgroups. Countries that scored in the top third overall are categorized as "strong," those in the middle third "medium," and those in the bottom third "weak." See IMF 2014. For panels 2 through 5, $t = 0$ is the year of the shock, dashed lines denote 90 percent confidence bands, and solid yellow lines represent the baseline result. See note 2 in the text for a list of countries that had or currently have a golden rule.

Box 3.5 *(continued)*

discriminate against desirable forms of private involvement in infrastructure, such as when it brings efficiency to the investment, and it may bias spending toward physical capital and sacrifice current expenditure on human capital such as health and education spending. Finally and importantly, the golden rule may induce creative accounting that excludes some current spending from fiscal targets by classifying it as investment. Strong institutional capacity is therefore needed to ensure that adopting the golden rule achieves its objective without raising fiscal risks. Moreover, in countries with serious concerns about debt sustainability, implementing the golden rule may simply not be feasible because there are few alternatives to focusing on the overall balance.

Has the golden rule been effective in protecting public investment from fiscal contractions? A novel database, the IMF's Fiscal Rules Dataset, facilitates an empirical investigation of this question for a set of 56 economies, including 6 with the golden rule in place at some point during 1985–2013.[2]

The way the golden rule shapes how fiscal adjustments affect public investment as a share of GDP is estimated using the following empirical specification:

$$\begin{aligned} y_{i,t+k} - y_{i,t} = {} & \alpha_i^k + \gamma_t^k + \beta_1^K GR_{i,t} FA_{i,t} \\ & + \beta_2^K (1 - GR_{i,t}) FA_{i,t} + \delta GR_{i,t} \\ & + \vartheta X_{i,t} + \varepsilon_{i,t}^k, \end{aligned} \qquad (3.5.1)$$

in which y is public investment as share of GDP; α_i are country fixed effects; γ_t are time fixed effects; $GR_{i,t}$ is a dummy variable that equals one when country i has in place a golden rule in year t; X is a vector of control variables, including lags of output growth and debt-to-GDP ratio; and FA is a dummy that equals one for the starting year t of the fiscal adjustment in each country i and zero otherwise. Fiscal consolidation (expansion) episodes are identified as two-year periods in which the cyclically adjusted primary-balance-to-GDP ratio improves (deteriorates) in each year and the cumulative improvement (deterioration) is equivalent to at least 2 percent of GDP (Alesina and Ardagna 2012).

The results (Figure 3.5.1) show that the golden rule has helped preserve public investment following periods of fiscal contraction (while having no statistically significant effect following periods of fiscal expansion). In particular, although public investment declined by about 0.4 percentage point of GDP on average one year after a consolidation episode in countries with no golden rule in place, the decline in investment was significantly smaller in countries with a golden rule. These results have to be interpreted with caution, however, because causality is difficult to establish. The results are robust to the inclusion of a broader sample of 18 countries with rules that fully or partially exclude public investment from the ceiling.

In recent years, a number of advanced economies have improved the design of their fiscal rules by adopting so-called second-generation fiscal rules, which allow for greater flexibility to accommodate shocks while maintaining the government's commitment to medium- and long-term fiscal sustainability (IMF 2014). The European countries with the largest economies (France, Germany, Italy, United Kingdom) have taken steps to enshrine their fiscal rules in law. Other advanced economies, including Australia, Canada, Japan, and Korea, have more clearly specified their fiscal policy objectives and rules without embedding them in law.

Fiscal rules are also increasingly supported by more comprehensive and binding medium-term expenditure frameworks. Since 2010, Germany, Italy, and the United Kingdom have strengthened their medium-term budget frameworks by either improving their institutional coverage or tightening multiyear expenditure limits.

[2]The database covers 56 advanced, emerging market, and developing economies, of which 9 had a golden rule in place at some point between 1985 and 2013 (Brazil, Costa Rica, Germany, Japan, Kosovo, Liberia, Malaysia, Pakistan, United Kingdom). Database limitations for Kosovo, Liberia, and Malaysia restrict the present analysis of golden-rule countries to the remaining 6.

