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Making Sense of Africa's Infrastructure Endowment

A Benchmarking Approach

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Abstract

The paper's objective is to explain factors underlying Africa's weak infrastructure endowment and to identify suitable infrastructure goals for the region based on benchmarking against international peers. The authors use a dataset covering the stocks of key infrastructure—including information and communication technology (ICT), power, roads, and water—across 155 developing countries over the period 1960 to 2005. The paper also examines subregional differences within Africa. They make use of regression techniques to control for a comprehensive set of economic, demographic, geographic, and historic conditioning factors, as well as adjusting for potential endogeneities.

Results show that Africa lags behind all other regions of the developing world in its infrastructure endowment, except in ICT. By far the largest gaps arise in the power sector, with generating capacity and household access to electricity at half the levels observed in South Asia. While it is often assumed that Africa's infrastructure deficit is largely a reflection of its relatively low income levels, the authors find that African countries have much more limited infrastructure than income peers in other parts of the developing world. Countries that face the most challenging environment, with low population density, weak governance, and history of conflict, have the poorest infrastructure endowments.

At the outset of the data series, Africa was doing significantly better than other developing regions for road density, generation capacity, and fixed-line telephones, but Africa's relative position has deteriorated over time. The most dramatic loss of ground has come in electrical generating capacity, which has stagnated since 1980.

This paper—a product of the African Sustainable Development Front Office, Africa Region—is part of a larger effort in the region to gauge the status of public expenditure, investment needs, financing sources, and sector performance in the main infrastructure sectors for 24 African focus countries, including energy, information and communication technologies, irrigation, transport, and water and sanitation. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at jirving@worldbank.org.

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Acknowledgments

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Contents

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The international community has recently committed itself to scaling up development assistance to Africa, in part to address the continent's major infrastructure deficit. But given its income and other constraints, what level of infrastructure should Africa aim for? A related issue is how well African institutions currently perform in sustaining and expanding infrastructure stocks based on the resources that they have at their disposal. Both questions are amenable to analysis through cross-country benchmarking of infrastructure stocks.

The objective of this paper is to shed light on Africa's current infrastructure endowment and clarify its future infrastructure goals. We pursue that objective by benchmarking the region's stock of key infrastructure—including information and communication technology (ICT), power, roads, and water—against a dataset comprising 155 countries over the period 1960 to 2005. The paper also sheds light on subregional differences, by comparing infrastructure stocks between southern, central, eastern, and western Africa. In addition to pinpointing the factors that have contributed to low infrastructure development on the continent, the benchmarking models serve to identify suitable infrastructure targets that take into account the environmental difficulties that countries face.

The paper is divided into three main sections. Section 1 lays down the methodological framework used in the paper and relates it to the academic literature. Section 2 undertakes a cross-sectional analysis that identifies the extent to which differences in infrastructure stocks across countries can be explained in terms of differences in the geographical, demographic, and economic environment that they face. Section 3 presents a panel data analysis that incorporates the evolution of infrastructure stocks over time and thus clarifies the role of historical factors in determining today's infrastructure endowments.

1 Methodological framework

Benchmarking is a technique widely used in the management and regulatory fields to compare the performance of firms against relevant peer groups. The benchmarking technique employed in this paper was first proposed by Shleifer (1985), as a means of regulating so-called "natural monopolies." Shleifer argued that regulators should select socially optimal prices for markets served by natural monopolies based on cost data from "similar" firms. Our approach also resembles that used by Battese and Coelli (1993) to determine levels of "technical inefficiency" among firms in a particular industry. Battese and Coelli estimated industry-level production functions based on firm-level data and defined the distance between a firm's actual and predicted levels of production as its "technical inefficiency." More recently, the World Bank's annual *Doing Business* report has illustrated the application of benchmarking techniques at the country level. By creating a global database of investment climate indicators and conducting cross-country comparisons, *Doing Business* has prompted a global debate about how to reduce red tape and motivated policy makers to improve their competitiveness. A similar approach has been applied to the infrastructure sectors in recent World Bank work at the country level (World Bank, 2004, 2005a, 2005b). Research in this area has benefited greatly from the availability of an international panel of data on infrastructure stocks provided in Estache and Goicoechea (2005).

Here we perform a country-level benchmarking exercise for infrastructure stocks in Sub-Saharan Africa, comparing them with a global peer group of developing countries. The paper extends and deepens the work of Bogetic (2006) for the countries of the Southern African Development Community (SADC), in particular by using regression techniques to control for a wide range of differences in the operating environment faced by particular countries. In this way, the benchmark against which each country is compared is individually adjusted to control for a comprehensive set of economic, demographic, geographic, and historic conditioning factors.

The analysis is based on a panel dataset of all developing countries for the years 1960 to 2004. Developing countries are defined to be those in the low-income, lower-middle-income, and upper-middle-income categories as defined by the World Bank. Data availability varies over the period according to the specific infrastructure variable under consideration. Thus, road data are available from 1960, ICT data from 1970, and electricity generation capacity data from 1980. In the case of water and sanitation, only two time periods are available (1990 and 2002), while for access to electricity no consistent time series could be found. The data are drawn from a variety of global sources, including the World Bank's *World Development Indicators*, the International Telecommunications Union, and the World Economic Forum's *Global Competitiveness Report*, among others.

Our study contributes to the international benchmarking literature in three ways. In terms of scope, it is the first study to benchmark the entire region of Sub-Saharan Africa, with an emphasis on comparing regions of the developing world as well as the diverse subregions of Africa. It is also the first study to base its predicted infrastructure levels on a panel dataset and to control for potential endogeneity of regressors.

