Policy Research Working Paper 8730

Hitting the Trillion Mark

A Look at How Much Countries Are Spending on Infrastructure

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Sustainable Development Practice Group
Office of the Chief Economist
February 2019

Abstract

The paper provides the first consistently estimated data set on infrastructure investments in low- and middle-income countries. To do so, the authors identify three possible proxies for infrastructure investments: two are variants on gross fixed capital formation from national accounts system data following ADB (2017) and one is based on fiscal data from the World Bank's BOOST database. Two of these proxies rely on the World Bank's Private Participation in Infrastructure database to capture the private share of infrastructure investments.

Given the limitations of each of these proxies, the authors employ several transformations to derive a lower-bound estimate for infrastructure investments in low-and middle-income countries of 3.40 percent of their gross domestic product, a central estimate of around 4 percent, and an upper-bound estimate of 5 percent for 2011. Corresponding absolute amounts are US$0.82 trillion, US$1.00 trillion, and US$1.21 trillion, respectively with East Asia and the Pacific accounting for 55 percent of infrastructure investments and Africa 4 percent. The public sector largely dominates infrastructure spending, accounting for 87–91 percent of infrastructure investments, but with wide variation across regions, from a low of 53–64 percent in South Asia to a high of 98 percent in East Asia.

Given the absence of fiscal or national accounts data capturing investments in infrastructure, these estimates are likely to be the best available in the near future. Nevertheless, the authors propose some possible avenues for future improvements (including an update when 2017 data are made available by the International Comparison Project), building on the excellent collaboration of multilateral development banks around this issue.

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Produced by the Research Support Team

Hitting the trillion mark—
A look at how much countries are spending on infrastructure

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Acknowledgments

We are grateful for the support extended to us by our Asian Development Bank colleagues, Rana Hasan and Kaushal Joshi, who kindly shared the methodology, knowledge, and experience accumulated while developing their Asia infrastructure estimates. In particular, we thank Kaushal Joshi for providing Annex C. We also want to acknowledge the extensive collaboration of our Inter-American Development Bank colleagues, Tomas Serebrisky, Ancor Suarez Aleman, and Cinthya Pastor Vargas.

Finally, we wish to thank the many World Bank colleagues and reviewers who have helped sharpen the focus of this study: Deblina Saha for many exchanges as well as for sharing the results of her work using publicly reported data on infrastructure projects sponsored by public entities (a key input for one of our "refinements"), and reviewers Jose Luis Andres, Punam Chuhan-Pole, Vivien Foster, Jens Kristensen, and Jordan Z. Schwartz.

Abbreviations

ADB	Asian Development Bank
EIB	European Investment Bank
FMIS	financial management information system
GDP	gross domestic product
GFCF	gross fixed capital formation
ICP	International Comparison Program
ICT	information and communication technology
IDB	Inter-American Development Bank
IMF	International Monetary Fund
INFRALATAM	Infrastructure in Latin America and the Caribbean
PPI	Private Participation in Infrastructure
SOE	state-owned enterprise

1. Introduction

> *The infrastructure gap is large: 1.2 billion individuals are without electricity, 663 million lack improved drinking water sources, 2.4 billion lack improved sanitation facilities, 1 billion live more than 2 kilometers from an all-weather road, and uncounted numbers are unable to access work and educational opportunities due to the absence or high cost of transport services. Infrastructure in low- and middle-income countries falls short of what is needed for public health and individual welfare, environmental considerations, and climate change risks—let alone economic prosperity or middle-class aspirations.*
>
> Rozenberg and Fay (2019)

Economic infrastructure continues to represent a significant challenge for low- and middle-income countries. In fact, the challenge is worse than the pure access gap described in Rozenberg and Fay (2019), as quality often is also an issue. Being connected to the grid does not ensure that electrons will flow reliably and continuously; having a water connection in the house does not guarantee that the water is safe or will flow 24/7. As a result, infrastructure services are a major impediment to both growth and improved welfare in many countries.

The infrastructure gap has been the subject of much attention in recent years, with a plea for countries to invest more and to engage in efforts to attract the private sector in the hope that it will bring fresh capital and greater efficiency to infrastructure services.

Yet, despite this attention, remarkably little is known about how much countries *should* be spending on infrastructure to get the services they want or about how much they actually *are* spending on infrastructure—the two sides of the "spending gap" that is often mentioned in the public debate on infrastructure. Rozenberg and Fay (2019) address the first question by providing careful and well-documented estimates of what countries need to spend on infrastructure, making the point that the amount needed depends on countries' goals and spending efficiency. This report tackles the question of how much countries actually spend.

Infrastructure economists are regularly asked how much countries spend on infrastructure, and it is the subject of endless surprise that these data are not generally available. The issue is that infrastructure spending spans different functional and economic classifications in fiscal accounts; it can be undertaken by different actors in the public sector—different ministries, central or local governments, and state-owned enterprises (SOEs), which are not usually included in readily available government statistics—or by the private sector. Further, infrastructure spending includes both capital and recurrent expenditure, which can be difficult to classify or track in fiscal accounts even where detailed budgetary data are available. And finally, infrastructure is both everybody's and nobody's business—no single agency is concerned with tracking infrastructure, as the World Health Organization is for health, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) for education, or the Food and Agricultural Organization (FAO) for agriculture.

In other words, figuring out how much countries spend on infrastructure is challenging. Here we use an old-fashioned "triangulation" approach, where we look at several possible methods and data sources, each with some advantages and disadvantages and with different errors of inclusion and errors of exclusion in what they cover. The approach builds on four initiatives. The first, known as the BOOST database, which is managed by the World Bank with financing from the Bill & Melinda Gates Foundation, collects the full fiscal accounts of 55 countries and painstakingly analyzes the data. The second, which follows the methodology developed by the Asian Development Bank (ADB) for its report *Meeting Asia's Infrastructure Needs* (ADB 2017), relies on national accounts data. The third is the World Bank's PPI database which collects data on private participation in infrastructure. The fourth is a new World Bank effort to apply the same methodology used by the PPI database to collect publicly reported data on infrastructure projects sponsored by state-owned enterprises and other public entities—henceforth referred to as the SPI database (Saha and others, forthcoming).

The result is a reasonable set of estimates—a high, a low, and a preferred one—for 120 countries; a detailed analysis of infrastructure spending and budgeting challenges for the 55 countries for which BOOST fiscal data are available; and a better understanding of how, going forward, it might be possible to develop a set of reliable estimates of how much countries spend on infrastructure.

This paper is structured as follows. We discuss previous efforts at estimating infrastructure spending, explain the available data sets as well as their relative advantages, compare the results obtained using these data sets, and propose methods to combine them to "triangulate" and improve accuracy. We then use the uniquely detailed BOOST fiscal data to provide some trend analysis and discuss some budgeting challenges. A final section concludes and discusses potential directions for further strengthening our understanding of what countries spend on infrastructure and the use that can be made of such data.

2. The State of Play on Estimating Infrastructure Spending

The most common and easiest—if inexact—way to estimate public spending on infrastructure involves relying on the gross fixed capital formation (GFCF) of general government (henceforth GFCF_GG). This information is readily available from the International Monetary Fund (IMF) Investment and Capital Stock Dataset, which covers all capital investments (dwellings, civil engineering, machinery and equipment) of central, state, or local governments. It is available for most countries in a time-series format but does not allow for any sectoral disaggregation.

Unfortunately, and as discussed in more detail below, GFCF _GG is unlikely to be a good measure of public investment in infrastructure—although whether it is an underestimate or an overestimate will vary across countries and over time. It excludes SOEs (which tend to be significant investors in infrastructure) and includes sectors other than infrastructure (health, education, mining).

On the private side of infrastructure investments, the situation is rosier given the existence of the Private Participation in Infrastructure (PPI) database, a World Bank initiative that harks back to the 1990s, when private investment in infrastructure took off. The PPI database collects information on both the public and private share of public-private partnerships in infrastructure. Its main limitation is that it records commitments rather than actual investments.

In addition, some efforts have been made to look in more detail at regional spending on infrastructure, typically through painstaking efforts to work with public authorities to collect fiscal data. Perhaps the earliest study was done for Africa in the context of an infrastructure country diagnostic (Foster and Briceño-Garmendia 2010). It found that in 2007 Africa spent approximately US$25 billion or about 1.5 percent of its regional gross domestic product (GDP) on infrastructure capital investments (public and private) in addition to about US$20 billion on operations and maintenance. The report concluded that, after potential efficiency gains, Africa's infrastructure funding gap was approximately US$31 billion, mostly in the power sector.

A similar diagnostic, also done at the World Bank, was conducted for South Asia (Andres and others 2013). It found that infrastructure spending in South Asia had increased from 4.7 percent of GDP in 1973 to 6.9 percent in 2009, fluctuating considerably during that time period.

However, service gaps remained significant, leading the report to conclude that a mix of investments and supportive reforms was needed.

More recently, the Inter-American Development Bank (IDB), collaborating with the United Nations Economic Commission for Latin America (ECLAC) and CAF (the Development Bank of Latin America), worked with budgetary authorities of the countries of the region to exploit fiscal accounts and develop estimates of public investment in infrastructure. These estimates were combined with the PPI database and are reported in the Infrastructure in Latin America and the Caribbean (INFRALATAM) database, providing infrastructure spending data for 15 Latin American countries from 2008 to 2015, disaggregated by sector and public or private source.

The most recent effort was undertaken by the ADB, which experimented with three approaches by combining country-specific estimates, where available, with two indicators based on GFCF data in national accounts, and with information from the PPI database. ADB (2017) offers a detailed discussion of the methodology and the strengths and weaknesses of the different estimates. We build on this approach, as explained in more detail in the next section.

Based on these studies and compilations of other (much rougher) estimates, Fay and others (2017) provide a very tentative estimate of global spending on infrastructure (table 1).

Table 1 Summarizing Existing Estimates of Infrastructure Investments, by Region, 2014

Region	*Infrastructure spending (% of GDP)*
East Asia and Pacific	7.7
Central Asia	4.0
Latin America and the Caribbean	2.8
Middle East and North Africa	6.9
South Asia	5.0
Sub-Saharan Africa	1.9

Source: Fay and others 2017.

Finally, the World Bank recently developed a regional baseline of public spending by leveraging the wealth of micro fiscal data collected by the BOOST initiative in more than 55 countries (with another 15 in progress). This baseline allows us to examine annual trends, execution rates, funding sources, and levels of capital expenditure by general government across infrastructure sectors. The BOOST database covers 25 countries in Africa—which has enabled the World Bank to develop a regional baseline of annual public spending across infrastructure sectors in Sub-Saharan Africa (World Bank 2017). It also includes 14 Latin American and Caribbean countries, which the World Bank and IDB teams are using to derive investment estimates ground-truthed in the IDB's country-specific fiscal analysis. The hope is that, in the future, estimates could be derived from BOOST data instead of requiring costly country visits.

3. Three Possible Proxies Based on Four Data Sets

Infrastructure typically includes transport, energy, and water and sewerage, with some debate about whether information and communication technology (ICT), flood defense, and irrigation should be included. In this report, we include the following four sectors:

- *Transport,* which includes civil engineering works on highways, bridges, streets, roads, railways, tunnels, airfield runways, ports and harbors, waterways, and related harbor and waterway facilities, among others, as well as nonresidential buildings. Related machinery and equipment, including ICT, are also included.
- *Energy*, which encompasses nonresidential buildings and civil engineering works for power plants, power stations, hydroelectric dams, electricity grids, long-transmission

lines, power lines, transformer stations, and gas and oil pipelines, among others. Related machinery and equipment, including ICT, are also included.[4]

- *Water and sewerage*, which includes nonresidential buildings, civil engineering works and machinery and equipment for dams, irrigation, and flood control waterworks, local water and sewer mains, local hot-water and steam pipelines, sewage, and water treatment plants. Related machinery and equipment, including ICT, are also included. However, BOOST does not include irrigation.
- *Information and communication technology*, which comprises nonresidential buildings and civil engineering works for telephone and Internet systems, land- and sea-based cables, communication towers, and telecommunication transmission lines, among others. Related machinery and equipment, including ICT, are also included. PPI data exclude fully privatized investment that is not part of a public infrastructure project.

We use four data sets to construct three estimates of capital spending in infrastructure (figure 1):

- *Two estimates based on systems of national accounts*.[5] Here we follow ADB (2017) and use GFCF as the key macroeconomic aggregate in national accounts relevant to assessing infrastructure investment. GFCF measures the total value of fixed assets that are used in production for more than one year plus specified expenditures on services that add to the value of nonproduced assets (European Commission and others 2009). In standard national accounts, an economy's GFCF can be decomposed further by the type of institution making the investment—general government, nonfinancial corporate (which in

4. The World Bank's standard definition of economic infrastructure typically excludes gas and oil pipelines, but fiscal data and national accounts data do not allow us to separate power (electricity).

5. This paragraph is based on ADB (2017).

national accounts includes SOEs), financial corporate, nonprofit institutions serving the household sector, and the household sector. GFCF can also be classified by type of asset (buildings, civil engineering, and machinery and equipment). Infrastructure investments are only a subset of a country's GFCF or overall investments (other sectors include health, education, mining, and defense, among others), as depicted in table 2. The available data limit us to two (imperfect) options, which are discussed below: (a) GFCF of the general government, complemented with data from the PPI database to capture private investment and (b) the civil engineering portion of total GFCF (which includes the GFCF of the general government, SOEs, and the private sector).

- *An estimate based on national treasury systems using the BOOST database,* which has produced more than 70 national and subnational data sets containing well-classified and highly disaggregated budget data.
- *An estimate of private investment in infrastructure using the PPI database.*

Figure 1 Four Data Sets to Derive Three Proxies

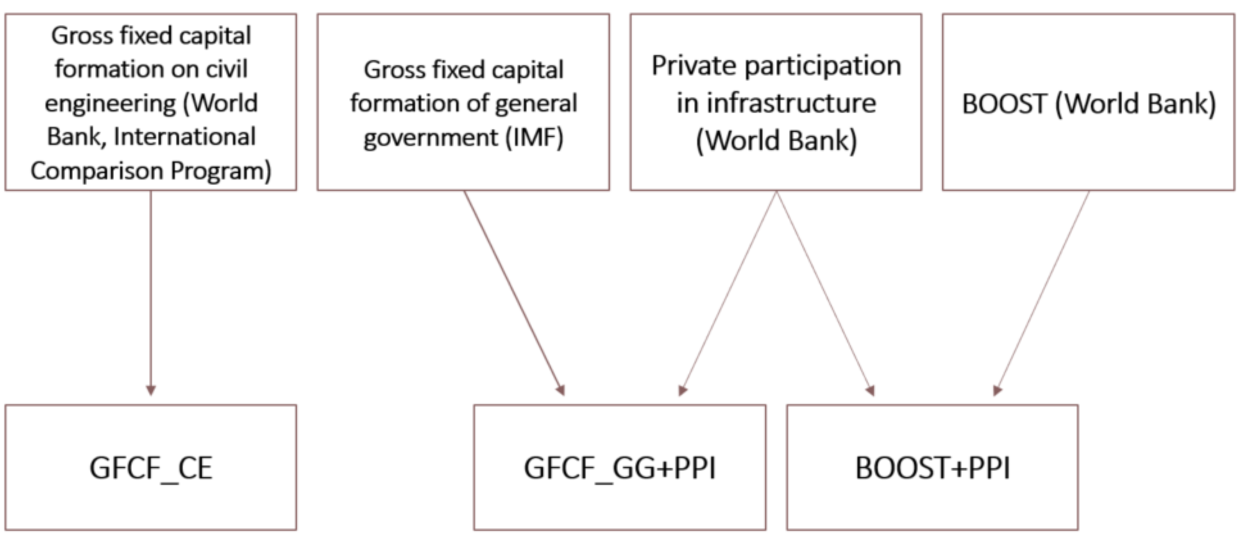


Table 2 Infrastructure as a Subset of an Economy's Capital Investments

Institutions	Asset Types	Sectors	
		Transport, ICT, Water & Sanitation, Energy	Other sector (Agriculture, Health, etc.,)
Government + SOE + Private	Residential buildings	-	Dwellings
	Non-residential buildings	E.g., terminal buildings	E.g., schools, hospitals, factory
	Civil Engineering	E.g., construction for highways, roads, harbors, dams, sewer systems, pipelines, power lines	E.g., construction for irrigations, waste dumps, mines, industrial plants, outdoor sports facilities
	Machinery & Equipment	E.g., network machines, turbine	E.g., personal computers

Note: The shaded area represents examples of gross fixed capital formation, and the hatched part is the infrastructure subset. SOE = state-owned enterprise; ICT: information and communication technology.

