CHAPTER 2

PUBLIC INVESTMENT FOR THE RECOVERY

Introduction

The immediate focus of governments during the COVID-19 crisis thus far has appropriately been to address the health emergency and provide lifelines for vulnerable households and businesses. Governments now also need to prepare economies for safe and successful reopening, foster recovery in employment and economic activity, and facilitate transformation to a post-pandemic economy that, with the right policies, can be more resilient, more inclusive, and greener. Public investment can make a crucial contribution toward these goals (see a discussion of the fiscal strategy for the recovery in Chapter 1 and Table 2.1).[1] This chapter outlines how governments can undertake public investment in a timely manner while safeguarding quality, estimates the potential for public investment to create jobs and boost growth, and sets out priorities for the types of investment that will strengthen resilience and sustainability.

From a macroeconomic standpoint, the case for public investment is strongest in advanced economies and many emerging market economies that—with nominal interest rates and inflation expected to remain at historic lows—can easily finance an investment scale-up. In many cases, borrowing to finance high-quality investment will be desirable, since cheap financing lowers the bar for whether to undertake an investment. In addition, the assets created generate taxable returns and are valued by markets when they price sovereign risk (October 2018 *Fiscal Monitor*). However, policymakers should ensure that the amount and quality of public investment are such as not to pose risks by overly worsening debt dynamics, especially for countries that do not issue reserve currencies. Abrupt changes in global market sentiment can result in sudden increases in financing costs (Caceres, Guzzo, and Segoviano 2010; Lizarazo 2013), and sovereign spreads tend to increase only shortly before debt crises (Mauro and Zhou 2019).

With ample underused resources, public investment can also have a more powerful impact than in normal times. Public investment and its crowding-in effects on private investment could mitigate secular stagnation and the savings glut, which predate the onset of COVID-19 (Rachel and Summers 2019; Eggertsson, Mehrotra, and Robbins 2019) but have been exacerbated by the crisis, since uncertainty about the course of the pandemic has further dampened private investment and spurred higher levels of precautionary saving. Moreover, the recovery of private sector activity is being constrained by weakened private sector balance sheets, losses in human capital because of unemployment, and skill mismatches as demand shifts from high-contact sectors to those that permit social distancing. Public investment can encourage investment from businesses that might otherwise postpone their hiring and investment plans.

For low-income developing countries and some advanced and emerging market economies, however, deteriorating debt dynamics and, in many cases, tight financing conditions have and will likely continue to constrain investment, especially in those economies with high levels of external debt denominated in foreign currency. Sizable market borrowing could increase risk premiums for both the public and the private sectors, undermining the short-term growth benefits of investment spending (Huidrom and others 2019). Based on preliminary information, financing constraints and competing spending priorities to save lives and livelihoods have caused many middle- and—especially—low-income countries to put domestically financed investment projects on hold (Chapter 1). Even so, a gradual scaling-up of public investment financed by borrowing could pay off with positive short- and long-term multipliers, as long as interest rates do not increase too much (Buffie and others 2012; Online Annex 2.1) and governments choose and manage investment projects to maximize economic

[1]Public investment usually refers to gross fixed capital formation (total value of acquisitions, less disposals, of fixed assets) by the state, whether through central or local governments or through publicly owned industries or corporations (see the April 2020 *Fiscal Monitor* for an analysis of the role of state-owned enterprises). Public investment encompasses physical or tangible investment in infrastructure (such as transport, telecommunications, and buildings), but in a broader sense, public investment can include human or intangible investment in education, skills, and knowledge.

Table 2.1. Public Investment in the Strategy for the Recovery

Phase	1. Great Lockdown	2. Partial Reopening	3. Post-Pandemic
Priority	Save lives and livelihoods	Safe reopening where possible	Transform to more inclusive, smart, and sustainable economies
Key fiscal policies	Lifelines for people and firms	Preserve lifelines; target support better; encourage workers to take new jobs	Depending on fiscal space, consider fiscal stimulus, repair balance sheets
Role of public investment	Continue projects where safe, start planning	Boost maintenance and job-rich projects; reassess priorities; prepare pipeline	Satisfy infrastructure needs and support progress toward the SDGs; increase resilience to crises
Preferable project characteristics	Maintenance	Maintenance; ready for implementation; small-size, job-intensive with large short-term multiplier	Large, transformational projects with large long-term multiplier
Public investment management actions	Review portfolio of planned and active projects	Review, reprioritize, restart feasible projects put on hold; plan for new priorities; prepare pipeline of appraised projects to be implemented within 24 months	Strengthen project planning, budgeting, and implementation practices to improve public investment efficiency
Priority sectors	Health	Health, including R&D in vaccine and therapeutics; water and sanitation; digital; safe buildings, schools and transportation	Health; climate change adaptation and mitigation; digital

Source: IMF staff.

Note: Countries do not necessarily progress smoothly through all phases of pandemic. Appropriate fiscal responses will be country-specific depending on the fiscal space, the development of the pandemic, and the strength of the recovery. Measures included here are not exhaustive. R&D = research and development; SDGs = Sustainable Development Goals.

returns for their citizens. Official support, especially if combined with private finance, would also help middle- and low-income countries scale up public investment significantly.

Thus, the quality and content of fiscal policy packages—and within them, public investment choices—will be key to supporting the economy and creating jobs in the near term but will also determine socioeconomic outcomes for decades. The stakes are high: although today's large fiscal packages are necessary, they will have long-lasting implications—directly, through choices made about expenditures and investments, and indirectly, by calling for lower levels of discretionary spending or higher levels of taxation if borrowing costs rise significantly in the years ahead.

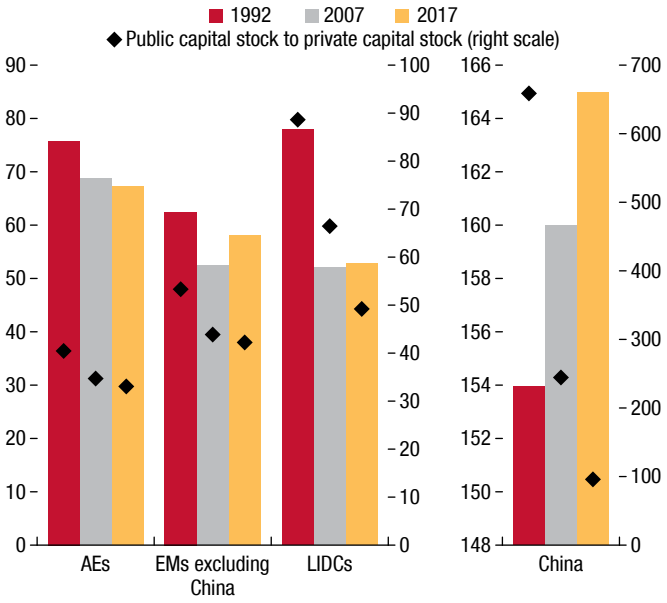
Beyond its macroeconomic implications, public investment is essential to raise long-term economic growth, to progress toward the Sustainable Development Goals (SDGs), and to strengthen economies' resilience to crises. In the long term, public investment in infrastructure can help reduce inequality by fostering structural transformation, which also facilitates regional convergence between rural and urban areas in low-income economies (Fabrizio and others 2017). Public investment has a further advantage: it preserves fiscal space, because it is by nature temporary. But policymakers need to ensure that the conditions outlined in this chapter are in place for choosing and implementing investments with the highest social payoffs.

Investment needs were clearly large before the pandemic and have increased since its onset. Public investment has slowed since the 1990s, reducing the capital-stock-to-GDP and public-to-private-capital ratios in all income groups (Figure 2.1; China is an exception).[2] Public investment ratios have been falling, especially in the health, housing, and environmental protection sectors, weakening societies' resilience to COVID-19, whereas investments in education and economic infrastructure have been preserved (Figure 2.2). Given public capital stock measurement issues such as discounting of flows (Pritchett 2000) and the limited institutional coverage in cross-country data sets, it is also worth looking at data on physical infrastructure.

Over the past decade or so, traditional infrastructure stocks have not risen fast enough. For example, between 2007 and 2016, the total number of miles of roads increased by a cumulative 56 percent in low-income countries and by 33 percent in emerging market economies; the number was nearly unchanged

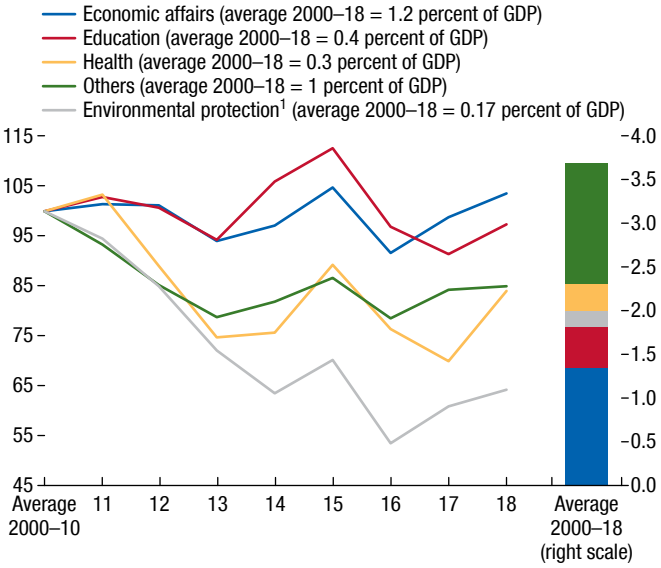
[2]In China, public capital stocks have increased, but traditional infrastructure investment may have reached a point of low returns, as the halving of total factor productivity growth in China after 2009 suggests (IMF 2019).