The benchmarking exercise compares each country's actual infrastructure endowments to an expected, or predicted, value based on its socioeconomic structure. The predicted values are derived from an econometric model that explains variation in infrastructure levels among developing countries based on a set of economic, demographic, and structural variables. This exercise produces a measure of infrastructure endowment that controls for differences in all of the socioeconomic variables included in the model. Thus, for example, it would be incorrect to explain a lower-than-predicted infrastructure endowment for a particular country in terms of the country's low income, because the model includes income as an independent variable. Hence the result already controls for differences in income. Note that here the concept of an expected, or predicted, infrastructure level does not refer to any concept of demand, since actual levels of infrastructure may also be driven by supply factors. Moreover, the expected value should not be treated as an ideal; it simply expresses the average endowment of countries with comparable characteristics.

Each country's infrastructure endowment is measured by the deviation between its actual endowment and the endowment predicted by the model (equation 1). A positive deviation indicates that the country outperforms the benchmark provided by the econometric model (i.e., the average for the relevant peer group) and vice versa. The larger the absolute size of the deviation, the greater the extent of the corresponding over- or underachievement.

(1) $deviation_i = (actual_i - predicted_i) / predicted_i$

Separate econometric models are estimated for nine different infrastructure variables—ICT (fixed and mobile telephone lines, Internet connections), power (generating capacity and access to electricity), roads (total and paved), water, and sanitation. All variables are normalized to facilitate comparisons across countries. Roads are measured in terms of their density across the country's surface area. However, to allow for the fact that some countries include large areas of uninhabitable wilderness, the total land area and total arable area are used as alternative means of normalization. Generation capacity is normalized per million inhabitants; ICT variables are normalized per thousand inhabitants. Electricity, water, and sanitation are expressed as percentage household access rates. Access to water and sanitation correspond to the definitions of improved water and sanitation specified in the Millennium Development Goals (United Nations 2007).

Our data reflect only the *quantity* of infrastructure; they say nothing of the quality and hence economic value of those stocks. For example, two countries may have the same paved road density, but one network may be well maintained and the other nearly impassable. Unfortunately, there is no global dataset available that documents the quality of infrastructure stocks, although some research does indicate a close correspondence between quality and quantity of infrastructure (Calderon and Serven 2004). **[**

The first step is to estimate a simple, cross-sectional, ordinary least squares (OLS) model, based on the most recent year of data available for each of the nine forms of infrastructure . This is done following the specification given in equation (2), where *y* is an infrastructure stock, *X* is a vector of independent variables (including economic, demographic, and environmental variables as discussed below), and ε is an error term.

(2) $y_i = \alpha + \beta' X_i + \varepsilon_i$

Our approach extends the work of Canning (1998) to include a much wider set of explanatory variables. In his seminal paper, Canning found that a significant portion of cross-country variation in infrastructure endowments could be explained by economic and demographic variables, such as per capita income, population density, urbanization rate, and growth of urban population. To Canning's set of regressors we add several demographic, public sector, and structural variables. Ethnic fractionalization is also included as a regressor, since competition between ethnic groups may affect infrastructure building programs. Similarly, a governance term based on Transparency International's Corruption Perceptions Index accounts for the impact of wasteful or corrupt government management of infrastructure projects. A per capita measure of foreign aid designated for infrastructure controls for significant variations in aid activity between countries. Lastly, structural variables such as the share of manufacturing, agriculture, and exports in GDP are incorporated, since the structure of the economy may affect demand for specific infrastructure services. Our choice of explanatory variables draws upon an extensive exploratory data analysis presented in the next section of the paper.

Several important limitations of this approach call for the use of panel data models. The simple OLS cross-section is of some interest in that it replicates the results of earlier literature (Canning 1998) and serves to isolate the effect of specific environmental variables that can be identified as relevant from the exploratory data analysis. Nevertheless, it is subject to important methodological limitations. First, the environmental variables only imperfectly control for the myriad differences that arise in different country situations, which can be fully reflected only by means of country-specific factors. Second, the long lag times in the development of infrastructure stocks mean that historic trends play an important role in explaining a country's current infrastructure endowment. Third, the potential reverse causality from per capita income to infrastructure stocks raises the possibility of endogeneity. All of these issues can be addressed using panel data models that analyze a repeated cross-section for the same countries across a number of years.

Our second step is therefore to estimate an OLS panel model that controls for country differences (fixed effects) that affect the ease or difficulty of providing infrastructure services. This is represented by equation (3), where y_{it} is defined as the infrastructure level for country i at time t, X_{it} is a matrix of socioeconomic and structural explanatory variables, and η_i is a time-invariant country-specific fixed effect.

$$(3) \quad y_{it} = \alpha + \beta' X_{it} + \eta_i + \varepsilon_{it}$$

Because the OLS fixed-effects model does not correct for the potential endogeneity of the explanatory variables, our third step is to control for potential endogeneity of relevant regressors using instrumental variables. It seems likely that per capita gross domestic product (GDP) will be endogenous in the specification given in (3). In fact, there is already a large literature based on the concept that causation lies in the opposite direction—that is, that expansion of infrastructure services increases income and income growth. This direction of causality has been examined extensively in Easterly and Serven (2003) and Calderon and Serven (2003, 2004). We draw on this literature to choose appropriate instruments for per capita GDP. Specifically, we employ some of the standard growth regressors from Calderon and Serven (2004), including trade openness (trade as share of GDP), inflation, political risk index, government involvement in economy (government consumption as share of GDP), domestic credit available to the private sector (as share of GDP), and the terms of trade index. Adding these regressors gives us the following equation:

$$(4) \quad y_{it} = \alpha + \beta' X_{it} + \gamma_t + \eta_i + \varepsilon_{it}$$

X_{it} contains the same set of regressors included in the cross-sectional OLS study. Per capita GDP is instrumented using the standard growth variables described above. Lastly, it is important to note that any time-invariant variables from the OLS regressions are dropped once country fixed effects are included, which accounts for the smaller sets of coefficients reported for panel data models later in the paper.[1]

[1] The regressors used in (4) were also considered in a dynamic panel specification, using the technique developed by Blundell and Bond (1998). These results are reported in Annex A.1 for comparison purposes,

2 The impact of environmental factors on infrastructure endowments

Here we examine cross-country variations in today's infrastructure stocks in the context of the very different operating environments that countries face. We begin with a simple benchmarking of infrastructure stocks by regions, subregions, income groups, and other subcategories. We then use a cross-sectional OLS model to isolate the impact of individual factors on infrastructure stocks in a multivariate framework. All averages presented are simple unweighted averages across countries, as opposed to population-weighted averages for the different country groupings. As a result, regional summary statistics may appear to differ from commonly reported regional averages, which typically are based on a population weighting of countries.

