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WPS8425

Policy Research Working Paper 8425

Infrastructure Development in Sub-Saharan Africa

A Scorecard

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Office of the Chief Economist
May 2018

Policy Research Working Paper 8425

Abstract

Infrastructure is viewed as a crucial ingredient to foster growth and productivity. Amid the post–global financial crisis slowdown, Sub-Saharan Africa is in dire need to continue the growth momentum it experienced during the period of the Africa Rising narrative. An emerging consensus in the empirical literature is that, under the right circumstances, an adequate supply of infrastructure can help foster growth in the region. This paper provides a scorecard on infrastructure development in Sub-Saharan Africa over the past decades along four sectors (telecommunications, electric power, transportation, and water and sanitation) and three dimensions (quantity, quality, and access). First, it documents the existence of a large gap in infrastructure in the region—although the magnitude of the gap depends on the sector, dimension, and country/group. Second, the potential growth benefits from closing the infrastructure gap are large. Third, the infrastructure financing needs are very large, and the public sector so far is unable to meet these needs. Other options that involve the private sector may be available for the region. Finally, there is room for improving the efficiency of public infrastructure spending (that is, the quality of public investment management systems and procurement methods), which, in turn, may increase the output multiplier of investment spending.

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Produced by the Research Support Team

Infrastructure Development in Sub-Saharan Africa: A Scorecard

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Key Words: Economic Infrastructure, Sub-Saharan Africa, Development
JEL Classification: H54, O40, O55

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A. Introduction

After two decades of strong growth that outpaced that of rich countries, economic activity in the Sub-Saharan Africa region has decelerated. There is an urgent need to regain the growth momentum amid an external environment characterized by lower global trade and commodity prices that may stay lower than pre-crisis levels for a longer period of time. Experts in academic and policy circles are advocating a "big push" to help the region escape poverty and narrow the income per capita gap vis-à-vis the rest of the developing world (for example, Sachs et al. 2004; Collier 2006; IMF 2014). These calls for action propose a wide array of policy agendas; however, virtually all of them list infrastructure development among the top priorities in the region.

An adequate supply of infrastructure services has long been viewed as a key ingredient for economic development in the academic literature (since the work of Aschauer 1989) as well as in policy debate (e.g. World Bank 1994; IMF 2014). Over the past quarter century, academic research has devoted considerable effort to theoretical and empirical analysis of the contribution of infrastructure development to growth and productivity. More recently, increasing attention has also been paid to the impact of infrastructure on poverty and inequality (Estache et al. 2002; World Bank 2003, 2006; Calderon and Serven 2004, 2010). An emerging consensus from the literature is that, under the right conditions, infrastructure development can play a major role in promoting growth and equity—and, through both channels, help reduce poverty.

Sub-Saharan Africa ranks at the bottom of all developing regions in virtually all dimensions of infrastructure performance. The region, which houses almost one-seventh of the world's population, has a score of 2.91 in the infrastructure category of the World Economic Forum's (WEF's) Global Competitiveness Report.[2] This score clearly states that there is a severe infrastructure bottleneck to be addressed. The region has some inherent characteristics that may enhance the potential role of infrastructure for its economic development—notably, the large number of landlocked countries, which are home to a major proportion of the region's total population (about 40 percent), and the remoteness of most of the region's economies from global market centers (Calderon and Serven 2010).[3]

The geographic disadvantages of the region result in high transport costs that hinder intra- and inter-regional trade (Limao and Venables 2001; Elbadawi et al. 2006; Behar and Manners 2008). Limited openness to trade is the main factor behind the stylized fact that, ceteris paribus, landlocked countries tend to grow slower than others.[4] However, adequate transportation and communication facilities can help overcome these geographic disadvantages. The region's problem is that poor infrastructure adds to its geographic disadvantage.

The main findings of this paper can be summarized as follows: first, there is a large gap in terms of quantity, quality and access to infrastructure. Our scorecard shows that the magnitude of this gap depends on the country, sector, and dimension under analysis. For instance, the region exhibits a dismal performance in the provision of reliable electricity and the length and quality of roads —especially among low-income-countries (LICs) and lower-middle-income countries (LMCs). Second, narrowing the infrastructure gap has potentially large growth benefits —and the growth benefits are the largest in the sectors with the greater gaps relative to global benchmarks. Third, meeting the infrastructure financing needs of the region is not trivial. It requires not only more efficient domestic resource mobilization from SSA governments but also innovative solutions to crowd-in private financing (e.g. the Cascade approach). Finally, strengthening the institutions governing public investment management systems and government procurement would increase the output multiplier of investment spending.

[2] This index takes values from 0 to 7 and higher scores indicate more competitiveness.
[3] Storeygard (2016) argues that the lack of infrastructure could also reflect the low population density in the region—which may play a role in explaining the low maintenance of most infrastructure networks.
[4] Note that 16 countries in the region are landlocked while 7 countries are insular.

Section B compares the trends in infrastructure development along different sectors and dimensions from an international perspective.[5] We compare the performance of the region (as well as selected groups/countries) vis-à-vis selected world geographic/income region/sub-regions. This analysis provides a scorecard of the magnitude of infrastructure gaps in Sub-Saharan Africa. At the country level, it conducts a benchmarking analysis of SSA countries vis-à-vis their level of development while simultaneously accounting for potential demographic and geographic drivers of infrastructure. Section C explores the relationship between infrastructure and economic growth in Sub-Saharan Africa. It reviews the empirical literature in the region and computes the potential growth benefits of closing the infrastructure gap in the region. Section D discusses the financing needs of the region to close the infrastructure gap and the different options available. Section E evaluates the efficiency of infrastructure spending by assessing the quality of public investment management systems and procurement methods. Section F provides some concluding remarks.

B. Infrastructure trends

The infrastructure network in Sub-Saharan Africa remains poor on average, despite recent government efforts to improve it. This section documents the evolution of infrastructure in Sub-Saharan Africa over time. It updates the benchmarking analysis for the region conducted by Calderón and Servén (2010), and confirms the existence of a wide gap in infrastructure provision between Sub-Saharan Africa and other developing regions.

Benchmarking the performance of infrastructure sectors in Sub-Saharan African countries involves the assessment of economic infrastructure across three dimensions: quantity, quality, and access. To place the infrastructure trends in Sub-Saharan Africa (SSA) in context, the report uses a comparative perspective. First, the analysis uses different comparator regions, namely, South Asia (SA), the Middle East and North Africa (MENA), Latin America and the Caribbean (LAC), and East Asia and the Pacific (EAP). Second, it examines infrastructure trends across income groups in the region—including low-income countries (LICs), lower-middle-income countries (LMCs), and upper-middle-income countries (UMCs). The full list of countries is presented in Annex 1.

B.1. Physical measures of infrastructure: Trends in quantity, quality and access

The evolution of infrastructure in Sub-Saharan Africa is evaluated for different sectors, namely, telecommunications, electric power, transportation, and water and sanitation. Within each of these sectors, and to the extent that the data permit, we examine infrastructure trends in terms of their quantity, quality, and access. Time series availability and country coverage across the different indicators of infrastructure are heterogeneous. Table 1 summarizes the indicators that are used to examine the performance of infrastructure in Sub-Saharan Africa.

[5] For an infrastructure definition and its multiple dimensions, see Cantu (2017).

Table 1. Indicators of infrastructure performance				
Dimension	**Telecom**	**Energy**	**Transport**	**Water & Sanitation**
Quantity	-Telecommunications density -Internet density -Fixed broadband	-Electricity-generating capacity	-Total road length -Total railroad length	
Quality	-International Internet bandwidth -Number of secure servers	-Energy quality (%) -WEF quality of power supply	-Paved roads (%) -WEF quality of roads -WEF quality of railroads	
Access		-Access to electricity (% people)		-Access to safe water (% people) -Access to sanitation facilities (% people)

Sources: see Appendix
Note: WEF, World Economic Forum

Infrastructure Quantity

Telecommunications. Sub-Saharan Africa has seen a dramatic jump in telecommunication density over the past quarter century. The median number of fixed and mobile phone lines per 1,000 people has risen sharply, from about three in 1990 to 736 in 2014 (Table 2). A similar pattern is observed in other benchmark regions in the world, reflecting the global nature of the boom in mobile phone technology. A comparison of telecommunications density across regions shows that, despite a surge, Sub-Saharan Africa is still far behind other regions.

Modern technological innovation has provided other forms of telecommunications connectivity: the number of Internet users and fixed broadband subscriptions (both normalized by population) are proxies for telecommunications density other than phone lines. Internet density—as measured by the number of users per 100 people—in Sub-Saharan Africa in 2015 was only 16.7, less than that of any other benchmark region. Another indicator of Internet penetration is the number of fixed broadband subscriptions per 100 people.[6] Again, Sub-Saharan Africa, with a penetration rate of only 0.19, lags significantly other regions.

Within Sub-Saharan Africa, progress is observed across all income groups. Telecommunications density expanded at the fastest pace among the region's LICs, although it started from low levels. Specifically, the number of fixed and mobile phones per 1,000 people among LICs grew from three in 1990 to 687 in 2014. The gap in telecommunications density relative to UMCs has narrowed significantly for LICs and LMCs over the past two decades. For instance, telecommunications density was twice as high in UMCs compared with LMCs in 2014 (while it was 11-fold in 1990). The fast growth of telecommunications density over the past two decades among the region's UMCs, increasing from 55 lines per 1,000 people in 1990, to 1,605 in 2014, has placed this group above the medians of other regions.

[6] This indicator refers to fixed subscriptions to high-speed access to public Internet, at downstream speeds equal to or greater than 256 kilobits per second.

Table 2. Infrastructure quantity trends

		Region					Income		
		SSA	SA	MENA	LAC	EAP	LIC	LMC	UMC
Telecommunications									
Telecommunication Density	1990	3	7	38	55	17	3	5	55
Fixed and mobile telephones per 1,000 people (median)	2014	736	807	1,323	1,240	1,444	687	794	1605
Internet Density	2005	1.3	2.1	11.2	12	11.8	1.1	1.3	7.5
Number of users per 100 people (median)	2015	16.7	22	48.5	51.6	45	11.4	20.8	50.1
Fixed broadband	2005	0.0	0.1	0.4	0.8	1.4	0.0	0.0	0.3
Number of subscriptions per 100 people (median)	2015	0.2	1.2	4.3	8.1	9.1	0.2	0.1	5.3
Power									
Electricity generating capacity	1990	0.03	0.07	0.25	0.3	0.15	0.02	0.06	0.33
Megawatts per 1,000 people (median)	2012	0.04	0.15	0.4	0.43	0.84	0.03	0.06	0.72
Transport									
Road Density	1990	0.11	0.31	0.11	0.13	0.16	0.09	0.12	0.27
km of road per sq km of land area (median)	2011	0.09	0.48	0.14	0.19	0.47	0.09	0.08	1.04
Railroad Density	1990	0.004	0.021	0.005	0.003	0.006	0.005	0.002	0.010
km of road per sq km of land area (median)	2014	0.002	0.016	0.006	0.007	0.007	0.003	0.002	0.010

Sources: International Telecommunications Union's World Telecommunication/ICT indicators; World Bank, World Development indicators. International Energy Agency; World Energy Outlook; International Road Federation, World Road statistics
Note: EAP= East Asia and Pacific; LAC= Latin America and the Caribbean; MENA= Middle East and North Africa; SA= South Asia; SSA= Sub-Saharan Africa; LIC=low-income countries; LMC= lower-middle income countries; UMC= upper-middle income countries.

Internet density has risen sharply over the past two decades for all income groups in Sub-Saharan Africa. For instance, the number of Internet users increased from 1.1 per 100 people in 2005, to about 11.4 in 2015 among LICs, while it grew from 7.5 to 50.1 for UMCs. Fast growth of Internet density among LICs and LMCs in the region has narrowed their gap relative to UMCs. Finally, the extent of Internet density among Sub-Saharan Africa's UMCs is above the regional median of countries in East Asia and the Pacific (45.5 users per 100 people).

The density of fixed broadband subscriptions is dismal for virtually all income groups in Sub-Saharan Africa. Notwithstanding the low penetration, there is a very large gap between the region's LICs and LMCs relative to UMCs. At the same time, the density of fixed broadband across UMCs (5.25 subscriptions per 100 people) is lower than that of Latin America and East Asia (8.1 and 9.1 subscriptions per 100 people, respectively).

Electric Power. Sub-Saharan Africa was vastly outperformed by the other benchmark developing regions in the power sector in 2012. The electricity-generating capacity of the region has changed little in over 20 years and is about 0.04 megawatts (MW) per 1,000 people—that is, less than a third of that of South Asia (with 0.15) and less than one-tenth of that of Latin America and the Caribbean (Table 2). Among the regions studied, East Asia and the Pacific registered the fastest growth in power generating capacity over the past two decades—jumping from 0.15 MW per 1,000 people in 1990 to 0.84.

Insufficient electricity power–generating capacity in Sub-Saharan Africa is explained by the trends observed in LICs and LMCs. There has been slight or no progress of MW of installed capacity per 1,000 people over the past two decades for these groups of countries; that is, keeping capacity at a low 0.03 and 0.06 MW per 1,000 people for LICs and LMCs, respectively, by 2012. Electricity-generating capacity more than doubled among UMCs, growing from 0.33 MW per 1,000 people in 1990, to 0.72 MW per 1,000 people in 2012.

Transportation. Assessing the performance of transport infrastructure involves the examination of trends in the lengths of road and rail networks (expressed in kilometers (km)) and normalized, in this case, by the surface area of the country (in square km). In 2011, Sub-Saharan Africa registered the lowest road density among the developing regions under analysis (Table 2). Moreover, Sub-Saharan Africa is the only region where road density has declined over the past 20 years. The density of the railroad network is likewise low, at less than 0.002 km per square km of surface area by 2014, and this density has been declining. Although South Asia has also seen a decline in rail density, it continues to outperform other regions in this measure.

The evolution of road density across income groups in Sub-Saharan Africa over the past two decades shows that road density has declined over time among LMCs. This might capture the fact that the expansion of the road network is not as fast as the pace of urbanization in these countries. The data also reveal a large gap in road density for LICs and LMCs relative to UMCs, and that this gap has increased sharply over time. Finally, the road density among UMCs in Sub-Saharan Africa (1.04 km per square km of surface area) is larger than the regional median of all other developing regions. The trends observed in railroad density are similar to those in roads: there has been a decline in the density of railroads among the region's LICs and LMCs over the past two decades, which might be attributed to poor maintenance. At the same time, railroad density remained almost invariant among UMCs, and it was outperformed only by South Asia.

Infrastructure Quality

It is imperative for the region to reduce the gap in the quantity of infrastructure. At the same time, the quality of these service-providing capital goods will be the major contributor to their optimal usage. The quality measures examined here can be objective or subjective. The former refers to hard/objective measurements (for example, electric power and transmission losses); the latter refers to perceptions of the quality and reliability of these services obtained from entrepreneur surveys—such as the quality of infrastructure indicators from the WEF's Global Competitiveness Report.[7]

Telecommunications. Lack of data availability across sections and, more importantly, over time prevents us from capturing the quality of the services of fixed telephone and mobile lines. However, the quality of Internet services can be approximated by the international bandwidth connection (which captures used capacity and average traffic load). Over the past 15 years, there has been a broad-based increase in Internet speed throughout the world. In Sub-Saharan Africa, the bits per second per Internet user grew from 97 in 2000, to 4,370 in 2015 (Table 3). In South Asia, this indicator is nearly twice as large (8,816), and in the remaining regions it is between 27,000 and 44,000 bits per second per Internet user.

There has been an increase in capacity and traffic on the Internet for all income groups in Sub-Saharan Africa. The largest improvement is evidenced for UMCs, with this group seeing Internet traffic volume greater than the regional median of other developing areas—except East Asia and Latin America (35,764 and 43,394 bits per second for every user, respectively).

[7] It is important to note that this survey, which was conducted by the WEF's Global Competitiveness Report, captures the perceptions of businesspeople about the quality of infrastructure in the country. These indicators take values from zero (worst) to seven (best). The periods under analysis for this section are 2006 and 2015.

Table 3. Infrastructure quality trends

		Region					Income		
		SSA	SA	MENA	LAC	EAP	LIC	LMC	UMC
Telecommunications									
Internet Traffic	2000	97	117	127	171	113	102	74	70
Bits per second per internet user (median)	2015	4,370	8,816	27,524	43,394	35,764	4,107	3,424	33,896
Power									
Power losses	1990	15.5	19.4	10.2	15.4	10.1	15.5	22.5	9.0
% of output (median)	2014	16.7	17.7	13.8	13.6	6.8	16.9	11.8	8.9
Transport									
Paved roads	1990	17	45	54	18	58	17.0	16.5	17.0
Share of paved roads (%)	2010	16	53	79	24	71	18.0	10	*
WEF - Road quality	2006	2.41	2.98	4.18	3.06	4.52	2.42	2.22	4.53
Score (0, worst - 7, best)	2015	3.34	3.95	3.97	3.57	4.53	3.31	3.23	4.78
WEF - Railroad quality	2009	1.93	3.24	3.24	1.53	3.57	1.87	1.97	3.54
Score (0, worst - 7, best)	2015	2.23	3.88	2.99	1.89	4.31	2.14	2.66	3.05

Sources: International Telecommunications Union's World Telecommunication/ICT indicators; World Bank, World Development indicators. World Economic Forum, Global competitiveness report; International Road Federation, World Road statistics
Note: EAP= East Asia and Pacific; LAC= Latin America and the Caribbean; MENA= Middle East and North Africa; SA= South Asia; SSA= Sub-Saharan Africa; LIC=low-income countries; LMC= lower-middle income countries; UMC= upper-middle income countries.