Figure 2.1. Public Capital Stocks, 1992, 2007, and 2017
(Ratio to GDP, left scale; ratio to private capital, right scale)



Source: IMF Investment and Capital Stock Dataset.
Note: The high ratio in low-income countries could hide statistical issues with the construction of a stock variable by cumulating flows, especially with inefficiencies in public investment management systems (Gupta and others 2014). "Public investment" refers to gross fixed capital formation by the general government. AEs = advanced economies; EMs = emerging markets; LIDCs = low-income developing countries.

Figure 2.2. Public Investment/GDP in Advanced Economies and Emerging Market Economies, 2000–18
(Ratio to GDP, left scale; ratio to private capital, right scale; index 100 = average 2000–10)



Sources: Organisation for Economic Co-operation and Development; and IMF staff estimates.
Note: Public investment refers to gross fixed capital formation by the general government. "Others" includes general public services, defense, social protection, housing, and so on.
[1]Covers waste management, protection of biodiversity, and so on.

in advanced economies.[3] This falls well short of estimated needs, especially for emerging market economies in which the demand for transportation is expected to more than double in the next two decades (Hellebrandt and Mauro 2016).

Digital infrastructure, which benefited from private investments, has grown much faster, but substantial gaps remain across countries. Between 2007 and 2018, the share of the population with internet access rose from 3 percent to 32 percent in low-income countries, from 16 percent to 72 percent in emerging market economies, and from 64 percent to 86 percent in advanced economies. These sizable digital gaps have adverse consequences for both economic convergence across countries and inclusive growth within countries (Broadband Commission 2019; April 2020 *Regional Economic Outlook: Sub-Saharan Africa*). Spending on digital infrastructure is essential and will have to be timely to provide countries with the ability to support social-distancing policies (Chiou and Tucker 2020), put in place a sophisticated contact-tracing system, improve cash transfer systems geared toward the poor (see Chapter 2 of the April 2020 *Fiscal Monitor*), and enable remote schooling and work.

The additional investment needed through 2030 to reach the SDGs for roads, electricity, water, and sanitation has been estimated at 2.7 percent of GDP and 9.8 percent of GDP per year in emerging markets and low-income developing countries, respectively (Gaspar and others 2019; Xiao, D'Angelo, and Lê 2020).[4]

Finally, investment needs for mitigation and adaptation to climate change are also sizable and crucial. Globally, as part of a policy package to reduce emissions to a level consistent with a target of a 2°C increase in temperature, energy investments, public and private, would have to rise from 2.0 to 2.3 percent of GDP by 2030 (October 2019 *Fiscal Monitor*;

[3]Data from the International Road Foundation's *World Road Statistics* (roads) and the World Bank's *World Development Indicators* (internet access).

[4]The estimates rely on economic projections from before COVID-19 (as per the October 2019 *World Economic Outlook*) and cover public and private investments. Gaspar and others (2019) express the estimates as a percentage of 2030 GDP. Xiao, D'Angelo, and Lê (2020) express them as a percentage of average GDP over the period 2019–2030. The figures in the text follow the latter.

see also the October 2020 *World Economic Outlook* for an analysis of the macroeconomic impact of climate change mitigation policies). A major challenge will be to change dramatically the composition of investment toward low-carbon technologies. Public investment needs for adaptation to climate change are also large, as documented at the end of this chapter.

This chapter explores how, and under which circumstances, increasing public investment can be an effective strategy for the recovery from the COVID-19 pandemic. Specifically, it asks (1) how investment can be accelerated and scaled up in the near term while retaining quality, (2) to what extent investment will foster job creation, (3) how the fiscal multiplier of investment could depend on different circumstances before and after the pandemic is brought under control, and (4) how investment can render societies more resilient to health crises and to the impacts of climate change.

A Timely and Effective Push to Investment

As part of stimulus packages, governments often hope to rely on "shovel-ready" projects that can be kick-started within a few months. Yet countries may find they have few such projects and thus may not be able to increase public investment in time to fight the current recession (Jones and Rothschild 2011). To support recovery, public investment needs to be timely while maintaining project quality. Four steps should be taken immediately: (1) focus on maintenance of existing infrastructure, (2) review and reprioritize active projects, (3) create and maintain a pipeline of projects that can be delivered within a couple of years, and (4) start planning for the new development priorities stemming from the crisis. These steps will facilitate identification of good investments that can be started immediately and projects that will prepare economies for the future.

Maintenance and COVID-19-Proofing

The case for boosting maintenance investment during a crisis is powerful: maintenance projects are relatively small, of short duration, and often less complex. Maintenance is even more attractive during the current pandemic, because lower infrastructure usage makes maintenance less disruptive than in normal times. Beyond maintenance, the current pandemic creates an urgent need for smaller, shorter-duration projects, not only in the health care sector, but also to facilitate social distancing in work and school activities, on transportation, and in public spaces. Such projects include both physical adaptation (for example, greater spacing and transparent barriers) and greater access to digital technologies. Empirical evidence and past experience relate primarily to maintenance and provide helpful lessons for the current situation.

Maintenance can be deployed quickly and has major economic benefits. The US American Recovery and Reinvestment Act of 2009 directed about 60 percent of the funds allocated to highways at repair or improvement, and most of the associated projects were completed within two years (GAO 2011). Maintenance contributes to preserving the substantial economic gains from investing in infrastructure: it alleviates the wear of assets, sustains the quality of service, contributes to the prevention of hazards, and limits waste, thus helping the environment (Wang and others 2020; Blazey, Gonguet, and Stokoe 2020). Fixing water network leaks in developing countries could prevent their losing the equivalent of the daily needs of 200 million people (Kingdom, Liemberger, and Marin 2006). Failure to perform routine maintenance now also increases costs later as assets depreciate faster: rehabilitation and replacement costs increase by 50 and 60 percent down the line in the transportation and the water and sanitation sectors, respectively (Rozenberg and Fay 2019).

But maintenance is often structurally underfunded. In many advanced economies, infrastructure assets need repair and are nearing the end of their typical life spans. In France, one-quarter of drinkable water pipes have reached their maximum life spans. According to Organisation for Economic Co-operation and Development (OECD) data, amounts spent on maintenance on roads, railways, waterways, and sea and air transport infrastructure in advanced economies ranged between 0.1 and 1 percent of GDP in 2018. Spending does not cover all needs: in the United States, the (one-time) expenditure needed to cover the backlog of highway and bridge repairs is estimated at 3.5 percent of GDP, and 20 percent of dams are considered to have high hazard potential (ASCE 2018). In emerging market and developing economies, ensuring a steady flow of maintenance spending will be key to achieving infrastructure SDGs, with average annual estimated costs of 2.75 percent of GDP (Rozenberg and Fay 2019).

To spend efficiently on maintenance projects in the short term, governments should first identify where pressing needs lie. Advanced economies can often

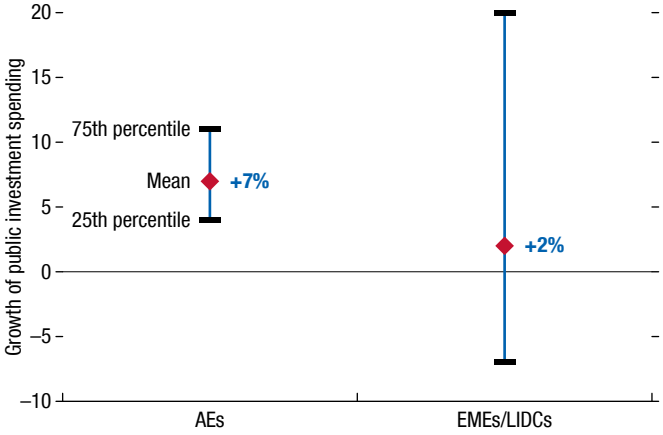
rely on asset registers and information systems. In lower-capacity settings, central authorities can build on the sectoral expertise of line ministries and local governments. Countries should consider shifting to a life cycle approach for public investment projects, which includes identifying maintenance needs at appraisal based on standards and methodologies set in each country's legal framework, securing funding for maintenance, and investing in systems to collect asset performance data. An integrated preparation of capital and current expenditure budgets, with a medium-term perspective, is needed to prevent mismatches between infrastructure assets and their maintenance needs, both routine and capital. Budgets should also report maintenance spending exhaustively. And capital maintenance projects should be selected and prioritized as part of countries' wider public investment strategy: in particular, governments should review their asset portfolios to ascertain whether maintaining existing assets is less efficient than replacing them (especially when assets are of poor quality in the first place) or leapfrogging to new technologies, which may lead to higher long-term benefits.