These three options are discussed next.

Option 1: GFCF of General Government Combined with Private Sector Infrastructure Investments from the PPI Database

GFCF_GG captures gross fixed capital formation by central, state, and local governments as reported in the IMF's Investment and Capital Stock Dataset. It is expressed here as a share of GDP (in constant 2011 international dollars). While it has the advantage of ready accessibility, wide coverage (119 emerging economies), and long time series, it suffers from two types of errors:

- *Errors of exclusion.* (a) SOEs, which is a major issue given that SOEs often dominate the water and sanitation and the electricity sectors, as well as much of transport (ICT, however, tends to be largely private), and (b) private sector investments, which we offset by combining GFCG_GG with the private share of PPI investment from the PPI database as described in box 1.

- *Errors of inclusion.* Residential dwellings and noninfrastructure sectors (including health, education, defense, mining). In other words, GFCF_GG could either underestimate or overestimate public investment in infrastructure depending on the relative importance of the share of infrastructure SOEs vs. the share of noninfrastructure sectors in public investment. An additional drawback is that the data available to us have no sectoral breakdown.

Box 1 Combining the PPI and GFCF_GG Data Sets While Avoiding Double Counting

The PPI database collects information on infrastructure investment through public-private partnerships. As such, it includes both private and public investments. But given that we are only interested in the private share of the investment, we extract it for each project according to the information available from the database, a nontrivial task, but one that is possible given the project information available in the PPI database (table B1.1).

Table Box 1.1 Private Spending on Infrastructure through Public-Private Partnerships, Annualized, by Region and Sector, 2011

US$, millions

Region	*Energy*	*Transport*	*Water and sewerage*	*Information and communication technology*	*Total*
Africa	761	599	12	5,237	6,608
	(0.07)	(0.06)	(0.00)	(0.50)	(0.64)
East Asia and Pacific	6,038	1,833	378	2,834	11,083
	(0.06)	(0.02)	(0.00)	(0.03)	(0.12)
Europe and Central Asia	6,354.0	1,241	20	9,901	17,517
	(0.17)	(0.03)	(0.00)	(0.26)	(0.46)
Latin America and the Caribbean	13,149	9,753	634	6,997	30,533
	(0.25)	(0.19)	(0.01)	(0.13)	(0.59)
Middle East and North Africa	667	777	461	2,211	4,115
	(0.05)	(0.05)	(0.03)	(0.16)	(0.29)
South Asia	20,355	9,205	38	8,493	38,091
	(0.90)	(0.41)	(0.00)	(0.37)	(1.68)
Total	47,323	23,409	1,543	35,673	107,947
	(0.20)	(0.10)	(0.01)	(0.15)	(0.45)

Source: World Bank, Private Participation in Infrastructure database, as of November 2017.
Note: The numbers in parentheses are the weighted regional average share of regional GDP.

Data on private investment in infrastructure are obtained from the World Bank's PPI database. The information is disaggregated by sector and collected annually. However, the PPI data record commitments rather than actual spending and do not track fully privatized investment (for example, investment in telecommunications network facilities by a fully private company or captive infrastructure). Since it typically reports total commitments associated with a public-private partnership, we subtract the public portion to avoid double counting (box 1). To transform commitments into actual spending, we annualize commitments for the following five years—an admittedly crude adjustment.[6]

Option 2: GFCF of the Whole Public Sector but Including Only Civil Engineering

The International Comparison Program (ICP) database of the World Bank Group provides data on GFCF for construction excluding buildings, which mainly includes expenditures on civil engineering works. This constitutes our second GFCF-based approach. We use GFCF_CE from the ICP 2011 data set expressed as a share of GDP (in current local currency units). This database has the advantage of including SOEs. As with GFCF_GG, GFCF_CE suffers from errors of inclusion and exclusion, albeit different ones:

- *Errors of exclusion.* Nonresidential buildings (airport terminals, railway stations) and machinery and equipment (turbines, locomotives)
- *Errors of inclusion.* Civil engineering works of non infrastructure sectors (including mining, irrigation, recreational facilities).[7]

6. The five-year spread may not be suitable for some sectors. This is a subject for future research.

7. Irrigation is often considered infrastructure; however, it is not included in our other estimates, so we refer to its inclusion as an error of inclusion.

Here again, we could either overestimate or underestimate infrastructure spending depending on the relative importance of investments in non infrastructure sectors vis-à-vis machinery and equipment.

The data do not allow for sectoral breakdowns and are currently only available for 2005 and 2011, although 2017 data will be available in late 2019 or early 2020.[8] As with GFCF_GG, the advantage of this measure is its wide coverage (114 emerging economies) and its consistent measurement across countries.

Option 3: Budgetary Data from the BOOST Data Set Combined with the PPI Data Set

Our third approach relies on expenditure flows from treasury systems as captured in the BOOST data set. After extracting the executed budget on infrastructure from treasury data, we tag annual capital spending for 2009–16 to infrastructure subsectors, using economic, administrative, and functional classification. The data are then smoothed over the entire period to produce an annual average. Data quality issues and challenges are discussed in annex C, along with ongoing efforts to harmonize estimates with those of partner organizations. While a much richer data set, this, again, is an imperfect one:

- *Errors of exclusion.* (a) Private sector investments (which we offset by combining them with the private share of infrastructure investment from the PPI database) and under identification of sectoral spending when national classification does not clearly identify sectoral spending; (b) spending by SOEs except for national capital transfers (see annex

8. The 2017 round is ongoing, with the final outputs scheduled for release in 2019.

B for a discussion); (c) other important off-budget spending (due to missing data on the execution of foreign-funded spending in some high-aid countries)

- *Errors of inclusion.* Potential mistagging of noninfrastructure spending, although this risk is minimal.

Typically, this approach tends to underestimate overall spending, especially when the prevalence of off-budget spending (SOE or donor funding) is high. However, the data allow for in-depth sectoral analysis and are available on an annual basis since 2009. One of the key advantages of this approach is that once the raw data have been tagged, subsequent annual updates are easy to compute provided the BOOST data sets are updated on a regular basis.

Pros and Cons of Our Three Proxies—Including How Much Work They Entail

Our three proxies enable us to achieve wide geographic and economic coverage: the 114 countries covered by the GFCF_CE option and the 118 covered by GFCF_GG+PPI represent more than 95 percent of low- and middle-income countries' GDP (tables 3 and 4). The BOOST database only covers 55 countries (50 of which overlap with the other data sets) and 24 percent of low- and middle-income countries' GDP. However, it offers good coverage for Africa and Latin America.[9]

Table 3 Number of Countries Covered, by Region and Estimation Methodology
number of countries

Region	*GFCF_GG*	*GFCF_CE*	*BOOST*
Africa	44	44	25
East Asia and the Pacific	11	11	5
Europe and Central Asia	21	19	9
Latin America and the Caribbean	25	24	11

9. Afghanistan, Argentina, Kiribati, Kosovo, and Solomon Islands do not have GFCF estimates due to the lack of national accounts.

Middle East and North Africa	10	9	1
South Asia	7	7	4
Total	118	114	55

Table 4 Share of Regional GDP, by Region and Estimation Methodology
% of GDP

Region	*GFCF_GG*	*GFCF_CE*	*BOOST*
Africa	98.6	98.6	25.7
East Asia and the Pacific	99.6	99.6	0.8
Europe and Central Asia	99.2	97.9	7.2
Latin America and the Caribbean	98.7	89.3	83.8
Middle East and North Africa	92.8	90.3	2.9
South Asia	99.2	99.2	15.9
Total	99.1	96.5	24.0

Table 5 summarizes the characteristics and sources of the four data sets.

Table 5 Characteristics and Sources of Data Used, by Methodology

Data	*Year*	*Characteristic*	*Source*
GFCF_GG	2011	-Executed investment -Headline numbers only	IMF, Investment and Capital Stock Dataset
GFCF_CE	2011	-Executed investment -Headline numbers only	World Bank, International Comparison Program
BOOST	Annual average based on 2009–17 data	-Executed investment -Sectoral breakdown	World Bank, BOOST database
PPI	2011 (annualized over five years)	-Planned investment -Sectoral breakdown -Public portion subtracted	World Bank, PPI database

In conclusion, all options present some advantages and some drawbacks. GFCF_CE and GFCF_GG+PPI may either underestimate or overestimate actual investments depending on the following:

- *The relative importance of infrastructure SOEs.* Where infrastructure SOEs are big investors, then GFCF_GG+PPI and BOOST are likely to be underestimates, and

GFCF_CE is preferable. Where infrastructure SOEs are small, BOOST (where available) is the preferred option, followed by GFCF_GG+PPI.

- *The relative importance of civil engineering investments relative to nonresidential buildings and machinery and equipment.* Where civil engineering is a small share of public investment, GFCF_CE may be an underestimate. Where civil engineering dominates, either GFCF_CE or BOOST is likely to be the preferred estimate, depending on the importance of SOEs.
- *The share of noninfrastructure sectors in civil engineering.* Where noninfrastructure sectors dominate national investment, both GFCF-based estimates could be overestimates, and BOOST may be preferable (depending on the importance of SOEs).

More generally, we can conjecture that BOOST will typically be a lower-bound estimate, reflecting the fact that SOE investments may not be captured. GFCF_GG+PPI is likely to offer an upper-bound estimate, except in countries where SOEs control an important share of public investment. Figure 2 offers a visual comparison among the four options, while table 6 summarizes the pros and cons of each estimate.

Figure 2 Visual Comparison of our Three Proxies for Capturing Infrastructure Spending

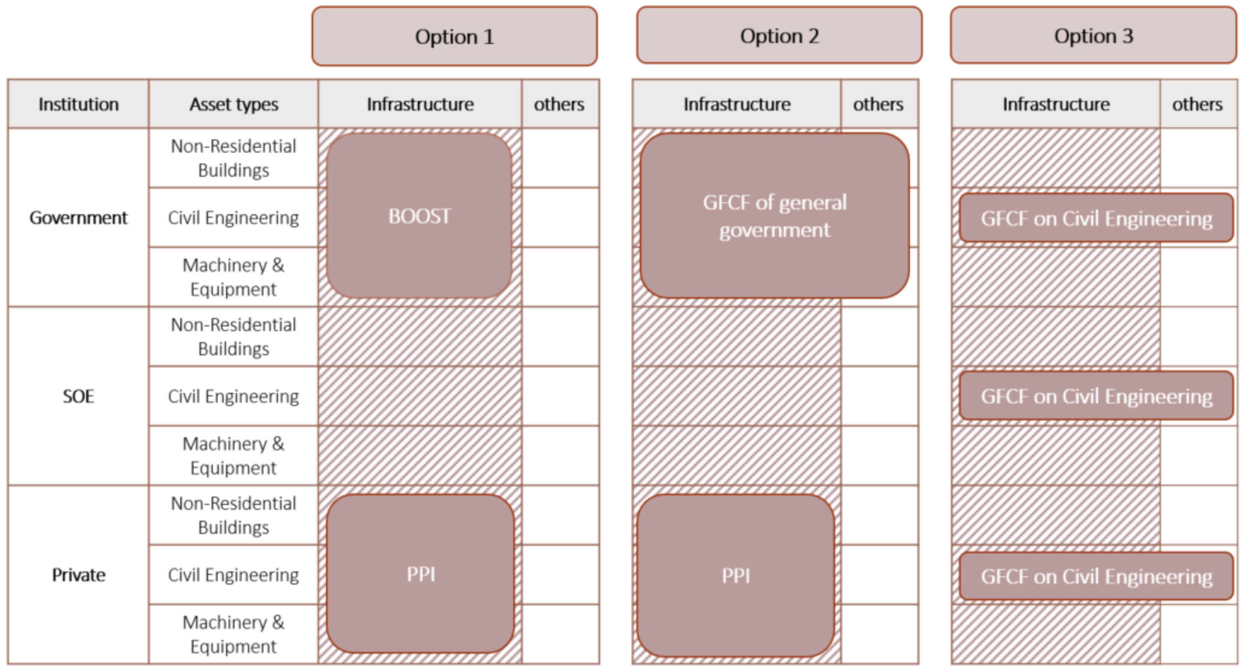


Table 6 Pros and Cons of Different Estimates

	Type of error			
Estimate	*Exclusion*	*Inclusion*	*Other advantages*	*Other drawbacks*
GFCF_GG+PPI	-SOEs -Fully privatized investment[a]	Noninfrastructure sectors	- Widely available (119 countries) - Time series	- No sectoral breakdown - Requires time-consuming PPI data cleaning to isolate private share
GFCF_CE	- Nonresidential buildings - Machinery and equipment		Widely available (114 countries)	- No sectoral breakdown - Very limited time series
BOOST+PPI	-SOEs[a] -Fully privatized investment[a]	n.a.	Sectoral breakdown available	- Time-consuming (BOOST and PPI data cleaning) - Limited sample (55 countries with 15 more in progress)

Note: SOE = state-owned enterprises. n.a. = not applicable.

a. For example, telecommunications.

b. BOOST data capture public capital transfers to SOEs, but do not capture self- or donor-financed capital investments by SOEs.

Finally, the different approaches vary tremendously as to the amount of effort they require to produce. The easiest method is GFCF_CE, which is available from the ICP.

GFCF_GG is readily available from the IMF, but needs to be combined with the annualized, private element of the PPI data set. This task requires a time-consuming data transformation of the relevant five-years' worth of projects to remove the public share of project financing and avoid double counting. The initial production of BOOST is time-consuming for countries with insufficient functional classification. However, for countries with good functional classification, the production of annual estimates can be largely automated.