References

Abbas, S. Ali, Nazim Belhocine, Asmaa ElGanainy, and Mark Horton. 2010. "A Historical Public Debt Database." IMF Working Paper 10/245, International Monetary Fund, Washington.

Abiad, Abdul, Aseel Almansour, Davide Furceri, and Petia Topalova. Forthcoming. "Estimating Current Infrastructure Needs." IMF Working Paper, International Monetary Fund, Washington.

Adam, Christopher, and David Bevan. 2014. "Public Investment, Public Finance, and Growth: The Impact of Distortionary Taxation, Recurrent Costs, and Incomplete Appropriability." IMF Working Paper 14/73, International Monetary Fund, Washington.

Akitoby, Bernardin, Richard Hemming, and Gerd Schwartz. 2007. "Public Investment and Public-Private Partnerships." IMF Economic Issues 40, International Monetary Fund, Washington.

Akitoby, Bernardin, and Thomas Stratmann. 2008. "Fiscal Policy and Financial Markets." *Economic Journal* 118 (533): 1971–85.

Albino-War, Maria, Svetlana Cerovic, Juan Carlos Flores, Francesco Grigoli, Javier Kapsoli, Haonan Qu, Yahia Said, and others. Forthcoming. "Making the Most of Public Investment in Oil-Exporting Countries." Staff Discussion Note, International Monetary Fund, Washington.

Alesina, Alberto, and Silvia Ardagna. 2012. "The Design of Fiscal Adjustments." NBER Working Paper 18423, National Bureau of Economic Research, Cambridge, Massachusetts.

American Society of Civil Engineers. 2013. 2013 Report Card for America's Infrastructure. Reston, Virginia.

Arezki, Rabah, Patrick Bolton, Sanjay Peters, and Frederic Samama. Forthcoming. "Global Infrastructure as an Asset Class: A Policy Proposal." IMF Working Paper, International Monetary Fund, Washington.

Aschauer, David Alan. 1989. "Is Public Expenditure Productive?" *Journal of Monetary Economics* 23 (2): 177–200.

Auerbach, Alan, and Yuriy Gorodnichenko. 2012. "Fiscal Multipliers in Recession and Expansion." NBER Working Paper 17447, National Bureau of Economic Research, Cambridge, Massachusetts.

———. 2013. "Measuring the Output Responses to Fiscal Policy." *American Economic Journal: Economic Policy* 4 (2): 1–27.

———. 2014. "Fiscal Multipliers in Japan." NBER Working Paper 19911, National Bureau of Economic Research, Cambridge, Massachusetts.

Balassone, Fabrizio, and Daniele Franco. 2000. "Public Investment, the Stability Pact and the 'Golden Rule.'" *Fiscal Studies* 21(2): 207–29.

Beetsma, Roel, Massimo Giuliodori, and Franc Klaassen. 2009. "Temporal Aggregation and SVAR Identification, with an Application to Fiscal Policy." *Economics Letters* 105(3): 253–55.

Ben Zeev, Nadav, and Evi Pappa. 2014. "Chronicle of a War Foretold: The Macroeconomic Effects of Anticipated Defense Spending Shocks." CEPR Discussion Paper 9948, Centre for Economic Policy Research, London.

Berg, Andrew, Rafael Portillo, Shu-Chun Yang, and Luis-Felipe Zanna. 2013. "Public Investment in Resource-Abundant Developing Countries," *IMF Economic Review* 61 (1): 92–129.

Blanchard, Olivier J., and Francesco Giavazzi. 2004. "Improving the SGP through a Proper Accounting of Public Investment." CEPR Discussion Paper 4220, Centre for Economic Policy Research, London.

Blanchard, Olivier J., and Daniel Leigh. 2013. "Growth Forecast Errors and Fiscal Multipliers." *American Economic Review* 103 (3): 117–20.