Review and Prioritization of Active Projects

Crises significantly affect public investment portfolios, as projects under implementation may be interrupted or suffer from delays and financing issues. Some countries have shown that construction work can proceed during the Great Lockdown with social distancing: monthly data suggest that so far, advanced economies have maintained investment spending. However, about half of emerging market and developing economies for which data have been collected have had to cut investment spending, likely owing to financing constraints (Figure 2.3). The October 2020 *World Economic Outlook* thus projects that public investment will be lower in 2020 than in 2019 in 72 out of 109 emerging markets and low-income developing countries. The average expected reduction in public investment is 1 percent of GDP for these 72 countries.

Prioritizing and restarting active projects would contribute to the timely delivery of a public investment stimulus. This ideally would require a well-coordinated system for actively monitoring projects, differentiated according to project size, complexity, and stage. Such active monitoring may enable governments to take on board potential needs related to the COVID-19 crisis: revisiting cost-benefit analyses in light of outdated

Figure 2.3. Public Investment Spending, March–June 2020
(Year-over-year percentage change)



Source: IMF staff estimates based on monthly execution numbers, for a sample of 13 countries.
Note: The figure shows the distribution of monthly execution of public investment, deflated by 2019 end-of-year consumer price index. Averages (square) are not weighted. See Online Annex 2.2. AEs = advanced economies; EMEs/LIDCs = emerging market economies/low-income developing countries.

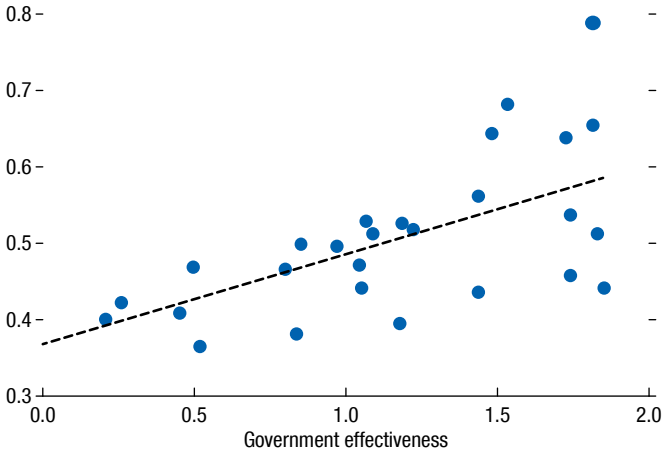
underlying assumptions, renegotiating financing, and procuring new contracts. As crises create uncertainties, new risks should be identified and mitigating measures planned (Monteiro, Rial, and Tandberg 2020).

Establishment of Pipeline of Projects

Selecting projects primarily on the basis of their immediate readiness may impede quality and allocation efficiency by casting aside projects with greater potential than those chosen. Readiness may not be accurately assessed, and even once projects are ready, administrative burden and red tape can slow implementation. In Europe, with only one year remaining in the 2014–20 plan, several countries had spent only 40 percent of the European Structural Funds allocated (Figure 2.4).

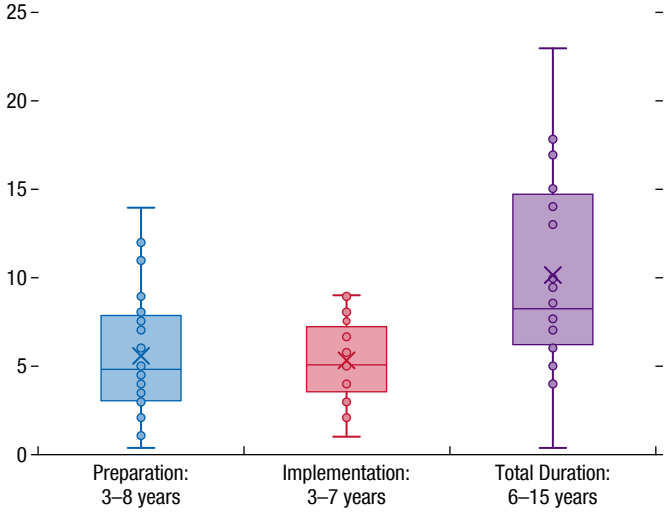
Governments should prepare a pipeline of carefully appraised projects that can be selected for financing and implemented within the following 24 months. This presents a challenge, however, because appraisal and selection processes are among the most common shortcomings in the public investment management cycle (Chaponda, Matsumoto, and Murara 2020). More than half of the 63 countries that have undergone an IMF Public Investment Management Assessment do not effectively maintain such a pipeline. An independent review of projects, communicated transparently, reduces the likelihood that low-quality

Figure 2.4. Government Effectiveness and Speed of Execution in Europe
(Amounts spent in 2014–19, in proportion of amounts allocated for 2014–20)



Sources: European Structural and Investment Funds; World Bank Worldwide Governance Indicators; and IMF staff calculations.
Note: The figure shows the correlation between the World Bank government effectiveness index and the speed of national implementation of projects financed by European Structural and Investment Funds. Instrument for Pre-Accession Assistance not included.

Figure 2.5. Duration of Infrastructure Projects
(Number of years)



Sources: IMF staff calculations based on Klakegg, Williams, and Shiferaw 2016; Avellan, Cavalcanti, and Lotti 2019; and GIH 2019.
Note: The figure shows the range of duration of infrastructure projects, distinguishing between the preparation phase and the implementation phase.

projects will be approved. Selection criteria should be disclosed; governments should look for strategic relevance, feasibility and affordability, and implementation readiness. Where appraisal is not systematic or formalized, a small task force of experts can be temporarily established, with a mandate to review the viability of major projects, both active and in the pipeline (Tandberg and Allen 2020). Fast-tracking project preparation through expedited appraisal and selection procedures, as in Australia, for instance, or temporary exemptions, often embedded in public procurement systems, can help overcome roadblocks but must be accompanied by transparency and quality control safeguards.

Planning for New Development Priorities

Governments should also take into account new development priorities stemming from the COVID-19 crisis and start planning accordingly for projects that will accompany the likely economic and social transformations as economies recover from the crisis. Project choices should give prominence to investments that reduce the likelihood or impact of future crises, including pandemics and climate change, and to foster digitalization. Because public investment project development usually spans many years (Figure 2.5), planning should start now. Project preparation entails ensuring consistency with development strategies, design, and appraisal of technical and financial feasibility and compliance with environmental and social safeguards. Though smaller projects can be prepared within a year, preparation typically takes five years or more for large infrastructure projects.

Maintaining Quality When Scaling Up Public Investment

Maintaining the quality of projects—in terms of selection and implementation—and bringing about the expected long-term growth dividends requires sound project planning and preparation, country ownership of projects, and a strategy that does not scale up public investment too much and too fast. Indeed, although there is a consensus that a temporary increase in public investment is likely to increase output significantly in the short to medium term (Leduc and Wilson 2012; Calderón, Moral-Benito, and Servén 2015), on average, more than one-third of the resources spent on public infrastructure are lost to inefficiencies (Baum, Mogues, and Verdier 2020; Schwartz and others 2020). Further, the evidence on the long-term growth benefits of big, long-lasting scaling-up is mixed (Warner 2014; Arezki and others 2017).

Fast increases in public investment carry the risk of facilitating corruption. The selection and procurement of public investment projects are already particularly vulnerable to corruption, as public officials benefit from a higher level of discretion for such projects than for current expenditure, and complex projects' unique features hamper the use of price comparators (April 2019 *Fiscal Monitor*; Pattanayak and Verdugo-Yepes 2020). Several public investment management and fiscal transparency practices, such as the publication of project selection criteria, the use of e-procurement systems and project-monitoring platforms, and the implementation of alert systems ("red flags"), can help ensure that projects are objectively selected and competitively procured.

Another key concern is that projects undertaken in periods of rapid scaling-up have been found to be less successful in achieving their intended targets (Isham and Kaufmann 1999; Presbitero 2016). Implementing multiple new projects simultaneously requires a varied set of technical and managerial resources that cannot be expanded in the short term, because absorptive-capacity constraints and supply bottlenecks may inflate costs and delay project implementation and completion (Flyvbjerg 2009; Gurara and others 2020).

To understand the mechanisms through which periods of investment scaling-up can lead to poor project outcomes, an analysis of the drivers of delays and cost overruns—two features of project execution that can be measured and can proxy implementation efficiency—is performed on World Bank–financed projects. Cost overruns and delays are pervasive in public investment projects. Data collected from more than 2,200 individual World Bank–financed project reports covering 110 emerging markets and developing economies indicate that almost 40 percent of projects cost more than the estimated appraisal cost and 75 percent of projects are delayed beyond their projected completion date at project outset (see Online Annex 2.3), even though the projects are planned by professional experts and subject to rigorous procedures (Limodio 2019).[5] The analysis sheds light on why the results of increases in public investment can fall short of expectations. Cost increases are greater and project delays are longer if projects are approved and undertaken when public investment is significantly scaled up. Individual projects can cost 10–15 percent more simply because they are undertaken at a time of particularly high public investment (Figure 2.6, panel 1). In low-income developing countries, scaling up investment by 3 percent of GDP leads to an increase in costs of 6 percent above appraisal costs, as well as delays extending project length by 2.5 percent beyond what was planned.