Variations across regions

Africa lags behind all other regions of the developing world in its infrastructure endowment, except in ICT (table 2.1). This finding holds across a wide range of indicators including the density of roads and paved roads, per capita capacity to generate electricity, and household access to electricity, water, and sanitation. By far the largest gaps arise in the power sector, with generating capacity and household access to electricity in Africa at around half the levels observed in South Asia, and about a third of the levels observed in East Asia. The conclusion on paved road density differs depending on whether one is considering total land area (in which case Africa comes in last) or only arable area (in which case Africa comes in ahead of South Asia and East Asia). In ICT, Africa significantly outperforms South Asia in density of mobile telephones and Internet connections and comes close in terms of fixed-line density.

but they should be treated with caution because the slow adjustment process for infrastructure stocks may overstate the significance of the lagged dependent variable.

Table 2.1 Infrastructure endowments by world region

Sector and measure	Sub-Saharan Africa	South Asia	East Asia and Pacific	Europe and Central Asia	Latin America and Caribbean	Middle East and North Africa
Transport						
Density of paved road network (km/1,000 km^2, 2001)	49	149	59	335	418	482
Density of paved road network (km/1,000 arable km^2, 2001)	1,087	675	588	1,208	4,826	6,890
Density of total road network (km/1,000 km^2, 2001)	152	306	237	576	740	599
Density of total road network (km/1,000 arable km^2, 2001)	2,558	1,400	5,385	2,160	8,850	30,319
Information and communication technology						
Density of fixed-line telephones (subscribers per 1,000 people, 2004)	33	39	90	261	197	100
Density of mobile telephones (subscribers per 1,000 people, 2004)	101	86	208	489	350	224
Density of Internet connections (subscribers per 100 people, 2004)	2.8	1.7	6.6	16.4	14.1	10.1
Energy						
Electrical generating capacity (MW per 1 million people, 2003)	70	154	231	970	464	496
Access to electricity (% of households with access, 2004)	18	44	57	—	79	88
Water and sanitation						
Water (% of households with access, 2002)	63	72	75	87	90	85
Sanitation (% of households with access, 2002)	35	48	60	78	77	77

Sources: For transport, Easterly & Serven (2003); for ICT, International Telecommunications Union; for energy, Energy Information Agency, U.S. Department of Energy); for water and sanitation, World Development Indicators.

Africa's deficit remains even when the countries of the region are compared with others in the same income bracket (table 2.2). It is often assumed that Africa's infrastructure deficit is largely a reflection of its relatively low income levels. But the comparison with other developing countries in the same income bracket shows that income does not tell the whole story. Africa's low-income countries (LICs) lag substantially behind those in other regions, while the same is true for lower-middle-income countries (LMCs) and upper-middle-income countries (UMC). The divergence is particularly striking for power and paved roads. Electrical generating capacity and access to electricity in Africa are less than a third of the levels found in other UMCs around the world.

Table 2.2 Infrastructure endowments by income group, Sub-Saharan Africa vs. other world regions

	Country group								
	Low-income			Lower-middle-income			Upper-middle-income		
	Africa	Other	Ratio	Africa	Other	Ratio	Africa	Other	Ratio
Sector and measure	(A)	(B)	(C=B/A)	(D)	(E)	(F=E/D)	(G)	(H)	(I=H/G)
Transport									
Density of paved road network (km/1,000 km^2, 2001)	31	134	4.3	94	141	1.5	238	781	3.3
Density of paved road network (km/1,000 arable km^2, 2001)	290	728	2.5	1,176	1,919	1.6	11,086	7,415	0.7
Density of total road network (km/1,000 km^2, 2001)	137	211	1.5	215	343	1.6	293	1,171	4.0
Density of total road network (km/1,000 arable km^2, 2001)	1,535	2,194	1.4	4,233	10,624	2.5	14,179	13,375	0.9
Information and communication technology									
Density of fixed-line telephones (subscribers per 1,000 people, 2004)	10	78	7.7	106	131	1.2	120	274	2.3
Density of mobile telephones (subscribers per 1,000 people, 2004)	55	86	1.6	201	298	1.5	422	554	1.3
Density of Internet connections (subscribers per 100 people, 2004)	2.0	3.2	1.6	5.1	8.0	1.6	10.3	26.2	2.5
Energy									
Electrical generating capacity (MW per 1 million people, 2003)	37	326	8.8	256	434	1.7	246	861	3.5
Access to electricity (% of households with access, 2004)	16	41	2.6	35	80	2.3	28	95	3.4
Water and sanitation									
Water (% of households with access, 2002)	60	72	1.2	75	86	1.2	90	93	1.0
Sanitation (% of households with access, 2002)	34	51	1.5	48	74	1.5	39	90	2.3

Sources: As for table 2.1.

Nevertheless, the African average masks significant variations within the region (table 2.3). To compare subregional endowments, we used four country groupings. They are SADC (all the SADC countries except Tanzania); the East African Community (EAC) of Kenya, Tanzania, and Uganda; the Economic Community of West African States (all the ECOWAS countries); and Central Africa, a default category comprised of Burundi, Cameroon, the Central African Republic, Chad, Comoros, Congo, Rep., Equatorial Guinea, Eritrea, Ethiopia, Gabon, Madagascar, Mauritania, Mozambique, Rwanda, Sao Tome and Principe, Somalia and Sudan.