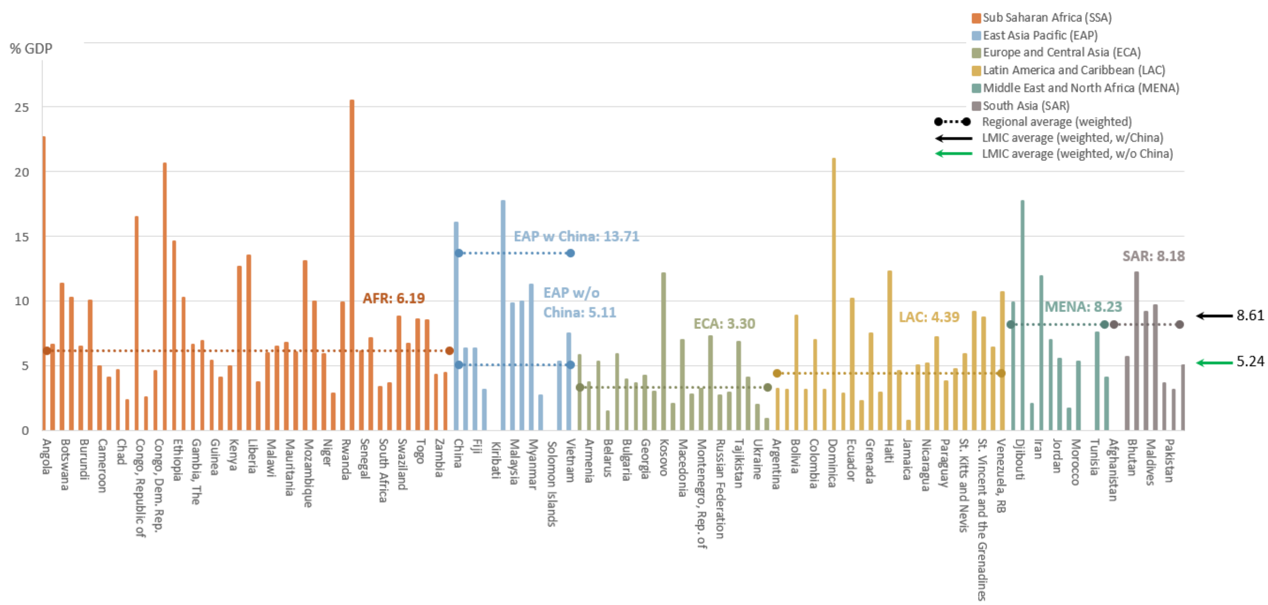
4. Too Hot, Too Cold, Just Right…

We look at our three proxies in turn. In the case of our two GFCF results, we provide global results both with and without China given its weight—due to both its size (China accounted for about 30 percent of low- and middle-income countries' GDP in 2011) and the fact that its GFCF numbers clearly include much more than infrastructure.

Comparing across Our Estimates

The GFCF_GG+PPI option estimates low- and middle-income countries' infrastructure investment to be a somewhat unbelievable 8.61 percent of their GDP in weighted global average, equivalent to some US$2.08 trillion in 2011 current U.S. dollars (figure 3). This share drops to 5.24 percent (or US$0.87 trillion) without China, whose GFCF_GG+PPI is 16 percent. Apart from China, seven other outliers have observations above 15 percent—all of which are either countries that are very small (for example, Dominica, Kosovo, and São Tomé and Príncipe) or countries where a large mining or hydroelectricity project is likely to account for the high investment (for example, Angola, the Democratic Republic of Congo, and Lao People's Democratic Republic).

Figure 3 Country and Regional Results Using GFCF_GG+PPI for 118 Countries, in 2011

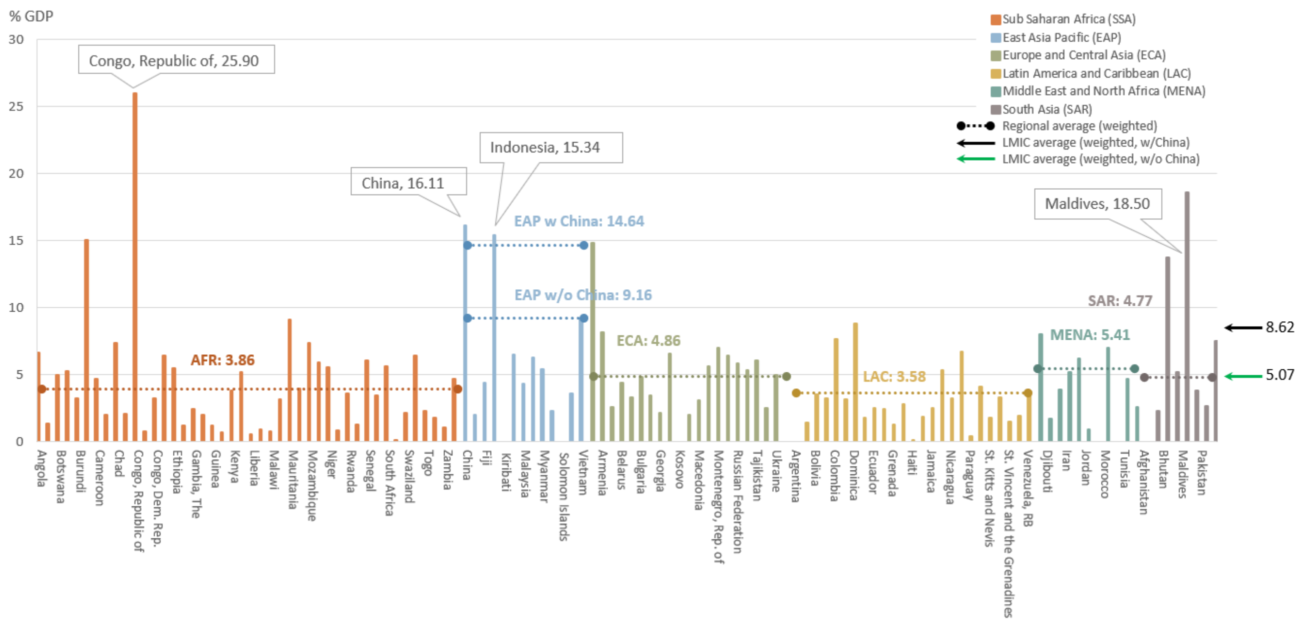


Note: Regional and global averages are weighted using GDP shares. See annex A for country data.

Among the regions, East Asia and Pacific exhibits the highest level of spending both with China (13.7 percent) and without China (5.1 percent). Europe and Central Asia exhibits the lowest level of investment (3.3 percent).

Surprisingly, the low- and middle-income-country average for GFCF_CE is a remarkably similar 8.62 percent of GDP, equivalent to US$2.03 trillion (figure 4). This average drops to 5 percent (US$0.81 trillion) without China. Apart from China, only three other observations are above 15 percent, suggesting that this proxy generates fewer outliers than GFCF_GG+PPI. East Asia and Pacific again exhibits the highest spending levels either with China (14.64 percent) or without China (9.16 percent), driven by Indonesia's high estimate (15.34 percent). Sub-Saharan Africa displays the lowest estimate (3.86 percent of GDP), a troubling finding given the region's high infrastructure needs and low GDP.

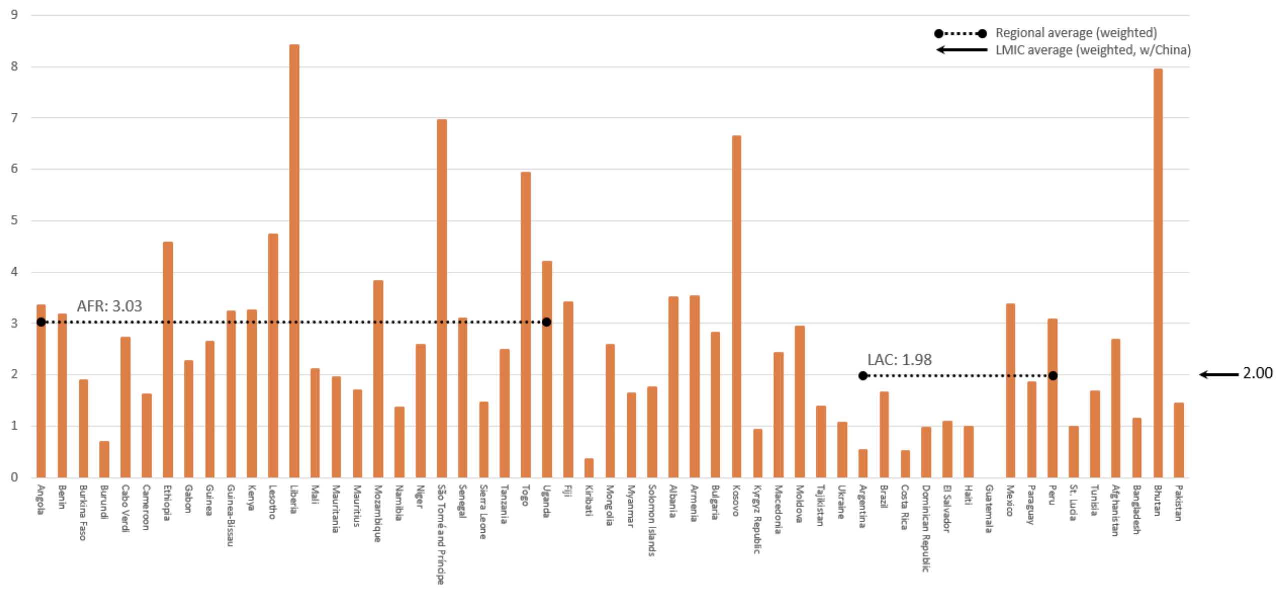
Figure 4 Country and Regional Results Using GFCF_CE for 114 Countries, 2011



The BOOST+PPI option yields a much more reasonable, but likely underestimated, 2 percent of GDP across its 55-country sample (figure 5). Applying this share to low- and middle-income countries' GDP yields an estimate of US$0.49 trillion for investment in infrastructure. This much lower result is likely driven by country coverage (notably the absence of China) and the incomplete treatment of SOE spending.[10] Regional weighted averages are only shown for Latin America and the Caribbean and for Sub-Saharan Africa, as the country coverage is too low to be regionally representative for the other regions.

Figure 5 Country and Regional Results Using BOOST+PPI for 55 Countries, 2011

10. If China's spending were computed according to the shares identified through national accounts—as opposed to applying the weighted average computed for the BOOST sample—then the global baseline would exceed US$1 trillion.



Comparing the three proxies for the 50 countries for which the 2011 data are available, we find, as expected, that the BOOST+PPI estimates offer a lower bound compared with national accounts estimations, GFCF_GG+PPI offers an upper bound, and GFCF_CE typically is in-between the other two (figure 6): 80 percent of BOOST estimates are the lowest; 60 percent of GFCF_CE estimates lie between GFCF_GG+PPI and BOOST+PPI; while 80 percent of GFCF_GG+PPI estimates are higher than the other two estimates.[11]

This pattern likely reflects the fact that the inclusion of noninfrastructure capital spending (such as dwellings, mines, industrial plants) more than offsets the exclusion of SOE capital spending. Analyzing underlying drivers for these patterns across regions would be an interesting future research project and would improve our ability to capture both overestimation and underestimation biases in these measurements.

11. Among the 55 BOOST countries, 5 countries do not have either GFCF_GG+PPI or GFCF_CE estimates: Afghanistan, Argentina, Kiribati, Kosovo, and Solomon Islands.

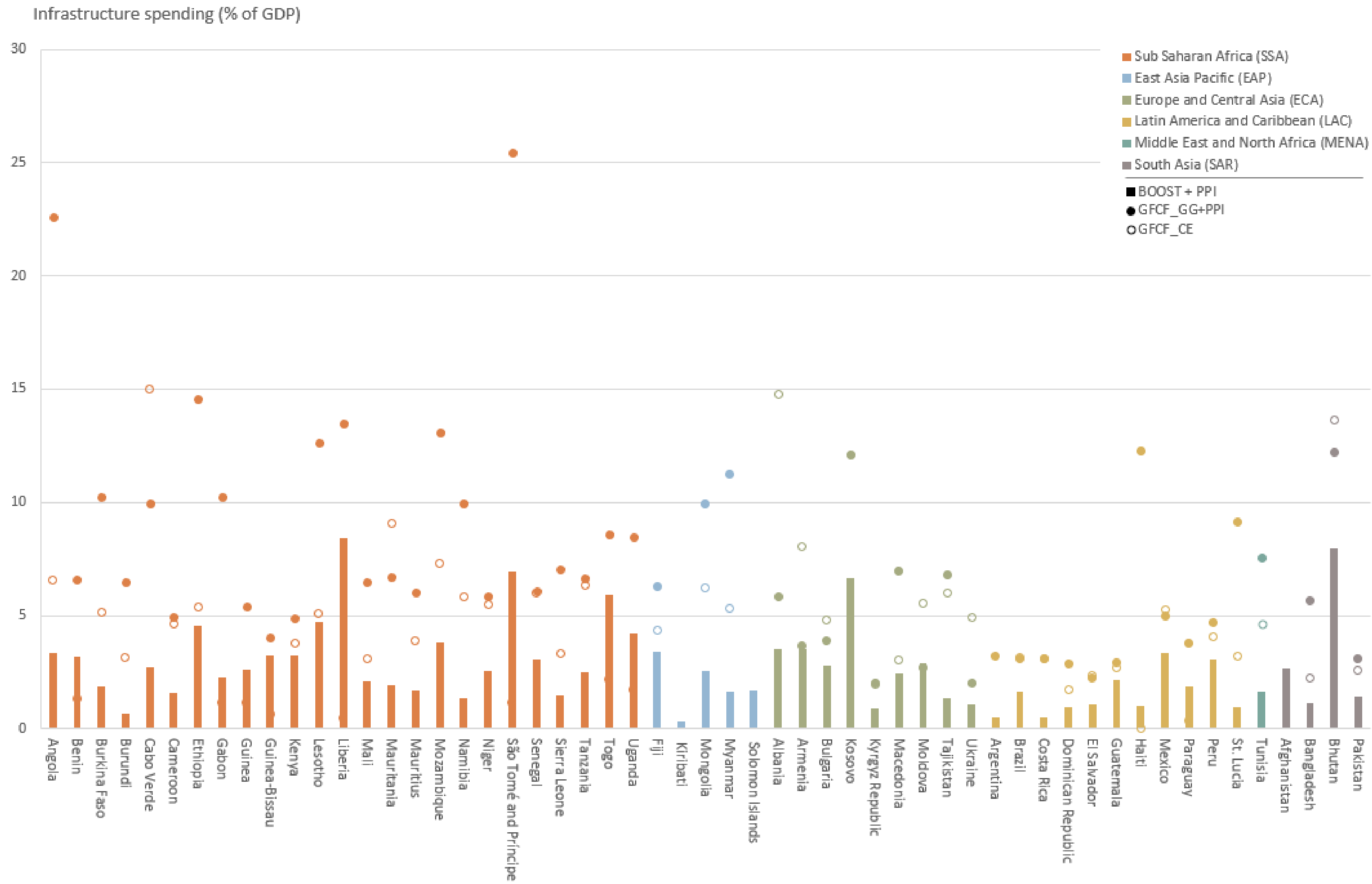
This pattern generally holds even when comparing across the full sample, as in figures 2–4, with the exception of East Asia (table 7, figure 6).

Table 7 Summarizing Results Using the Full Sample

Measure	*Africa*	*East Asia and Pacific*	*Europe and Central Asia*	*Latin America and the Caribbean*	*Middle East and North Africa*	*South Asia*	*All available countries*	*Sample size (number of countries)*
GFCF_GG+PPI (2011)	6.19	13.71 (5.1)	3.30	4.39	8.23	8.18	8.61 (5.24)	118
GFCF_CE (2011)	3.86	14.64 (9.16)	4.91	3.96	5.41	4.77	8.62 (5.07)	114
BOOST+PPI (average 2009–15)	3.02	n.a.	n.a.	2.16	n.a.	n.a.	2.00	55

Note: Numbers in parentheses are the average excluding China. We would expect them to be larger than the BOOST estimate given that BOOST data do not capture investments of state-owned enterprises. n.a. = not applicable.