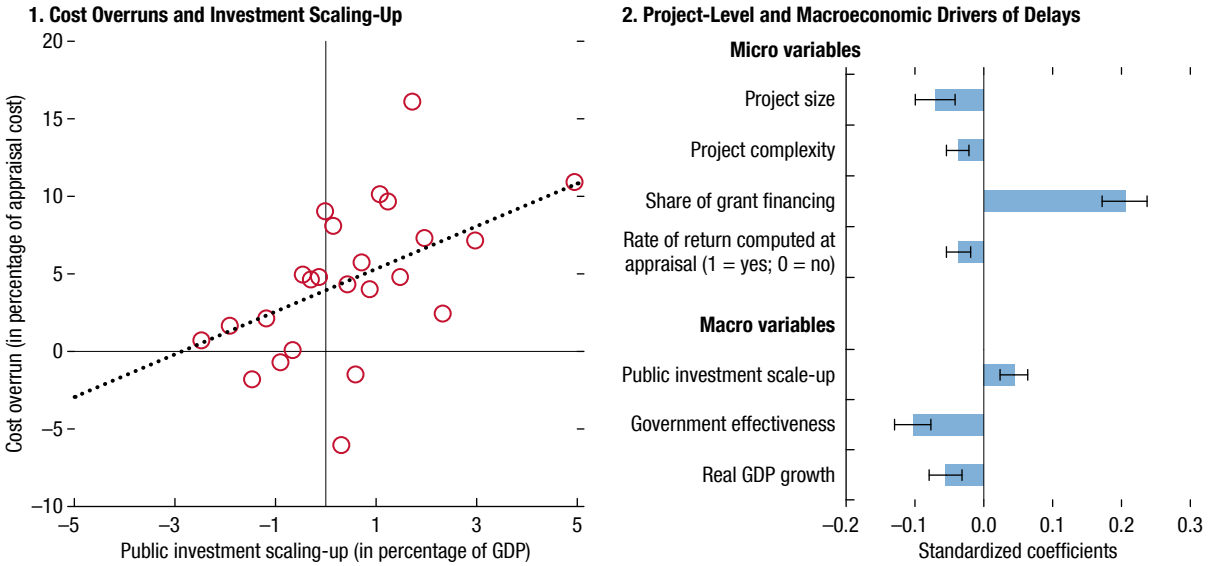
Good project planning and the quality of policies and institutions matter for project outcomes (Isham and Kaufmann 1999; Denizer, Kaufmann, and Kraay 2013). Countries with better public investment management are better placed to implement projects on time and on budget (IMF 2018). For instance, World Bank projects in which the expected rate of return is assessed at appraisal, suggesting careful project preparation, have shorter delays (Figure 2.6, panel 2). The same holds for larger and more complex projects (as measured by the number of sectors a project spans), possibly because they are more carefully planned and designed. Yet projects funded fully by grants have a time overrun 14 percentage points higher than those funded without grants (Figure 2.6, panel 2). A three-year project thus suffers from an extra five-month delay, on average, if it is fully funded by grants. Country ownership and the leadership of local authorities are important elements for project success and for the effectiveness of a scaling-up of investment (Bourguignon and Sundberg 2007; Edwards 2015). Project analysis is also crucial, and where capacity is limited, technical support by multilateral development banks could be beneficial and help countries attract private finance (Chelsky, Morel, and Kabir 2013; Broccolini and others, forthcoming). Countries' capacity to implement quality projects in a timely way will be essential if public investment is to boost growth and create jobs in both the short and long term.

Job Creation

How many jobs can a policymaker expect to create by increasing public investment? The COVID-19 pandemic has resulted in the sharpest rise in unemployment since the Great Depression, and job creation will be an essential criterion in deciding on the size and composition of a fiscal stimulus. Experience suggests that fiscal packages have significant job intensity. For example, the US American Recovery and

[5]Cost overruns and time delays do not always result from errors in evaluations. Sometimes circumstances extraneous to the project change project scope. Existing evidence shows that analyses based on World Bank projects can be generalized to other donors (Briggs 2019; see also Online Annex 2.3).

Figure 2.6. Cost Overruns and Delays



Source: Analysis of the performance of more than 2,200 World Bank–financed projects approved in 110 emerging and developing countries based on text mining of World Bank Independent Evaluation Group completion reports.
Note: Panel 1 is a binned scatter plot controlling for project-specific and macro variables as well as fixed effects. Panel 2 plots the standardized coefficients and the associated 90 percent confidence intervals of selected variables of a regression in which the dependent variable is the measure of the time delays (see column 6 in Online Annex Table 2.3.2 in Online Annex 2.3). The regression includes year, sector, region, and country group fixed effects. One standard deviation of the dependent variable—time delay—is 17.7 days. The standard deviations of the other variables used in the analysis are shown in Online Annex Table 2.3.1 in Online Annex 2.3.

Reinvestment Act created six to eight jobs in the short term per $1 million spent (Wilson 2012; Garin 2019; Ramey 2020). Firm-level information on revenues and employment for selected sectors, covering 27 advanced economies and 14 emerging markets over 1999 to 2017, shows that job intensity ranges from about two jobs per $1 million invested in schools and hospitals to three jobs in electricity in advanced economies, and from five jobs in roads to eight jobs in water and sanitation in emerging market economies (Figure 2.7).[6]

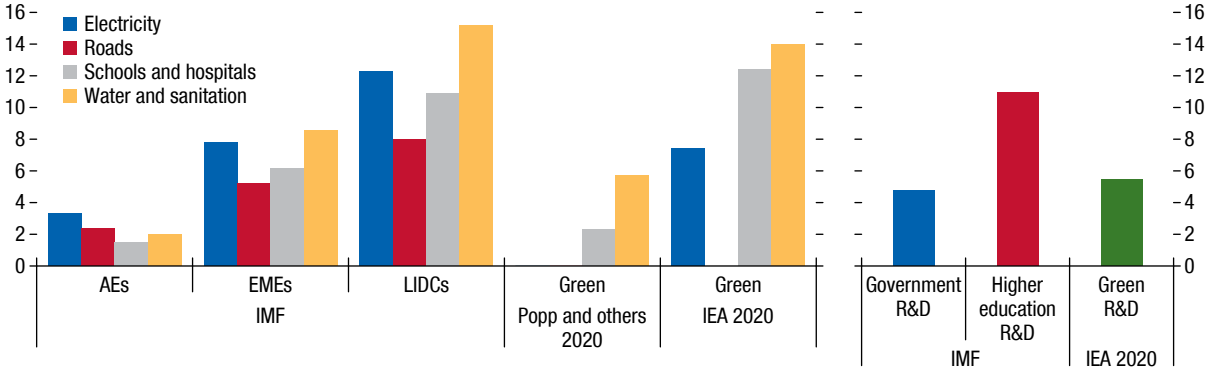
Government research and development (R&D) spending generates an estimated five jobs per $1 million invested in OECD member countries, and these are high-quality jobs. Public spending on R&D is a small component of public investment and goes primarily toward the government and higher education, but it is expected to increase, particularly in the health sector. The job content of higher education R&D is twice as high, possibly because it focuses on fundamental research and requires less capital than government R&D (which includes, for example, the military). Although the data set does not cover digital infrastructure, a conservative estimate is that the job content in digital infrastructure could lie between the estimates for electricity and those for R&D, at each income level.

The sectoral ranking of job intensity is similar across income groups, with water and sanitation and electricity displaying greater job intensity than roads, schools, and hospitals (Schwartz, Andres, and Dragoiu 2009). Job intensity increases as country income decreases: in addition to wages being lower in poorer countries, technology is also more labor intensive there, as evidenced by labor income's higher share in GDP (see the April 2017 *World Economic Outlook*; see also Dao and others 2017).

The numbers presented may underestimate the capacity of public investment to create jobs. First, they exclude jobs outsourced to companies not included in the data set and jobs created indirectly through higher demand for other products and services. Second, projects with a larger unskilled labor component will create more jobs (as a dollar can go further in employing more workers) and reduce inequality.

[6]These numbers are consistent with what would be found using a wage share of income of 30–40 percent in the construction sector, at the firm level. For instance, the implied gross wage for infrastructure in electricity would be about $90,000 in advanced economies, $38,000 in emerging market economies, and $24,000 in low-income developing countries.

Figure 2.7. Job Content Per US$1 Million of Additional Investment
(Selected infrastructure sectors)



Sources: Compustat; Orbis; and IMF staff estimates.
Note: The figure shows for different sectors, types of investment, and for country groups, the estimates of the job content of US$1 million of investment. The figure is based on regressions of employment on revenues over 1999–2017, covering 47,580 observations for 5,679 privately owned and state-owned enterprises. The estimates for low-income countries are extrapolated from the other estimates. For R&D spending, the figure is based on cross-country panel regressions based on OECD data. Green estimates are available in the literature but only for a few sectors. See Online Annex 2.4 for details. AEs = advanced economies; EMEs = emerging market economies; LIDCs = low-income developing countries; OECD = Organisation for Economic Co-Operation and Development; R&D = research and development.