Electric Power. One measure of the quality of the electric power infrastructure sector is captured by the percentage of electric power transmission and distribution losses (as a percentage of electricity output). Table 3 depicts that electric power losses increased in Sub-Saharan Africa over the past quarter century, from 15.5 percent in 1990, to 16.7 percent in 2014, while declining in most other regions. Another measure of the quality of power supply is from WEF; it is a qualitative indicator that fluctuates from a low of 0 to a high of 7. According to this indicator, the perceived quality of power supply in the region dipped from 3.1 to 2.9 between 2006 and 2015. Sub-Saharan Africa registered the lowest scores in quality of power supply in 2015, with a regional median of 2.9, practically the same as for South Asia, which also experienced a decline in quality. Other benchmark regions, such as Latin America and the Caribbean or East Asia and the Pacific, saw an improving trend in quality and scored above 4.5.

Within Sub-Saharan Africa, there is considerable disparity in the evolution over time of power losses across the different income groups. For instance, power losses declined sharply in LMCs, to 11.8 percent of output in 2014, from 22.5 percent in 1990; power losses in UMCs remained almost invariant over the past decade (Table 3). By contrast, power losses slightly increased, from 15.5 percent of output to 16.9 percent during this period among the region's LICs. Power losses in Sub-Saharan Africa's LMCs and UMCs are smaller than those in other regions, except for East Asia and the Pacific.

The perception of the quality of power supply in the region is comparable across income groups. This convergence is the outcome of different trends between 2006 and 2015: quality increased slightly among LICs, varying between 2.8 and 2.9; it increased from 2.4 to 3.1 among LMCs; and it declined sharply among UMCs, from about 5 to 2.9.

Transportation. The quality of transport infrastructure is measured by (i) the share of paved roads in total roads, and (ii) the WEF perception scores on the quality of roads and railroads. The results with the objective measures should be taken with caution, as not all road networks in the country are necessarily meant to be paved. Other likely measures—for example, percentage of roads in good condition—are not available for the wide array of countries and over time.

Table 3 shows that the share of paved road in Sub-Saharan Africa declined from 17 percent in 1990 to 16 percent in 2010, bucking the rising trend observed in other regions. Sub-Saharan Africa also has the lowest share of paved roads in the total road network of any region, and well below that of South Asia (53 percent) and East Asia and the Pacific (71 percent).

The perception of road quality in Sub-Saharan Africa, as well other developing regions, shows an improving trend during 2006–15. WEF scores for Sub-Saharan Africa on perceived road quality climbed from 2.4 in 2006, to 3.3 in 2015. Still, Sub-Saharan Africa is the weakest performing region in this category of quality, well below the score of 4.5 for East Asia and the Pacific. There is also a slight increase in the surveyed perception of railroad quality in Sub-Saharan Africa, from a score of 1.9 in 2006, to 2.2 in 2015. But the region has among the lowest perceptions of railroad quality among developing regions, and is well below regions such as South Asia and East Asia, which have scores in the range of 3.9 and 4.3, respectively.

The share of paved roads in total roads is similar across income groups in Sub-Saharan Africa for 1990 (in the range of 16.5 to 17 percent). It grew slightly to 18 percent among LICs and declined to 10 percent among LMCs.[8] The trends in perceived road quality are quite different from those of the share of paved roads in the total road network. First, the perception of road quality increased for all income groups in Sub-Saharan Africa—although at different rates. Second, at a score of 4.8, the median perception of road quality among UMCs in Sub-Saharan Africa outperforms the regional median of other developing areas. The evolution of the perception of railroad quality for the different country groups in Sub-Saharan Africa during 2006–15 shows improvement among LICs and LMCs in the region, and a decline among UMCs.

Infrastructure Access

Infrastructure performance relies not only on assessing its quantity and quality, but also on the universality of access. From the point of view of equality of opportunities and poverty reduction, it is important to examine the extent to which infrastructure assets yield services to the broad population rather than just a few. This subsection discusses the evolution of indicators of access to electricity, safe water sources, and improved sanitation facilities.

Access to electricity. Table 4 presents the percentage of the population with access to electricity in Sub-Saharan Africa and other developing areas for 1990 and 2014. The figures depict total access as well as access rates for urban and rural populations. The data show that total rates of access to electricity almost doubled over the past two decades, growing from 14 percent in 1990, to 35 percent in 2014. Yet, all developing regions significantly outperformed Sub-Saharan Africa in access to electricity in 2014, with close to universal access to electricity in MENA, LAC and EAP. The disparity in rates of access to electricity between urban and rural areas is especially marked in Sub-Saharan Africa, where about 63 percent of the urban population and only 19 percent of the rural population had access to electricity in 2014.

Access to electricity has increased across all Sub-Saharan Africa income groups over the past two decades—although at a slower pace among LICs. Overall access rates to electricity went from 10 percent in 1990, to 23 percent in 2014 among this income group, while it increased from 29 to 45 percent among LMCs over the same period. The region's UMCs have the largest overall access rate to electricity (with 89 percent of the population in 2014).

The fast increase in the overall access rate in the region is driven by rising rural access rates—although they were coming from low levels in 1990. Yet, there is great disparity between urban and rural rates of access

[8] For UMCs, we do not have available information for that year.

to electricity across income groups in Sub-Saharan Africa. For instance, in LICs about 62 percent of the urban population had access to electricity in 2014, while only 8 percent had access in rural areas. The urban and rural rates of access for the region's LMCs are 83 and 18 percent, respectively. Finally, the rural rate of access to electricity in UMCs (about 67 percent) is still below than that of other developing regions.

Access to safe water. Total access rates to improved sources of water grew sharply in Sub-Saharan Africa over the past quarter century (to a median of 77 percent in 2015, from 51 percent in 1990). Although more than three-fourths of the region's population had access to water in 2015, other benchmark regions have access rates that exceed 90 percent (Table 4). Again, there is a large disparity in urban and rural access rates in Sub-Saharan Africa, despite the sharp growth of rural access. In 2015, more than 90 percent of the urban population had access to water, while only 67 percent had access in rural areas. For other developing regions, rural access exceeded 85 percent of the population.

The percentage of the population with access to improved water sources increased over the past quarter century across all income groups in Sub-Saharan Africa—with LICs showing the largest improvement rates. Their overall access rates jumped from 48 percent in 1990, to 77 percent in 2015. The disparities across income groups are driven by those in rural areas. Interestingly, a greater proportion of the rural population has access to water among LICs in the region (67 percent in 2015) than among LMCs (57 percent). Among UMCs in the region, access is nearly universal in urban areas, while it covers 81 percent of the population in rural areas. Despite covering four-fifths of the rural population in 2015, rural access rates among UMCs in Sub-Saharan Africa are not higher than those in other developing areas.

Access to improved sanitation facilities. Over the past quarter century, Sub-Saharan Africa has doubled total access rates to sanitation; however, they are still low relative to other benchmark regions. Sanitation access rates went from under 15 percent in 1990, to about 30 percent in 2015 (Table 4). In 2015, about 55 percent of the population of South Asia had access to sanitation facilities, while that proportion exceeded 80 percent for Latin America and the Caribbean and East Asia. With a median rate of 38 percent, access to sanitation has changed little for Sub-Saharan Africa's urban population. In the region's rural areas, only 25 out of 100 people had access to improved sanitation facilities in 2015, up from 9 in 1990.

Overall access rates increased over the past 25 years for LICs and LMCs in Sub-Saharan Africa, and declined among UMCs. Again, these developments are primarily driven by the evolution of rural access rates. Across rural areas, access rates more than doubled among LICs (jumping from 7 percent in 1990 to 16 percent in 2015). Gains in access were significant, although not as high, in LMCs (they went from 18 percent in 1990, to 25 percent in 2015). Among UMCs, rural access rates declined, from 64 percent in 1990, to 61 percent in 2015. Finally, the rural access rate for UMCs is only higher than the regional median for South Asia.

Table 4. Infrastructure Access

		Region					Income		
		SSA	SA	MENA	LAC	EAP	LIC	LMC	UMC
Electricity									
Total	1990	14	65	94	87	87	10	29	73
percent of population (median)	2014	35	76	92	95	94	23	45	89
Urban	1990	50	95	97	99	96	44	67	99
percent of population (median)	2014	63	96	98	98	99	62	83	98
Rural	1990	1	42	90	69	86	1	8	28
percent of population (median)	2014	19	72	78	85	91	8	18	67
Safe Water Sources									
Total	1990	51	69	92	86	84	48	59	91
percent of population (median)	2015	77	93	96	94	96	77	76	93
Rural	1990	39	64	84	68	77	36	52	83
percent of population (median)	2015	67	92	92	87	93	67	57	81
Improved Sanitation Facilities									
Total	1990	15	20	77	66	72	11	27	71
percent of population (median)	2015	29	55	92	83	85	21	30	66
Urban	1990	34	58	93	79	79	27	52	79
percent of population (median)	2015	38	73	96	87	88	38	37	70
Rural	1990	9	5	65	38	64	7	18	64
percent of population (median)	2015	25	47	82	75	83	16	25	61

Sources: World Bank, World Development indicators.
Note: EAP= East Asia and Pacific; LAC= Latin America and the Caribbean; MENA= Middle East and North Africa; SA= South Asia; SSA= Sub-Saharan Africa; LIC=low-income countries; LMC= lower-middle income countries; UMC= upper-middle income countries.

Sub-Saharan Africa's Infrastructure: A scorecard

Table 5 depicts a scorecard of Sub-Saharan Africa's infrastructure gaps in terms of quantity, quality, and access, including the performance scorecard for SSA's subregions and selected percentiles of the regional distribution of the corresponding infrastructure indicator. The scorecard summarizes the information from the previously described infrastructure variables presented in Tables 2 through 4. It captures the gap between the region, subregion, or percentile of the regional distribution vis-à-vis the top decile of the world excluding countries in Sub-Saharan Africa. This gap is represented by the ratio of the infrastructure measure in Sub-Saharan Africa vis-à-vis the equivalent measure for the top decile of the rest of the world. In this context, the regions, subregions, and countries in brown (or marked "D") represent those whose ratio is lower than 0.25—that is, their infrastructure gap is greater than 75 percent. These are the most lagging areas in infrastructure provision. We denote in yellow (or marked "C") those areas with a ratio between 0.25 and 0.5 (a gap that is greater than 50 percent but lower than 75 percent). Geographic areas with an infrastructure ratio relative to the benchmark between 0.5 and 0.75 are represented in light green (or marked "B"), whereas those with a ratio greater than 0.75 are depicted in dark green (or marked "A"). The last group represents those countries and regions with the smallest gap relative to the benchmark (that is, a gap less than 25 percent).

When looking at the region (as captured by the median across countries in Sub-Saharan Africa) and its different groups classified by income level, all of them (except UMCs) have a gap that exceeds 75 percent relative to the top decile of the world sample in energy-generating capacity as well as road density and quality (Table 5, panel A). For telecommunications penetration, the gap for most regions exceeds 50 percent—except for UMCs (with a gap lower than 10 percent). In the case of total access to improved water sources, the gap in Sub-Saharan Africa vis-à-vis the benchmark is lower than 50 percent—and it is even lower than 10 percent for UMCs in the region. Qualitatively, these gaps hold for rural access to improved sources of water.

Table 5. Infrastructure Performance in Sub-Saharan Africa: A Scorecard

	Quantity			*Quality*		*Access*					
	Telecom	Energy	Transport	Energy	Transport	Energy Total	Energy Rural	Water Total	Water Rural	Sanitation Total	Sanitation Rural
Panel A. SSA and sub-regions											
Sub-Saharan Africa	C	D	D	D	D	C	D	B	B	C	D
LIC	C	D	D	C	D	D	D	B	B	D	D
LMC	C	D	D	B	D	C	D	B	B	C	D
UMC	A	C	B	A	A	A	B	A	A	B	B
Panel B. SSA percentiles											
Top 10%	A	D	C	B	C	A	C	A	A	B	B
Top 25%	C	D	C	C	C	B	C	A	B	C	C
Bottom 25%	D	D	D	D	D	D	D	B	C	D	D
Bottom 10%	D	D	D	D	D	D	D	C	C	D	D

***Leyend** : D or brown represents a ratio lower than 0.25, C or yellow represents a ratio between 0.25 and 0.5, B or light green represents a ratio between 0.5 and 0.75, and A or dark green represents a ratio greater than 0.75.*
Quantity: Telecom *is fixed and mobile lines per 1,000 workers (in logs),* Energy *is electricity generating capacity per 1,000 workers (in logs), and* Transport *is length of the road network in km. per sq. km (in logs).* ***Quality:*** Energy *is electric power transmission and distribution losses (% of output in logs), and* Transport *is the share of paver roads (% total in logs).* ***Access:*** Energy *is access to electricity (% of population in logs),* Water *is improved water sources (% of population in logs), and* Sanitation *is improved sanitation facilities (% of population in logs).*

Panel B in table 5 shows the gap for best and worst performers in the region (relative to the top 10 percent of the world distribution), as approximated by the top decile, top quartile, bottom quartile, and bottom decile of the Sub-Saharan Africa distribution. For the bottom percentiles of the distribution (10th and 25th percentiles), the gap in quantity and quality of infrastructure is greater than 75 percent—regardless of the infrastructure sector. The same holds for access to electricity and access to sanitation. The gaps for the bottom percentiles are not as large in access to safe water. For the best performers in the region (75th and 90th percentiles), the performance is still dismal in electric power–generating capacity. For the top decile of the distribution in Sub-Saharan Africa, there is a narrow gap in telecommunications penetration (about 20 percent), overall access to electricity, and access to water. The gaps in energy quality and access to sanitation facilities are moderate.

B.2. Conditional comparisons

Regional differences in infrastructure trends may partly reflect the differences across regions in key infrastructure drivers—for instance, geographic and demographic factors, as well as real income per capita (see Canning 1998). It is far from trivial to assess this hypothesis, since some of these drivers—notably, income levels—are themselves affected by infrastructure trends. The cross-regional comparison presented in the previous section implicitly takes some of these factors into account, to the extent that it focuses on infrastructure stocks normalized by population or labor force (or, in the case of transport networks, by country area) and includes benchmark groups among the relevant comparators for Sub-Saharan Africa.

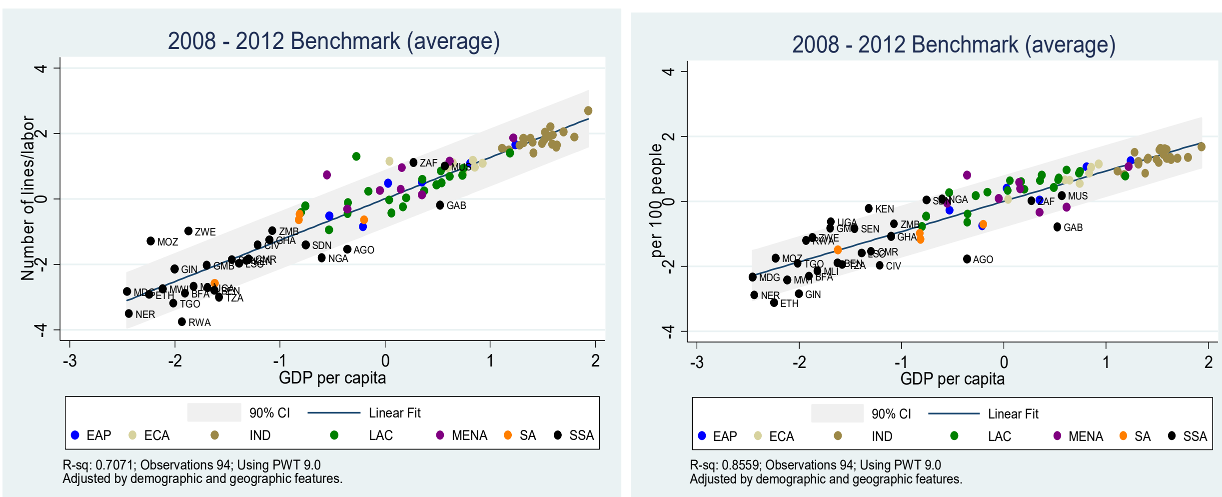
Benchmarking infrastructure sectors across countries in Sub-Saharan Africa involves a systematic approach to examining the trends in infrastructure after adjusting for the effect of country-specific characteristics. This procedure is conducted in two stages. First, measures of adjusted infrastructure quantity—as well as quality and access—and adjusted income per capita are defined by the residuals from projecting these variables on indicators of country size (population and/or labor force) and geographic characteristics (surface area of the country). Second, the relationship between these adjusted measures of infrastructure and per capita income is examined—and this constitutes a partial correlation between infrastructure development and the levels of development. This exercise is conducted for two time periods: the averages for 1998–2002 and 2008–12. For reasons of space and without loss of generality, the focus here is on the benchmarking exercise for the latter period.[9]

Infrastructure Quantity

Telecommunications. The partial correlation results show a positive association between telecommunications density and real income per capita (figure 1.a). This implies that, even after controlling for geographic and demographic factors, countries with greater income per capita tend to have a greater density of telecommunications. The analysis also finds that there has been a significant increase in telecommunications density among some countries in Sub-Saharan Africa over time.