Figure 6 Comparing Infrastructure Spending Proxies across the 50 Countries for Which Fiscal Data (BOOST) Are Available, 2011



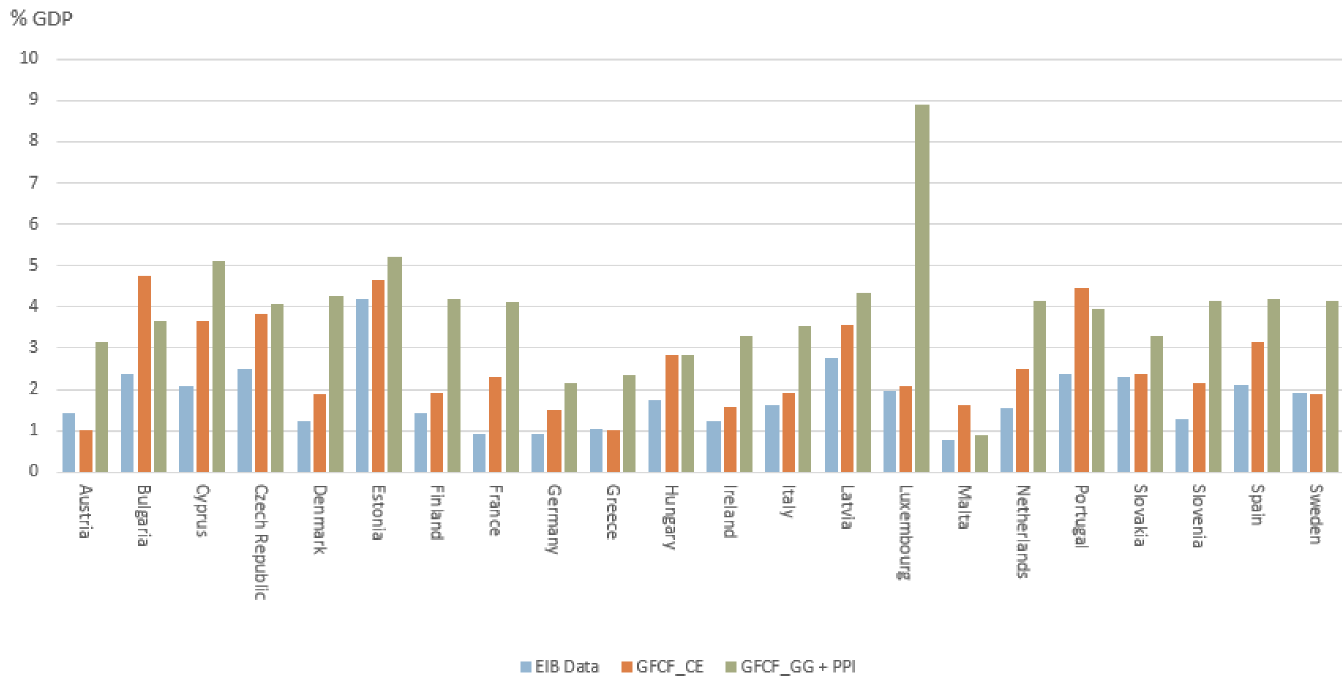
A Robustness Check

Here we test the robustness or accuracy of our options by comparing them with more detailed data from the European Investment Bank (EIB) (Revoltella and Brutscher 2017). A recent data update from Eurostat allowed EIB to distinguish between GFCF in infrastructure and other sectors and to do so by asset types and to capture (1) investment in civil engineering works by infrastructure sectors and (2) investment in nonresidential buildings by infrastructure sectors for the 22 countries covered by Eurostat (annexes A and B).

While the data are still not perfect (they do not include machinery and equipment), they are still a better approximation than what we have, inasmuch as they cover only infrastructure and include both civil engineering and nonresidential structures. Unfortunately, however, these data are only available for 22 high-income European countries.

The comparison suggests that, at least for high-income countries, GFCF_CE is generally a more accurate measure than GFCF_GG, with 20 out of 22 observations of GFCF_CE closer to the EIB estimates than the GFCF_GG+PPI ones (figure 7). However, assuming that the EIB estimate is the better one (even if it is an underestimate given the omission of machinery and equipment), this comparison suggests that both GFCF_GG and GFCF_CE generally overestimate infrastructure spending. Even the lower estimate (GFCF_CE) is about 40–50 percent higher than the EIB one, suggesting that the inclusion of non infrastructure sectors is an issue. Unfortunately, the EIB database overlaps with the BOOST database for only one country (Bulgaria), which precludes a comparison.

Figure 7 Comparing EIB Data with the Two GFCF Proxies for 22 European Countries, 2011



We also compare our estimates with the results of studies for two countries: Kenya and Indonesia. For Kenya, we collected data for fiscal 2015–16 on public, SOE, and private investments in transport, water and sanitation, and energy. The resulting estimate is 6.1 percent of GDP, close to the 4.8 percent for GFCF_GG+PPI but considerably higher than the 3.77 percent for GFCF_CE and 3.2 percent for BOOST+PPI—which admittedly are estimated for a different year (2011).

A second comparison is carried out with data collected in Indonesia by the World Bank from budget reports of central and local governments, SOE financial reports, and PPI data covering transport, water and sanitation, energy, and irrigation (World Bank 2015). The 2011 result is 2.6 percent of GDP, reasonably close to the 3.1 percent for GFCF_GG+PPI, but substantially less than the 15.3 percent for GFCF_CE.

It is hard to conclude from these results whether any one of our three estimates is better than the other. In the case of European countries, GFCF_CE appears to be the better approximation. But the opposite holds with our comparison of two countries. This variation in performance suggests that a hybrid approach that finds common ground between the three proxies might be the best approach to enhance the accuracy and robustness of a global baseline.

5. Why Settle with What We Have? Refining Our Estimates

There is scope for further refinement of our measurements. Above all, China's importance in the overall results calls for more accurate data—we therefore use ADB's estimate of public infrastructure investment for China (6.31 percent of GDP) in lieu of a BOOST estimate.

We then experiment with three more refinements. The first entails using regression analysis over the sample of 50 countries with common coverage between BOOST and the two GFCF estimates to infer missing values for countries not covered by BOOST (Refinement 1). The second is a simpler way to combine the data sets and eliminate outliers by using BOOST, where it is available, and the minimum value of GFCF_GG+PPI and GFCF_CE, where it is not (Refinement 2). The third involves adjusting GFCF_CE's tendency toward overestimation (likely due to the inclusion of non infrastructure investment), by adjusting it downward using a crude estimate of the share of non infrastructure investments in total public investments derived from BOOST data (Refinement 3). The fourth attempts to address the omission of SOE investments in BOOST by augmenting it using the average regional share of SOEs in public infrastructure from the SPI database on infrastructure projects (Saha and others forthcoming), which combines newly collected data on public infrastructure projects with the PPI database and identifies the share of commitments that is financed by SOEs (Refinement 4).

Refinement 1: Fitted Values Using All Our Proxies

We estimate a regression model for the BOOST methodology to get a fitted value for infrastructure spending for each country. The model specification is as follows:

$$Y = \alpha + \beta1 * Xgg + \beta2 * Xce + \beta3 * \text{logGDP} + \beta4 * \text{dummy} + \varepsilon \quad (5.1)$$

where Y is the BOOST estimates (excluding PPI), Xgg and Xce are estimates from GFCF_GG (excluding PPI) and GFCF_CE, respectively, log GDP is the logarithm of current GDP in 2011, and the dummy variable identifies whether a country has a federal government system or not.[12]

When this regression model is estimated using the sample of 50 countries with all three estimates, all coefficients are significant (table 8) with an R-square of 0.56. When some of the independent variables in the model are omitted, some coefficients become significant, suggesting that the model specification is reasonable. But because GFCF_CE, GFCF_GG, and GDP are correlated, implying multicollinearity, we cannot interpret each coefficient directly.

Table 8 Regression Results

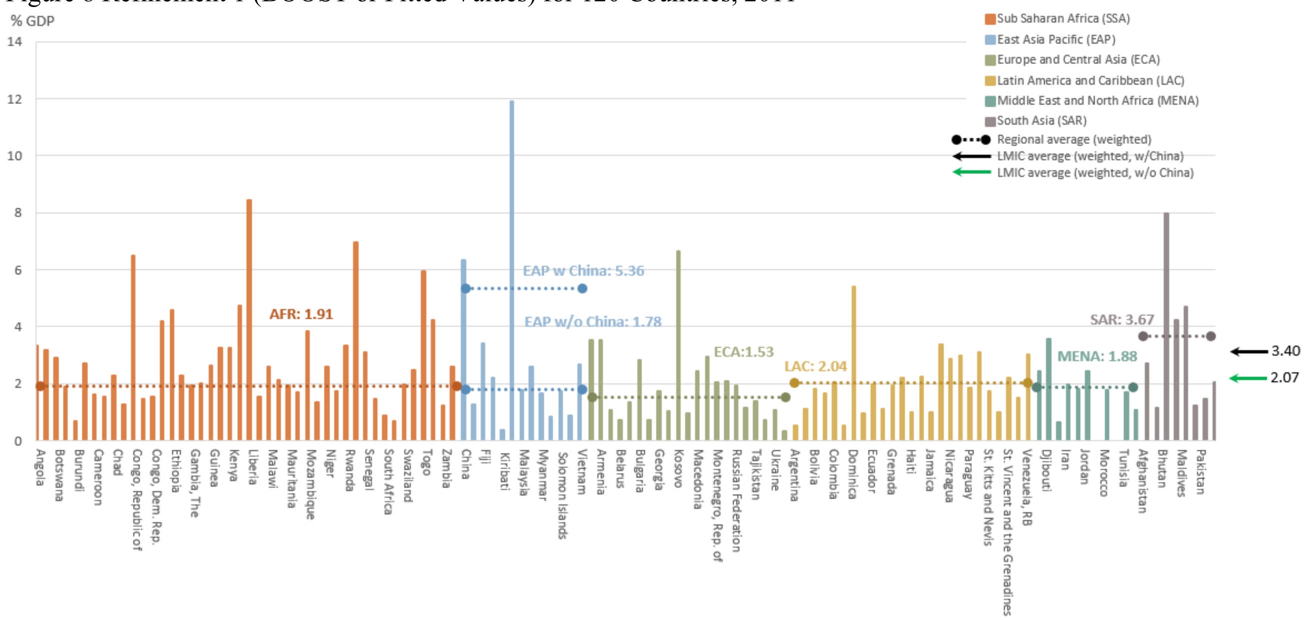
Variable	*Coefficient*	*Standard error*	*t-statistic*	*P-value*
Intercept	4.586	2.715	1.689	0.098
GG	0.164	0.034	4.837	0.000
CE	0.153	0.047	3.243	0.002
LogY	−0.461	0.261	−1.770	0.084
Federal	1.397	0.682	2.047	0.047

Combining this regression model with the PPI data, we estimate infrastructure spending for countries without BOOST data. This enables us to derive estimates for the large emerging economies not included in BOOST such as India and the Russian Federation, which we estimate at 4.2 percent and 1.9 percent of GDP, respectively. This approach yields an average of 3.40 percent of low- and middle-income countries' GDP, equivalent to US$0.82 trillion (figure 8). This estimate is higher than the original BOOST+PPI estimates but still lower than either of the

12. We tried a different model that included PPI (for example, BOOST+PPI and GFCF_GG+PPI), but it resulted in a worse fit.

GFCF proxies. Refinement 1 suggests that East Asia, at 5.36 percent, spends the most, while Europe and Central Asia (1.53 percent) and the Middle East and North Africa (1.88 percent) spend the least.

Figure 8 Refinement 1 (BOOST or Fitted Values) for 120 Countries, 2011



Note: Lao PDR remains an outlier because of a large PPI value of 11.9%, even though the fitted value for BOOST is 2.3%. The number of estimated countries increases to 120 thanks to the combination of data sets.

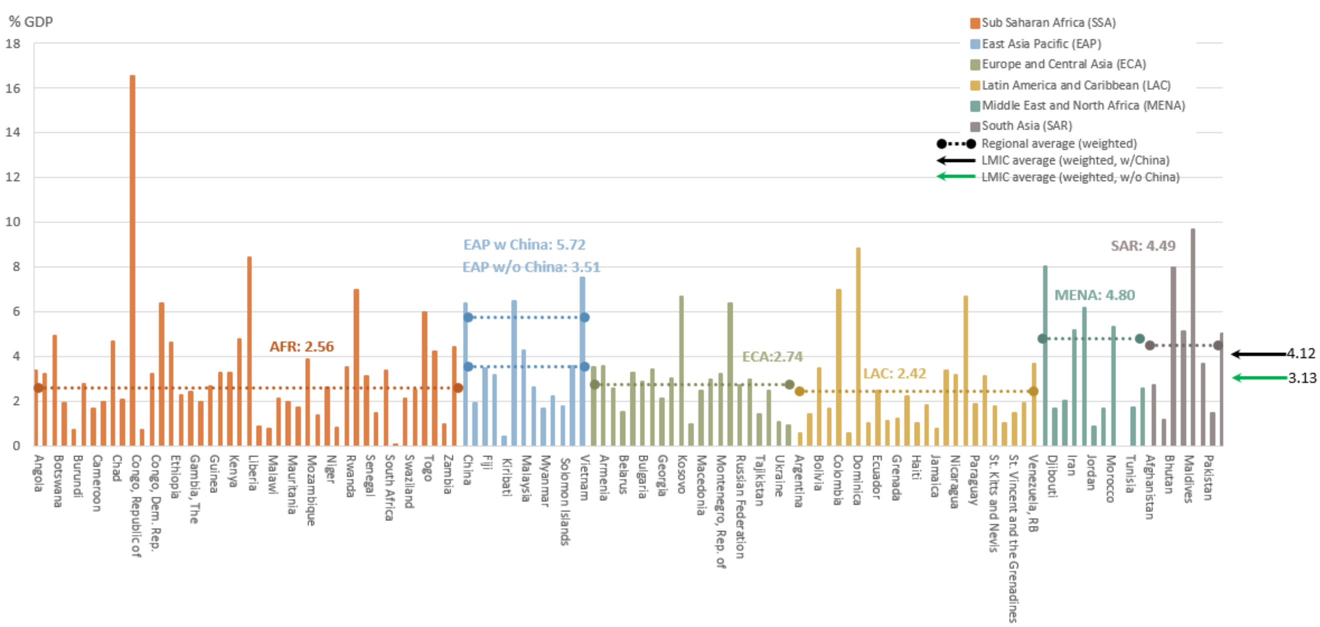
Refinement 2: BOOST+PPI Supplemented by the Minimum of the Two GFCF Estimates

Refinement 2 uses BOOST+PPI where it is available, supplemented by the minimum value of the two GFCF estimates where it is not. Since BOOST+PPI is normally a lower bound, using BOOST as the primary source and complementing it with GFCF estimates for missing values after eliminating outliers makes the new data set quite conservative. For example, spending is estimated at 6.4 percent for the Lao PDR instead of 17.7 percent (GFCF_GG+PPI), 3.1 percent for Indonesia instead of 15.3 percent (GFCF_CE), and 6.3 percent for Equatorial Guinea instead of 20.6 percent (GFCF_GG+PPI). However, if a country has two GFCF estimates with similar bias, then this approach does not necessarily remove outliers. This was the case for the

Democratic Republic of Congo, for instance, where both GFCF_GG+PPI and GFCF_CE were extremely high (16.5 percent and 25.9 percent of GDP, respectively).