Green investment can also create jobs (Chapter 3 of the October 2020 *World Economic Outlook*; Garrett-Peltier 2017; Coalition of Finance Ministers for Climate Action 2020). In advanced economies, job intensity appears to be greater for green investment than for traditional investment. For example, job intensity—net of job losses in traditional industries—is estimated at 8 jobs per $1 million invested in green electricity, 2–13 jobs in efficient new buildings such as schools and hospitals, and 6–14 jobs in green water and sanitation through efficient agricultural pumps and recycling (Figure 2.7; see also IEA 2020 and Popp and others 2020). In addition, many jobs in renewables do not require high educational attainment and have low barriers to entry. In the United States, less than 20 percent of workers in clean-energy production and energy-efficient occupations have college degrees (Muro and others 2019).

Clean-energy infrastructure has been found to be labor intensive in the short term (Garrett-Peltier 2017), although not all green investments create jobs quickly (Popp and others 2020). Some forms of green investment are also not job rich in the long term and require specific skills: for example, windmills are capital intensive and produced in only a few countries. Whereas green investments offer clear global welfare gains, they do not have straightforward distributional effects, especially in low-income countries. Green and environmental investment can be combined with public employment programs to maximize investment's job impact (as with the Green Army projects in Australia or the Conservation Corps in the United States), retrain the labor force, and protect people in the informal sector (for example, tree-planting programs in Ethiopia and Pakistan).

Although creating jobs is a critical objective in this crisis, there may be trade-offs between job quality and job quantity. Supporting the creation of low-wage, low-productivity jobs using public work programs or investment in labor-intensive sectors could bring down unemployment quickly but create fewer high-wage, high-productivity jobs in capital-intensive sectors. Generating high-quality formal jobs will be more difficult if adjusting to the pandemic necessitates permanent changes in the sectoral allocation of the workforce, as such changes would exacerbate skill mismatches between the unemployed and the jobs on offer (OECD 2020a). Governments will need to allocate resources, including resources for digital investment, to train displaced workers and allow them to move to jobs that satisfy pandemic and post-pandemic needs.

Fiscal Multipliers in the COVID-19 Crisis and Recovery

In addition to its direct effect on jobs, public investment has the potential to boost growth and increase employment through the usual macroeconomic interlinkages. A meta-analysis of existing studies

suggests that public investment has larger short-term multipliers than public consumption, taxes, or transfers (April 2020 *World Economic Outlook*; Gechert and Rannenberg 2018). In addition, medium- to long-term multipliers for public investment have often been estimated to be larger than 1.0 (Abiad, Furceri, and Topalova 2016). However, such results are not guaranteed, and these fiscal multipliers are also sometimes estimated to be close to 0 (Ramey 2020). Macroeconomic conditions as well as the quality of the investments undertaken affect their size. Multipliers tend to be larger (from the domestic economy's perspective) in countries less open to trade, as low propensity to import reduces leakage of the demand gains to other countries. Multipliers are also larger in recessions (because resources are idle) and in countries with fixed exchange rate regimes or where central banks have hit their effective lower bound (Ilzetzki, Mendoza, and Végh 2013; Chodorow-Reich 2019).

The quality of investment also matters, as discussed earlier, and this is reflected in macroeconometric estimates. For advanced economies that do well on the World Economic Forum's index of government-spending wastefulness, public investment has been found to have a fiscal multiplier of 0.8 in the first year and above 2.0 at the four-year horizon. But the fiscal multiplier is estimated to be four times smaller for countries with a worse rating (Abiad, Furceri, and Topalova 2016). Differentiating emerging markets and low-income countries by the quality of public investment management, as measured in the IMF's Public Investment Management Assessment (Miyamoto and others 2020), yields similar estimates.

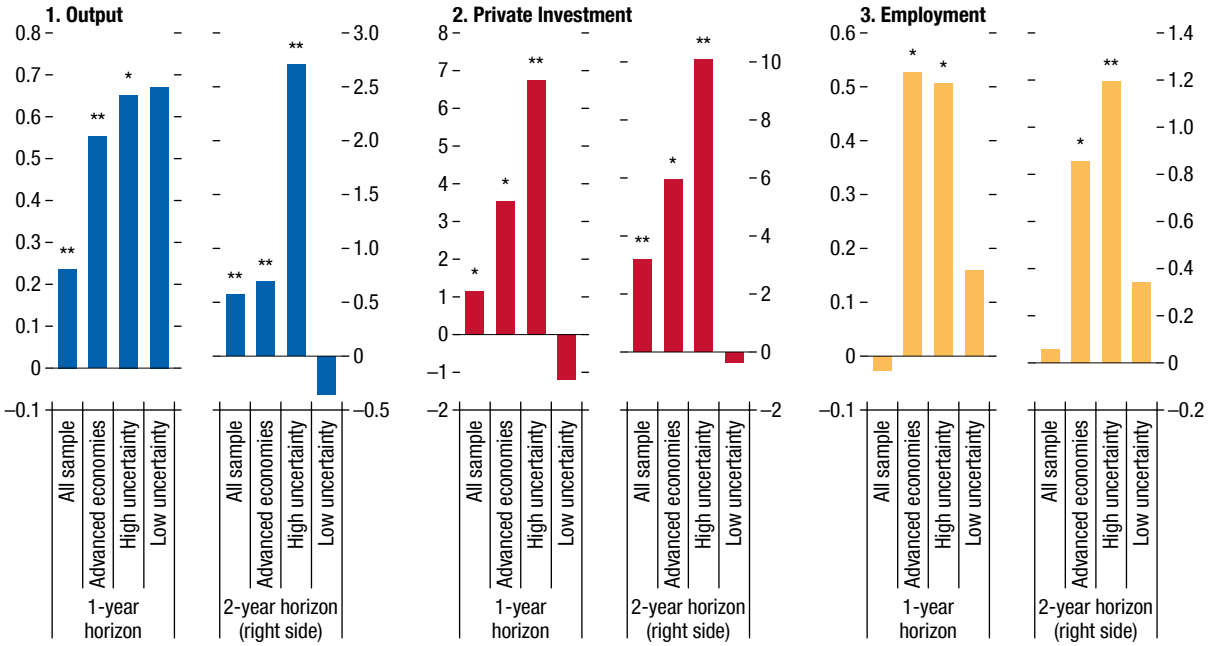
When assessing the possible size of multipliers, important initial conditions and unique features of the COVID-19 crisis should be taken into account:

- *High levels of public debt.* Public debt levels across the world are at historic highs (see Chapter 1). Whereas sovereign spreads have recently remained stable, history suggests that they occasionally rise abruptly as investors lose confidence and refinancing becomes difficult (Mauro and Zhou 2019). High levels of public debt can lower fiscal multipliers (Huidrom and others 2019) if deficit-financed investment leads to greater sovereign spreads and thus higher private financing costs. A sovereign debt model calibrated to represent a typical emerging market or frontier economy with high external debt shows that a strategy of borrowing to invest can lead to crowding-out of the private sector if spreads increase significantly, even if public investment has high returns. Fortunately, smaller scaling-up of investment mitigates this effect (Online Annex 2.1).
- *Supply constraints.* While fiscal multipliers tend to be larger in deeper recessions (Blanchard and Leigh 2013; Fatás and Summers 2018), macroeconomic theory suggests that fiscal multipliers will be lower in phase 2 of the pandemic, when social-distancing policies constrain supply (Guerrieri and others 2020), than in phase 3, when lockdowns will be lifted but slack may remain high.
- *Acute uncertainty*. The trajectory of the virus and the economy has a highly uncertain outlook, especially during the prevaccine phase. This uncertain trajectory could reduce the fiscal multiplier if private spending does not react to a fiscal stimulus as a result of uncertainty and precautionary saving (Alloza 2018; Bloom and others 2018). Alternatively, uncertainty could increase the fiscal multiplier if demand reacts positively to a government's commitment to economic stability (Bachmann and Sims 2012; Berg 2019).
- *Weak balance sheets*. The balance sheets of many firms—especially those whose business models are incompatible with social distancing—are likely to deteriorate severely as a result of COVID-related lockdowns and the extent of the COVID-spurred recession (see October 2020 *Global Financial Stability Report;* Caceres and others 2020). Firms with weak balance sheets may be unable to increase investment (Borensztein and Ye 2018). Highly leveraged firms are likely to use future profits to repay debt rather than to finance new investments (Myers 1977), and default risk increases borrowing costs. Because of frictions in loans and capital markets, cash flow constraints will also affect firms' investment spending, especially that of small firms (Fazzari, Hubbard, and Petersen 1998; Carpenter and Guariglia 2008; Gbohoui 2019).

An empirical exercise covering 72 advanced economies and emerging markets with data on economic uncertainty regarding GDP forecasts, proxied by disagreement among forecasters, sheds light on how the fiscal multiplier depends on macroeconomic uncertainty (Figure 2.8, panel 1). An unanticipated positive shock to public investment of 1 percent of GDP increases the level of output by between 0.25 and

Figure 2.8. Uncertainty and the Fiscal Multiplier of Public Investment in Advanced and Emerging Market Economies

(Effect, in percentage change, of an unexpected increase of public investment by 1 percent of GDP)



Source: IMF staff estimates.