Comparing infrastructure endowments across these subregions reveals that the SADC countries have a substantial advantage over the others. That advantage is most pronounced in the case of paved roads, ICT, and power, where SADC is ahead of the other regions by several multiples. Generating capacity (per capita) in SADC, for example, is more than five times that reported in other parts of Africa, although, strikingly, household access to electricity is relatively similar. At the other end of the spectrum, EAC has the lowest infrastructure endowment on most measures. Western and central Africa are similar in their results. The least divergence in stocks

across subregions is seen in water and sanitation, with all regions reporting water access in the 60–70 percent range and sanitation access in the 30–45 percent range.

Table 2.3 Infrastructure endowments by African subregion

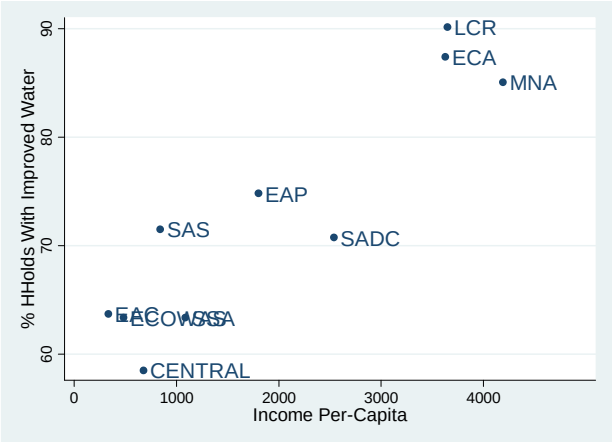
	African subregion			
	ECOWAS	EAC	SADC	Central
Transport				
Density of paved road network (km/1,000 km^2, 2001)	38	8	92	41
Density of paved road network (km/1,000 arable km^2, 2001)	301	93	3,636	416
Density of total road network (km/1,000 km^2, 2001)	144	105	214	132
Density of total road network (km/1,000 arable km^2, 2001)	1,279	1,286	6,164	1,790
Information and communication technology				
Density of fixed-line telephones (subscribers per 1,000 people, 2004)	28	6	74	13
Density of mobile telephones (subscribers per 1,000 people, 2004)	72	54	180	74
Density of Internet connections (subscribers per 100 people, 2004)	2.4	2.1	5.5	1.7
Energy				
Electrical generating capacity (MW per 1 million people, 2003)	31	24	175	44
Access to electricity (% of households with access, 2004)	18	7	21	18
Water and sanitation				
Water (% of households with access, 2002)	63	64	71	58
Sanitation (% of households with access, 2002)	35	45	43	28

Sources: As for table 2.1.

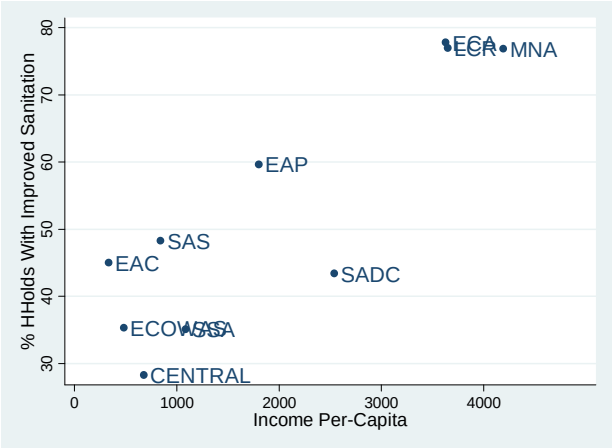
East Asia is the closest comparator for the SADC countries; South Asia for the other African subregions. Figure 2.1 brings together the regional and subregional analysis by plotting infrastructure stocks against income for all of the regions and subregions we have considered so far. In income terms, the SADC countries are most comparable to East Asia and the Pacific. Nevertheless, the SADC countries have less infrastructure than the countries of East Asia and the Pacific by all measures, particularly access to sanitation and electricity. The only exception is paved road density, where SADC has some edge over EAP. By contrast, all other African subregions are, in income terms, similar to each other and to South Asia. On the whole, their endowments do not diverge substantially from that of the whole of Sub-Saharan Africa, although the Central African countries lag behind in terms of water and sanitation.

Figure 2.1 Infrastructure endowments plotted against national income, by world region

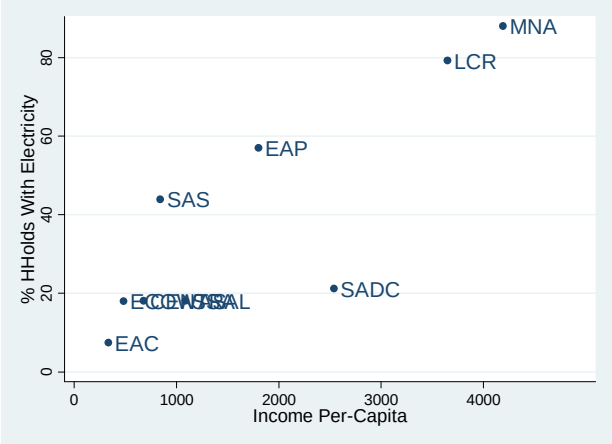
a. Percentage of households with improved water