Refinement 2 results in a weighted low- and middle-income-country average of 4.12 percent of GDP, amounting to US$1 trillion invested in infrastructure in 2011 (figure 9). This estimate is very close to the GFCF_GG+PPI estimates—which is not surprising because it is the dominant data source. When China is omitted, the global weighted average is significantly lower, dropping to 3.13 percent. With China, East Asia and Pacific spends the most (5.72 percent), while Africa spends the least (2.56 percent). If China is omitted, then the East Asia and Pacific regional weighted average drops to 3.51 percent, and the Middle East and North Africa becomes the region that spends the most. These results once again emphasize the importance of accounting accurately for China's high impact on global estimates.

Figure 9 Refinement 2 (BOOST or Minimum of [GFCF_GG+PPI, GFCF_CE]) for 121 Countries, 2011



Note: The number of estimated countries increases to 121 because Refinement 2 includes Lebanon, which has only GFCF+GG+PPI data.

Refinement 3: Attempting to Correct for the Inclusion of Non infrastructure Sectors

Refinement 3 entails revising GFCF_CE estimates by attempting to isolate noninfrastructure shares. In the absence of disaggregated data for GFCF_CE, we use the original BOOST data (which include complete general government budgets) to identify noninfrastructure spending in GFCF_CE—such as health or agricultural facilities. This spending amounts to an average of about 10 percent of total capital expenditure. We then apply this amount to our original GFCF_CE estimates, reducing it by 10 percent.[13] This approach needs to be addressed more rigorously with microdata to account for country idiosyncrasies, but at this juncture it offers the best result given data availability.[14]

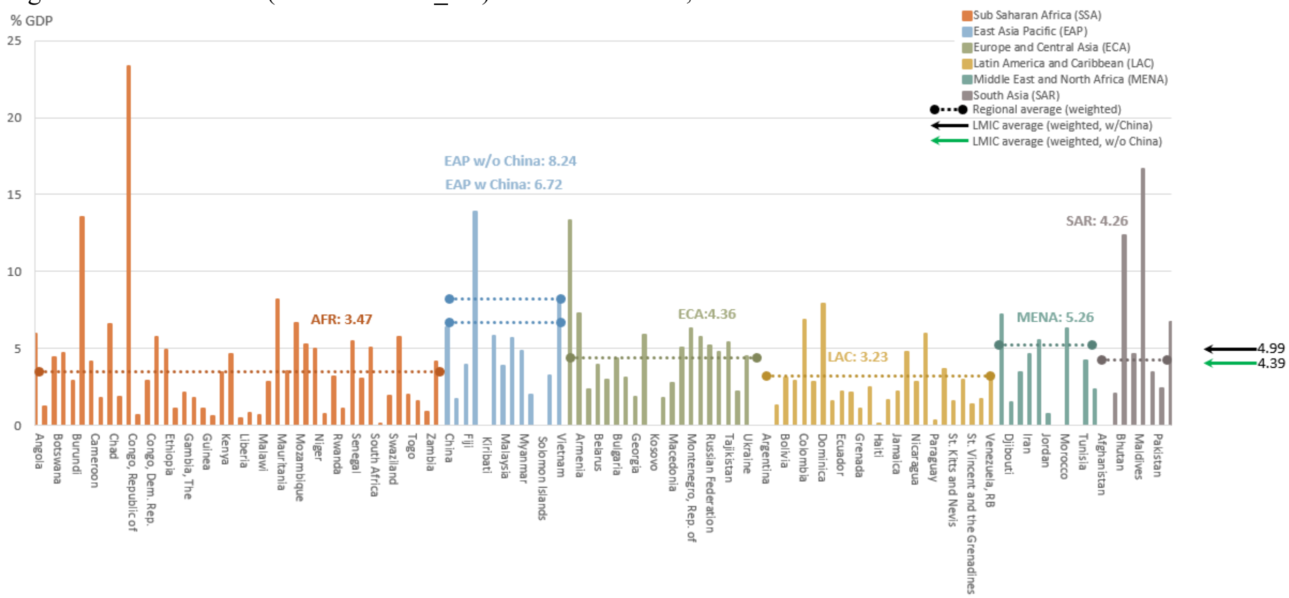
With this refinement, we estimate infrastructure investment at 4.99 percent of GDP, equivalent to US$1.21 trillion (figure 10). Without China, the weighted average drops to 4.39

13. The regional averages for the noninfrastructure portion are 0.89 for Africa and 0.94 for Latin America and the Caribbean. The averages of the remaining regions are not representative due to lack of enough data. See tables 2 and 3.

14. Each refinement implies some risks or limitations depending on the nature of refinement. For example, Refinement 1 runs the risk that the regression still cannot capture SOE investment because its dependent variable is from BOOST, which does not include SOE investment. And whenever new BOOST data arrive, the regression coefficients will change, and the extrapolations should be recalculated. In addition, other econometric techniques, such as principal component analysis, may constitute a better approach. Refinement 2 is a simple merged series of three different sources that does not guarantee a significant improvement for a country with similar value for the two GFCF estimates. Finally, Refinement 3 has the limitation that the 10 percent estimate for the share of noninfrastructure investment is based on an evaluation of health and agriculture investments only—it does not include mining, industrial plants, or other errors of inclusion. These sectors can be important, depending the country's characteristics.

percent. East Asia and Pacific (6.72 percent) spends the most, and Latin America and the Caribbean (3.22 percent) spends the least.[15]

Figure 10 Refinement 3 (Revised GFCF_CE) for 114 Countries, 2011



Refinement 4: Attempting to Improve BOOST Data by Using SPI Data on SOE Shares

Refinement 4 addresses the omission of SOE investments in BOOST by using the regional share of SOE investments from the SPI data set of Saha and others (forthcoming). The reason for using regional share is that the SPI data set yields very unlikely estimates for some countries—with either all investments done by SOEs or all investments done by the general government and none at all by SOEs.[16] We then use these regional shares to calculate an estimated total public (SOE

15. When China is omitted, East Asia and Pacific's regional weighted average increases to 8.23 percent due to Indonesia's extremely high GFCF_CE (13.79 percent even after refinement).

16. The SPI database shows six countries with zero general government investments (Algeria, Botswana, Malaysia, Moldova, Paraguay, and Thailand), implying all public infrastructure investments are done by SOE while

and general government) investment from BOOST or from the fitted values.[17] We then add the PPI data to get total investment for each country.

Regional SOE shares of infrastructure investment from the SPI data set are 26 percent for Sub-Saharan Africa, 46 percent for East Asia and Pacific, 38 percent for Europe and Central Asia, 25 percent for Latin America and the Caribbean, and 35 percent for the Middle East and North Africa and for South Asia.

The result is an estimated infrastructure investment of 3.89 percent of GDP in weighted global average, equivalent to US$0.94 trillion (figure 11). If China is omitted, the global weighted average drops to 2.79 percent. East Asia and Pacific (5.61 percent) spends the most, while Europe and Central Asia (2.18 percent) spends the least.[18]

Figure 11 Refinement 4 (Augmented BOOST) for 120 Countries, 2011

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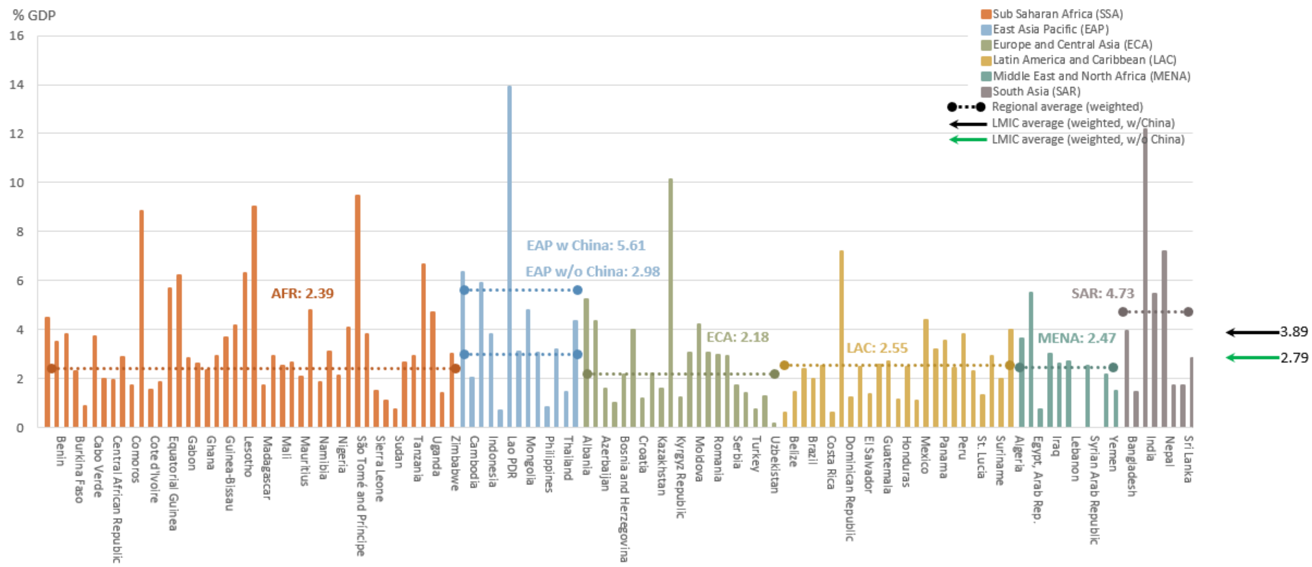
other countries are shown as having close to 100 percent of investments done by the general government and close to none by SOEs (Azerbaijan China, and the Maldives).

17. We use the following formula: $I = IG + IS = gI + sI = IG / (1 - s)$, with IG and IS denoting total general government and SOE infrastructure investments, respectively, and g and s, denoting the *share* of total infrastructure investments attributable to the general government and SOEs, respectively (so that $g + s = 1$). For any country with a very high s (for example, Azerbaijan, China), we would have to multiply IG by an absurdly large number (for example, by 20 for China, since $s = 0.95$) tending to infinity as s approaches 1.

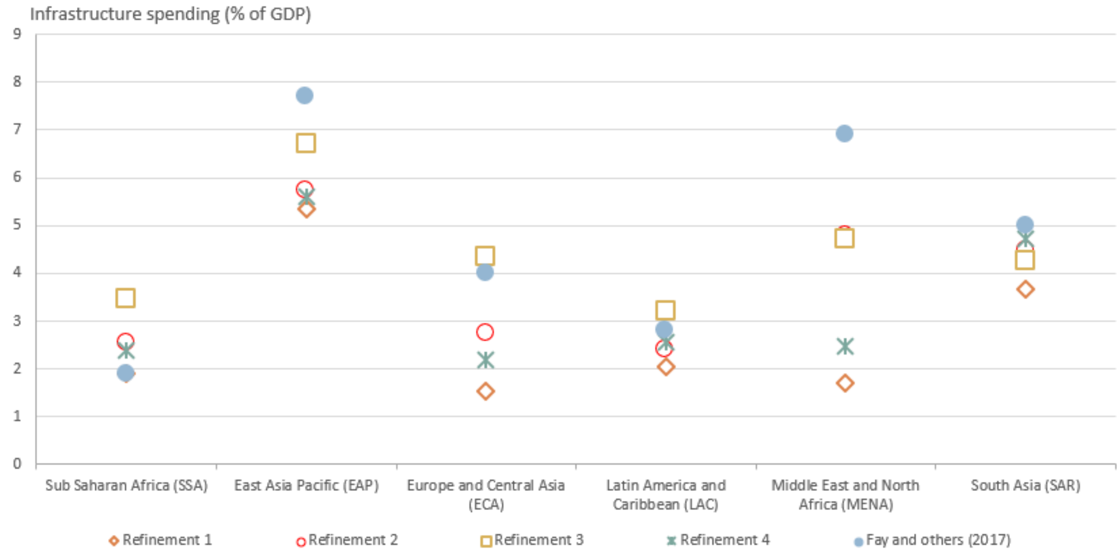
18. When China is omitted, East Asia and Pacific's regional weighted average drops to 2.98.



Pulling It All Together: Triangulating to Define a Range

Our results, shown in figure 12 and table 9, are a lower-bound estimate of 3.40 percent, a central estimate of 3.89–4.12 percent, and an upper-bound estimate of 4.99 percent of low- and middle-income countries' GDP. Corresponding total infrastructure spending in 2011 amounted to US$0.82 trillion, US$0.94 trillion to US$1.00 trillion, and US$1.21 trillion, respectively. Rounding it off, this suggests high and low estimates of 3.4 percent and 5 percent (US$0.8 trillion and US$1.2 trillion), respectively, and a central estimate of 4 percent (US$1 trillion).

Figure 12 Weighted Regional Averages for Infrastructure Spending, by Methodology, 2011



Regional weighted averages from the four resulting estimates are shown in table 9. Among the regions, East Asia and Pacific spends the most regardless of the estimation method used. Latin America and the Caribbean and Sub-Saharan Africa are the regions that spend the least—at least based on the central and upper-bound estimates.

Comparing our results to those of previous studies and accounting for the fact that the studies cover different years, we find generally comparable results. In terms of regional variations, both this report and Fay and others (2017) show significant consistency, especially for East Asia and Pacific (top spender) and for Africa (bottom spender), but less so for the Middle East and North Africa, which is the least well documented of the regional estimates reported in Fay and others (2017).