Figure 1. Telecommunications and Income per Capita

a. Telecommunications density | **b. Internet density**



Sources: International Telecommunications Union's World Telecommunication/ICT indicators; World Bank, World Development Indicators. GDP per capita is from Feenstra, Inklaar, and Timmer 2015.
Note: CI = confidence interval; EAP = East Asia and the Pacific; ECA = Europe and Central Asia; GDP = gross domestic product; IND = Industrial Countries; LAC = Latin America and the Caribbean; MENA = Middle East and North Africa; SA = South Asia; SSA = Sub-Saharan Africa.

Given certain idiosyncratic features (say, demographic and geographic characteristics), some countries in the region perform above the international norm according to their level of development (as depicted by the regression line), while others remain below that norm. For 2008–12, South Africa and Mauritius register the highest extent of telecommunications density (as measured by the *adjusted* fixed and mobile lines per 1,000 people), and they are both above the international norm for that period. However, some countries have similar levels of telecommunications density as that of South Africa but with lower levels of income per capita (say, Paraguay and Jordan), while other countries have similar levels of telecommunications density despite having higher levels of development (for example, Greece and Turkey).

[9] The benchmarking exercises for the period 1998-2002 are available upon request.

A closer look at MICs in the region, other than South Africa and Mauritius, shows that most of these countries are below the international norm—especially Gabon, Nigeria, and Angola. This implies that, for their level of development, there is significant under-provision of telecommunications services in these countries. Most of the low-income countries in the region are along or below the international norm that characterizes the relationship between infrastructure and development. The weakest performers (as measured by the negative distance to the norm) are Niger, Rwanda, and Tanzania. Finally, one of the most improved countries in the provision of telecommunications services is Ethiopia—a country that shifted from being one of the weakest performers in 1998–2002 to being at the international norm for its level of development in 2008–12.

A positive conditional correlation between Internet density and income per capita is also observed, along with marked progress among countries in Sub-Saharan Africa over time—almost half of the SSA countries in the sample are above the international norm in 2008–12. Nonetheless, the region still lags behind other developing countries with similar levels of economic development. For 2008–12, controlling for geographic and demographic variables, Mauritius, Nigeria, and Sudan show remarkable progress in Internet density (figure 1.b). Other MICs in the region (such as Gabon and Angola) have a level of Internet density that is significantly below their level of development. Kenya is significantly above the international norm and has experienced significant progress over the past decade. Low-income countries in the region with significant under-provision of Internet services according to the international norm are Ethiopia, Guinea, and Côte d'Ivoire.

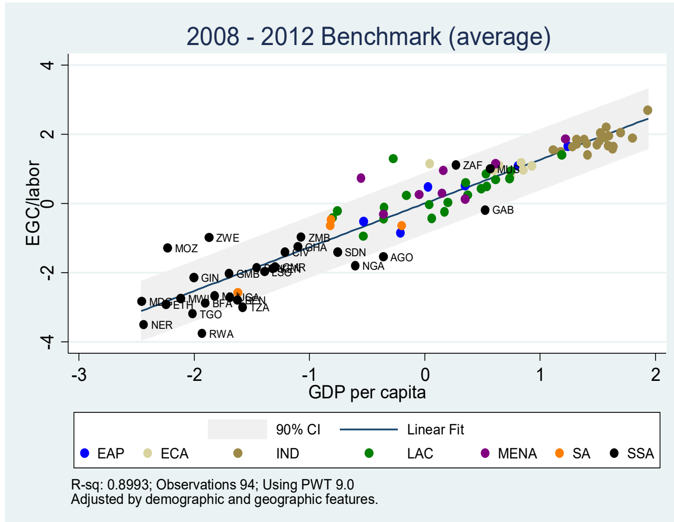
Fixed broadband services, which is another quantity variable for telecommunications infrastructure, were only available in a few countries in Sub-Saharan Africa (only seven) in 1998–2002. With time, in 2008–12, more countries in Sub-Saharan Africa delivered fixed broadband subscriptions. In the latter period, Mauritius led all African countries whereas Ethiopia, Malawi, and Guinea were at the lower end of the spectrum.

Electric Power. There is a positive relationship between electricity-generating capacity and real income per capita across countries in the world. Hence, countries with greater income per capita tend to have larger electric power infrastructure stocks. For 2008–12, South Africa and Mauritius are the best performers in the region in power infrastructure quantity —after controlling for geography and demographics (figure 2). Their adjusted levels of infrastructure provision are greater than those of countries with higher income per capita, like Hungary and Chile. Other MICs (for example, Gabon, Nigeria, and Angola) clearly underperform for their level of development in 1998–2002. A closer look at low-income countries in the region shows sharp progress in electricity-generating capacity in Ethiopia over the past decade. By contrast, Rwanda, Togo, and Tanzania continue to underperform according to the international norm.

Transportation. There is a positive partial correlation between real income per capita and road density in 2008–12 (figure 3). However, there appears to be a greater cross-country dispersion along the international norm when compared with infrastructure stocks in telecommunications and power. During this period, Ghana appears to be the best performing country in the region, with adjusted road density that is not only higher when compared with other countries in Sub-Saharan Africa, but also significantly above the international norm.[10] Other countries with good performance in transport infrastructure quality include Guinea and Madagascar. Finally, most of the countries in the region lie close to or below the international norm for 2008–12.

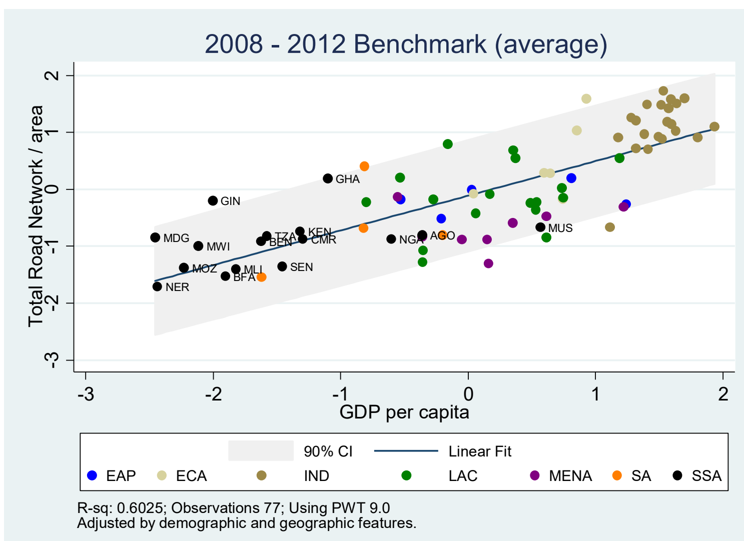
[10] South Africa did not have available information for this period.

Figure 2. Electricity-Generating Capacity and Income per Capita



Sources: International Energy Agency, World Energy Outlook. GDP per capita is from Feenstra, Inklaar, and Timmer 2015.
Note: CI = confidence interval; EAP = East Asia and the Pacific; ECA = Europe and Central Asia; EGC = electricity-generating capacity; GDP = gross domestic product; IND = Industrial Countries; LAC = Latin America and the Caribbean; MENA = Middle East and North Africa; SA = South Asia; SSA = Sub-Saharan Africa.

Figure 3. Road Density and Income per Capita



Sources: International Road Federation, World Road Statistics; World Bank, World Development Indicators. GDP per capita is from Feenstra, Inklaar, and Timmer 2015.
Note: CI = confidence interval; EAP = East Asia and the Pacific; ECA = Europe and Central Asia; GDP = gross domestic product; IND = Industrial Countries; LAC = Latin America and the Caribbean; MENA = Middle East and North Africa; SA = South Asia; SSA = Sub-Saharan Africa.

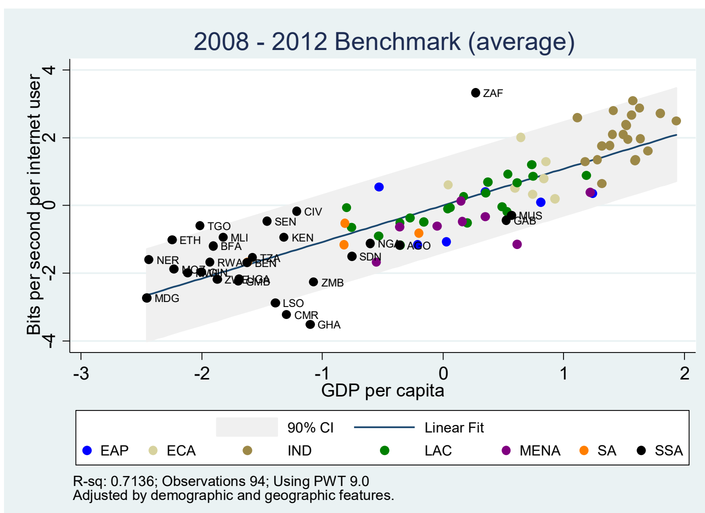
Another important mode of transportation infrastructure is the railroad sector. The data on the length of the railroad network are not as complete as those of the road network. There is information available only for 74 countries for 1998–2002 and 65 countries for 2008–12. Still, there is a positive and significant relationship between income per capita and rail density. For 2008–12, South Africa continues to have the highest rail density in the continent, and its rail network remains over the international norm. The adjusted rail density is larger than those of countries with larger gross domestic product per capita (for example, Chile and Malaysia, among others). By contrast, Côte d'Ivoire, Cameroon, and Burkina Faso have underperformed relative to their level of income per capita, and also show the lowest density of the railroads in the region.[11]

Infrastructure Quality

Telecommunications. Figure 4 depicts a positive relationship between international Internet bandwidth (in bits per second per Internet user) and real income per capita after controlling for demographic and geographic indicators. One finding that emerges from this analysis is that the partial correlation between Internet density and income per capita has increased over time (when comparing 1998–2002 vis-à-vis 2008–12), and most countries in Sub-Saharan Africa are above the international norm in the latter period.

In 2008–12, South Africa registered an astounding increase in Internet density, thus becoming the best performer in the region and a significant over-provider of these services according to the country's level of development. Other MICs in the region (for example, Gabon, Nigeria, Angola, and Sudan) are below the international norm. Finally, when looking at LICs in the region, Ghana, Cameroon, and Lesotho have levels of Internet infrastructure quality that are way below what the international norm predicts for their level of economic development.

Figure 4. Internet Traffic and Income per Capita



Sources: International Telecommunications Union's World Telecommunication/ICT indicators; World Bank, World Development Indicators. GDP per capita is from Feenstra, Inklaar, and Timmer 2015.
Note: CI = confidence interval; EAP = East Asia and the Pacific; ECA = Europe and Central Asia; GDP = gross domestic product; IND = Industrial Countries; LAC = Latin America and the Caribbean; MENA = Middle East and North Africa; SA = South Asia; SSA = Sub-Saharan Africa.

Electric Power. The partial correlation analysis shows that countries with higher income per capita tend to have a lower percentage of power losses (that is, higher quality of electricity supply). For 2008–12, Mauritius, Cameroon, Ethiopia, and Mozambique are among the best performers in the region (with the lowest level of

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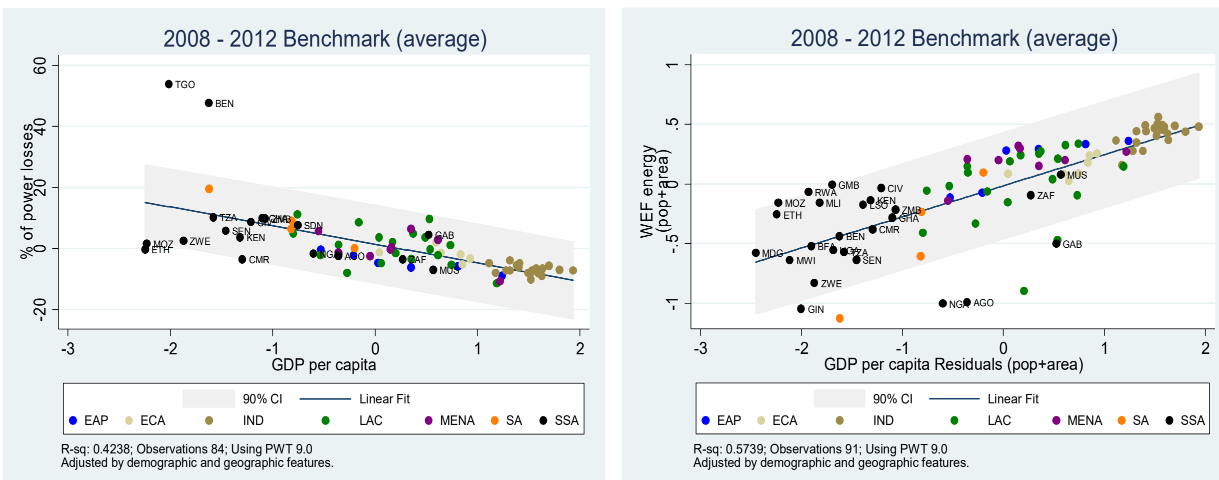
[11] Adding road and rail networks and assessing their performance as a whole would lead to similar results to those for the total road network. This analysis is not reported, but it is available from the team upon request.

adjusted losses). All these countries over-perform when compared with the predicted level of power losses according to the international norm (figure 5.a). Togo and Benin, by contrast, continue to underperform, with massive power losses.

Benchmarking the quality of power infrastructure is complemented by the analysis of WEF perception measures of the quality of electricity supply. Figure 5.b, plots a positive partial correlation between income per capita and the *perceived* quality of power for 2008–12. For most MICs in Sub-Saharan Africa, the perceived quality of the power infrastructure sector is lower than what the international norm predicts for their level of income per capita. However, for some LICs, such as The Gambia, Côte d'Ivoire, and Rwanda, the perception of the quality of electricity supply is way above the level predicted by the international norm. Finally, Gabon, Nigeria, Angola, and Guinea have a level of power quality that is significantly below the one predicted by the international norm.

Figure 5. Power Quality and Income per Capita

a. Power losses **b. WEF power quality**



Sources: World Bank, World Development Indicators; World Economic Forum, Global Competitiveness Report. GDP per capita is from Feenstra, Inklaar, and Timmer 2015.
Note: CI = confidence interval; EAP = East Asia and the Pacific; ECA = Europe and Central Asia; GDP = gross domestic product; IND = Industrial Countries; LAC = Latin America and the Caribbean; MENA = Middle East and North Africa; SA = South Asia; SSA = Sub-Saharan Africa; WEF = World Economic Forum.

Transportation. Benchmarking the quality of transport infrastructure involves assessing the performance of African countries on the hard and perceived measures of road and rail quality. Figure 6 depicts a positive relationship between the share of paved roads (a proxy for road quality) and income per capita for 2008–12. This implies that, after controlling for geographic and demographic factors, countries with higher income per capita tend to have a greater share of paved roads.

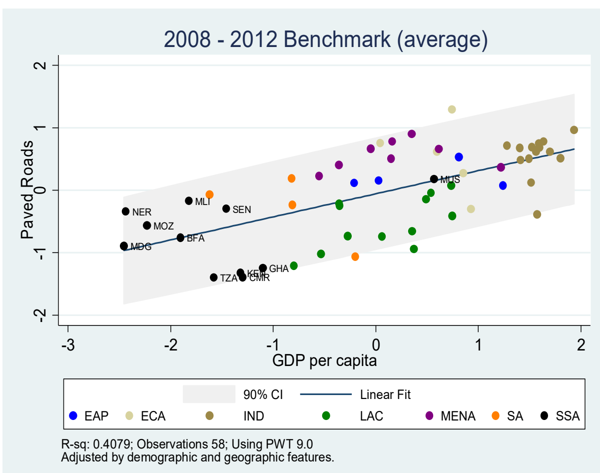
For 2008–12, Mauritius appears to be the leader in the share of paved roads (figure 6. a). The country's (adjusted) share of paved roads is close to the level predicted by the international norm, and it outperforms countries with greater levels of income per capita (for example, Poland). Tanzania, Cameroon, Kenya, and Ghana are the weakest performers in the region—with shares of paved roads that are significantly below those predicted by the international norm.