Blanchard, Olivier J., and Roberto Perotti. 2002. "An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output." *Quarterly Journal of Economics* 107 (4): 1329–68.

Bom, Pedro R., and Jenny E. Ligthart. Forthcoming. "What Have We Learned from Three Decades of Research on the Productivity of Public Capital?" *Journal of Economic Surveys*.

Born, Benjamin, and Gernot Müller. 2012. "Government Spending Shocks in Quarterly and Annual Time Series," *Journal of Money, Credit and Banking* 44 (2–3): 507–17.

Bova, Elva, Robert Dippelsman, Kara Rideout, and Andrea Schaechter. 2013. "Another Look at Governments' Balance Sheets: The Role of Nonfinancial Assets." IMF Working Paper 13/95, International Monetary Fund, Washington.

Buffie, Edward, Andrew Berg, Catherine Pattillo, Rafael Portillo, and Luis-Felipe Zanna. 2012. "Public Investment, Growth, and Debt Sustainability: Putting Together the Pieces." IMF Working Paper 12/144, International Monetary Fund, Washington.

Buiter, Willem H. 2001. "Notes on 'A Code for Fiscal Stability.'" *Oxford Economic Papers* 53 (1): 1–19.

Calderón, César, Enrique Moral-Benito, and Luis Servén. 2014. "Is Infrastructure Capital Productive? A Dynamic Heterogeneous Approach." *Journal of Applied Econometrics.* Published electronically January 8, 2014. doi: 10.1002/jae.2373.

Calderón, César, and Luis Servén. 2008. "Infrastructure and Economic Development in Sub-Saharan Africa." World Bank Policy Research Working Paper 4712, World Bank, Washington.

Canning, David. 2007. "A Database of World Stocks of Infrastructure: Update 1950–2005." Version 1. http://hdl.handle.net/1902.1/11953. Updated version of "A Database of World Stocks of Infrastructure: 1950–1995," *World Bank Economic Review* 12 (3): 529–48.

Caselli, Francesco. 2005. "Accounting for Cross-Country Income Differences." NBER Working Paper 10828, National Bureau of Economic Research, Cambridge, Massachusetts.

Coenen, Günter, Christopher J. Erceg, Charles Freedman, Davide Furceri, Michael Kumhof, René Lalonde, Douglas Laxton, and others. 2012. "Effects of Fiscal Stimulus in Structural Models." *American Economic Journal: Macroeconomics* 4 (1): 22–68.

Collier, Paul, Frederick van der Ploeg, Michael Spence, and Anthony J. Venables. 2010. "Managing Resource Revenues in Developing Economies." *IMF Staff Papers* 57(1): 84–118.

Corsetti, Giancarlo, Andre Meier, and Gernot J. Müller. 2012. "What Determines Government Spending Multipliers?" IMF Working Paper 12/150, International Monetary Fund, Washington.

Cubeddu, Luis, Alex Culiuc, Ghada Fayad, Yuan Gao, Kalpana Kochhar, Annette Kyobe, Ceyda Oner, and others. 2014. "Emerging Markets in Transition: Growth Prospects and Challenges." IMF Staff Discussion Note 14/06, International Monetary Fund, Washington.

Dabla-Norris, Era, James Brumby, Annette Kyobe, Zac Mills, and Chris Papageorgiou. 2012. "Investing in Public Investment: An Index of Public Investment Efficiency." *Journal of Economic Growth* 17 (3): 235–66.

Dalgaard, Carl-Johan, and Henrik Hansen. 2005. "The Return to Foreign Aid." Discussion Paper 05-04, Institute of Economics, University of Copenhagen.

Delong, J. Bradford, and Lawrence H. Summers. 2012. "Fiscal Policy in a Depressed Economy." *Brookings Papers on Economic Activity* 44 (1): 233–97.

Eden, Maya, and Aart Kraay. 2014. "Crowding In and the Returns to Government Investment in Low-Income Countries." World Bank Policy Research Working Paper 6781, World Bank, Washington.