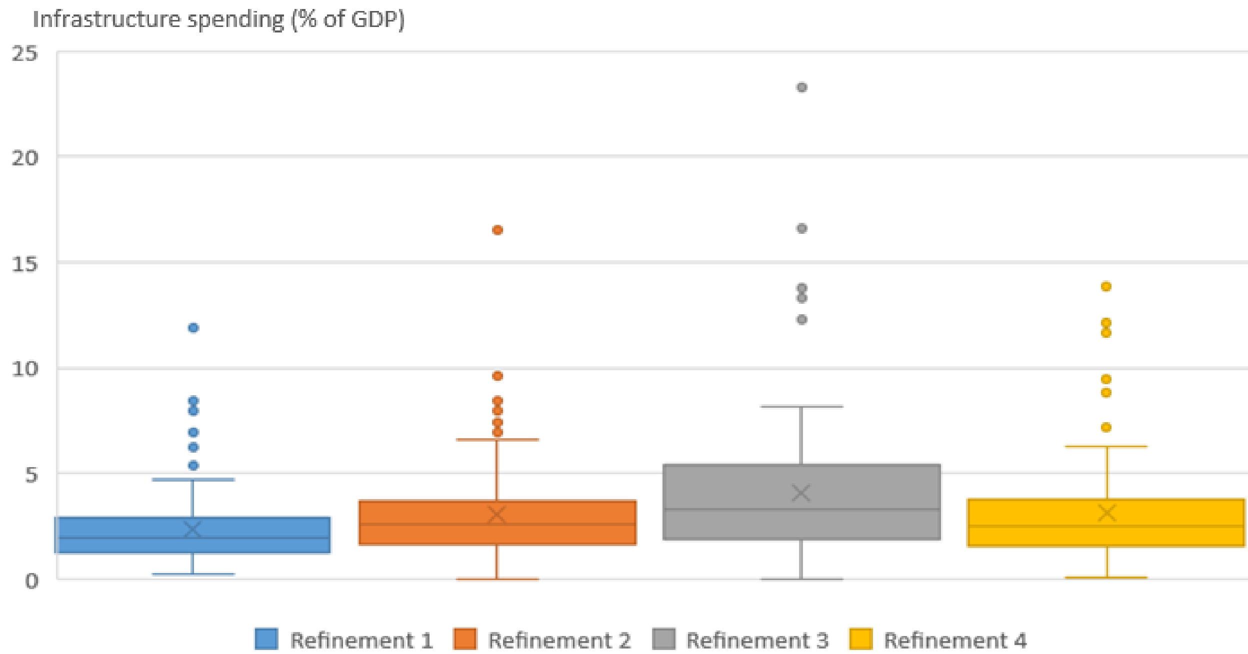
Table 9 Summary Estimates for Infrastructure Spending, by Methodology

Indicator	*Lower-bound estimate: Refinement 1 (fitted values)*	*Central estimate: Refinement 2 (BOOST or Min of two GFCFs)*	*Upper-bound estimate: Refinement 3 (0.9 GFCF_CE)*	*Refinement 4 (SOE-augmented BOOST and fitted values)*	*Estimate from Fay and others (2017)*
% of GDP					
Africa	1.91	2.56	3.47	2.39	1.9
East Asia and the Pacific	5.36	5.72	6.72	5.61	7.7
*East Asia and the Pacific, without China**	*1.78*	*3.51*	*8.24*	*2.98*	
Europe and Central Asia	1.53	2.74	4.36	2.18	4.0
Latin America and the Caribbean	2.04	2.42	3.23	2.55	2.8
Middle East and North Africa	1.88	4.80	5.26	2.47	6.9
South Asia	3.67	4.49	4.26	4.73	5.0
LMIC weighted average	**3.40**	**4.12**	**4.99**	**3.89**	—
LMIC weighted average, without China	***2.07***	***3.13***	***4.39***	***2.79***	
(2011 US$, trillions)					
LMIC total	0.82	1.00	1.21	0.94	1.5
LMIC total, without China	**0.34**	**0.52**	**0.73**	**0.46**	—
Target year	2011	2011	2011	2011	Various

Note: All refinements use Asian Development Bank data for China. The results reported in Fay and others (2017) were drawn from a variety of sources, covered different years, and were derived with varying methodologies and degrees of care. — = not available.

Another way of comparing these four methods is to compare their basic statistics using a box-whisker plot that shows median, minimum, maximum, quantiles 1 and 3, and outliers (figure 13).

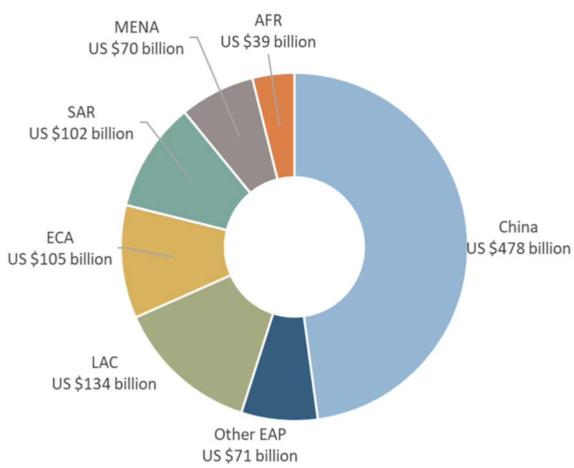
Figure 13 Characteristics of Estimation, by Methodology



Note: x = the mean. Middle line in the box = the median. Boundaries of the box = the lower and upper quartile. Upper or lower whisker = the largest or the smallest value of inner points. Dots = outlier points (defined as values outside 1.5 times the interquartile range above the upper quartile and below the lower quartile).

We derive the amount of infrastructure spending for each region by applying our central estimate to regional 2011 GDP (figure 14). This approach suggests that China alone accounts for about 48 percent of LMIC infrastructure investments, while Sub-Saharan Africa accounted for less than 4 percent.

Figure 14 Regional Distribution of Infrastructure Spending Using Central Estimate (Refinement 2), 2011



Finally, we derive an estimation of the public and private share of infrastructure investments (table 10). The public sector clearly dominates, with the private sector accounting for only 9 to 13 percent of total infrastructure investments (14 and 31 percent without China). However, there is considerable variation across regions, from a low of 2 percent in East Asia and the Pacific to a high of 35-46 percent in East Asia and Pacific.

Table 10 Private Share of Infrastructure Investments

% of total investments

Region	*Lower bound (Refinement 1)*	*Central estimate (Refinement 3)*	*Upper bound (Refinement 3)*	*Refinement 4*
Sub-Saharan Africa	23	17	13	18
East Asia and Pacific	2	2	2	2
Europe and Central Asia	30	17	10	21
Latin America and the Caribbean	27	23	17	22
Middle East and North Africa	17	6	6	11
South Asia	46	37	39	35
All LMICs	**13**	**11**	**9**	**11**
China	1	1	1	1
LMICs without China	***31***	***20***	***14***	***23***

Note: These estimates are derived using the estimated private share of infrastructure financing from the PPI database as explained in table B1.1 and total investments from table 9.

6. Making the Most of Rich Data Sets: What Else Can We Learn about Infrastructure Spending by Exploring the BOOST Database?

While BOOST has the drawback of not being comprehensive both in terms of countries and sources of spending, it has the distinct advantage of providing perfectly disaggregated data, over time, and for most countries both as budgeted and as actual spending. This makes it a great database for learning more about the business of public spending on infrastructure.

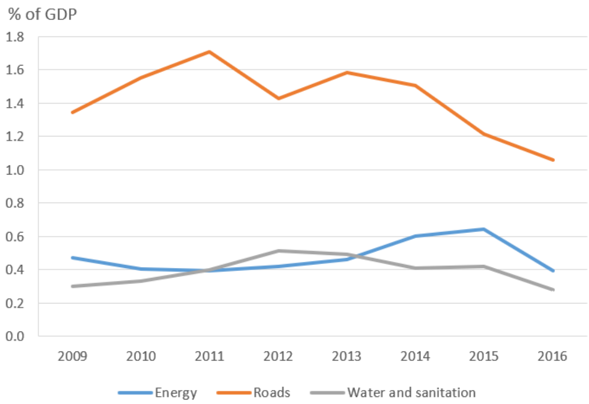
The main output of the BOOST analysis is a global baseline of capital spending in infrastructure for 55 countries, disaggregated by subsector (road, water, and air transport; electricity; telecommunications; water and sanitation), spending ministry, and economic classification for the period 2009–16. The BOOST analysis allows us to explore issues of financing, credibility, drivers, and efficiency. Most important, it also yields a methodological approach that can facilitate annual updates.

As shown on figure 15, public infrastructure investments, at 1.6 percent of GDP on average between 2009 and 2017, are rather small among the 55 countries covered by BOOST—partly reflecting its greater coverage of two regions known for relatively low spending on infrastructure (Latin America and Sub-Saharan Africa). This finding also reflects difficulties in the execution of budgeted spending particularly in Sub-Saharan Africa: overall spending on infrastructure was considerably lower than capital allocations during the same period (around 2.4 percent of GDP), reflecting substantial under execution of such investments.

Figure 15 Approved and Executed Infrastructure Spending, by Region, 2009–17

BOOST also allows us to look at the evolution over time of public spending on infrastructure, which has stagnated over the past seven years, particularly in the three main subsectors (figures 16 and 17). Total capital allocations for roads have been decreasing after reaching a peak of 1.8 percent of GDP in 2011. Similarly, capital allocations for water supply and sanitation have reverted to 2009 levels, after peaking at around 0.6 percent of GDP. Energy allocations have also decreased gradually, following a peak of 0.5 percent of GDP in 2012, with increasing reliance on externally funded investment projects and limited mobilization of domestic revenue toward this sector.

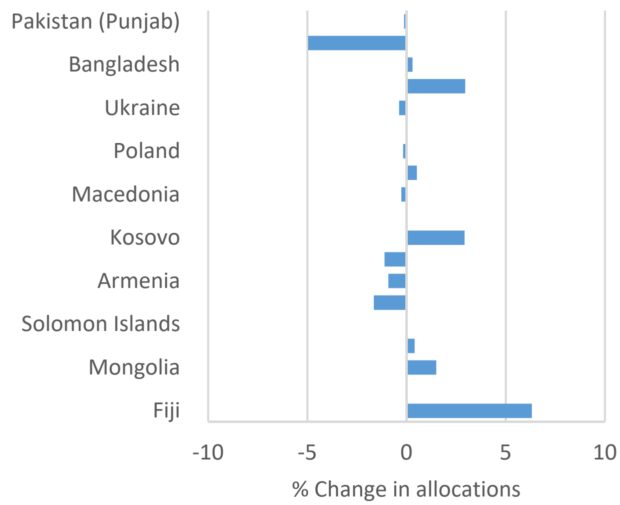
Figure 16 Annual Capital Flows, by Subsector, 2009–16



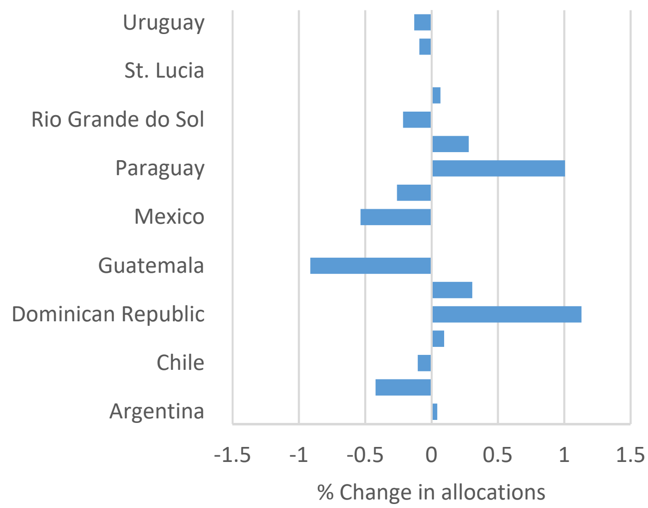
There are, however, significant differences among the countries in the sample (figure 18). With regard to capital budget allocation, countries like Afghanistan, the Dominican Republic, Fiji, Paraguay, and Togo experienced increases of 3 percent of GDP or more between 2009 and 2017, driven mostly by increases in allocations for roads. On the other end of the spectrum, Angola, Benin, and São Tomé and Príncipe recorded the largest percentage decreases in public capital spending for infrastructure from 2009 levels. While Angola and São Tomé and Príncipe continue to experience high spending levels overall (4.5 percent and 5.6 percent of GDP, respectively), the slowing pace of capital spending in Benin—driven mostly by roads and water and sanitation—is more problematic in light of lower spending levels overall and acute infrastructure gaps.

Figure 17 Change in Capital Allocation for Infrastructure, by Region, 2009–17

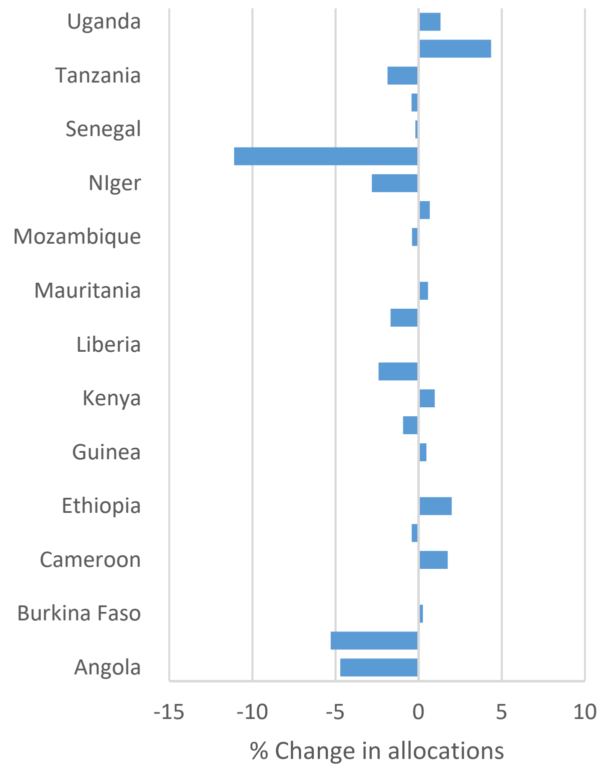
Asia



Latin America and Caribbean



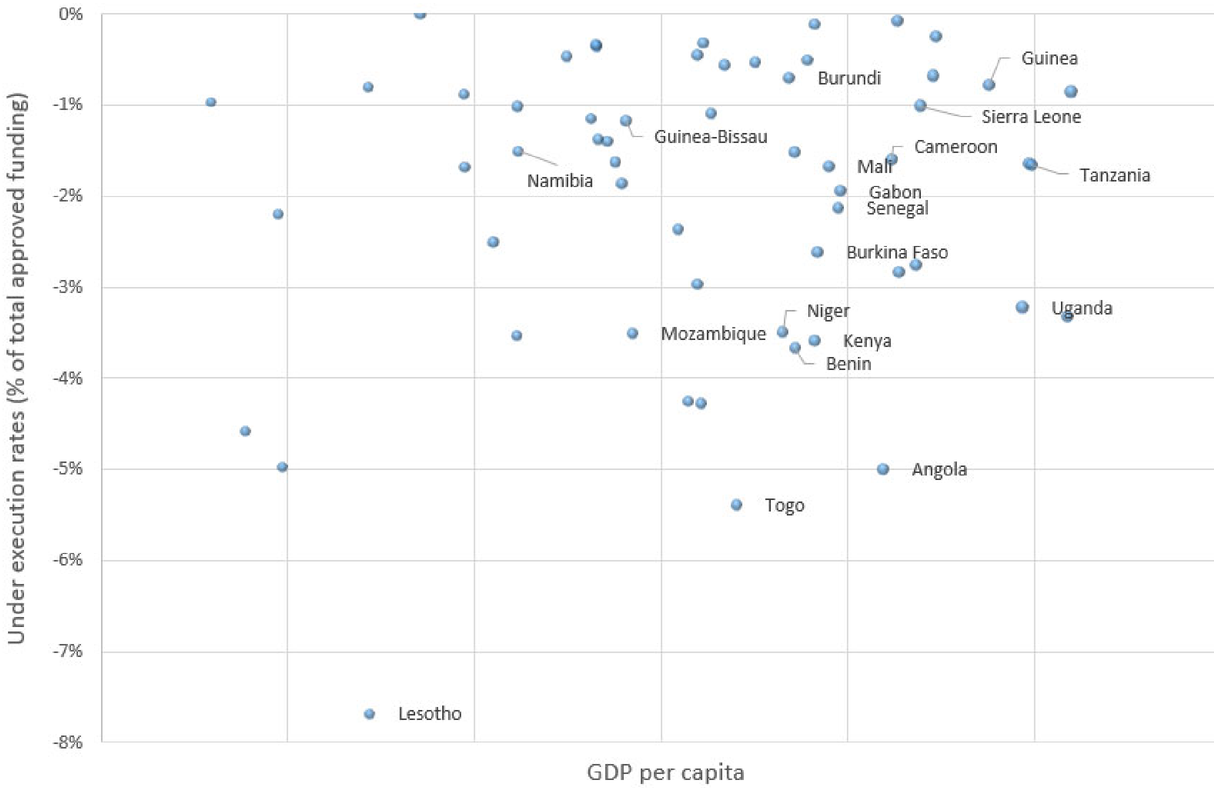
Sub-Saharan Africa



Under execution affects the efficiency of public investment. Analyzing under execution of public investment (deviation from the original approved budget) can help to assess the degree to which residual approaches to capital spending might be at play and, more generally, to assess the level of credibility built into approved capital budgets. Given the uneven availability of information on the spending of foreign-funded aid, the analysis relies on examining deviations between capital allocations and execution of domestically funded projects. This approach provides a better assessment of the ability of national systems to implement capital projects.