Figure 6.b, depicts the partial association between income per capita and the WEF perception of road quality during 2008–12. The figure confirms the findings of figure 6.a, that countries with higher income per capita tend to have better road quality. Perceived quality of the road network is the highest in South Africa (and above the international benchmark) for 2008–12—thus, outperforming countries in South America, like Brazil and Colombia. Other MICs in the region (for instance, Nigeria and Gabon) clearly underperform for their level of income per capita. Among LICs in the region, Guinea appears to have the lowest level of road quality, whereas the quality of roads in Rwanda and Ethiopia is far better than the one predicted by the international norm.

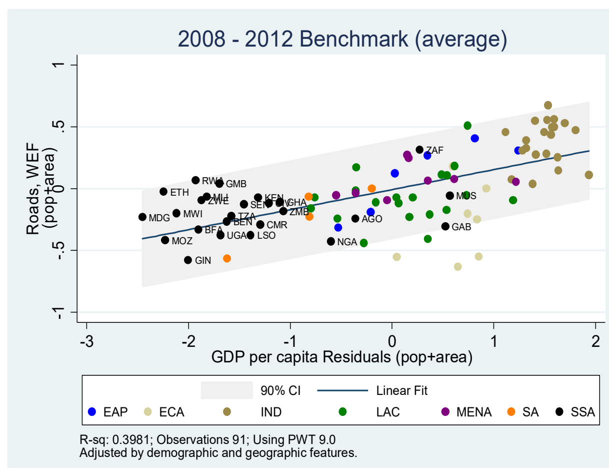
Railroad quality also exhibits a direct and positive relationship with income per capita after controlling for demographic and geographic indicators. The perception of railroad quality is the highest in Gabon, closely followed by South Africa. Countries with lower income per capita (say, Sri Lanka and Morocco) display similar levels of rail quality. Among MICs in the region, the perception of rail quality in Nigeria and Angola is lower than that predicted by the international norm. In the group of LICs in Sub-Saharan Africa, Uganda exhibits the largest distance to the international norm.

Figure 6. Transport Quality and Income per Capita

a. Share of paved roads



b. WEF perception of road quality

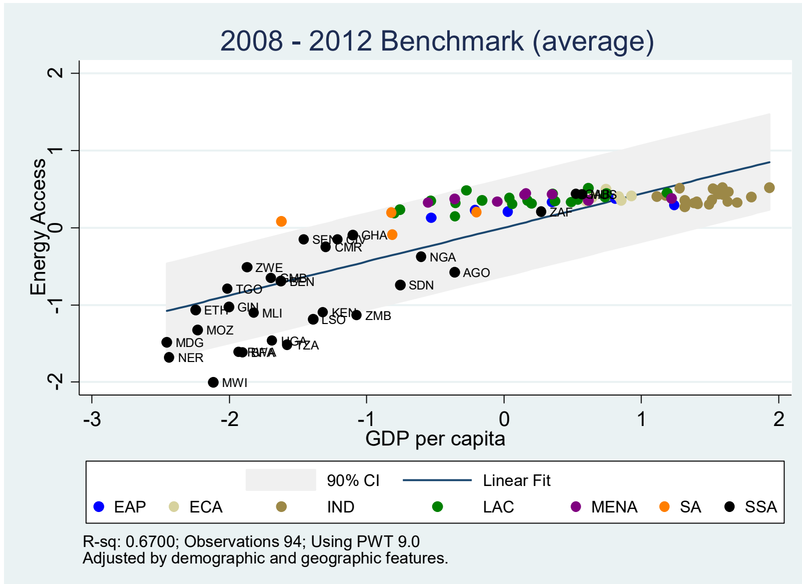


Sources: International Road Federation, World Road Statistics; World Bank, World Development Indicators; World Economic Forum, Global Competitiveness Report. GDP per capita is from Feenstra, Inklaar, and Timmer 2015.
Note: CI = confidence interval; EAP = East Asia and the Pacific; ECA = Europe and Central Asia; GDP = gross domestic product; IND = Industrial Countries; LAC = Latin America and the Caribbean; MENA = Middle East and North Africa; SA = South Asia; SSA = Sub-Saharan Africa; WEF = World Economic Forum.

Infrastructure Access

Access to Electricity. Countries with greater income per capita tend to provide greater access to electricity. This finding holds after controlling for geography and demography (figure 7). For 1998–2002, the countries with the highest rates of access to electricity are Gabon and Mauritius—with adjusted rates that are higher than those of countries with similar income per capita (for example, Brazil and Mexico). Several LICs in this period have weak performance when compared with the international norm, namely, Malawi, Rwanda, and Lesotho. Over 2008–12, Gabon and Mauritius continued to display higher rates of access in the region. South Africa moved closer to the international norm. There was improvement over time in Rwanda and Tanzania, and Malawi remained the weakest performer in electricity access.

Figure 7. Access to Electricity and Income per Capita



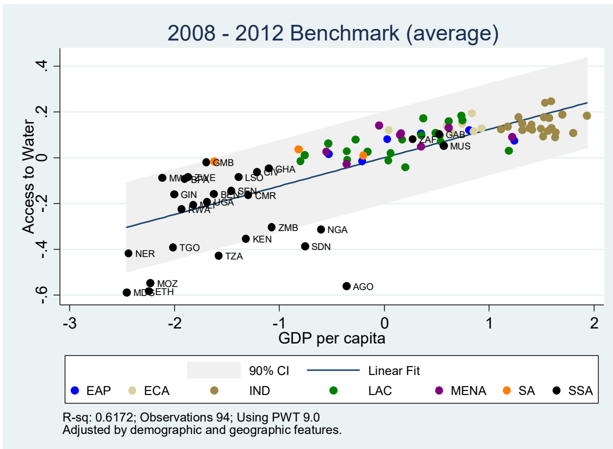
Sources: World Bank, World Development Indicators. GDP per capita is from Feenstra, Inklaar, and Timmer 2015.
Note: CI = confidence interval; EAP = East Asia and the Pacific; ECA = Europe and Central Asia; GDP = gross domestic product; IND = Industrial Countries; LAC = Latin America and the Caribbean; MENA = Middle East and North Africa; SA = South Asia; SSA = Sub-Saharan Africa.

Access to improved water sources. Figure 8. a, plots the conditional correlation between income per capita and access to safe water in 2008–12. For this period, Gabon, Mauritius, and South Africa remain the best performing countries in Sub-Saharan Africa in access rates to water, and these rates are either similar or slightly above the ones predicted by the international norm. MICs in the region, such as Sudan, Nigeria, and Angola, have access rates that are significantly lower than those predicted by the benchmarking exercise. The same holds for Madagascar and Ethiopia (both countries continue to underperform) among LICs.

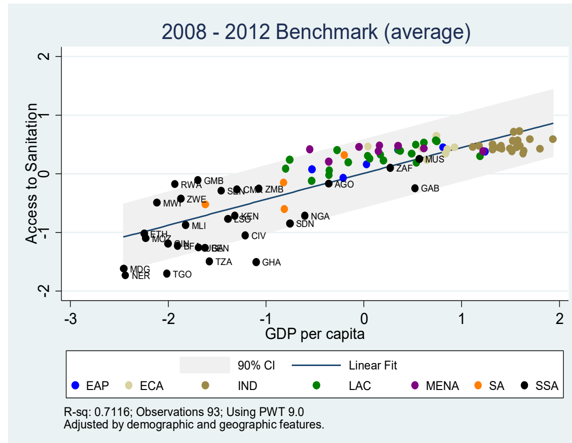
Access to improved sanitation facilities. Countries with greater income per capita also tend to have greater rates of access to improved sanitation facilities. For 2008–12, Mauritius and South Africa remain along the international norm, while Gabon appears to have fallen off track (figure 8.b). Over the past decade, Ethiopia moved from being the weakest performer to being close to the access rates predicted by the international norm. Niger, Togo, and Tanzania continue to have the lowest adjusted rates of access in the region.

Figure 8. Access to Water and Sanitation and Income per Capita

a. Improved water source



b. Improved sanitation facilities



Sources: World Bank, World Development Indicators. GDP per capita is from Feenstra, Inklaar, and Timmer 2015.
Note: CI = confidence interval; EAP = East Asia and the Pacific; ECA = Europe and Central Asia; GDP = gross domestic product; IND = Industrial Countries; LAC = Latin America and the Caribbean; MENA = Middle East and North Africa; SA = South Asia; SSA = Sub-Saharan Africa.

C. Growth benefits of closing the infrastructure gap

In academic or policy circles, few experts would dispute the view that infrastructure development fosters growth. However, there is no consensus on the magnitude of the effect and the factors that shape it. Starting with Aschauer (1989), there is a massive empirical literature that focused on the impact of infrastructure on the level and growth rate of aggregate output or productivity. One strand of this literature examines the long-term growth impact of infrastructure —primarily using a reduced-form growth regression framework that links long-term growth to indicators of infrastructure, public capital or public investment.[12] Growth regressions have used either monetary measures of public capital and/or investment as well as physical indicators of infrastructure stocks. Using physical indicators renders invariably significant growth effects. Some studies have focused on single-sector analysis (typically, indicators of telecommunications penetration or density) while others have used synthetic indicators that capture stocks of physical infrastructure in different sectors —say, telecommunications, electric power, and transport.

This section looks closely at the growth benefits from improved infrastructure development. It consists of three different sub-sections: first, it reviews the current evidence on infrastructure in SSA; second, it presents a methodology to estimate the growth returns from infrastructure, and finally, it calculates the potential benefits of growth effects from narrowing the infrastructure gap.

C.1 What the empirical evidence tells us about infrastructure in Sub-Saharan Africa

Most of the empirical literature on the growth effects of infrastructure in Sub-Saharan Africa has primarily relied on examining the real effects of the *transportation sector* —despite the data availability problems. The region has been experiencing rapid demographic changes. Major urban areas are densely populated and still have poor road and rail networks while farmers in rural areas have limited opportunities due to their lack

[12] The growth regression approach often includes standard control variables from the empirical growth literature (see Calderon and Servén 2004, 2010).

of connectivity with markets (Kessides 2005, Lall et al. 2017). The road network in the region comprises trading corridors no longer than 10,000 km that carry US$ 200 billion of trade per annum. The access rate to roads is about 34 percent while it is, on average, 50 percent in other developing areas (African Union 2014). High transportation costs have hindered the maintenance and repair or the expansion of the road network (African Union 2014; Storeygard, 2016). Expansion of roads and railways is responsible in some cases for decentralization (Storeygard 2016, Baum-Snow et al. 2012, Ghani et al. 2012) and also for the connectivity of large metropolitan areas (Faber 2014).

Jedwab and Moradi (2016) show that railroads had significant impact on the distribution and level of economic activity during the colonial period in Ghana (1901-1931). This impact still lingers in the post-independent period —even though the railroad network faltered, and road networks expanded. Railroads were mostly built in the colonial periods in Sub-Saharan Africa. Initial transport investments in these poor countries had large effects. Rail lines helped lower domestic trade costs and fostered the local cultivation of cocoa in Ghana. The rural population grew along these lines as more labor was required in cocoa-producing villages. Urban population also grew as villages used the towns as trading stations. As the country develops, increasing returns consolidate their distribution across space and new investments may have smaller effects. In this context, Jedwab and Moradi find that transport technologies after colonial railroads (that is, the expansion of road networks) fail to decentralize economic activity away from railroad locations.

In the case of electricity, there is ample evidence that *electric power systems* in Sub-Saharan Africa lag most regions in the world. Deficiencies in the generation, transmission and distribution of electricity are reflected in the low rates of electrification, high cost of electricity generation, and insufficient supply resulting from power system failures and unreliable equipment. However, renewable energy is becoming a more important source of energy in the region —namely, solar, wind, and biomass (Suberu et al. 2013). While data on Africa are limited, the evidence suggests that closing the energy gap would significantly reduce rural poverty in Africa.

Projections by Bazilian et al. (2012) estimate that by 2030, Sub-Saharan Africa would show a roughly threefold increase in installed generation capacity. However, renewable power is not feasibly due to cost for large-scale applications. In order for the region to have moderately full access, countries must increase installed generation by more than a tenfold amount (Bazilian et al., 2012; Eberhard et al., 2011).[13] PIDA assumes that the access rate will increase to 65% by 2030 and keep similar rates in 2040. Diechmann et al. (2011) suggest that decentralized renewable energy will play an important role to grant more access to electricity.

Finally, it has been argued that the expansion of *telecommunication services* (including ICT) could help SSA "*leap frog*" stages of economic development thanks to five spillover effects (Aker and Mbiti 2010). First, an efficient telecommunications infrastructure reduces search costs, improves coordination among agents and enhances market efficiency by increasing access and use of information. Second, it improves firms' supply chains and, hence, their productive efficiency. Third, it generates demand in rural and urban areas for new jobs in mobile services. Fourth, it facilitates social network communication —which reduces the exposure of households to risks and improves their response to shocks. Finally, smart phone applications or development projects may facilitate services in the financial, agricultural, health, and educational services.

C.2 Infrastructure and Growth in Sub-Saharan Africa

Empirical research on the impact of infrastructure on long-term growth in Africa has taken off. Ndulu (2006) presents a diagnostic view of the main issues in infrastructure for the region while Ayogu (2007) surveys the literature on the growth and productivity effects of infrastructure development. For instance, Estache et al. (2005) estimate an augmented Solow model using pooled OLS and find that roads, power and telecommunications infrastructure (rather than water and sanitation) have a significant association with long-

[13] The authors only include countries with low rates of access —that is, South Africa is excluded.

run growth in Africa. Other studies follow a production function approach. For instance, Ayogu (1999) estimates an infrastructure-augmented production function using regional panel data from Nigeria and finds a strong association between infrastructure and output. Kamara (2006) evaluates the dynamic effects of infrastructure in an aggregate production function for a panel of African countries. Analogously, Boopen (2006) estimates the output contribution of transport infrastructure using panel data.

Among country studies, South Africa and Nigeria have attracted special attention —this partly reflects the better quality of their data when compared to other countries in the region. Perkins and associates (2005) estimated the existence of a long-run relationship between infrastructure (investment and capital stocks) and real economic activity over a span of 100 years. They find two-way causality for most of their monetary measures of infrastructure. Kularatne (2005) examines the impact of infrastructure investment (and also spending on health and education) on output. He also finds bi-directional effects; however, the impact of infrastructure investment is indirect —specifically, it boosts growth by crowding-in private investment. Dykelman (2008) finds a significant impact of household electrification on employment in South Africa's rural labor markets.

Few papers address the multi-dimensionality of infrastructure and its impact on long-term growth. Calderón and Servén (2010) find that both the quantity and the quality of infrastructure have a positive impact on growth and the distribution of income in Sub-Saharan Africa. Narrowing the infrastructure gap for SSA countries yields significant growth benefits but the costs of financing are also high. More recent evidence for the region shows that there are no short-term growth effects of improved quantity and quality of infrastructure (Kondongo and Ojah 2016).

Infrastructure's effect on growth: A methodology

Since Aschauer's (1989) seminal work on infrastructure, more sophisticated techniques have been developed to compute the short- and long-run effects of infrastructure on growth. Researchers have either used monetary measures of public capital and/or investment (e.g. Devajaran et al, 1996) or physical stocks (Calderon & Serven, 2004, 2010). Estimating the impact of infrastructure should address the issues of: (a) multi-dimensionality at the sectorial level, (b) improving quantity and/or enhancing quality of infrastructure, and (c) ameliorating issues of likely endogeneity and reverse causality.

Computing the growth benefits of narrowing the infrastructure gap in Sub-Saharan Africa is not trivial. It will depend not only on: (a) the infrastructure sectors included in the analysis, (b) the economic approach used to examine this impact, (c) econometric techniques utilized, and (d) the sample of countries. In this context, this section uses the empirical estimation undertaken by Calderón and Servén (2010); that is, a cross-country panel data regression model that includes synthetic indicators of quantity and quality of infrastructure —and other standard growth determinants as identified by Loayza, Fajnzylber and Calderón (2005); namely, education, financial development, trade openness, lack of price stability, government burden, institutional quality, and terms of trade shocks.

The synthetic measure of infrastructure quantity, IK_1, as the first principal component of three variables: (fixed and mobile) phone lines per 1,000 people (Z_1/L), electric power generating capacity expressed in MW per 1,000 people (Z_2/L), and the length of the road network in km per sq. km of arable land (Z_3/A). Each of these variables is expressed in logs and standardized by subtracting its mean and dividing by its standard deviation. All three infrastructure stocks enter the first principal component with roughly similar weights:

$$IK_1 = 0.6036\, ln\left(\frac{Z_1}{L}\right) + 0.6105\, ln\left(\frac{Z_2}{L}\right) + 0.5096\, ln\left(\frac{Z_3}{A}\right)$$

On the other hand, we compute a synthetic index of infrastructure quality by computing the first principal component of the (arithmetic inverse) of electric power transmission and distribution losses as percentage of output (Q_2) and the share of paved roads in total road network (Q_3). The first principal component is defined as: $IQ_1 = 0.7071\ ln(Q_2) + 0.7071\ ln(Q_3)$.