European Investment Bank. 2010. "Public and Private Financing of Infrastructure: Evolution and Economics of Private Infrastructure Finance." *EIB Papers* 15 (1).

Fitoussi, Jean-Paul, and Jérôme Creel. 2002. *How to Reform the European Central Bank*. London: Centre for European Reform.

Forni, Mario, and Luca Gambetti. 2010. "Fiscal Foresight and the Effects of Government Spending." CEPR Discussion Paper 7840, Centre for Economic Policy Research, London.

Foster, Vivien, and Cecilia Briceño-Garmendia, eds. 2010. *Africa's Infrastructure: A Time for Transformation.* Washington: World Bank.

Fujita, Yasuo. 2012. "Policy Challenges for Infrastructure Development in Asian LICs: Lessons from the Region." JICA-RI Working Paper 40, JICA Research Institute, Tokyo.

Gelb, Alan H. 1988. *Oil Windfalls: Blessing or Curse?* New York: Oxford University Press.

Group of Twenty (G20) Development Working Group. 2011. "Supporting Infrastructure Development in Low-Income Countries." Submission to the G20 by the Multilateral Development Bank Working Group on Infrastructure. Washington.

Gupta, Sanjeev, Alvar Kangur, Chris Papageorgiou, and Abdoul Wane. 2014. "Efficiency-Adjusted Public Capital and Growth." *World Development* 57 (C): 164–78.

Hemming, Richard, Max Alier, Barry Anderson, Marco Cangiano, and Murray Petrie. 2006. *Public-Private Partnerships, Government Guarantees, and Fiscal Risk*. Washington: International Monetary Fund.

International Monetary Fund (IMF). 2013. "Reassessing the Role and Modalities of Fiscal Policy in Advanced Economies." IMF Policy Paper, Washington.

———. 2014. "Budget Institutions in G-20 Countries: An Update." IMF Policy Paper, Washington.

———. Forthcoming. "Toward More Productive Public Investment." IMF Policy Paper, Washington.

Jordà, Òscar. 2005. "Estimation and Inference of Impulse Responses by Local Projections." *American Economic Review* 95 (1): 161–82.

Kamps, Christophe. 2006. "New Estimates of Government Net Capital Stocks for 22 OECD Countries, 1960–2001." *IMF Staff Papers* 53 (1): 120–50.

Kraay, Aart. 2012. "How Large Is the Government Spending Multiplier? Evidence from World Bank Lending." *Quarterly Journal of Economics* 127 (2): 829–87.

———. Forthcoming. "Government Spending Multipliers in Developing Countries: Evidence from Lending by Official Creditors." *American Economic Journal: Macroeconomics*.

Kumhof, Michael, and Douglas Laxton. 2007. "A Party without a Hangover? On the Effects of U.S. Government Deficits." IMF Working Paper 07/202, International Monetary Fund, Washington.

Kumhof, Michael, Dirk Muir, and Susanna Mursula. 2010. "The Global Integrated Monetary and Fiscal Model (GIMF)—Theoretical Structure." IMF Working Paper 10/34, International Monetary Fund, Washington.

Leeper, Eric M., Alexander W. Richter, and Todd B. Walker. 2012. "Quantitative Effects of Fiscal Foresight." *American Economic Journal: Economic Policy* 4 (2): 115–44.

Leeper, Eric M., Todd B. Walker, and Shu-Chun S. Yang. 2013. "Fiscal Foresight and Information Flows." *Econometrica* 81 (3): 1115–45.

Lenain, Patrick. 2002. "What Is the Track Record of OECD Economic Projections?" Organisation for Economic Cooperation and Development, Paris.

Manzano, Osmel, and Roberto Rigobón. 2007. "Resource Curse or Debt Overhang?" In *Natural Resources: Neither Curse nor Destiny*, edited by Daniel Lederman and William F. Maloney. Washington: World Bank.