The analysis reveals very large levels of under execution, particularly in Sub-Saharan Africa. On average, more than 30 percent of total domestic allocations were not executed every year from 2009 to 2016 (figure 18). This amounted to almost 1 percent of GDP remaining unspent on capital infrastructure every year, with roads accounting for two-thirds of overall underspending. This trend is particularly worrisome since most domestic resources are mobilized toward roads, with capital spending on electricity and water and sanitation still dominated by foreign assistance.

Figure 18 Under execution Rates of Spending on Domestically Funded Infrastructure, 2009–16

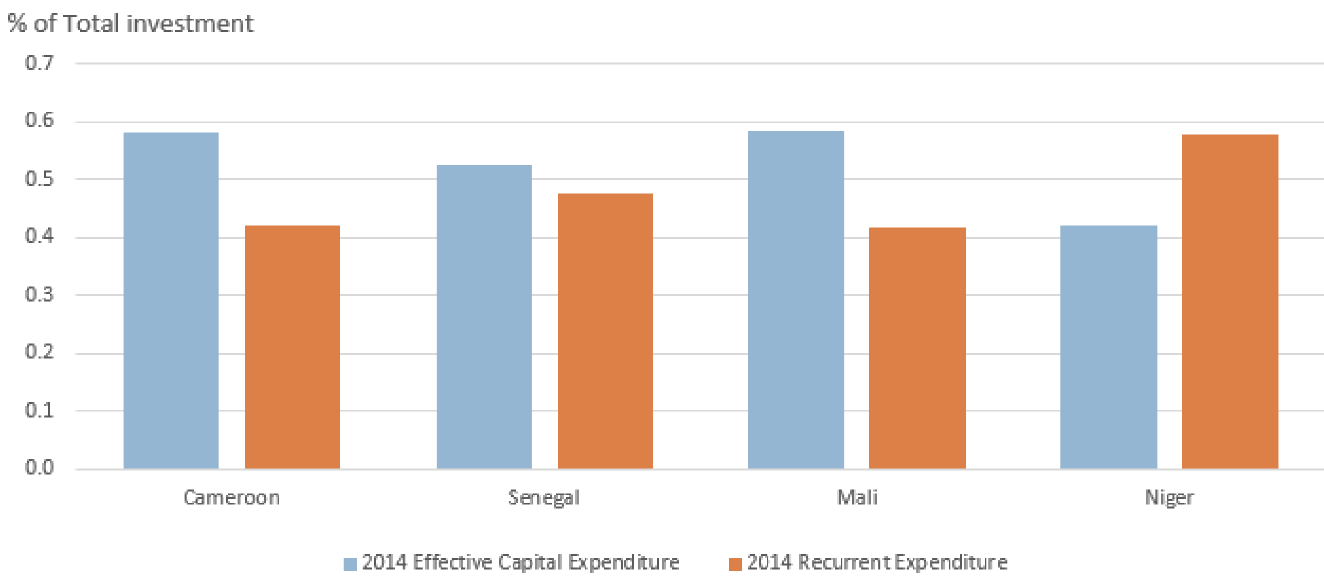


Several reasons could account for these high levels of under execution. Historically, most African countries have taken a residual approach to capital spending, which often results in a midyear decrease in disbursement in typical scenarios of overly optimistic revenue projections leading to in-year prioritization toward recurrent expenses. Further explanations include late release of disbursements, which is typical of countries without a proper medium-term capital commitment framework, implementation gaps due to weak absorptive capacity, and other institutional bottlenecks (that is, inefficient procurement systems), and pervasiveness of corruption and lack of accountability leading to suboptimal delivery of infrastructure.

A second key finding of the BOOST analysis is that a very large share of reported capital expenditures consists of recurrent expenditures. A preliminary analysis of four Francophone

African countries concluded that close to 50 percent of capital expenditures are recurrent expenditures (figure 18). Combining these findings with the high rates of under execution, this analysis provides compelling evidence of the need to look beyond budget allocations, which likely overestimate actual capital formation.

Figure 18 Composition of Public Investment in Select Sub-Saharan African Countries, 2014



7. Conclusion

This study has sought to develop a consistent set of estimates of infrastructure spending and financing. We explored the robustness and consistency of four alternative methodological approaches to estimate actual capital spending on infrastructure, highlighting the merits and flaws of each. We estimated and analyzed infrastructure spending in about 120 countries according to each methodology. Finally, we established a global baseline on infrastructure investments along with an analysis of stylized facts and implications, recognizing persistent deficiencies in these estimates as well as their catalytic value in motivating further advances in the field.

Based on the four methodologies, we developed a reasonable range of infrastructure spending. We combined the informative content of each data set into representative series and estimated total infrastructure spending to range between US$0.8 trillion and US$1.2 trillion across the low- and middle-income world, with significant regional variations. In absolute terms, East Asia and Pacific was found to account for more than half (54 percent) of total infrastructure investment by low- and middle-income countries, followed by Latin America and the Caribbean as a distant second (about 15 percent). The vast majority (87-91 percent) of low and middle income countries investment in infrastructure is undertaken by the public sector.

More work is needed to refine these estimations, and there are several possible ways forward:

- Expand on the BOOST database to include more countries as well as investment data from (at least) large SOEs. Such data have been collected for the electricity sector, and a pilot effort is under way to gauge the feasibility of expanding the data collection to cover water and transport. In addition, collaboration with other multilateral development banks will continue to ground-truth the analysis.
- Expand the time series for the GFCF_CE estimate, which will be possible in 2019, when 2017 data from the ICP will become available.
- Access the rich set of disaggregated data that underpins GFCF estimates. As recommended by ADB (2017) and discussed in annex C, this approach would be ideal because it would follow the Eurostat approach and would collect infrastructure data from national accounts, disaggregated by sector and asset type—a task that would require an effort on the part of national statistics bureaux. While ideal, this approach would require a new global initiative to support the effort.

Annex A. Country-Level Results

Table A.1 Estimation of Consolidated Global Infrastructure Spending in 2011 with New Series—

Region and country	*PPI*	*GG+PPI*	*CE*	*BOOST +PPI*	*Refinement 1 (BOOST or_Regression)*	*Refinement 2 [BOOST or Min (GG,CE)]*	*Refinement 3 (revised CE)*
Sub-Saharan Africa							
Angola	0.22	22.63	6.55	3.33	3.33	3.33	5.89
Benin	2.32	6.62	1.31	3.17	3.17	3.17	1.18
Botswana	0.49	11.33	4.89	-	2.91	4.89	4.40
Burkina Faso	0.76	10.11	5.16	1.78	1.78	1.78	4.64
Burundi	0.14	6.45	3.17	0.68	0.68	0.68	2.85
Cabo Verde	-	9.98	15.00	2.71	2.71	2.71	13.48
Cameroon	0.55	4.88	4.60	1.57	1.57	1.57	4.14
Central African Republic	0.33	4.03	1.94	-	1.52	1.94	1.74
Chad	0.42	4.54	7.26	-	2.15	4.54	6.53
Comoros	-	2.33	2.02	-	1.24	2.02	1.82
Congo, Rep.	-	16.50	25.90	-	6.49	16.50	23.29
Côte d'Ivoire	1.21	2.55	0.69	-	1.44	0.69	0.62
Congo, Dem Rep.	0.43	4.39	3.16	-	1.36	3.16	2.84
Equatorial Guinea	-	20.59	6.33	-	4.18	6.33	5.69
Erwatini	0.09	8.78	2.09	-	1.96	2.09	1.88
Ethiopia	0.00	14.55	5.39	4.56	4.56	4.56	4.85
Gabon	0.63	10.24	1.13	2.25	2.25	2.25	1.02
Gambia, The	-	6.58	2.35	-	1.90	2.35	2.12
Ghana	0.75	6.65	1.94	-	1.72	1.94	1.75
Guinea	1.89	5.38	1.14	2.63	2.63	2.63	1.03
Guinea-Bissau	2.05	4.03	0.63	3.23	3.23	3.23	0.57
Kenya	0.68	4.84	3.77	3.18	3.18	3.18	3.39
Lesotho	0.35	12.63	5.09	4.73	4.73	4.73	4.58
Liberia	6.70	13.48	0.46	8.40	8.40	8.40	0.41
Madagascar	0.73	3.46	0.84	-	1.29	0.84	0.76
Malawi	1.39	5.59	0.71	-	2.21	0.71	0.64
Mali	0.86	6.39	3.10	2.02	2.02	2.02	2.79
Mauritania	-	6.72	9.05	1.93	1.93	1.93	8.13
Mauritius	0.67	6.02	3.89	1.68	1.68	1.68	3.50
Mozambique	1.08	13.06	7.32	3.81	3.81	3.81	6.58
Namibia	-	9.94	5.83	1.35	1.35	1.35	5.24
Niger	1.21	5.87	5.50	2.57	2.57	2.57	4.94
Nigeria	0.55	2.79	0.78	-	1.67	0.78	0.70
Rwanda	1.04	9.61	3.50	-	3.04	3.50	3.14
São Tomé and Príncipe	-	25.46	1.17	6.95	6.95	6.95	1.06
Senegal	1.00	5.93	6.02	2.94	2.94	2.94	5.41

Sierra Leone	1.33	7.07	3.35	1.45	1.45	1.45	3.01
South Africa	0.29	3.34	5.55	-	0.87	3.34	4.99
Sudan	0.58	3.64	0.00	-	0.68	0.00	0.00
Tanzania	1.22	6.63	6.36	2.47	2.47	2.47	5.72
Togo	2.03	6.72	2.19	4.07	4.07	4.07	1.97
Uganda	2.58	8.27	1.73	3.99	3.99	3.99	1.55
Zambia	0.63	4.26	0.95	-	1.18	0.95	0.86
Zimbabwe	1.46	4.40	4.58	-	2.59	4.40	4.12
East Asia and Pacific							
Cambodia	-	5.97	1.89	-	1.20	1.89	1.70
China	0.03	16.00	16.11	-	6.31	6.31	6.31
Fiji	0.40	6.16	4.34	3.29	3.29	3.29	3.91
Indonesia	0.27	3.12	15.34	-	2.17	3.12	13.79
Kiribati	-	-	-	0.35	0.35	0.35	-
Lao PDR	9.52	17.69	6.43	-	11.86	6.43	5.78
Malaysia	0.25	9.78	4.24	-	1.77	4.24	3.81
Mongolia	0.00	9.92	6.24	2.57	2.57	2.57	5.61
Myanmar	0.00	11.21	5.31	1.63	1.63	1.63	4.78
Philippines	0.85	2.69	2.19	-	0.84	2.19	1.97
Solomon Islands	-	-	-	1.72	1.72	1.72	-
Thailand	0.22	5.22	3.54	-	0.84	3.54	3.19
Vietnam	0.67	7.43	9.00	-	2.62	7.43	8.09
Europe and Central Asia							
Albania	0.64	5.82	14.79	3.49	3.49	3.49	13.29
Armenia	2.05	3.56	8.07	3.39	3.39	3.39	7.26
Azerbaijan	0.24	5.27	2.54	-	1.06	2.54	2.29
Belarus	0.23	1.47	4.36	-	0.72	1.47	3.92
Bosnia and Herzegovina	0.04	5.84	3.25	-	1.34	3.25	2.92
Bulgaria	0.80	3.80	4.77	2.73	2.73	2.73	4.29
Croatia	-	3.61	3.38	-	0.72	3.38	3.04
Georgia	0.70	3.89	2.06	-	1.44	2.06	1.85
Kazakhstan	0.17	2.98	6.53	-	1.01	2.98	5.87
Kosovo	0.53	11.72		6.26	6.26	6.26	-
Kyrgyz Republic	0.43	2.02	1.94	0.92	0.92	0.92	1.74
Macedonia	1.40	6.98	3.04	2.41	2.41	2.41	2.74
Moldova	0.44	2.31	5.54	2.51	2.51	2.51	4.98
Montenegro, Rep. of	0.38	3.19	6.94	-	2.04	3.19	6.24
Romania	0.50	7.13	6.35	-	1.96	6.35	5.70
Russia Federation	0.34	2.69	5.74	-	1.92	2.69	5.16
Serbia	0.21	2.92	5.28	-	1.13	2.92	4.74
Tajikistan	1.36	6.79	5.99	1.38	1.38	1.38	5.38

Turkey	0.66	4.00	2.44	-	0.68	2.44	2.20
Ukraine	0.65	1.96	4.93	1.02	1.02	1.02	4.43
Uzbekistan	0.53	0.84	-	-	0.25	0.84	-
Latin America and the Caribbean							
Argentina	0.29	3.22		0.53	0.53	0.53	-
Belize	-	3.10	1.38	-	1.08	1.38	1.24
Bolivia	-	8.83	3.44	-	1.78	3.44	3.09
Brazil	0.68	3.06	3.15	1.62	1.62	1.62	2.84
Colombia	0.51	6.93	7.61	-	2.00	6.93	6.84
Costa Rica	0.17	2.96	3.07	0.39	0.39	0.39	2.76
Dominica	-	20.96	8.77	-	5.37	8.77	7.89
Dominican Republic	0.12	2.71	1.74	0.82	0.82	0.82	1.56
Ecuador	0.37	10.15	2.43	-	1.92	2.43	2.19
El Salvador	0.28	2.20	2.36	1.01	1.01	1.01	2.12
Grenada	-	7.48	1.18	-	1.90	1.18	1.06
Guatemala	0.42	2.71	2.70	1.97	1.97	1.97	2.43
Haiti	0.50	12.12	0.00	0.87	0.87	0.87	0.00
Honduras	1.27	4.19	1.78	-	1.88	1.78	1.60
Jamaica	0.24	0.24	2.44	-	0.51	0.24	2.19
Mexico	0.34	4.99	5.24	3.35	3.35	3.35	4.71
Nicaragua	1.19	4.52	3.13	-	2.20	3.13	2.81
Panama	1.05	6.99	6.61	-	2.77	6.61	5.94
Paraguay	0.19	3.76	0.33	1.85	1.85	1.85	0.30
Peru	0.78	4.54	4.04	2.93	2.93	2.93	3.63
St. Kitts and Nevis	-	5.88	1.71		1.72	1.71	1.54
St. Lucia	-	9.11	3.23	0.98	0.98	0.98	2.90
St. Vincent and the Grenadines	-	8.70	1.45	-	2.17	1.45	1.31
Suriname	-	6.39	1.88	-	1.48	1.88	1.69
Venezuela, RB	-	10.64	3.64	-	2.99	3.64	3.27
Middle East and North Africa							
Algeria	0.27	9.85	7.96	-	2.44	7.96	7.16
Djibouti	-	17.72	1.64	-	3.56	1.64	1.48
Egypt, Arab Rep.	0.46	2.00	3.83	-	0.65	2.00	3.45
Iran, Islamic Rep.	0.04	11.91	5.13	-	1.94	5.13	4.61
Iraq	0.38	6.99	6.12	-	1.80	6.12	5.50
Jordan	1.29	4.83	0.81	-	1.76	0.81	0.73
Lebanon	-	1.65		-	0.00	1.65	-
Morocco	0.35	5.30	6.96	-	1.74	5.30	6.26
Syrian Arab Republic	-	-	-	-	-	-	-
Tunisia	0.47	7.19	4.64	1.34	1.34	1.34	4.17