Note: Panel 1: one- and two-year fiscal multipliers of public investment; panel 2: semi-elasticity of private investment to public investment; panel 3: semi-elasticity of employment to public investment. * (resp. **) for statistically significant coefficient at one (resp. two) standard deviation confidence interval. Nonlinear local projections estimated following IMF (2014) and Miyamoto and others (2020) using the model $y_{i,t+k} - y_{i,t} = \alpha_i^k + \gamma_t^k + \beta_1^k G(z_{i,t}) FE_{i,t}^+ + \beta_2^k(1 - G(z_{i,t})) FE_{i,t}^+ + \theta^k M_{i,t} + \varepsilon_{i,t}^k$, where *FE* is the unexpected shocks to public investment shocks, in deviation from IMF forecasts (following Auerbach and Gorodnichenko 2012), z is an indicator of the degree of uncertainty, and $G(z_{i,t})$ is the corresponding smooth transition function between different levels of uncertainty. *M* includes lagged GDP growth and lagged shocks. Data cover 72 advanced economies and emerging markets for which standard deviation of GDP forecasts across forecasters were available. See Online Annex 2.5.

0.5 percent in the first year, but the effect after two years is much larger in periods of higher uncertainty. The multiplier could be above 2.0, versus 0.6 for the baseline estimate.

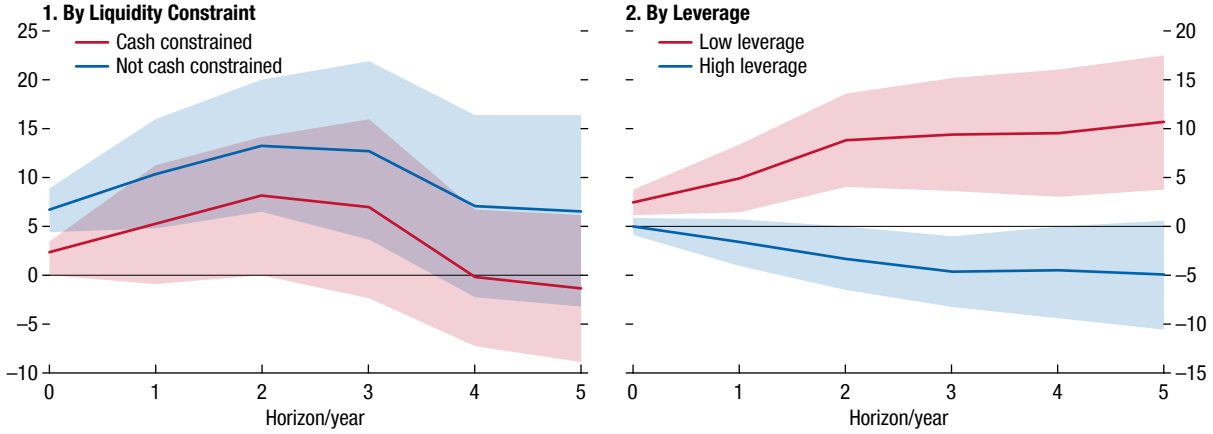
Public investment also has strong effects on employment. The results indicate that in periods of uncertainty, employment increases by between 0.9 and 1.5 percent over two years in response to a shock of 1 percent of GDP to public investment.[7] Applying these lower- and upper-bound estimates to total employment in advanced and emerging market economies (about 2.2 billion workers) shows that increasing public investment by 1 percent of GDP would create between 20 and 33 million jobs. This number is larger than the estimate based on direct job creation (about 7 million jobs when applying the numbers presented in Figure 2.8, panel 3)[8] because of the indirect macroeconomic effects of an investment stimulus.

The results suggest that demand reacts strongly to public investment shocks, possibly because they signal a government's commitment to growth and stability. By raising confidence, a push in public investment is also likely to foster investment from businesses that might otherwise remain cautious in their hiring and

[7]The point estimate in a period of high uncertainty is 1.2, but the 10–90 percent confidence interval is 0.9–1.5.

[8]The number of 7 million jobs is obtained by applying (1) a job content of 4.9 jobs per $1 million invested for advanced economies (unweighted average of 2.3 in construction, 7.5 for green investment, and 4.8 for research and development) to an increase in investment worth 1 percent of the GDP in advanced economies (about $500 billion in 2020) and (2) a job content of 14.7 for emerging markets (three times the estimate for advanced economies, in accordance with the regression estimates for the construction sector) to 1 percent of the GDP of emerging markets (about $320 billion).

Figure 2.9. Response of Private Firms' Net Investment to Public Investment
(Effect, in percentage change, of an increase of public investment by 1 percent)



Source: IMF staff estimates.
Note: The figure shows the cumulative effect on private investment of a 1 percent shock in public investment. It is obtained by nonlinear local projections, estimated based on a database of about 400,000 private firms in eight sectors at NACE level 2, covering 26 advanced economies and 23 emerging market and developing economies. The net investment rate is defined as the annual change in tangible fixed assets. Confidence intervals are set at 95 percent (shaded area). A firm is considered cash constrained if it has at least three consecutive years of negative cash flow. A firm has high leverage if its debt is above the mean of the distribution (based on a logistic function) of the debt-to-asset ratio. See Espinoza, Gamboa, and Sy (2020).

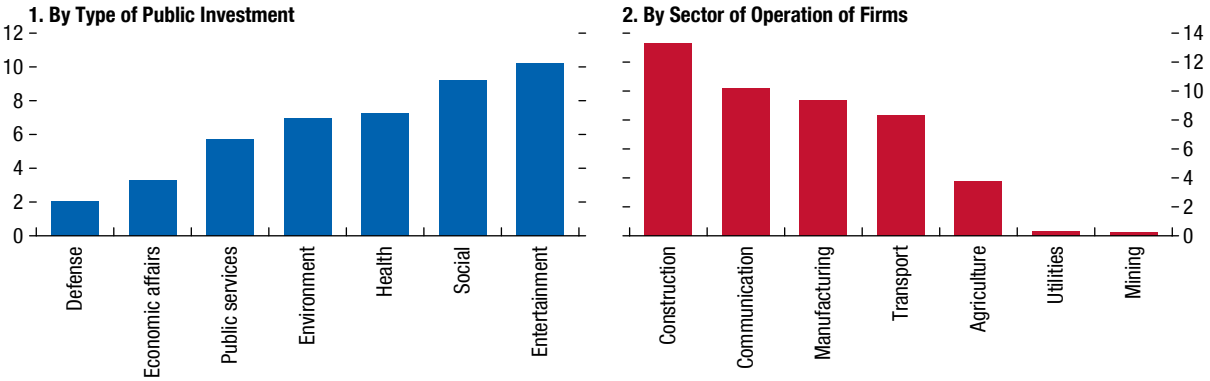
investment decisions.[9] Similar results—that is, fiscal multipliers higher than 2.0 in high-uncertainty periods—have been found for Germany and the United States (Bachmann and Sims 2012; Berg 2019). However, high efficiency and good institutional quality are required to reap such large benefits from public investment. Although the level and nature of uncertainty in this crisis make it difficult to extrapolate from historical patterns, these findings suggest that the public investment multiplier could be larger than in normal times.

Counterbalancing this effect, cash constraints and high levels of corporate leverage stemming from the pandemic's adverse economic impact could lower the fiscal multiplier. Estimates based on data for about 400,000 individual firms show that shocks to public investment tend to increase private investment among both firms with cash constraints and firms without such liquidity constraints (Figure 2.9, panel 1). Nevertheless, the impact is higher for firms that are less financially constrained. Likewise, the response to a public investment shock is stronger for firms with low leverage (Figure 2.9, panel 2). In the first period of the shock, their net investment rates increase by 2.5 percent, and the cumulative impact is 11 percent after six years, whereas for firms with high leverage, the multiplier is marginally insignificant statistically. Liquidity provision to firms and an effective debt resolution system including a streamlined restructuring framework (as discussed in Chapter 1; see also Balibek and others 2020) would not only help preserve the economy's long-term productive capacity but also strengthen fiscal policy's capacity to fight the recession. This mechanism would operate more strongly if the support were targeted to vulnerable but viable firms (October 2020 *Global Financial Stability Report*). In advanced economies, support for firms has been extensive, and it can be expected that the multiplier will be higher than 1.0.

Finally, it is important to consider which sectors would benefit the most from an increase in public investment and what kind of public investment is most efficient at stimulating private investment. An analysis of the firm-level response to public investment shocks that separates public investment by type and distinguishes firms by sectors of activity shows that public investments in health care and other social services are associated with sizable increases in private investment at the one-year horizon (Figure 2.10, panel 1). This complements earlier findings that health care

[9]Online Annex 2.5 provides further details on how public investment shocks affect confidence. The correlation between uncertainty and low growth does not drive the results. Even when growth is high, the multiplier is larger in periods of uncertainty. And when uncertainty is high, there is no statistically significant difference in the size of the multiplier between high- and low-growth periods.