The econometric technique used to estimate the impact of infrastructure on long-term growth is the system GMM estimator (Arellano and Bover 1995, Blundell and Bond 1998) that combines the growth equation expressed in first differences —using lagged levels of the regressors as internal instruments— and in levels — using lagged differences of the regressors as instruments. In addition to internal instruments (i.e. lagged levels and differences of the regressors), we also used demographic and geographic variables as external instruments.

The consistency of the system GMM estimator depends on the validity of the internal and external instruments. In turn, this is examined through two specification tests: first, the test of over-identifying restrictions (Hansen and difference-Sargan tests) that tests the null hypothesis that instruments are uncorrelated with the estimated residuals. Failure to reject the null hypothesis gives support to the model. Second, tests of serial correlation of the residual, where the null hypothesis is that the estimated residuals of the regressions in differences do not exhibit second-order serial correlation. Again, failure to reject the null hypothesis gives support to the model.

The standard errors of the efficient two-step system GMM estimator are significantly downward biased in small samples. The bias arises from the fact that the approximation to the asymptotic standard errors does not account for the extra small-sample variation due to the use of estimated parameters in constructing the efficient weighting matrix. Windmeijer (2005) proposes a correction that accounts for this fact. The correction term vanishes with increasing sample size and provides a better approximation in finite samples when all moment conditions are linear.

Table 6 reports the GMM estimates of the parameters of the growth regression augmented by the synthetic indices of infrastructure performance (quantity IK1 and quality IQ1, respectively). Columns [1]-[3] of Table 6 report the coefficient estimates of the baseline growth regression equation including both the synthetic quantity and quality indicators in the regression. This baseline specification is estimated using three different sets of instruments for infrastructure: (i) lagged synthetic IK1 and IQ1 indicators (column [1]), (ii) lagged values of the individual components of the synthetic indicators (quantity and quality of telecommunications, power and transport (column [2]), and (iii) lagged values of external instruments, namely urban population, labor force and population density (column [3]).

Regression estimates in Table 6 yield a positive and significant coefficient estimate for the infrastructure quantity index that is robust to the different sets of instruments used. Hence, expanding infrastructure quantity contributes positively to long-term growth —although note that the coefficient estimate is smaller when using external instruments than when using internal ones (columns [3] and [1], respectively). Furthermore, infrastructure quality also contributes positively to long-term growth. In this case, the coefficient estimate is larger when using external instruments than otherwise.

C.3 Potential benefits from closing the infrastructure development gap

Once we have identified the gaps and estimated the growth returns from infrastructure, we proceed to compute the potential growth benefits of narrowing or closing the infrastructure development gap —as measured by the quantity and quality of infrastructure. Using the regression estimates of column [3] in Table 6, the growth effects of narrowing the infrastructure gap of Sub-Saharan African countries is computed. We present two different scenarios: first, closing the gap of the region as well as selected groups within the region relative to the world median (excluding SSA) of the infrastructure distribution. The second scenario involves closing the infrastructure gap relative to the world's top decile of the infrastructure distribution. Note that the scorecard in Table 6 corresponds to this second scenario.

Table 6. Infrastructure and Economic Growth

Dependent Variable: Growth in GDP per capita (annual average, percent), Sample: 97 countries, 1960-2005 (non-overlapping 5-year period observations), GMM-IV System Estimation

Variable	[1]	[2]	[3]	[4]
Infrastructure Development (synthetic indexes):				
Infrastructure Quantity (IK1) 1/	2.6641 **	2.1927**	2.0260*	1.0609
	(1.105)	(0.981)	(1.328)	(1.403)
IK1 squared	..	..	-0.0403	..
			(0.247)	
IK1 * Sub-Saharan Africa	..	..	..	0.2897
				(1.450)
Quality of Infrastructure Services (IQ1) 2/	..	1.9581**	1.9373**	1.5233 *
		(0.549)	(0.598)	(0.800)
IQ1 squared	..	..	-0.0265	..
			(0.298)	
IQ1 * Sub-Saharan Africa	..	..	..	1.3582
				(1.281)
Control Variables				
Initial Output per capita / per worker	-4.3056 **	-6.2404**	-5.9773**	-5.2489 **
(in logs)	(1.099)	(1.285)	(1.815)	(1.635)
Education	1.9914 *	2.7857**	2.8253**	2.9420 **
(secondary enrollment, in logs)	(1.095)	(1.160)	(1.175)	(1.376)
Financial Development	0.4856	-0.0147	-0.0231	-0.0489
(private domestic credit as % of GDP, logs)	(0.605)	(0.492)	(0.508)	(0.640)
Trade Openness	1.2705	1.0965	1.1278	0.9347
(trade volume as % of GDP, logs)	(1.053)	(1.410)	(1.380)	(1.363)
Lack of Price Stability	-0.0990 **	-0.0510*	-0.0511*	-0.0618 **
(inflation rate)	(0.036)	(0.033)	(0.033)	(0.031)
Government Burden	-1.3229	-1.9217*	-2.0330*	-1.2706
(Government consumption as % GDP, logs)	(1.274)	(1.281)	(1.297)	(1.363)
Institutional Quality	0.4748	-0.3029	-0.2769	0.2056
(ICRG Political risk index, logs)	(2.418)	(1.735)	(1.632)	(2.408)
Terms of Trade Shocks	0.0197	0.0944*	0.0991*	0.0768
(first differences of log terms of trade)	(0.066)	(0.051)	(0.053)	(0.055)
Observations	**582**	**582**	**582**	**582**
Specification Tests (p-values)				
(a) A-B test for 2nd-order serial correlation	(0.360)	(0.482)	(0.484)	(0.481)
(b) Hansen test of overidentifying restrictions	(0.241)	(0.275)	(0.211)	(0.190)
(c) Difference-Sargan tests				
All instruments for levels equation	(0.166)	(0.340)	(0.290)	(0.197)

*Numbers in parentheses are robust standard errors. Our regression analysis includes an intercept and period-specific dummy variables. * (**) denotes statistical significance at the 10 (5) percent level. Standard errors are computed using the small-sample correction by Windmeijer (2005) 1/ See Calderon and Serven (2010) for the definition of the synthetic indices of infrastructure quantity and quality.*

Figure 9 depicts the growth benefits of closing the gap in terms of quantity and quality of infrastructure relative to the median of the world (excluding SSA) for each infrastructure sector.[14] For instance, growth per capita for the region would increase by 1.7 percentage points per year if it were to close the gap with the regional median of each infrastructure indicator. Narrowing the quantity infrastructure gap would deliver higher growth per capita by 1.2 percentage points per annum, while catching up in terms of quality brings about higher growth

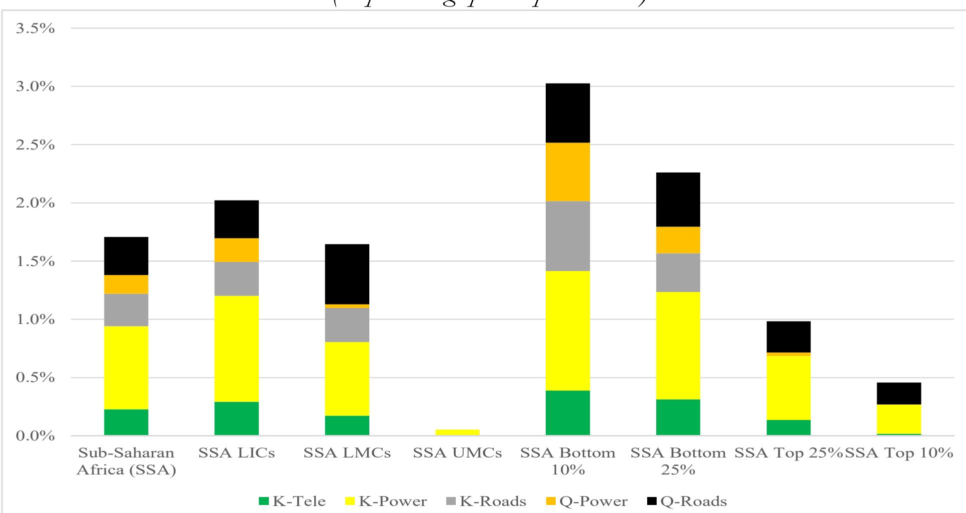
[14] Note that if the contribution is zero, there is no gap between the region (and/or sub-region within SSA) and the benchmark.

by 0.5 percentage points per annum. Zooming in the quantity of infrastructure, the largest growth benefits are obtained by narrowing the gap in electric power (0.7 percentage points higher per year). In terms of quality, improving road quality provides the largest benefits.

The results for income groups in SSA (Figure 9): while distance to the benchmark (and, hence, the growth effect) is greater for LICs in electric power installed capacity, it is greater for quality of roads among LMCs. On the other hand, UMCs in the region only trail the world median in terms of electric power installed capacity. The gap is narrow and so are the growth benefits (about 0.05 percentage points per annum). Finally, narrowing the infrastructure gap among the worst performers in the region (bottom 10 percent) improves growth per capita by 3 percentage points per year (2 percentage points attributing to closing quantity gaps) while it is only about 0.5 percentage points per annum (0.2 percentage points attributed to closing quality gaps) for the best performers (top 10 percent).

Figure 9. Growth benefits of narrowing the gap vis-à-vis world median in infrastructure

(In percentage points per annum)



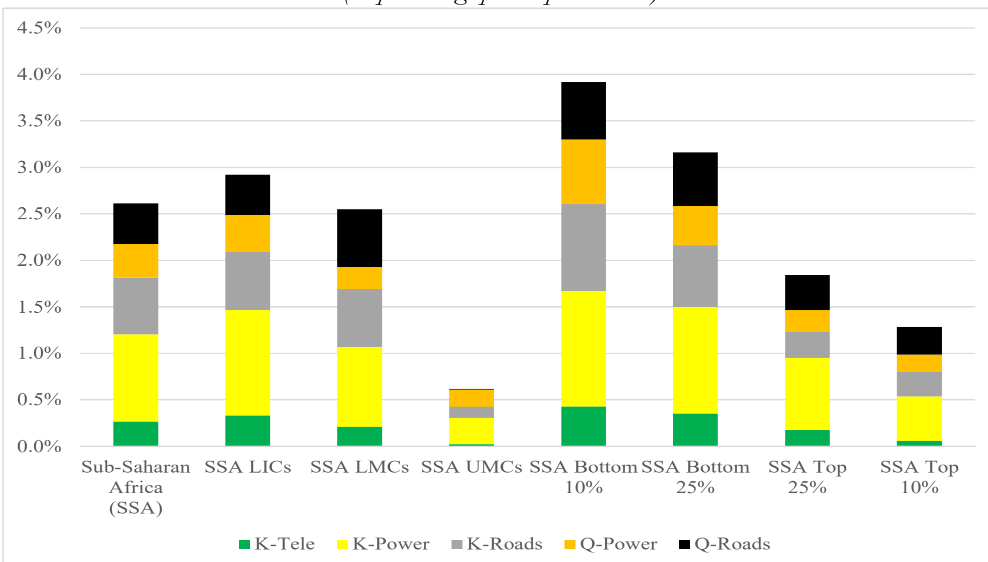
Note: The coefficient estimates are taken from column [3] of Table 6 (Calderón and Servén 2010).

Figure 10 depicts the second scenario of countries in the region closing the infrastructure gap relative to the best performers in the world —the latter being proxied by the top decile of the distribution of infrastructure stocks and quality. For the region, closing the quantity and quality of the infrastructure gap renders higher growth rate per capita of about 1.8 and 0.8 percentage points per annum, respectively. This amounts to greater growth per capita of 2.6 percentage points per annum. Note that the largest potential growth benefits are coming from closing the gap in electric power generating capacity and the length of the road network.

The growth benefits for the region are closer to the gaps and potential gains of narrowing the gap for LICs and LMCs in the region. Energy appears to be a more binding constraint among LICs whereas roads is the most binding constraint among LMCs —both in terms of quantity and quality. The worst performer in the region (bottom 10 percent) is bound to have a growth rate higher by 3.9 percentage points per year if it were to close its infrastructure gap with the top decile of the world distribution. About 2/3 of these potential growth gains are attributed to closing the gap in quantity. For the best performers in the region, growth per capita might increase by 1.3 percentage points per year in this scenario (with 0.8 percentage points attributed to closing the quantity gap). Note that the sectors with the greatest potential contribution to growth are electric power and roads —even for the top performers in the region.

Figure 10. Growth benefits of narrowing the gap vis-à-vis world's top decile in infrastructure

(In percentage points per annum)



Note: The coefficient estimates are taken from column [3] of Table 6 (Calderón and Servén 2010).

D. Fostering investment and closing the financing gap

Sub-Saharan Africa ranks at the bottom of all developing regions in virtually all dimensions of infrastructure performance: it trails the rest of the developing world not only in terms of the quantity of infrastructure but also in the quality of and access to these services. The evidence shows that there is a severe infrastructure bottleneck to be addressed and that the potential growth benefits of addressing these bottlenecks are large.

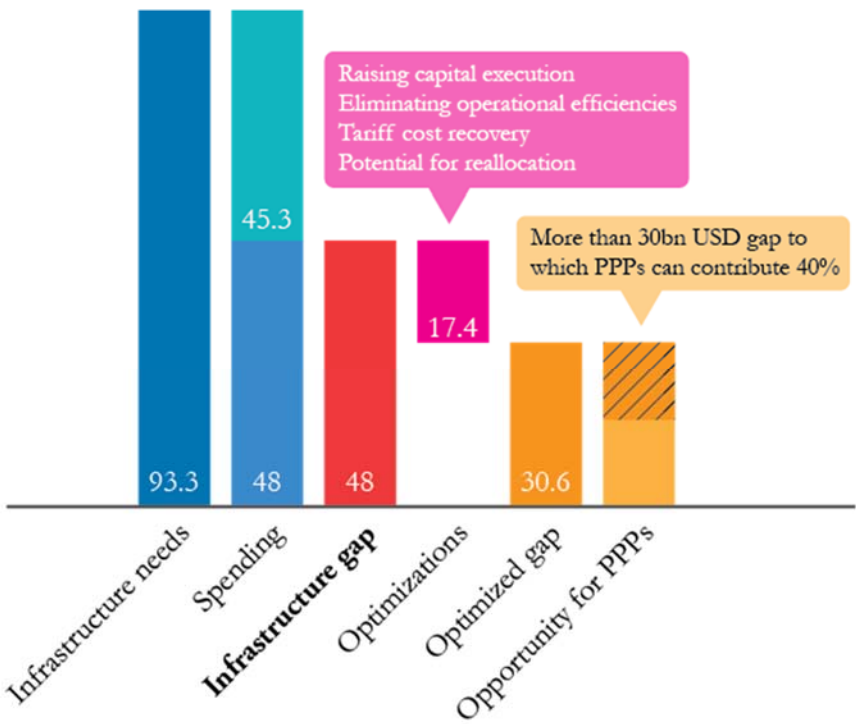
Narrowing the large infrastructure gap in Sub-Saharan Africa requires the mobilization of financial resources. The private sector has limited involvement in the different infrastructure sectors across the region —except for South Africa. If the additional spending needed to close the infrastructure gap falls on the public sector, it imposes a heavy burden. First, these countries have limited domestic resource mobilization. Total government revenues fall short of 20 percent of GDP in many SSA countries. Second, in the presence of scarce resources, governments need to assess the benefits of infrastructure investment vis-à-vis other pressing demands (say, education, health, among others).

The financing needs to close the infrastructure gap in the region are estimated to be approximately US$93 billion per year over the next decade —that is, about 15 percent of the region's GDP (Foster and Briceño-Garmendia 2010). To date, less than half of that amount is being provided: actual investments in infrastructure amount to US$45 billion annually —with more than half being funded by the public sector. This leaves a financing gap of US$48 billion per year. Estimates show that about one-third of the infrastructure gap can be met through operational optimization —thus narrowing the gap to US$31 billion (5 percent of the region's GDP). Public-Private Partnerships (PPPs) could potentially represent 40 percent of this optimized gap with an amount of US$12 billion annually or about 2 percent of GDP (Figure 11).[15]

Financing public infrastructure investment will depend on the country's fiscal position. Its real effects, more generally, would depend on how public investment is financed and on the existing levels of debt and the different tax instruments. Christie and Rioja (2012) developed a two-sector endogenous growth model to examine the impact on long-term growth of the composition and financing of infrastructure spending. They find that: (a) raising taxes to fund public investment may promote long-run growth in an environment when tax rates are not high, (b) public investment promotes growth if funded by restructuring the composition of total public spending if tax rates are high, and (c) debt-financed public spending can have adverse effects on long-run growth if it results in rising interest rates and debt-servicing costs.