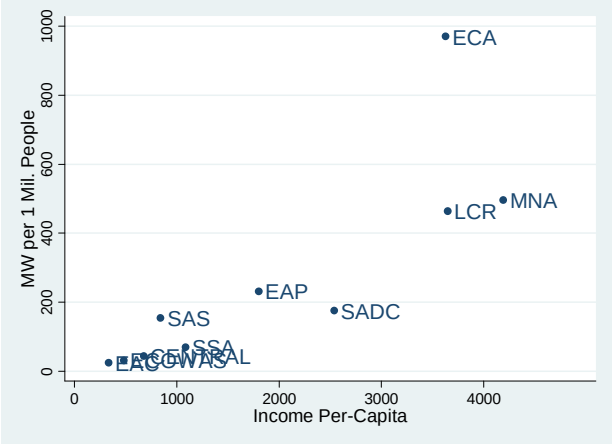
b. Percentage of households with improved sanitation



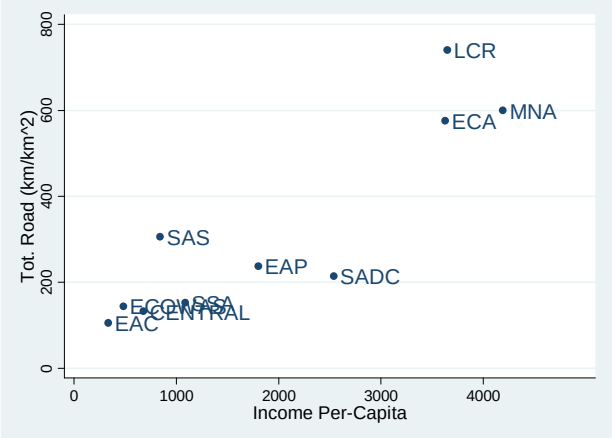
c. Percentage of households with electricity



d. MW installed generating capacity per 1 million people



e. Total roads (km/km2)



f. Paved roads (km/km2)

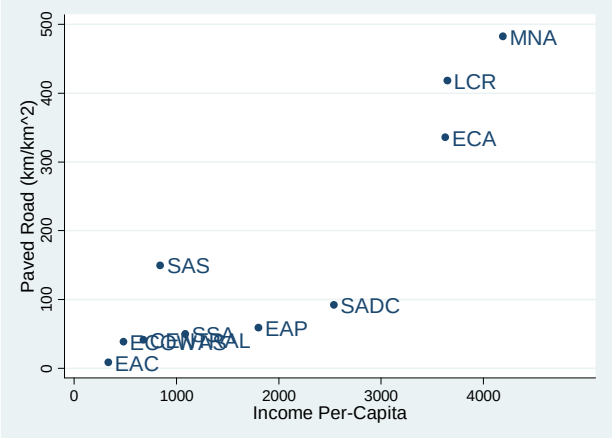
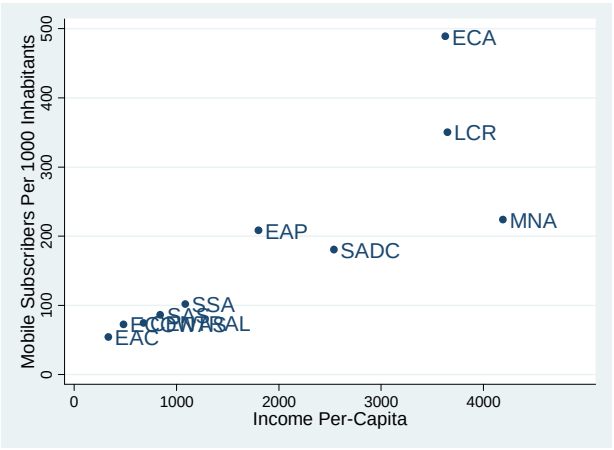
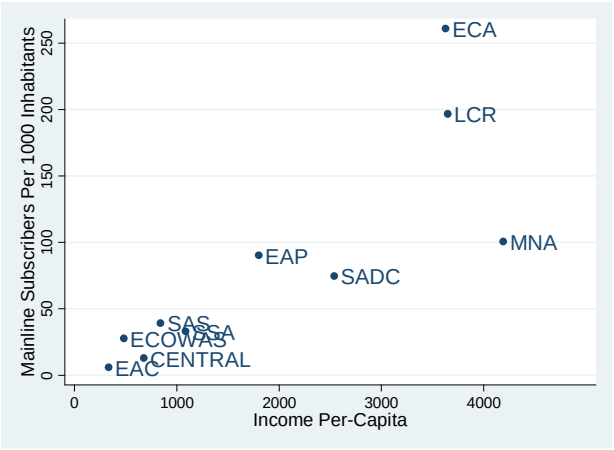


Figure 2.1 Infrastructure endowments plotted against national income, by world region, continued

g. Mobile telephone subscribers per 1,000 inhabitants



h. Landline telephone subscribers per 1,000 inhabitants



Source: As for table 2.1.

Variations across types of countries

Relative to other developing regions, Sub-Saharan Africa faces a difficult environment for the development of infrastructure, and the region's infrastructure shortfall may be traceable to those environmental disadvantages (table 2.4). Building infrastructure tends to be more difficult in countries characterized by low population density and low levels of urbanization, weak governance, high incidence of conflict, and geographical isolation—all of which distinguish Africa from other developing regions. Africa has the lowest population density, the lowest governance index, and the second-lowest urbanization rate of all developing regions. The incidence of conflict in Africa is similar to that in other regions in percentage terms, but the absolute number of countries in conflict is higher in Africa than in any other region.

Table 2.4 Difficulty of infrastructure environment across regions

Regional characteristic	Sub-Saharan Africa	South Asia	East Asia and Pacific	Europe and Central Asia	Latin America and Caribbean	Middle East and North Africa
Population density (pop./km2)	67	436	121	71	133	150
Urbanization rate (%)	37	23	42	57	63	69
Governance index (0=most corrupt; 10=least corrupt)	3.7	4.3	4.2	3.9	3.8	4.5
Landlocked countries (%)	30	38	9	29	6	0
Countries in conflict (%)	23	25	14	25	12	25
Income per capita (US$)	999	842	1,801	3,628	3,649	4,193

Sources: As for table 2.1.