Figure 2.10. The Effect of Public Investment on Private Firms' Net Investment
(Effect, in percentage change, of an increase of public investment by 1 percent; one-year horizon)



Sources: Orbis; and IMF staff calculations.
Note: The effect of public investment on private investment depends both on the type of public investment (panel 1) and on the economic sector in which firms operate (panel 2). Estimated based on a database of about 400,000 private firms in eight sectors at the NACE 2 level covering 26 advanced economies and 23 emerging market and developing economies. See also the note to Figure 2.9.

and social spending have strong Keynesian multipliers because import leakages are small and these sectors are labor intensive (Reeves and others 2013). Crowding-in is stronger for private investment in industries that are critical for the resolution of the health crisis (for example, communications and transport) or for the recovery (for example, construction and manufacturing; see Figure 2.10, panel 2). In addition to the short-term multipliers, the long-term benefits of investing in crisis prevention and mitigation are well documented (World Bank 2013). A survey found that leading experts, including academics and senior Group of Twenty (G20) officials, considered spending on clean-energy infrastructure, energy efficiency upgrades for buildings, and green spaces to have sizable long-term multipliers (Hepburn and others, forthcoming). Investing in adaptation to climate change also has high returns, often exceeding 100 percent (Global Commission on Adaptation 2019; Rozenberg and Fay 2019). Long-term savings from investment in resilience and coping mechanisms can reach 300 percent for droughts and 1,200 percent for storms in sub-Saharan Africa (see Chapter 2 of the April 2020 *Regional Economic Outlook: Sub-Saharan Africa*).

Investment in Resilience and the Role of the International Community

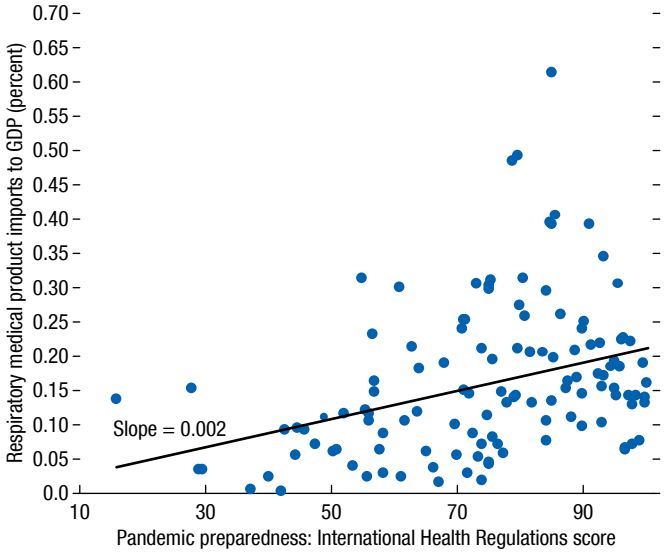
As countries design packages that include additional public investment, two key questions are which sectors they should prioritize and, for the most vulnerable and fiscally constrained countries, what level of financial support could come from the international community.[10] Reallocating spending, increasing investment efficiency, and strengthening domestic revenue mobilization are essential to make room for additional investments, but official aid will also be needed to support low-income developing countries through the crises they are facing. Supporting vulnerable and fiscally constrained countries would help reduce the dramatic impact of crises on poverty.

Fighting COVID-19 is the most urgent priority. At the global level, a significant step has been taken in committing amounts for R&D in vaccine and therapeutics (Chapter 1). For the pandemic to subside and the global recovery to be sustained, universal access to COVID-19 vaccines or treatments at low cost will be indispensable. While developing a safe vaccine may still take some time, countries need to start planning vaccine procurement and delivery immediately to ensure access at the right time (OECD 2020b). According to the Gates Foundation, the cost of global distribution of vaccines has been estimated in the range of about $25 billion,[11] but wide and rapid

[10]International cooperation initiatives that help relax countries' financing constraints, such as the Debt Service Suspension Initiative sponsored by the World Bank Development Committee, the IMF, and the G20 Finance Ministers, can play a significant role in participating countries.

[11]Bloomberg interview with Joe Cerrell, Managing Director of Global Policy and Advocacy at the Gates Foundation (Paton 2020).

Figure 2.11. Spending on Medical Products and World Health Organization Index of Pandemic Preparedness
(Percent of GDP)



Sources: World Health Organization, International Health Regulations; UN Comtrade; and IMF staff estimates.
Note: The figure shows the correlation between the International Health Regulations index and spending on imported medical products such as respiration apparatus, X-ray equipment, protective glasses, hand sanitizer, and surgical gloves (see Online Annex 2.6).

access will reduce the overall cost of the crisis by multiple times this amount. To reduce the risk of future crises, it would be crucial for such spending not to crowd out R&D spending to fight other zoonotic infectious diseases, an amount previously estimated to be $4.5 billion annually (Commission on a Global Health Risk Framework for the Future and National Academy of Medicine 2016).

At the national level, the correlation between a country's World Health Organization (WHO) index of pandemic preparedness and spending on imported medical products suggests that increasing preparedness by 10 index points would cost about 0.02 percent of GDP per year in medical products (Figure 2.11). Public investment in health care spending is also higher by about 0.1 to 0.2 percent of GDP in countries that score 10 points higher on the same WHO index (Online Annex 2.6).

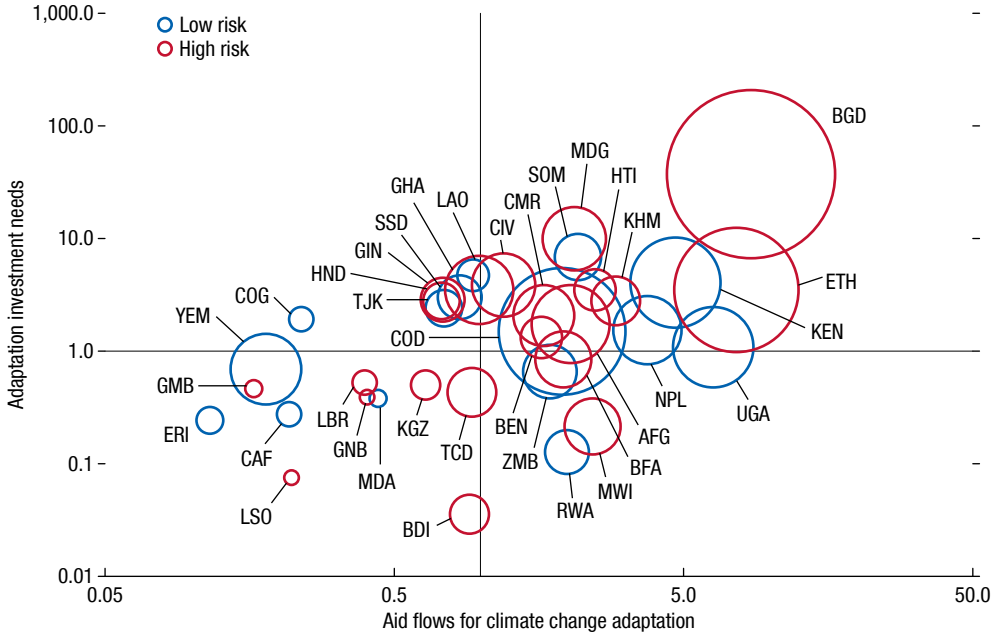
Digital infrastructure needs to be developed urgently to mitigate the effect of the COVID-19 crisis on the economy and human capital. Half of the 1.5 billion students affected by COVID-related school closures do not have access to a computer, and more than 40 percent have no internet access at home (UNESCO 2020). Low-income developing countries are most in need of digital infrastructure investment: only about 35 percent of the population in developing countries has access to the internet (versus about 80 percent in advanced economies). Africa's average broadband penetration was only 25 percent in 2018. Access to reliable electricity is also a major constraint on the expansion of digital infrastructure in Africa. Sub-Saharan Africa has the lowest household electrification rate in the world, averaging 44 percent of the population in 2017 (half of the world average; Broadband Commission 2019). Within sub-Saharan Africa, there is a digital divide too: more than half of the population is engaged in e-commerce in some countries, whereas the share in other countries remains below 15 percent (April 2020 *Regional Economic Outlook: Sub-Saharan Africa*).

Looking ahead, rapid technological progress will transform economic and social structures (Allen and Macomber 2020). Improvements in digital infrastructure will be essential to harness these changes, to strengthen government capacity, and to adapt economies to the disruptions the technological revolution could entail, such as income polarization (Autor, Dorn, and Hanson 2016; October 2017 *Fiscal Monitor*). Spending on digital infrastructure also provides an opportunity to boost government revenues (see April 2018 *Fiscal Monitor*) and generate jobs (for example, extending fiber-optic cable). The growing digital divides across and within countries show that public funds would be required in both low-income developing countries' and advanced economies' lagging areas (Shenglin and others 2017).

Global warming is perhaps the most significant crisis that is looming, threatening our planet as well as living standards around the world. To respond to this threat, investment in adaptation is urgent. A new IMF staff assessment based on World Bank data (Box 2.1) finds that low-income countries need about $25 billion annually (1.1 percent of GDP) in public investment for adaptation.