McKinsey Global Institute. 2013. *Infrastructure Productivity: How to Save $1 Trillion a Year*. Seoul.

Melina, Giovanni, Shu-Chun S. Yang, and Luis-Felipe Zanna. 2014. "Debt Sustainability, Public Investment, and Natural Resources in Developing Countries: The DIGNAR Model." IMF Working Paper 14/50, International Monetary Fund, Washington.

Organisation for Economic Co-operation and Development (OECD). 2014. *Pooling of Institutional Investors Capital—Selected Case Studies in Unlisted Equity Infrastructure*. Paris.

Ostry, Jonathan D., Atish R. Ghosh, and Raphael Espinoza. 2014. "Public Debt, Public Investment, and Growth: Normative Considerations." Unpublished, International Monetary Fund, Washington.

Perotti, Roberto. 1999. "Fiscal Policy in Good Times and Bad." *Quarterly Journal of Economics* 114 (4): 1399–436.

Pritchett, Lant. 2000. "The Tyranny of Concepts: CUDIE (Cumulated, Depreciated, Investment Effort) Is Not Capital." *Journal of Economic Growth* 5 (4): 361–84.

Rioja, Felix. 2013. "What Is the Value of Infrastructure Maintenance? A Survey." In *Infrastructure and Land Policies,* edited by Gregory K. Ingram, and Karin L. Brandt. Cambridge, Massachusetts: Lincoln Institute of Land Policy.

Romp, Ward, and Jakob de Haan. 2007. "Public Capital and Economic Growth: A Critical Survey." *Perspectiven der Wirtschaftspolitik* 8 (S1): 6–52.

Staiger, Douglas, and James Stock. 1997. "Instrumental Variables Regression with Weak Instruments." *Econometrica* 65 (3): 557–86.

Stock, James H., and Mark W. Watson. 2007. "Why Has U.S. Inflation Become Harder to Forecast?" *Journal of Money, Credit and Banking* 39 (S1): 3–33.

Straub, Stephane. 2011. "Infrastructure and Development: A Critical Appraisal of the Macro-level Literature." *Journal of Development Studies* 47 (5): 683–708.

Summers, Lawrence H. 2013. Remarks in honor of Stanley Fischer. Fourteenth Jacques Polak Annual Research Conference, International Monetary Fund, Washington, November 7–8.

Syed, Murtaza, Kenneth Kang, and Kiichi Tokuoka. 2009. "'Lost Decade' in Translation: What Japan's Crisis Could Portend about Recovery from the Great Recession." IMF Working Paper 09/282, International Monetary Fund, Washington.

Teulings, Coen, and Richard Baldwin, eds. 2014. *Secular Stagnation: Facts, Causes and Cures. VoxEU*, August 15. http://www.voxeu.org/content/secular-stagnation-facts-causes-and-cures.

United States International Trade Commission. 2009. "Sub-Saharan Africa: Effects of Infrastructure Conditions on Export Competitiveness, Third Annual Report." Investigation 332-477, Washington.

van der Ploeg, Frederick, and Anthony J. Venables. 2011. "Harnessing Windfall Revenues: Optimal Policies for Resource-Rich Developing Economies," *Economic Journal* 121 (551): 1–30.

Vogel, Lukas. 2007. "How Do the OECD Growth Projections for the G7 Economies Perform? A Post-mortem." OECD Working Paper 573, Organisation for Economic Co-operation and Development, Paris.

Warner, Andrew M. 2014. "Public Investment as an Engine of Growth." IMF Working Paper 14/148, International Monetary Fund, Washington.

World Bank. 1994. "Overview" and "Infrastructure: Achievements, Challenges, and Opportunities. In *World Development Report 1994: Infrastructure for Development*, 1–26. Oxford: Oxford University Press.

———. Forthcoming. *Global Financial Development Report 2015: Long-Term Finance*. Washington.

World Economic Forum. 2010. *Paving the Way: Maximizing the Value of Private Finance in Infrastructure.* New York.