To explore the potential impact of environmental variables, we compare the infrastructure endowment of countries *within the region* according to the difficulty of their environment. As

expected, countries facing a more challenging environment perform systematically worse on infrastructure (table 2.5). The differences in endowment are largest for landlocked countries, countries in conflict, and countries with low population density. Countries with low urbanization perform worse on service coverage, but better on road density. Countries with poor governance also perform worse than their comparators, but the differences are less pronounced. Overall, paved road density is the infrastructure variable that shows the largest variation across types of countries, while water and sanitation show the least variation.

Striking differences also emerge when countries are grouped according to their oil-exporting status and language (table 2.6). Oil-exporting countries score systematically and substantially *worse* than oil-importing countries, suggesting that oil revenues are not being channeled into infrastructure investments. With respect to language groupings, francophone countries have the lowest infrastructure stocks overall. Once again, the largest differences are to be found in the area of paved road density, and the smallest in water and sanitation.

Table 2.5 Infrastructure endowments by demographic, political, and geographic variables

	Population density		Urbanization		Governance		Conflict status		Coastline	
Sector and measure	Low	High	Low	High	Poor	Good	Yes	No	No	Yes
Transport										
Density of paved road network (km/1,000 km^2, 2001)	11	131	51	21	45	54	12	62	16	65
Density of paved road network (km/1,000 arable km^2, 2001)	273	2,829	1,144	308	354	1,819	212	1,378	218	1,492
Density of total road network (km/1,000 km^2, 2001)	79	315	155	112	178	126	135	158	148	154
Density of total road network (km/1,000 arable km^2, 2001)	1,878	4,065	2,585	2,178	1,532	3,631	1,927	2,762	1,174	3,183
Information and communication technology										
Density of fixed-line telephones (subscribers per 1,000 people, 2004)	21	56	33	28	10	51	15	36	14	50
Density of mobile telephones (subscribers per 1,000 people, 2004)	92	133	82	321	68	128	44	115	49	131
Density of Internet connections (subscribers per 100 people, 2004)	2.2	4.1	2.7	3.8	2.6	3.0	1.0	3.3	1.3	3.5
Energy										
Electrical generating capacity (MW per 1 million people, 2003)	79	49	46	410	47	92	39	79	40	83
Access to electricity (% of households with access, 2004)	18	17	16	49	15	21	10	21	9	22
Water and sanitation										
Water (% of households with access, 2002)	59	72	62	77	63	64	52	67	61	64
Sanitation (% of households with access, 2002)	34	39	34	48	35	35	27	38	32	36

Sources: As for table 2.1.

While the preceding analysis is suggestive, it does not take into account the high correlations that exist among these different variables, and with income. Indeed, correlation coefficients between these different indicators of "difficulty" range in absolute value between 0.3 and 0.6. In order to isolate the effect of individual factors we must perform a multivariate regression analysis that looks at all of the effects simultaneously.

As described in equation (1) above, we perform simple OLS cross-sectional analysis for each category of infrastructure. Many control variables are considered—among them income per capita; demographic measures (population density, urbanization, urban growth rates, and ethnic fractionalization); measures of the quantity and quality of public spending on infrastructure (proxied by governance and infrastructure aid per capita); measures capturing the geographical and cultural heritage of the country (including language group, location, and natural resources); and indicators of the structure of the economy (such as the share of exports, agriculture, and manufacturing in GDP). In addition, an Africa dummy is used to see if any specific disadvantages are associated with the continent as a whole.

Table 2.6 Infrastructure endowments by historical variables

	Oil-exporter	Not oil exporter	Lusophone	Anglophone	Francophone
Transport					
Density of paved road network (km/1,000 km^2, 2001)	14	57	95	84	31
Density of paved road network (km/1,000 arable km^2, 2001)	246	1,273	1,315	2,705	188
Density of total road network (km/1,000 km^2, 2001)	70	173	152	240	136
Density of total road network (km/1,000 arable km^2, 2001)	1,909	2,720	2,295	4,861	1,425
Information and communication technology					
Density of fixed-line telephones (subscribers per 1,000 people, 2004)	16	38	148	48	4
Density of mobile telephones (subscribers per 1,000 people, 2004)	118	97	86	139	46
Density of Internet connections (subscribers per 100 people, 2004)	1.7	3.1	3.7	4.8	1.5
Energy					
Electrical generating capacity (MW per 1 million people, 2003)	66	71	49	145	22
Access to electricity (% of households with access, 2004)	26	16	15	23	15
Water and sanitation					
Water (% of households with access, 2002)	59	64	59	72	60
Sanitation (% of households with access, 2002)	34	35	35	46	29

Sources: As for table 2.1.

The OLS regression analysis reveals that levels of infrastructure stocks are primarily related to per capita income and demographic variables, and less so to other variables (table 2.7). Income is statistically significant in almost all cases, except for household access to water and electricity. Demographic variables also seem to be important. Higher levels of urbanization are associated with significantly higher rates of household access to water, sanitation, electricity. By contrast, higher rates of urban growth significantly hold back rates of access to services, suggesting difficulties in keeping up with the rate of urban expansion. Moreover, countries with higher population density seem to have significantly less road area, although this difference disappears when arable land is used to measure road density.

None of the other geographical, cultural, or structural variables prove to be statistically significant in explaining infrastructure stocks. This suggests that in the earlier analysis, the seeming effect of geographical and cultural variables was likely being confounded with the effect of income and demographic variables with which they are associated. Finally, it is noteworthy that the coefficients for infrastructure aid per capita and governance are rarely significant and do not always have the expected signs.