Official creditors are already allocating aid for climate change adaptation: the correlation between IMF estimates of needs and official aid for adaptation to climate change is about 56 percent. However, annual aid to low-income developing countries was $10 billion in 2018 and would thus have to more than double to fulfill the needs (Figure 2.12). Although private finance for cleaner activities has increased rapidly at the global

Figure 2.12. Public Investment in Adaptation to Climate Change: Needs and Aid Flows
(In 100 million US dollars, log scale)



Sources: Bellon (forthcoming); OECD; and IMF staff estimates.
Note: The size of the bubble is the population size. Aid flows for climate change adaptation (horizontal axis, in log scale) are correlated with the IMF estimates of adaptation needs (vertical axis, in log scale). The correlation between aid and needs in ratio to GDP is also high, at 0.57. The United Nations University Institute for Environment and Human Security World Risk Index for 2018 is used to measure natural disaster risk. The threshold suggested by the World Risk Report 2018 for high-risk and very-high-risk country, at 7.14 percent, is used to differentiate countries into high and low risk. See also Box 2.1 and Online Annex 2.6. Data labels use International Organization for Standardization (ISO) country codes.

level since 2008, it is unfortunately less viable for these countries, owing to their limited access to capital markets.[12]

Conclusion

In response to the COVID-19 crisis, governments around the world are taking extraordinary measures to save lives and limit the sharpest and deepest global economic collapse in contemporary history. Public investment is urgently needed in sectors critical to controlling the pandemic—in particular, health care, schools, digital infrastructure, safe buildings, and safe transportation. In addition, public investment should play an important role in fiscal packages allocated for the recovery, to promote job creation and private investment in the near term and to increase productivity, make progress toward the SDGs, and strengthen resilience to crises in the longer term.

Public investment is a potentially powerful element of any stimulus package. It would create millions of jobs directly in the short term and could also create many additional jobs indirectly and in the longer term. The unique features of the COVID-19 crisis make it difficult to anticipate the size of the fiscal multiplier that would result from such investment. But it is reasonable to expect that in advanced economies and several emerging market economies, the multiplier will be larger than in normal times and well above 1.0, if projects chosen are of good quality, because resources are idle, interest rates are stuck at the effective lower bound, and fiscal packages may increase confidence in the recovery.

The macroeconomic case for public investment is not as strong in those emerging market economies and low-income countries that face tighter financing constraints, but the investment needs to meet the SDGs' call for reallocating spending, enhancing domestic revenue mobilization, and improving investment

[12]Green bond issuance has grown significantly in recent years, from an average annual issuance of $52 billion between 2008 and 2018 to a total issuance of $255 billion for 2019 alone (Climate Bonds Initiative 2019; Fatin 2020). Other resilience-oriented financing vehicles that fund coastal restoration, marine biodiversity, sustainable fisheries, and pollution control could be explored (such as blue bonds).

efficiency so as to safeguard as much investment as is compatible with other key spending priorities. Strengthening revenue administrations and reforming tax policy are essential to scale up domestic revenue mobilization. Vulnerable and fiscally constrained countries will also need international support to weather the crises they are facing. In all countries, policymakers can increase the impact of public investment on jobs and private sector activity by taking public health measures that bring COVID-19 under control and allow safe reopening and easing of supply constraints, improving mechanisms for private debt resolution, and strengthening public investment management institutions.

To be timely and efficient, any investment scaling-up must meet several conditions. First, priority should be given to maintenance spending and to existing projects, because designing new or complex projects too quickly will impede investment quality. Second, governments should identify a pipeline of projects that can be carefully appraised and ready for implementation within the next 24 months. A pipeline with a longer horizon is also needed for more complex projects that will address the new priorities stemming from structural transformations associated with the pandemic, particularly projects that increase resilience to crises and climate change. Third, the procedures for selection and procurement of public investment projects should be strengthened immediately. Project outcomes are more often disappointing, and short- and long-term fiscal multipliers are lower, in countries with weak public investment management practices.

Satisfying these conditions may not be possible for every project in every country, especially because responding to such a multifaceted crisis is placing tremendous pressure on governments. Although the global fall in interest rates has set a low bar for investment projects to be beneficial, the bar is higher to pass when governments with limited resources face competing spending priorities. Investments that contribute to the resolution of the COVID-19 crisis, can create jobs quickly, and help countries become more resilient—including in respect to preparing for global warming—should be given priority and supported by the international community.

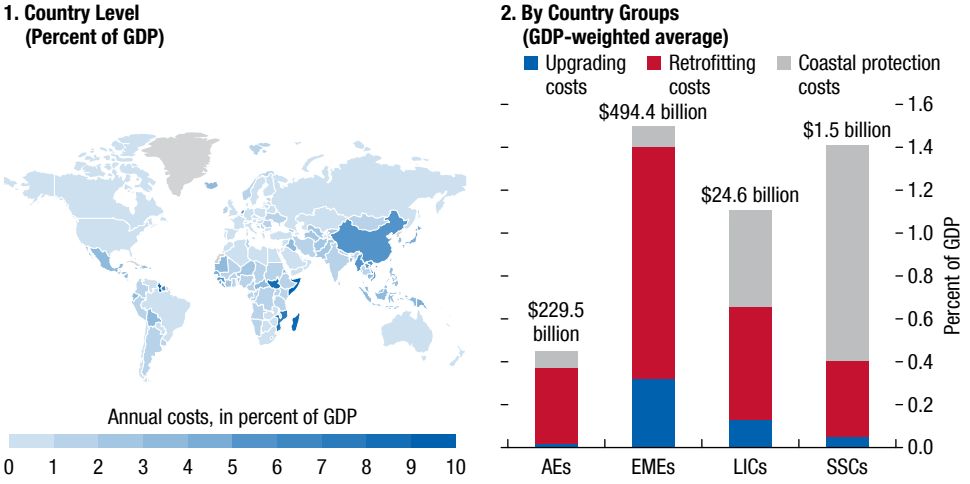
Box 2.1. Estimating Public Investment Needs for Climate Change Adaptation

Building protection and strengthening physical assets are key to addressing the challenges natural disasters and climate change pose and thus to making progress toward the Sustainable Development Goals. Countries should consider three types of adaptation investment: (1) upgrading investment projects, (2) retrofitting existing assets, and (3) building new coastal protection infrastructure. This list excludes certain other investment needs, such as preparing for droughts and other temperature changes, but such investments, although needed, are substantially less expensive (Global Commission on Adaptation 2019). This box presents cost estimates for public investment for climate change adaptation by country and income group, as well as the methodology underpinning IMF staff estimates.

For new infrastructure projects in all sectors subject to hazards (energy, water, transportation, and social sector facilities), the additional up-front cost to increase resilience standards is estimated to average about 15 percent of the typical initial cost (Rozenberg and Fay 2019). Retrofitting assets is substantially more expensive and would incur costs greater than 50 percent of the asset value. Countries with exposed coasts should also consider building new infrastructure, such as dikes, dedicated to protecting and reducing risks for other assets.

High returns to adaptation imply that, over the medium term, an average annual investment of 1 percent of GDP globally would be beneficial. These costs exceed previous estimates (see the April 2020 *Fiscal Monitor*; UNEP 2016; and Global Commission on Adaptation 2019) because they encompass more types of investment (for example, investment dedicated to coastal protection and the retrofitting of exposed assets) and because they extend coverage to all countries. Costs are estimated using a bottom-up approach: the analysis uses data on the share of exposed assets by country, constructed thanks to two detailed global maps, one of natural hazards and another of road and railway asset data (Koks and others 2019). Upgrading and retrofitting costs are based on this evaluation of exposed assets and the engineering techniques known to improve resilience (see Online Annex 2.7).

Figure 2.1.1. Annual Upgrading, Retrofitting, and Protection Investment Costs



Sources: Nicholls and others 2019; Rozenberg and Fay 2019; IMF Investment and Capital Stock Dataset 2019; IMF World Economic Outlook database; and IMF staff estimates.
Note: Upgrading costs are estimated using public investment projections, the share of exposed assets, and a unit cost of 15 percent. Retrofitting costs are calculated using the share of exposed public assets and a unit cost of 50 percent, spreading costs equally over 10 years. Coastal protection costs are based on global high-definition representations of coastal zones and the climate model in Nicholls and others (2019). The boundaries, colors, denominations, and any other information shown on the maps do not imply, on the part of the International Monetary Fund, any judgment on the legal status of any territory or any endorsement or acceptance of such boundaries. AEs = advanced economies; EMEs = emerging market economies; LICs = low-income countries; SSCs = small-state countries.

Box 2.1. ***(continued)***

Disparities across countries in needed adaptation investment are vast, and low-income countries and small states face greater challenges. Countries in Asia and the Pacific, Africa, and the Caribbean face above-average costs because a large share of their existing and future infrastructure is exposed to climate hazards (Figure 2.1.1, panel 1). Across the globe, coastal protection is most expensive for low-income countries and small states. Low-income countries and emerging markets can encounter large upgrading costs because these countries typically have more investment projects. By contrast, retrofitting costs are more evenly distributed, as even advanced economies face substantial expenses (Figure 2.1.1, panel 2).

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