In some cases, fiscal discipline efforts have come along with persistent infrastructure investment declines. Reduced public investment is not a cause of concern if it reflects improved efficiency of spending, improved public procurement, reduced red tape and corruption, among others. If private and public investment are close substitutes, retrenchment of the public sector may have to be fully offset by private sector entry without adverse effects on service delivery. However, this has not been the case in many infrastructure sectors of developing countries. With reduced budgets, the government may also try to crowd-in private investment. When combined with better commitment to regulation, rising private investment in infrastructure will improve access, affordability, quality of infrastructure and enhance public savings (Estache 2005).

Figure 11. Infrastructure financing needs in Africa (*in USD$ billions*)



Source: Foster and Briceño-Garmendia (2010)

[15] Recently, the African Development Bank launched an initiative called Program for Infrastructure Development in Africa (PIDA) to increase infrastructure provision. Its main objective is to build a strategic network for the development of regional and continental economic infrastructure over the time span of 2012- 2040.

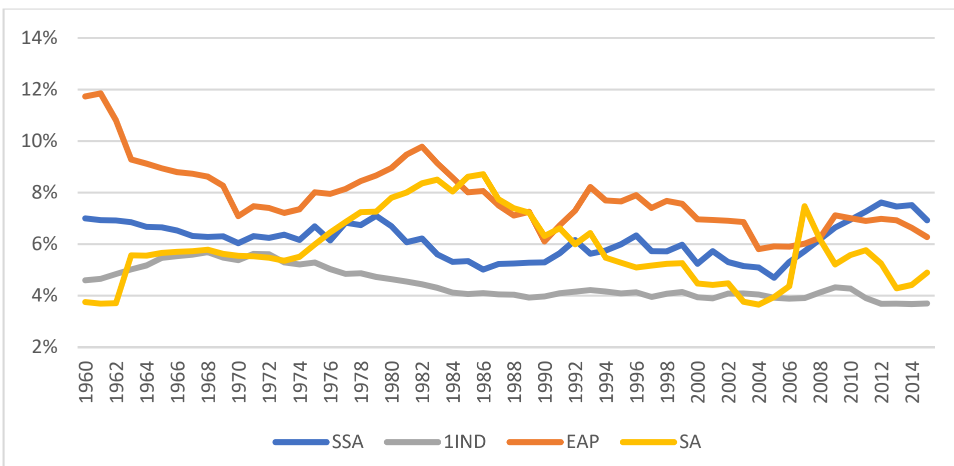
This section documents stylized facts on public investment in Sub-Saharan Africa: (a) Its trends and interplay with the private sector, regarding crowding-in or crowding-out investments, and the current spending levels. The second section (b), reviews the interplay with the private sector in providing economic infrastructure for the region: what have been the mayor roles, concentration of projects, if any, and the financing structure from both public and private counterparties?

D.1. Public Investment in SSA

The unprecedented economic performance in Sub-Saharan Africa (SSA) over the past two decades, coined as *Africa Rising*, was characterized by many SSA countries growing at a rate that exceeded 5 percent per annum. The *Africa Rising*'s earlier narrative attributes the region's faster growth to external tailwinds, progress in macroeconomic management and robust public investment. As economies in the region decelerated in the post-crisis period, there was a significant countercyclical effort to support aggregate demand among countries in the region; partly reflected in a large increase of public investment. For instance, the cumulative increase of public investment exceeded 5 percentage points of GDP in Togo, Guinea and Ethiopia during the period 2008-2015.

The evolution of public investment as a percentage of GDP in the region exhibits three marked periods: (a) a rising trend in the 1970s that reaches a peak of about 7.8 percent in 1977-78, (b) a steady decline throughout the 1980s and stagnation in the 1990s that reached a trough of 3 percent of GDP in 2002, and (c) an increase in public investment that reaches a peak of 5.8 percent of GDP in 2014. When comparing the public investment for the region, East Asia and the Pacific outperform all other regions with levels of public capital spending that exceed 10 percent of GDP (figure 12).

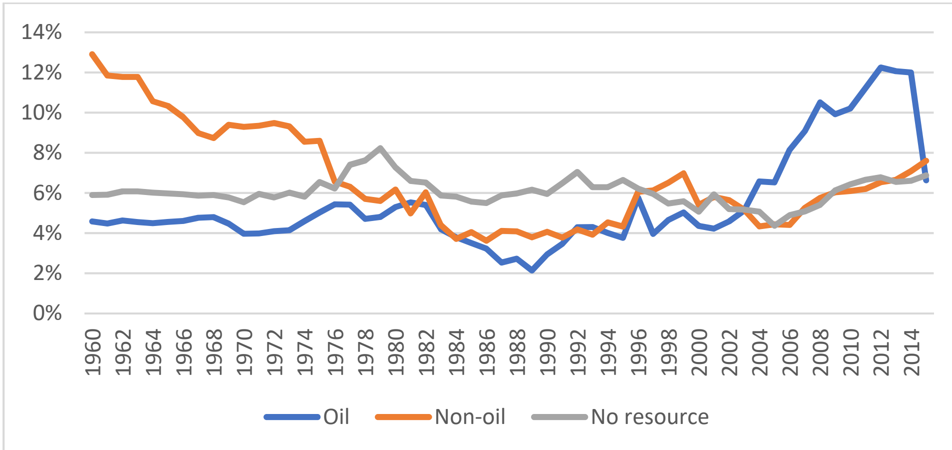
Figure 12. Public investment in Sub-Saharan Africa, 1960-2015 *(% GDP)*



Source: International Monetary Fund (2017)

Focusing on averages for Sub-Saharan Africa masks the heterogeneity across country groups. Splicing the data across resource abundant countries in the regions shows different trends and phases in public investment across resource and non-resource abundant countries (figure 13). Public investment, on average, among on oil-abundant nations followed a rising path since early 1990s. After reaching a peak of about 12 percent of GDP in 2012-14, public investment among oil-abundant countries declined sharply to 6.6 percent of GDP in 2015 –partly due to lower commodity-based public revenues. For non-oil abundant and non-resource rich countries, public investment has experienced a steady increase since 2003 (with a cumulative variation up to 2015 of about 2 and 1.7 percentage points of GDP respectively).

Figure 13. Public investment in Sub-Saharan Africa by resource abundance, 1960-2015 *(% GDP)*



Source: International Monetary Fund (2017)

There is a great deal of heterogeneity across countries in the distribution of public investment (as a percentage of GDP) in the Sub-Saharan Africa region: SSA countries can be classified by their investment-output ratios as low (less than 5 percent of GDP), medium (between 5 and 10 percent of GDP) and high (more than 10 percent of GDP).[16] Seven out of 45 countries in the region have low investment, 23 have medium investment, and 15 have high investment. Low investment countries in the region have an average public investment of 3.1 percent of GDP while medium countries have an average of 6.8 percent. High investment SSA countries have an average ratio of 18.2 percent of GDP. Note that the medium public investment group has the highest average private investment rate with 15.1 percent of GDP, followed by the high and low public investment groups (12.4 and 10 percent, respectively).

The level of public investment could be low in some SSA countries; however, it warrants to ask whether public investments crowds-in, say, the participation of (domestic and/or foreign) private investors in infrastructure sectors (say, transportation or energy projects). If that is the case, the relevant policy question becomes how to maximize the complementarities and prioritize public investment in sectors with high productivity and/or large positive spillover effects (for example, infrastructure). In contrast, if private investment is crowded-out by public investment, the relevant policy question is what can be done to reduce this crowding-out effect so that countries can reap more benefits from higher public <private?> investment (Cavallo and Daude 2011).

The World Bank (2017) examines the correlation between public and private investment ratios for 45 SSA countries over the period 1970-2015. It ranges from -0.59 (Equatorial Guinea) to 0.85 (Chad) and the regional median (average) public-private investment correlation is 0.11 (0.08). The report finds that: (i) 19 out of 45 countries display a negative correlation between public and private investment, and the median correlation for these 19 countries is -0.275. (ii) There is a positive association between private and public investment for 26 out of 45 SSA countries and their median correlation is 0.282. In other words, the evidence suggests that public and private investment are substitutes in 19 SSA countries while they are complements in 26 SSA countries. Although central measures of correlation do not appear to be that large, there are countries where either the degree of substitutability is important (say, Equatorial Guinea, Zambia, South Africa, and Senegal) or the extent of complementarity (say, Botswana, Zimbabwe, Rwanda, and Chad).

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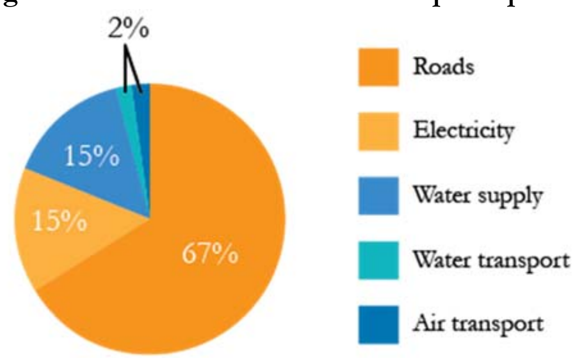
[16] Note that the thresholds of 5 and 10 percent of GDP are similar to the bottom and top tercile of the distribution of investment-output ratios in the world for the period 2011-15.

To reduce the crowding-out effect of public investment on private investment or to foster crowding-in effects, there is the need to formulate policies that either elevate the marginal product of capital or alleviate financial constraints (Aschauer 1989, Cavallo and Daude 2011). In this context, policies to foster institutional quality and/or enhance access to international credit markets will help either reduce the substitutability or increase the complementarity between private and public investment. Cross-country evidence for 116 countries from 1980 to 2006 shows that the crowding out effects of public investment through weak public institutions or borrowing constraints tend to outweigh crowding-in effects from rising marginal product of private capital (Cavallo and Daude 2011).[17] Finally, actions to increase the efficiency of public investment and improving the ability to crowd in private investment should be at the top of the policy agenda. In this context, efforts to improve institutions (at the country and project level) and implement policies to alleviate borrowing constraints (say, creating fiscal space and fostering financial openness) are necessary.

D.2. Current public spending levels are too low to address infrastructure needs[18]

Figure 14 depicts the distribution across sectors of the capital spending in infrastructure for 24 Sub-Saharan African countries for the period 2009-2015. The infrastructure sectors included are road, water, air transport, electricity, telecommunications, and water and sanitation. The sample of SSA countries accounts for about 70 percent of the regional GDP. The list of countries in the sample along with basic indicators on data quality is presented in Annex 1.

Figure 14. Sectorial distribution of capital spending



Source: Mastruzzi (2017)

On average, the 24 SSA countries in the sample have spent around 1.8 percent of GDP annually between 2009 and 2015 to build, rehabilitate or improve their existing infrastructure capacity across the main subsectors. Roads accounted for over two-thirds of overall investments, while capital spending in electricity and water supply and sanitation each accounted for 15% of total capital expenditures (Figure 14). Overall actual spending in infrastructure was considerably lower than capital allocations during the same period, which amounted to around 3.4% of GDP), reflecting substantial under-execution of such investments (Mastruzzi 2017).

D.3. Public-Private Partnerships in Sub-Saharan Africa are still modest and highly concentrated[19]

There is renewed interest in PPPs. However, they remain a very small market in Sub-Saharan Africa to attract private investors into the region's different infrastructure sectors. The development of PPPs has been

[17] The empirical findings of Cavallo and Daude (2011) are consistent with those of Blejer and Khan (1984) and Everhart and Sumlinski (2001). Note that the latter two papers use a smaller sample of countries and earlier time sample periods.

[18] This sub-section draws heavily from Mastruzzi (2017).

[19] This subsection draws heavily from Ruiz Nunes (2017).

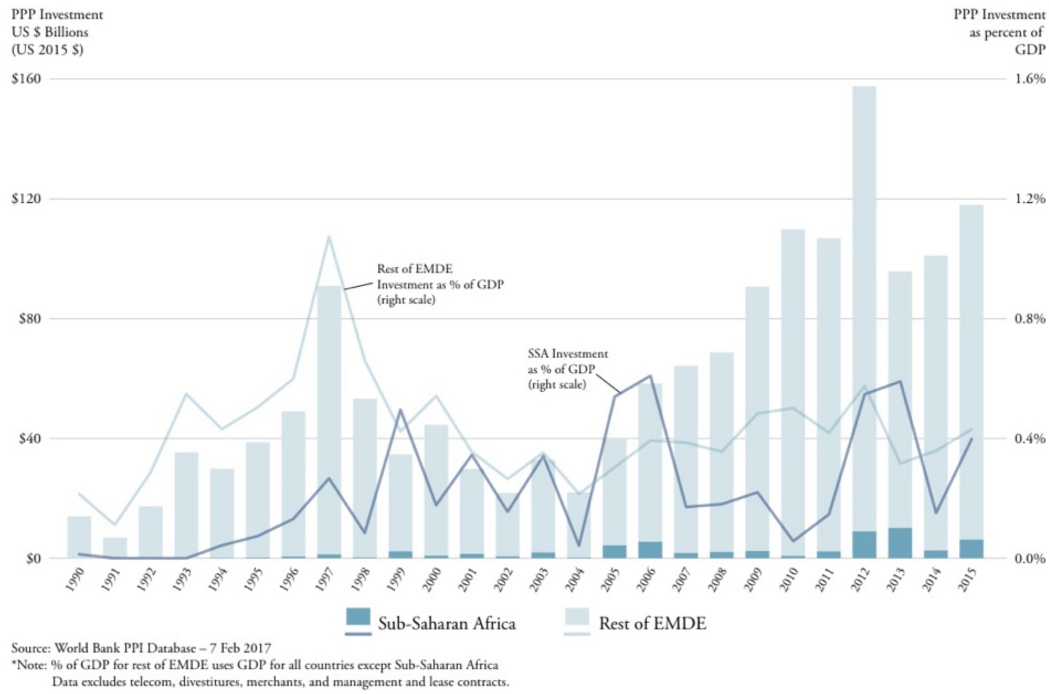
slow and started in the early 1990s —starting with projects in South Africa and Côte d'Ivoire in 1990. It eventually spread to 41 of the 48 countries in Sub-Saharan Africa, most recently Botswana and Somalia in 2011 and 2013, respectively. According to the World Bank's Private Participation in Infrastructure (PPI) database there are 335 PPP infrastructure projects in Sub-Saharan Africa that have reached financial closure[20] in the last 25 years. Burundi, Eritrea, Equatorial Guinea, Mauritania, the Seychelles, South Sudan, and Swaziland did not have any PPPs throughout this period.

Although many SSA countries started early, they never produced another PPP after their first one — e.g. Central African Republic (1991), Guinea-Bissau (1991) and DRC (1995). The most active countries in the region are South Africa (85 projects), Nigeria (35), Kenya (22) and Uganda (22). There were 9 countries that have only produced one PPP, and another 13 that have produced only two or three in the last 25 years. The low number of PPPs in these countries can be attributed to the fact that some are small economies, others have been in conflict for several years or they have a weak legal and regulatory framework to procure and implement PPPs (The World Bank 2017).

The number of PPP infrastructure projects in SSA is a relatively small proportion of the total number of projects in Emerging Markets and Developing Economies (EMDE), ranging from 2 to 12 percent. Additionally, PPP investment commitments in Sub-Saharan Africa are also relatively modest: they account for a small portion (2–10%) of PPP commitments in EMDEs. When adjusting the data by the size of the economy, it can be observed that before the Asian Financial crisis (1997-1998), PPP investment as a percentage of GDP was clearly below the average for the rest of the EMDEs, reaching a peak of 0.2 percent in 1997 compared to 1.1% for the rest of the EMDEs. However, after the Asian financial crisis, investment as a percentage of GDP fluctuated between 0.2 and 0.6, closer to the average for the rest of the EMDEs (see Figure 15).

[20] A PPP is defined as "any contractual arrangement between a public entity or authority and a private entity, for providing a public asset or service, in which the private party bears significant risk and management responsibility." PPP in infrastructure refers to the energy, transport and water and sanitation sectors as defined by the PPI database (www.ppi.worldbank.org). The definition of financial or contractual closure varies among types of private participation as a result of availability of public information: (a) For *management and lease contracts*, a contract authorizing the commencement of management or lease service must be signed with the private consortium assuming the operation of the services. (b) For *brownfield* concession projects, contractual closure is reached when the concession agreement is signed, and the date for taking over the operations is set. (c) For *greenfield projects*, financial closure is the date that whereby a) there is the existence of a legally binding commitment of equity holders and/or debt financiers to provide or mobilize funding for the full cost of the project; and b) the conditions for funding have been met and the first tranche of funding is mobilized. If this information is not available, the construction start date is used as an estimated financial closure date. (d) For *divestitures*, the equity holders must have a legally binding commitment to acquire the assets of the facility. Such commitment usually occurs at the signing of the share purchase contract.