An alternative log-log specification of the model, designed to test the sensitivity of the estimates, yields similar results, while revealing relatively low income elasticities and somewhat

higher urbanization elasticities (table 2.8). The main differences from the first OLS model are these: In the log-log model, income is no longer significant for road density, and some of the structural variables (exports, agriculture, manufacturing) become more significant. Overall, the fit of the model is also somewhat improved. The log-log specification also allows the coefficients on continuous variables to be interpreted as elasticities. The results suggest that the income elasticity of infrastructure stocks is generally well below unity, with the highest values (around 0.5 to 0.7) found for ICT and generating capacity and the lowest (around 0.1 to 0.2) for access to water, sanitation, and electricity, and for roads. The elasticity of urbanization is somewhat higher, particularly for access to electricity and ICT services.

In summary, Africa presents a major infrastructure deficit relative to other developing regions that appears to reflect low urbanization as much as low income. The region lags behind all others in the developing world in almost all areas of infrastructure. The strongest endowments are found in the ICT sector, where Africa is somewhat ahead of South Asia. By far the lowest endowment is in the power sector. Rates of access to electricity in the middle-income countries of Africa, for example, are a fraction of those found in middle-income countries in other regions.

The regional average masks significant geographic variations in infrastructure endowments from country to country. The SADC countries are substantially ahead of the others, while the EAC countries are significantly behind.

Africa's deficit remains even when countries are compared with others in the same income bracket. The reason appears to be that—compared with other regions of the world—Africa is a difficult environment in which to develop infrastructure. The proof is that infrastructure is weakest in those countries that face the most challenging environment. However, some environmental factors are more important than others. When all environmental variables are considered simultaneously, demographic variables (notably urbanization) appear to have the most substantial effect on infrastructure endowments.

Table 2.7 Effect of country variables on infrastructure endowments, part 1

Cross-sectional OLS analysis, data in levels

Variable	Density of roads	Density of roads (arable)	Density of paved roads	Density of paved roads (arable)	Access to water	Access to sanitation	Access to electricity	Generating capacity	Internet connections	Mobile telephones	Fixed-line telephones
Income per capita	0.0001	0.002	0.0001	0.001	0.001	0.003	0.001	0.0001	0.003	0.056	0.021
	(5.73)**	(3.07)**	(4.20)**	(3.15)**	–0.66	(2.76)**	–0.84	(4.87)**	(5.25)**	(5.75)**	(5.37)**
Urbanization	–0.515	–8.845	–0.288	–2.697	26.93	40.957	63.355	0.345	3.878	105.594	97.429
	–1.66	–1.16	–1.06	–0.85	(2.66)**	(3.31)**	(4.81)**	–1.55	–0.59	–0.82	–1.89
Population density	0.001	–0.007	0.002	0.003	0.031	0.007	0.019	–0.0001	0.01	–0.004	0.074
	(4.29)**	–0.87	(5.53)**	–0.84	(3.04)**	–0.55	–1.4	–0.56	–1.49	–0.03	–1.36
Urban growth	–0.052	0.451	–0.061	–0.052	–2.081	–4.273	–3.097	–0.095	–0.485	–16.292	–15.805
	–1.92	–0.67	(2.55)*	–0.19	(2.23)*	(3.66)**	(2.11)*	(4.62)**	–0.82	–1.43	(3.34)**
Fractionalization	0.036	–1.447	–0.048	–2.14	0.567	4.632	14.682	0.297	–0.583	71.167	–9.624
	–0.23	–0.38	–0.36	–1.37	–0.11	–0.72	(2.23)*	(2.56)*	–0.18	–1.08	–0.36
Governance	0.003	–0.197	0.005	0.198	0.507	–0.4	–0.717	–0.011	0.283	–6.042	0.024
	–0.15	–0.39	–0.29	–0.96	–0.74	–0.46	–0.73	–0.74	–0.66	–0.74	–0.01
Infrastructure aid (per capita)	0.002	0.003	–0.002	–0.032	0.035	0.263	0.231	0.0004	–0.059	0.635	0.55
	–0.89	–0.07	–1.34	–1.81	–0.62	(3.76)**	(2.15)*	–0.33	–1.38	–0.72	–1.69
Africa	–0.119	–1.954	0.034	1.226	–7.198	–19.246	–35.293	–0.198	–2.237	–73.992	–29.09
	–1.03	–0.69	–0.34	–1.05	–1.95	(4.27)**	(7.13)**	(2.37)*	–0.89	–1.39	–1.42
Anglophone	0.141	3.394	–0.001	1.001	–3.101	7.351	–5.68	–0.103	0.088	8.696	–1.339
	–1.1	–1.08	–0.01	–0.78	–0.73	–1.41	–1.04	–1.08	–0.03	–0.15	–0.06
Francophone	0.043	–0.113	0.061	0.01	–6.511	–0.918	1.79	–0.034	1.266	28.44	–2.927
	–0.36	–0.04	–0.59	–0.01	–1.68	–0.2	–0.39	–0.39	–0.5	–0.55	–0.14
Landlocked	0.012	–0.864	0.041	–0.397	–1.434	–2.953	–4.667	0.075	–0.131	20.189	–0.019
	–0.12	–0.36	–0.49	–0.4	–0.44	–0.75	–1	–1.06	–0.06	–0.47	0
Oil-exporting	–0.109	0.698	0.037	0.213	–3.356	–6.323	5.269	0.001	–3.03	–53.872	–15.892
	–1.25	–0.33	–0.48	–0.24	–1.15	–1.79	–1.35	–0.01	–1.65	–1.48	–1.08
Conflict	0.09	0.104	0.003	–0.173	–6.223	5.548	–2.748	–0.0001	–2.37	4.995	–2.097
	–0.85	–0.04	–0.03	–0.16	–1.84	–1.36	–0.58	0.0766	–1.08	–0.11	–0.12
Exports (% GDP)	–0.0003	0.07	0.0004	0.038	–0.099	–0.068	–0.131	0.001	0.114	1.497	–0.029
	–0.15	–1.29	–0.2	–1.75	–1.38	–0.71	–1.44	–0.63	(2.45)*	–1.62	–0.08
Agriculture (% GDP)	0.002	–0.056	0.003	–0.004	–0.164	0.192	–0.196	0.006	0.052	–1.379	0.578
	–0.52	–0.49	–0.71	–0.09	–1.05	–1.02	–1	–1.63	–0.52	–0.64	–0.73
Manufacturing (% GDP)	–0.008	–0.275	–0.006	–0.062	–0.294	0.113	0.572	0.002	0.138	2.601	0.304
	–1.21	–1.79	–1.04	–0.96	–1.47	–0.46	–1.98	–0.56	–1.05	–0.97	–0.29
Constant	0.343	7.331	0.126	0.385	81.37	45.274	38.376	0.092	–4.259	44.459	41.711
	–1.13	–0.99	–0.48	–0.13	(8.18)**	(3.51)**	(2.93)**	–0.42	–0.66	–0.35	–0.84
Observations	105	104	104	103	101	99	82	110	108	93	107
R–squared	0.62	0.28	0.55	0.35	0.61	0.74	0.87	0.69	0.63	0.74	0.74