Yemen, Rep.	0.33	4.03	2.53	-	1.06	2.53	2.27
South Asia							
Afghanistan	0.18	-	-	2.54	2.54	2.54	-
Bangladesh	0.59	5.65	2.24	1.14	1.14	1.14	2.01
Bhutan	-	12.18	13.65	7.94	7.94	7.94	12.27
India	1.90	9.10	5.08	-	4.19	5.08	4.57
Maldives	0.00	9.64	18.50	-	4.68	9.64	16.63
Nepal	0.20	3.64	3.77	-	1.19	3.64	3.39
Pakistan	0.89	3.04	2.61	1.38	1.38	1.38	2.34
Sri Lanka	0.46	4.89	7.41	-	1.93	4.89	6.66

Note: - = not available

Table A.2 Comparison of Infrastructure Spending in 2011 between European Investment Bank (EIB) Data and Three Methodologies

	EIB data			*This study*		
Country	*Governmen GFCF_CE+ other building (A)*	*Private GFCF_CE+ other building (B)*	*GFCF_CE+ other building (C = A + B)*	*GFCF_CE*	*GFCF_GG +PPI*	*BOOST +PPI*
Austria	0.646	0.781	1.426	1.016	3.137	-
Bulgaria	1.207	1.188	2.395	4.775	3.650	2.588
Cyprus	0.546	1.534	2.080	3.637	5.108	-
Czech Republic	1.396	1.121	2.517	3.854	4.071	-
Denmark	0.401	0.849	1.250	1.876	4.267	-
Estonia	1.098	3.092	4.190	4.653	5.200	-
Finland	0.624	0.797	1.420	1.932	4.191	-
France	0.816	0.096	0.912	2.307	4.121	-
Germany	0.414	0.501	0.915	1.508	2.164	-
Greece	1.013	0.024	1.037	0.992	2.330	-
Hungary	0.940	0.782	1.723	2.860	2.858	-
Ireland	0.705	0.518	1.223	1.581	3.302	-
Italy	0.533	1.091	1.624	1.924	3.539	-
Latvia	1.266	1.497	2.763	3.587	4.340	-
Luxembourg	1.080	0.896	1.976	2.074	8.898	-
Malta	0.566	0.206	0.772	1.615	0.896	-
Netherlands	1.247	0.275	1.522	2.504	4.150	-
Portugal	0.952	1.422	2.375	4.440	3.972	-
Slovakia	1.426	0.899	2.325	2.395	3.316	-
Slovenia	0.770	0.515	1.285	2.168	4.130	-
Spain	1.198	0.920	2.118	3.162	4.190	-
Sweden	0.790	1.116	1.905	1.904	4.127	-

Note: - = not available

Annex B. Addressing Data Quality through BOOST Sample Description

The BOOST program is a World Bank–led effort launched in 2010 to provide quality access to budget data. The initiative strives to make well-classified and highly disaggregated budget data available for policy makers and practitioners within government, researchers, and civil society and to promote their effective use for improved budgetary decision making, analysis, transparency, and accountability. The program has designed and delivered more than 70 national and subnational BOOST data sets in standardized formats with country-specific content.

Using a government's own data from public expenditure accounts held in its financial management information system (FMIS) and benefiting from a consistent methodology, the program transforms highly granular fiscal data into accessible and readily available formats to facilitate expenditure analysis. Each data set typically allows for approved, revised, and executed budgets to be cross-referenced across years with categories such as the following:

- Government levels (central, local)
- Administrative units (ministries, departments, agencies, schools, hospitals)
- Subnational authorities (districts, municipalities, other local government units)
- Economic classification categories (staff salaries, procurement of goods)
- Sources of funding (budget funds, off-budget funds, external financial)
- Budget programs (if the country uses a program-based budgeting system).

Efforts were made to ensure consistency between amounts computed through BOOST and those computed separately by partner organizations (for example, the IDB for its INFRALATAM database). Consistent with emerging international standards, the team employed a two-prong approach to quantify capital infrastructure from the BOOST database. First, using the economic classification, only pure gross capital formation was used to identify true capital spending. In other words, recurrent expenditures classified under capital budgets were removed from the calculations when possible. Second, the team used functional classification to identify each individual infrastructure subsector: rail, road, water and air transport, energy, water and sanitation, and telecommunications. This process was not always straightforward, as discussed below.

Inevitably these figures were not always consistent with the ones computed by the other multilaterals. Therefore, several measures were taken to ensure consistency of these efforts while maximizing long-term sustainability. These measures included working sessions with staff members of the IDB to identify the source of discrepancy between country figures and achieve consensus regarding the optimal framework moving forward using BOOST as the main instrument. For instance, in Paraguay discrepancies were connected to different treatment of intergovernmental transfers as well as underestimation of road investments that were not properly identified by functional classification: most projects were recorded as "public works" rather than as "road transport." After these adjustments, estimates between the two organizations converged.[19] Further interactions with both the IDB and ADB staff would be welcomed to refine estimates further and achieve greater consistency and convergence across estimates.

Several data challenges undermining the potential for improving the capture of public capital spending in infrastructure were encountered during the BOOST exercise. On the one hand, many countries had minimal identification of functional purpose, making it particularly

19. In other countries, typical differences arose from using different expenditure parameters (Mexico), institutional coverage (Guatemala), and functional tagging (that is, irrigation is not included in water and sanitation data in Mexico).

hard to identify spending accurately across the various sectors, often relying on administrative classification or availability of project information. This was the case in Burundi, Niger, Sierra Leone, and Togo, among others. In Sub-Saharan Africa, only seven countries presented accurate and sufficiently granular project-level information in their treasury systems. On the other hand, many countries—particularly low-income ones—did not present sufficient disaggregation of economic categories to enable the identification of pure gross capital formation from operations expenditures. This problem was particularly acute in cases of foreign-funded projects presenting no economic disaggregation, therefore likely overestimating the amount of true capital spending built into such projects. Coverage of the source of funding was also inconsistent, preventing a thorough analysis of foreign vs. domestic funding dynamics across subsectors. Box B.1 presents an overview of data challenges encountered in Sub-Saharan Africa.

Box B.1 Data Challenges in Tagging Infrastructure Spending in Sub-Saharan Africa

Data quality issues make the task of properly tagging capital expenditure in infrastructure challenging, and constrain the range and quality of analytics. Issues include:

- Only general government expenditures are typically included in capital transfers to SOEs—potentially underestimating capital spending in key infrastructure subsectors.
- Only information captured in treasury systems is included in the analysis—foreign-funded spending on infrastructure that is kept off-budget is therefore not included in this analysis. To enhance the integration of these funds on-budget, the BOOST program is rolling out a new approach that would complement existing national aid management systems with other sources of donor data—particularly data from the International Aid Transparency Initiative—to align off-budget donor spending better with national spending. A pilot is currently under way in Haiti.
- In some Francophone countries, budget classifications are not fully integrated with the chart of account, making it difficult to ensure the seamless tracking of transactions covering a typical expenditure chain. Countries like Mali use bridge tables to link accounting data with budgetary operations, effectively retrieving execution data from their systems fully consistent with budget nomenclature. Others, like Mauritania, Niger, and Togo, do not have such tables and, as a result, only present data at committed and payment-order stage but not actual payments.
- Equatorial Guinea and Zimbabwe provide only minimal information at the administrative and economic level, which does not allow for the proper identification of infrastructure spending and are therefore excluded from the analysis. These data will be featured once the full BOOST database is completed. Guinea-Bissau treasury systems do not capture the execution amount of capital expenditures; as such, only approved amounts are used for the analysis.
- Several Francophone African countries merge accumulated spending by multiple ministries into one administrative unit (*dépenses communes*), which does not allow for proper functional identification. This is the case in Guinea and Mali, leading to potential underestimation of spending.
- In several countries such as Benin, Guinea, and Togo, foreign-funded capital expenditure data are only available at the budget level. For these countries, deviation analysis is only conducted for domestic-funded expenditures.
- In several Francophone countries (Haiti, Tunisia), development expenditures are presented on aggregate form by project, preventing us from isolating recurrent shares of reported capital amounts.

Quality issues—such as proliferation of special and manual procedures in Francophone countries—also present challenges for collecting executed amounts through treasury systems, further complicating efforts to compile reliable fiscal statistics. The work carried out in Burundi, Niger, and Togo points to the importance of focusing on the proliferation of special procedures during data-quality vetting processes. If these processes are not regularized, these special procedures are not captured in the FMIS, therefore underestimating the true amount of expenditures in a given year. These issues were resolved through technical assistance workshops that supported Ministry of Finance officials in the regularization of such procedures so that payments would be recorded regularly in treasury systems (as in Niger). However, they still present challenges in countries like Burundi and Togo, among others.

Foreign-funded investments in infrastructure play a big role, particularly in water and sanitation and electricity. However, in most countries, a substantial amount of foreign aid remains off-budget, particularly as it relates to disbursements and execution. In Guinea, Guinea-Bissau, Liberia, Sierra Leone, and Togo, budget data are recorded in the system, but there is no trace of execution amounts. In Uganda, information on the execution of certain foreign-funded projects is either absent or incomplete. This situation affects not only measurements of total spending in a sector (underestimated) but also potential deviation analysis (difference between originally planned and executed), leading to spurious upward bias. While innovative approaches are being pioneered to integrate execution data into national systems (box B.1), the magnitude of the amount of foreign aid not being captured on-budget calls for caution in interpreting overall amounts of spending.

Similarly, capital spending in infrastructure by SOEs is complex to capture. This spending might be significant, particularly in energy and water and sanitation sectors. In particular, two challenges need to be addressed. On the one hand, little information is available about spending by SOEs given the opacity of financial reporting of these entities. Second, without proper identification of funding source, it might be difficult to disentangle SOE spending financed by central government (which is typically captured in BOOST) from spending financed through own revenues or commercial financing.

Finally, only a subset of countries[20] present significant geographic disaggregation of capital spending, undermining potential equity analysis of public investments. Although this lack of disaggregation of spending data do not affect the primary objective of this study—to derive a global baseline of infrastructure capital spending—it does limit the informational and analytical potential. Given the well-known existence of wide within-country variations in terms of economic need and performance, it is critical for public spending data to provide geographic disaggregation to allow for systematic assessment of equitable targeting of public investments in infrastructure and to analyze execution patterns more systematically across national and subnational spheres.

More generally, fragmentation of financial management systems and duality of roles between planning and finance ministries often prevent researchers from accessing more integrated views of project data across its full cycle. In best-case scenarios, treasury systems capture annual budget, allocation, and expenditure amounts dissected by basic economic

20. In Europe and Central Asia, Albania, the Kyrgyz Republic, Moldova, Poland, Romania, and Ukraine; in Latin America and the Caribbean, Brazil, Bulgaria, El Salvador, Guatemala, Mexico, and Peru; in Sub-Saharan Africa, Angola, Ethiopia, Kenya, Mali, Mozambique, Tanzania, and Uganda.

categories across all government levels. However, detailed project information, such as appraisal information (when available), expected cost, time frame, and outputs, among others, is scattered among various departments and ministries and often in formats inconsistent with treasury data. This inconsistency inhibits systematic analysis of project performance and stronger evidence-based assessment of efficiency in public investment management. Significant efforts are needed to ensure greater integration and interoperability of information systems across low- and middle-income countries.

Annex C. Improving Infrastructure Investment Estimates Using Disaggregated National Accounts Data

When gross fixed capital formation is broken down by asset type and industrial sector of the investor, infrastructure investment can be estimated more accurately. Specifically, asset classes for each infrastructure sector are identified as follows:

- *Transport.* Civil engineering works, buildings other than dwellings, and information and communication technology and rail-related machinery and equipment
- *Energy.* Civil engineering works, buildings other than dwellings, and machinery and equipment not transport related
- *Water supply and irrigation*. Civil engineering works, buildings other than dwellings, and machinery and equipment not transport related
- *Telecommunications*. Civil engineering works, buildings other than dwellings, and machinery and equipment not transport related.

Adding up asset-sector-specific infrastructure investment gives the total infrastructure investment. The example of Fiji has two implications:

1. The majority of infrastructure investment—approximately 80 percent—goes to civil engineering works. This lends support to using GFCF on construction excluding buildings (GFCF_CE) to approximate infrastructure investment when there is no better alternative.
2. A nontrivial amount of infrastructure investment is not captured by GFCF_CE. This is mainly on machinery and equipment (used mainly in telecommunications, energy, and water infrastructure)—accounting for about 20 percent of Fiji's infrastructure investment

(with about half in ICT equipment). Nonresidential buildings are also missing from GFCF_CE, but the amount is small.

One problem with this approach is that not all road investment is classified as transport. For example, public works (or public administration) may also contain information on road investment. The practice seems to vary by country. Nevertheless, the measure described above offers a conservative, or lower-bound, estimate.

One way to address this issue is to include civil engineering works for all sectors, while keeping unchanged the investment in machinery and equipment and nonresidential buildings in energy, water, and telecommunications. This creates an upper bound (higher estimate), as some non infrastructure components in civil engineering would also be included (mines and industrial plants, mining construction, other construction for manufacturing, outdoor sports and recreation facilities, and other civil engineering works such as satellite-launching sites and defense).

Comparing alternative estimates for infrastructure investment in Fiji, India, and Pakistan produce interesting results (table C.1).

Table C.1 Comparison of Alternative Estimates of Infrastructure Investment for Three Countries
% of GDP

Measure of total infrastructure investment	*Fiji, 2011*	*India, 2013*	*Pakistan, 2011*
Ideal measure: GFCF breakdown	[5.58, 6.46]	[4.03, 8.39]	[1.23, 2.15]
Measure 1: Budget + PPI	3.78	5.50	2.14
Measure 2: GFCF_GG + PPI	5.96	7.78	3.29
Measure 3: GFCF_CE	5.48	5.79	2.21

Source: Asian Development Bank estimates; country sources.
Note: GFCF = gross fixed capital formation. GFCF_CE = gross fixed capital formation in construction excluding buildings. GFCF_GG = general government GFCF. PPI = Private Participation in Infrastructure database.

First, combining information from the alternative estimates may provide a more refined measure of infrastructure investment. For example, in Pakistan the Budget+PPI (a conservative estimate) and the upper bound of the GFCF breakdown approach are very close, suggesting that the actual infrastructure investment is near 2.1 percent.

Second, even using detailed GFCF data, the constructed lower and upper bounds may still show a fairly large gap, especially in India. For this gap to narrow, statistics on road investment in all relevant sectors, such as public works, are needed.

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