Figure 15. PPP Investment in Sub-Saharan Africa vs the rest of EMDE



Source: Ruiz Nunes (2017)

PPP projects in Sub-Saharan Africa have been concentrated in only a few countries, namely - *South Africa, Nigeria, Kenya, and Uganda*, which are the top four countries in terms of both investment and number of projects. Together they account for 48 percent of the 335 total PPP projects in Sub-Saharan Africa in the last 25 years.[21] This amounts to $36.7 billion of investment commitments, or 62 percent of the $59 billion of total investment commitments in the region.[22] Investment as a percentage of GDP tends to be somewhat sporadic for the top four countries, jumping during boom years such as 2005-06, 2012-13, and 2015. In three of the past five years, the top four countries (especially South Africa and Nigeria) have played a significant role in the development of SSA PPPs. This has been largely due to renewable energy initiatives in South Africa, and port renovations in Nigeria.

PPP financing may come from different sources. Public sector financing includes (a) governments providing part of a project's upfront capital costs through grants or viability gap funding (government subsidies[23]); (b) state-owned enterprises (SOE) investing equity; and (c) state-owned banks extending loans. Private sector financing includes equity (including equity financed by corporate debt) through the project's developer or project finance debt through private lenders, which can be either commercial banks or institutional financiers. Development Financial Institutions (DFIs) also provide various forms of support in the form of loans and equity.

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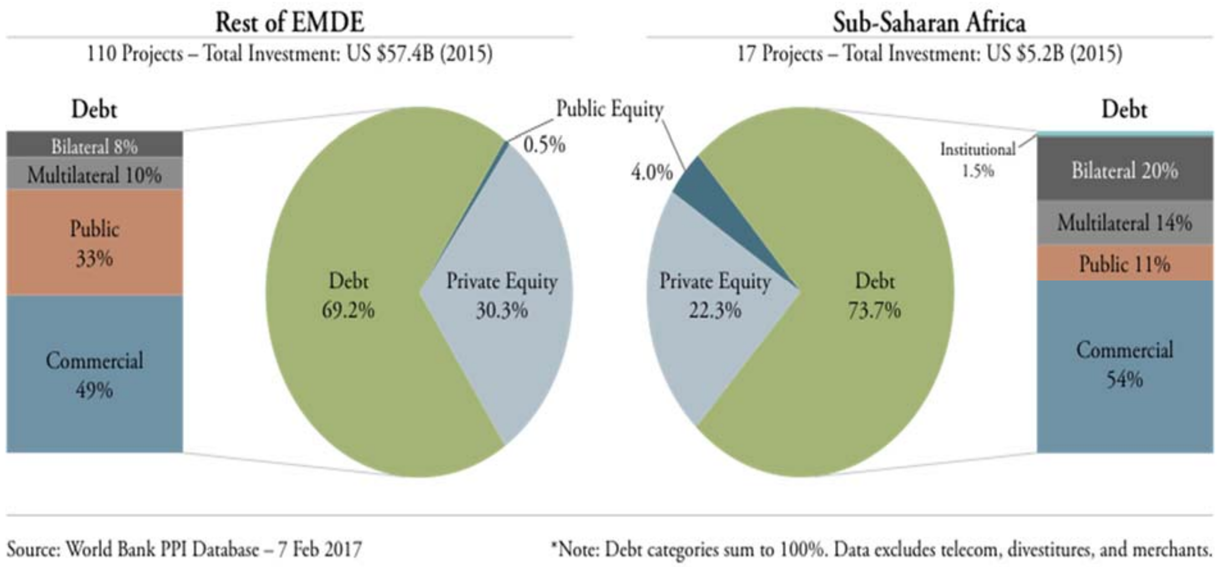
[21] Projects that cross borders are counted only once, and this count only represents each country's portion of those projects divided evenly between the participating countries. For example, the Belt-bridge Border Post project between South Africa and Zimbabwe, where only half of the project is represented by the top 4 countries. Another example is the West African Gas Pipeline, which is split among Togo, Ghana, Benin, and Nigeria. Again, only ¼ of this project is counted for the top 4 countries.

[22] The same information about cross-border projects applies to these investment sums. Total investment is divided among countries participating in cross-border projects, and then only applied to their category of aggregation. For example, only ¼ of the total investment for the West African Gas Pipeline is attributed to Nigeria's aggregated investment.

[23] The term *government subsidies* in this note refers to all cash subsidies provided by a government for capital investments of a project to cover the costs of the physical assets during construction.

There is limited data in terms of financing for PPP projects in Sub-Saharan Africa. In 2015, there were 334 projects for all EMDEs, 24 of which were in Sub-Saharan Africa, and only 17 of those have complete financial information. The data that are available, however, show that the projects in Sub-Saharan Africa are financed in a very similar way to those in the rest of the EMDEs. In general, projects are financed with about 70% debt and 30% equity, most of which is private. There is a slight variation in the debt structure between EMDEs and Sub-Saharan Africa. In both cases, debt tends to be about half commercial, but in SSA international financial institutions play a larger role in financing the other half, about 34% as opposed to only 18% in the rest of the EMDEs, where public debt plays a larger role (Figure 16).

Figure 16. 2015 Sources of PPP Financing in Sub-Saharan Africa and the rest of EMDE



Source: Ruiz Nunes (2017)

D.4. Optimizing the funding of the financing gap: The cascade approach

The World Bank Group estimates that about 50 percent of infrastructure needs in developing countries can be financed on a commercial basis. In the light of evidence suggesting that public investment is insufficient, that it tends to crowd-out private investment in some countries and that PPP intervention is concentrated and has yet a long road for project and implementation maturity, there is a new suggested approach formulated by the World Bank Group to promote private investment and solve the infrastructure finance gap: The cascade approach.

This approach deploys resources based on a hierarchy of financing considerations. It examines a set of questions at each level of investment decision-making to promote the efficient use of public and concessional resources, crowd in commercial capital, and minimize public debt burden. The approach is not restricted to infrastructure projects only, but when focused on infrastructure, it consists of searching for every other instance of participation from either the private sector or foreign aid towards infrastructure finance.

The cascade approach has four levels of diagnosis (Figure 17). Initially, it identifies whether a development program can be financed on commercial terms. When diagnosed as commercially viable and cost effective without government guarantees, then the investment is not a priority for concessional or public financing. When commercial financing is not viable, due to perceived risks or market failures, upstream reforms to strengthen policies, regulations, and institutions and capacity are needed. If risk and cost remain high, governments need to explore the possibility for lowering financing costs by deploying concessional and public resources in risk-sharing instruments, such as guarantees. Finally, where commercial financing is not cost-effective or viable, despite sector reform and risk mitigation, governments need to mobilize public and concessional resources.

Figure 17. The cascade approach to infrastructure

Source: World Bank, "A Cascade Decision-Making Approach to Infrastructure Finance: Guiding Principles for the World Bank Group".

Countries determine whether and how to follow such an approach. The role of the World Bank Group is to assist governments to assess options systematically based on the approach. The cascade approach will allow a more systematic emphasis on upstream reforms at the national and sector levels, and maximize the development impact of concessional and public resources.

E. Efficiency: Infrastructure spending quality

Public investment (in infrastructure and services) is capable of crowding-in private efforts and boosting inclusive growth. However, public investment also attracts political interest —often the kind that lowers efficiency. Inadequately designed, under-funded, long-delayed, or poorly implemented public projects have either a negligible or an adverse impact on real economic activity. Furthermore, some countries lack the absorptive capacity to execute their limited investment budget whereas others fail to have a portfolio of "shovel-ready" projects to stimulate the economy (Rajaram et al. 2014).

In this context, the productivity of public capital is at the top of the academic and economic policy debate.[24] So far, the literature has argued that infrastructure does contribute positively to real economic activity but there is no consensus on the magnitude of this effect (Agénor 2011). Recent literature, on the other hand, focuses on the quality of spending. It suggests that economic production is the outcome of an effective stock of infrastructure at work —or what is called economic public capital.[25]

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[24] See Sturm, Kuper, and De Hann, (1998) and Romp and De Hann, (2007) for extensive surveys of the literature.

[25] Note that infrastructure efficiency can be constrained by political issues (Drazen, 2000; Grossman & Helpman, 2001; Persson & Tabellini, 2000).

Recent evidence examines the long-run growth effects of surges in public investment (Warner 2014): the impact is limited due to poor institutions governing the life cycle of infrastructure products. In this context, enhancing institutions and procedures associated to project appraisal, selection and monitoring plays a key role in raising the quality of infrastructure spending. There are several channels through which more efficient public investment can foster growth (IMF 2015): (a) reducing transaction costs for the private sector, (b) increasing marginal productivity of private physical and human capital, (c) generating fiscal space by the provision of low-cost, better infrastructure services, and (d) releasing resources for growth-enhancing recurrent expenditure.

Closing efficiency gaps in public investment could significantly increase the public investment multiplier. For instance, a one-off 1 percent of GDP increase in public investment will boost output by about 0.3 percent among countries in the lowest quartile of public investment efficiency. However, an analogous increase of public investment will raise output by 0.6 percent among countries in the highest quartile (IMF 2015). In other words, closing the efficiency gap between the top and bottom quartiles could double the impact of public investment on growth.

This section looks first at the quality of institutions governing public investment management systems (PIMs) as well as the transparency of procedures associated to the procurement cycles of public and PPP projects. Next, it looks at the correlations of the soundness of public investment management and economic performance. Countries with sound PIMs tend to have greater growth and efficiency, higher private investment and lower public investment. Finally, it looks at the relationship between PIMs and governance. Again, countries with sound PIMs tend to also display strong levels of governance —i.e. improved control of corruption, rule of law and regulatory quality.

E.1. Public Investment Management

The efficiency of public investment is closely tied to the quality of institutions at the country and the project level. Rajaram et al. (2014) identify several institutional features that countries need to adopt to deliver growth-enhancing public investment. This implies: (a) the implementation of a transparent and accountable system for guiding, appraising, reviewing and selecting projects that will enhance inclusive growth, and (b) design mechanisms and procedures to implement, adjust, operate and evaluate projects so as to optimize public service delivery. Weaknesses in any of these areas may lead to poor investment and lower growth.

Fostering development through public investment requires the strengthening of institutions for public investment management.[26] Dabla-Norris and associates (2012) constructed an index that evaluates the underlying institutional features of public investment management systems (PIMI index) for 71 developing countries from 2007 to 2010 across four different stages: project appraisal, selection, implementation and evaluation. Scores for this index range from 1 to 4 with higher scores denoting better performance. Figure 18 displays the averages for each category that comprises the overall PIMI score in three selected regions (SSA, LAC and EAP). The SSA region's overall score (1.53) lags behind that of EAP (1.59) and LAC (1.84).[27] Note that the score on *project selection* for SSA outperforms EAP, but not LAC —while the region trails in the other three subcategories (project appraisal, managing, and evaluation).

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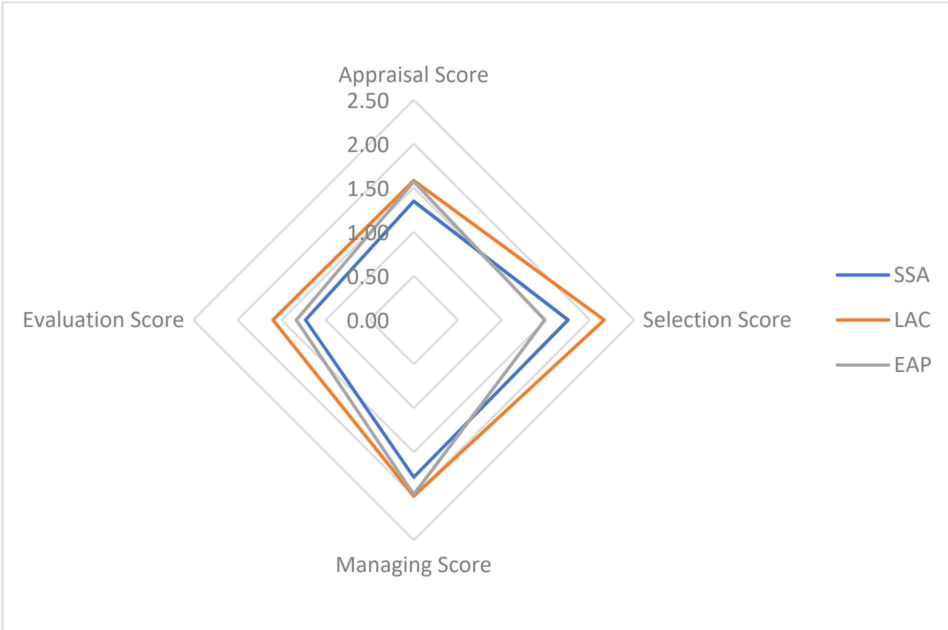
[26] This implies enhanced practices of project appraisal, dealing with uncertainty, the integration of procurement practices into project design and implementation, and managing the decision on public-private partnerships.

[27] The SSA region comprises 32 <31 are listed here> countries: Benin, Botswana, Burkina Faso, Burundi, Chad, Rep. Congo, Cote d'Ivoire, Ethiopia, Gabon, The Gambia, Ghana, Guinea, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritius, Mozambique, Namibia, Nigeria, Sao Tome and Principe, Senegal, Sienna Leone, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia. This figure also includes 10 LAC countries (Barbados, Belize, Bolivia, Brazil, Colombia, El Salvador, Haiti, Jamaica, Peru, and Trinidad and Tobago) and 7 EAP countries (Cambodia, Indonesia, Lao PDR, Mongolia, the Philippines, Solomon Islands, and Thailand).

Figure 18 Public investment management index (PIMI), SSA vs. Other Developing Areas



Source: Dabla-Norris, Brumby, Kyobe, Mills, and Papageorgiou (2012)

Figure 19 depicts the performance of public investment management within the region by income level.[28] The highest average PIMI index is achieved by UMCs (2.07) as opposed to LMCs (1.33) and LICs (1.45). LICs in the region are outperformed by the two other country groups in the phases of project appraisal and evaluation whereas LMCs are outperformed in project managing (monitoring). Note that UMCs and LICs have comparable scores in project management.

E.2. Public procurement practices

Delivering infrastructure may require that governments acquire goods, services or works from the private sector. This process of acquisition is called *public procurement* and it involves a wide array of economic sectors. For instance, governments may rely on the private sector to supply goods and services to construct schools and hospitals, build a dam, or expand the road network (Djankov 2016). Governments in developing countries are important players in the markets of goods and services. South Asia has the highest share of public procurement in GDP (19.3 percent), followed by Sub-Saharan Africa (14.9 percent of GDP). For some countries in the region (e.g. Eritrea and Angola), a considerable amount of development assistance goes through public procurement. Hence, the shares of public procurement in Eritrea and Angola are 33 and 26 percent of GDP (World Bank 2017).

The efficiency of investment depends not only on the strength of institutions and government public management systems, but also on sound procurement practices and sound institutions governing public and PPP project cycles. Broadly speaking, the enhancement of public procurement practices (say, transparency, equal treatment, open competition and sound procedural management) may boost competition in the markets for government goods and services, and it may render benefits for consumers in the form of greater quality and

[28] Classifying countries in the region by income renders: 21 LICs (Benin, Burkina Faso, Burundi, Chad, Rep. Congo, Ethiopia, Gambia, Ghana, Guinea, Kenya, Madagascar, Malawi, Mali, Mozambique, Rwanda, Senegal, Sierra Leone, Tanzania, Togo, Uganda, Zambia), 6 LMCs (Cote d'Ivoire, Lesotho, Nigeria, Sao Tome and Principe, Sudan, Swaziland) and 5 UMCs (Botswana, Gabon, Mauritania, Namibia, South Africa).

lower prices. Furthermore, transparent procurement processes will help reduce corruption (World Bank 2016a). In this context, this section benchmarks two different aspects of procurement:

Figure 19 Public investment management, by SSA income groups

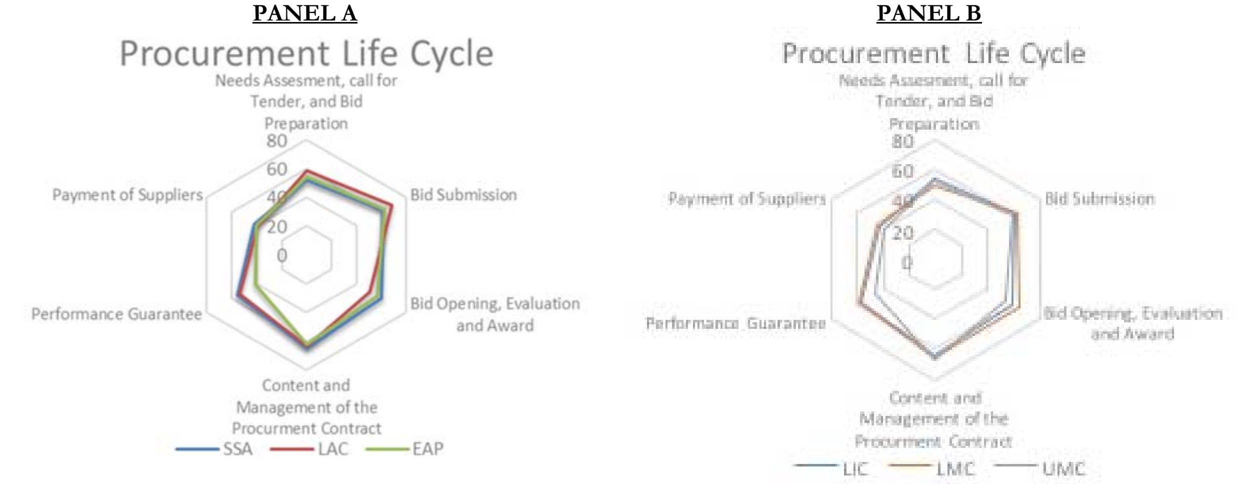
Source: Dabla-Norris, Brumby, Kyobe, Mills, and Papageorgiou (2012)

First, the procurement life cycle of infrastructure projects which covers the following dimensions: (i) needs assessment, call for tender, and bid preparation, (ii) bid submission phase, (iii) bid opening, evaluation, and awarding phase, (iv) content and management of the procurement contract, (v) performance guarantee, and (vi) payment of suppliers. The rationale and areas covered in these six stages of the procurement process are described in World Bank (2016a).

Second, the regulatory frameworks and practices governing the project cycle of public-private partnerships (PPP). It involves the following dimensions: (a) preparation of PPPs (activities that precede and inform the decision to launch a PPP procurement process), (b) procurement of PPPs (evaluates the selection process of private partners), and (c) contract management of PPPs (well-established and comprehensive PPP contract management framework that enables smooth implementation). These data allow the benchmarking of PPP practices that promote transparency and fair competition (World Bank 2016b).

Figure 20 benchmarks the different stages of the procurement life cycle of infrastructure projects by the public sector in SSA vis-à-vis other developing regions, namely, EAP and LAC (panel A). The region is outperformed by both EAP and LAC in the initial stages of the procurement cycle —that is, needs assessment, call for tender, and bid preparation, as well as bid submission. On the other hand, the score on performance guarantee in SSA is comparable to that of LAC and outperforms that of EAP. Looking at the income groups within the region, LICs and LMCs have comparable scores in the different stages of the procurement cycle, and they tend to outperform UMCs in two areas: bid opening, evaluation and award, and performance guarantee (panel B).

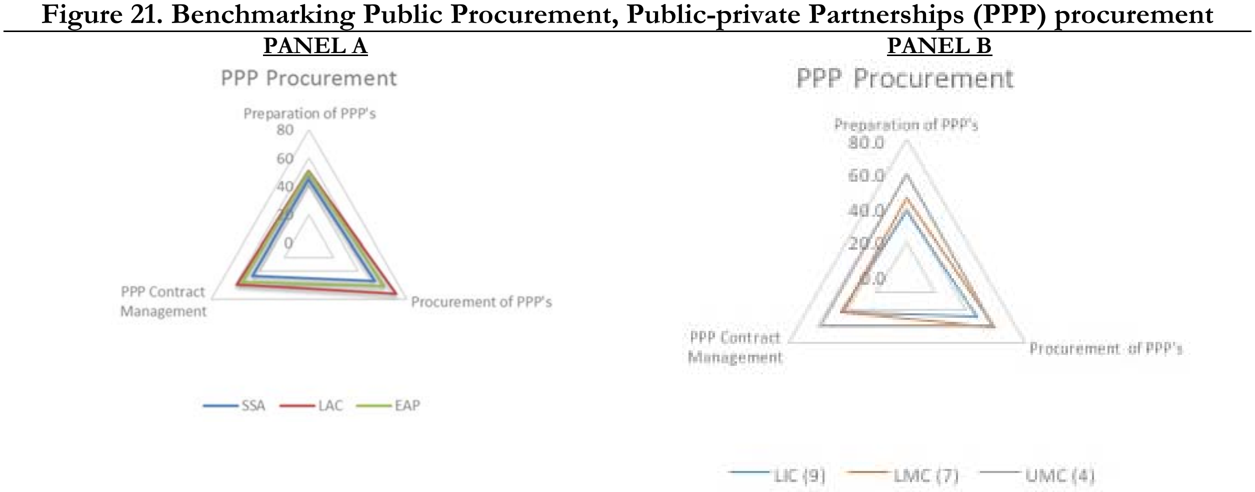
Figure 20. Benchmarking Public Procurement, Procurement life cycle



Source: World Bank (2016b)

Regarding the institutions governing the project cycle of PPPs, the region has a weak performance in the three different stages (preparation, procurement, and contract management) compared to the benchmark regions, EAP and LAC (Figure 21, panel A). When looking at income groups within the region, UMCs outperform LICs and LMCs in terms of preparation and contract management of PPP projects while all regions have comparable scores in terms of PPP procurement (Figure 21, panel B).

Figure 21. Benchmarking Public Procurement, Public-private Partnerships (PPP) procurement



Source: World Bank (2016b)

E.3. Public Investment management and economic performance

Weak institutions tend to distort the effectiveness of public investment —thus limiting its impact on growth (Cavallo and Daude 2011). In other words, one dollar invested by the public sector in an economy with high levels of rent-seeking and corruption renders a smaller amount of public services compared to an economy with good institutions. This section looks at the association between the institutions governing public investment management (as proxied by the PIMI index) and economic performance; namely, growth per capita, (public and private) investment, and efficiency of investment.

Figure 22 plots the overall PIMI index vis-à-vis growth per capita for a sample of countries across the world. It shows that there is a positive relationship between these two variables: that is, countries with stronger public investment management tend to have higher per capita growth rates. Figure 23 investigates the relationship between PIMI and public investment (panel A) as well as PIMI and private investment (panel B). Some interesting findings emerge from these figures:

First, countries with stronger public investment management systems (i.e. higher values in the PIMI index) tend to have lower ratios of public investment to GDP (see panel A) and higher ratios of private investment to GDP.

Second, the lower public investment in countries with high PIMI values can be attributed to improved efficiency of these investments. In this context, lower public investment may imply an improvement in public procurement, lower red tape and corruption, among others. Note that for the PIMI level, several countries in the region have a ratio of public investment to GDP that is above the international norm (say, Republic of Congo, Ethiopia, and Mozambique, among others).

Third, having sound public investment management systems appears to attract private investment — as suggested by the positive association. Having transparent procurement rules and best practices in terms of project appraisal, selection, implementation and evaluation may help de-risk the country (as well as its investment procedures).

Finally, note that for the PIMI level, some countries in the region have a ratio of private investment to GDP that is above the international norm (say, Botswana, Namibia and Zambia). Large countries in the region (South Africa and Nigeria), on the other hand, are close to the international norm.

Figure 22. Public investment management and growth per capita

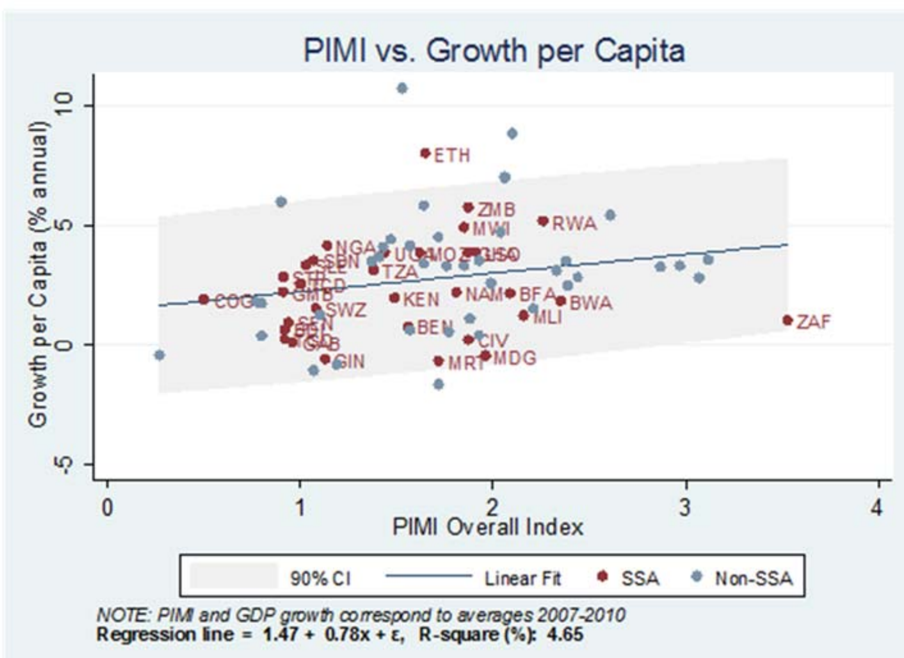
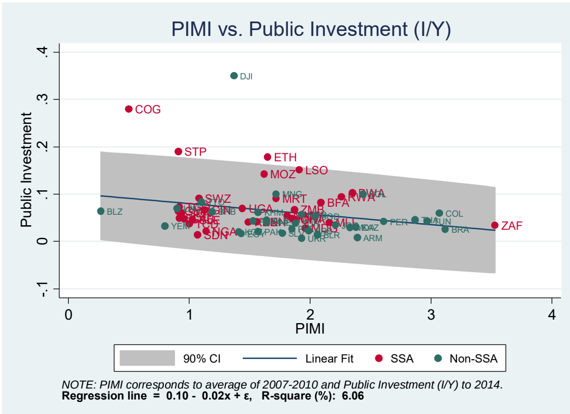
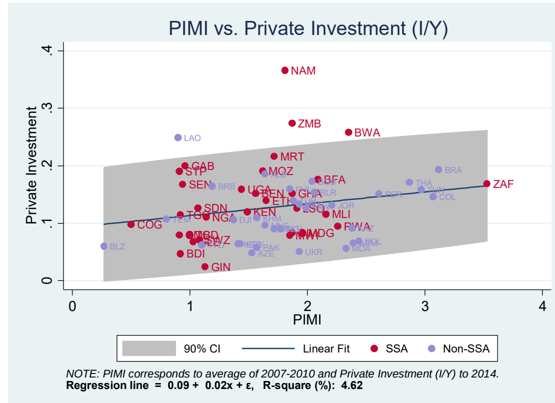


Figure 23. PIMI and Investment

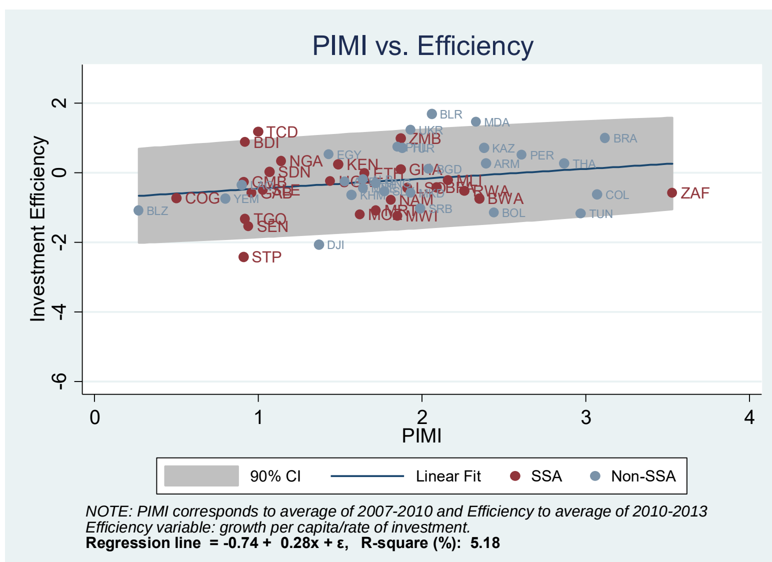
PANEL A	PANEL B





Finally, Figure 24 displays the relationship between PIMI and what we call the efficiency of public investment.[29] There is a positive and significant relationship between public investment management and the efficiency of public investment.[30] Interestingly, Figures 23 and 24 show that countries with better PIMs tend to have lower but more efficient levels of public investment, and they tend to crowd-in private investment. Relative to the international norm, some countries are clearly underperforming —which is the case of Sao Tome and Principe, Senegal, Mozambique, Malawi, among others.

Figure 24. PIMI and Efficiency of Public Investment



[29] This is a very broad measure computed as the ratio of growth per capita to investment-GDP ratio —as suggested by King and Levine (1993).

[30] World Bank (2017) also shows that countries with sound PIMIs tend to have strong institutions —that is, greater regulatory quality, improved rule of law and better control of corruption. However, there is a great deal of heterogeneity. Some countries in the region exhibit not only high PIMIs but also high levels of country governance —e.g. South Africa, Rwanda and Botswana. Others show the opposite —e.g. Sudan and Republic of Congo are among the countries with low PIMIs and low levels of governance.

F. Conclusions

This paper examines the performance of four different infrastructure sectors (telecommunications, electric power, transportation, and water and sanitation) along three different dimensions (quantity, quality and access) in Sub-Saharan Africa. Five important messages emerge from our analysis:

First, our analysis reveals that infrastructure development has improved in Sub-Saharan Africa although at a slower pace relative to other regions in the world. The region considerably lags the rest of the world in virtually all infrastructure sectors and dimensions considered. Even when we control for demographic and geographic characteristics, our benchmarking analysis shows that, despite progress over the past quarter century, the performance of infrastructure sectors and dimensions for most countries in the regions is dismal not only relative to their level of development but also when compared with the rest of the world. This confirms the hypothesis that infrastructure is a bottleneck to development in Sub-Saharan Africa that needs to be addressed promptly.

Second, our statistical analysis confirms not only that infrastructure development contributes positively to growth but that the potential growth benefits of narrowing the infrastructure gap in Sub-Saharan Africa are large. Specifically, our estimates show that if the Sub-Saharan Africa region were to close their gaps relative to certain benchmarks (that is, the world median excluding SSA), economic growth would increase by 1.7 percentage points per annum —of which 1.2 percentage points per annum would be attributed to greater availability of infrastructure and the remaining 0.5 percentage points would be explained by improved infrastructure quality.

Third, the potential growth benefits of closing the infrastructure gap calculated in this paper represent an upper bound estimate as they do not take into account the associated costs of building the new infrastructure and/or the ability to get funding. In this context, closing the infrastructure gap is not trivial. It has been estimated that the financing needs to close this gap are about US$93 billion. Although public investment has increased in the Sub-Saharan Africa region in recent years, it is still insufficient to meet these financing needs (i.e. more than half of the countries in the region have low to moderate levels of public investment).

Fourth, there is evidence of complementarities between private and public investment for 26 out of 45 SSA countries. This finding implies that there is margin for public investment to crowd-in rather than crowd-out the participation of (domestic and foreign) private investors in infrastructure. In this context, PPPs emerge as an alternative option for infrastructure financing. Having said this, there are still relatively fewer projects in the region that are concentrated in only a few countries and in specific sectors. Another option to engage private sector participation is the application of the Cascade approach to infrastructure financing.

Fifth, the efficiency of infrastructure spending in the region (as proxied by the strength of the institutions governing public investment management systems and procurement of infrastructure projects) is considerably lower relative to other regions across the world. For instance, we show that the region lags in the different aspects and dimensions of governance at the project level (appraisal, selection, evaluation and management) and life cycle of the regulatory framework of infrastructure projects. According to the evidence presented in this paper, improving the efficiency of infrastructure spending will not only foster growth per capita but also increase the output multiplier of infrastructure investment.

Overall, the scorecard for infrastructure development in Sub-Saharan Africa shows that: (a) there is a large gap in terms of the quantity, quality and access to infrastructure. However, the size of the gap depends on the sector and dimension. (b) The potential growth benefits are the largest in the sectors with the largest gaps relative to already defined benchmarks; however, meeting the financing needs to narrow these gaps is not trivial. (c) Financing infrastructure would require not only greater domestic resource mobilization from African governments (along with more efficient spending) but also innovative solutions to crowd-in private financing (e.g. the Cascade approach). (d) Strengthening the institutions governing public investment management systems and government procurement would increase the effectiveness of investment spending.

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Annex

1. Country classification by income in Sub-Saharan Africa

Low- income countries (LIC)	Lower-middle-income countries (MIC)	Upper-middle-income countries (UMC)
Benin	Cabo Verde	Angola
Burkina Faso	Cameroon	Botswana
Burundi	Congo, Republic	Equatorial Guinea
Central African Republic	Côte d'Ivoire	Gabon
Chad	Kenya	Mauritius
Comoros	Ghana	Namibia
Congo, Democratic Republic	Lesotho	South Africa
Eritrea	Mauritania	
Ethiopia	Nigeria	
Gambia, The	São Tomé and Príncipe	
Guinea	Sudan	
Guinea-Bissau	Swaziland	
Liberia	Zambia	
Madagascar		
Malawi		
Mali		
Mozambique		
Niger		
Rwanda		
Senegal		
Sierra Leone		
Somalia		
South Sudan		
Tanzania		
Togo		
Uganda		
Zimbabwe		