Note: * = significant at 5%; ** = significant at 10%. T-statistics are reported below coefficients. Parentheses denote that T-statistics have been reported in absolute value.

Table 2.8 Effect of country variables on infrastructure endowments, part 2

Cross-sectional OLS analysis, data in logs (except dummy variables, which are in levels)

Variable	Density of roads	Density of roads (arable)	Density of paved roads	Density of paved roads (arable)	Access to water	Access to sanitation	Access to electricity	Generating capacity	Internet connections	Mobile telephones	Fixed-line telephones
Income per capita	0.112	0.262	0.082	0.222	0.135	0.041	–0.061	0.451	0.693	0.492	0.748
	(2.87)**	(2.93)**	–0.57	–1.65	–0.75	–0.2	–0.27	(2.30)*	(5.19)**	(3.05)**	(5.13)**
Urbanization	0.188	0.461	0.991	0.341	0.426	–0.126	–0.023	0.942	0.885	0.859	0.54
	(3.19)**	(3.40)**	(4.93)**	–1.62	–1.5	–0.38	–0.06	(3.05)**	(4.07)**	(3.53)**	(2.29)*
Population density	0.071	0.081	0.09	0.729	1.111	–0.036	0.341	0.193	0.062	–0.048	0.121
	(4.80)**	(2.38)*	–1.72	(14.12)**	(16.12)**	–0.44	(3.95)**	(2.57)*	–1.18	–0.75	(2.11)*
Urban growth	–0.07	–0.149	–0.181	–0.208	–0.598	0.201	–0.205	–0.243	–0.138	–0.488	–0.346
	(2.26)*	(2.04)*	–1.46	(2.23)*	(4.76)**	–1.39	–1.31	–1.72	–1.53	(4.42)**	(3.28)**
Fractionali-zation	–0.011	–0.018	0.047	–0.088	–0.013	–0.146	–0.073	–0.019	–0.022	0.08	–0.08
	–0.69	–0.51	–0.88	–1.61	–0.18	–1.72	–0.81	–0.24	–0.4	–1.28	–1.37
Governance	0.035	0.034	0.086	–0.308	–0.122	–0.259	–0.05	–0.191	–0.339	0.016	0.035
	–0.81	–0.33	–0.55	(2.09)*	–0.62	–1.13	–0.2	–0.88	(2.43)*	–0.09	–0.22
Infrastructure aid (per capita)	–0.006	0.023	0.033	0.008	–0.006	0.025	0.009	0.002	0.067	–0.016	0.019
	–0.67	–1.05	–0.99	–0.27	–0.14	–0.54	–0.17	–0.04	(2.24)*	–0.45	–0.57
Africa	–0.05	–0.251	–0.871	–0.097	–0.029	–0.249	–0.169	–0.042	–0.003	–0.998	–0.451
	–1.01	(2.19)*	(5.14)**	–0.55	–0.12	–0.9	–0.57	–0.16	–0.02	(4.93)**	(2.26)*
Anglophone	–0.024	0.265	–0.135	0.526	–0.214	0.565	–0.144	0.039	0.269	0.246	–0.364
	–0.44	(2.13)*	–0.73	(2.81)**	–0.85	–1.94	–0.46	–0.14	–1.4	–1.08	–1.67
Francophone	–0.153	–0.23	–0.075	–0.11	–0.322	–0.347	–0.53	–0.331	–0.057	–0.621	–0.825
	(3.01)**	–1.96	–0.45	–0.61	–1.33	–1.24	–1.76	–1.26	–0.31	(2.95)**	(4.19)**
Landlocked	0.018	0.059	–0.221	0.314	–0.107	0.016	–0.474	–0.04	0.142	0.107	–0.076
	–0.36	–0.52	–1.18	–1.92	–0.48	–0.06	–1.67	–0.16	–0.89	–0.54	–0.42
Oil exporting	–0.017	–0.033	0.195	–0.453	–0.001	–0.305	0.156	–0.294	–0.014	0.005	0.002
	–0.41	–0.34	–1.34	(3.06)**	0	–1.32	–0.63	–1.37	–0.1	–0.03	–0.01
Conflict	–0.091	0.011	–0.109	0.088	–0.347	0.002	–0.425	–0.272	0.171	–0.169	–0.286
	–1.98	–0.11	–0.66	–0.54	–1.58	–0.01	–1.55	–1.15	–1.08	–0.89	–1.62
Exports (% GDP)	–0.078	0.079	–0.015	0.365	0.479	0.585	0.666	0.444	0.474	0.285	0.034
	(2.18)*	–0.92	–0.12	(2.86)**	(2.82)**	(2.92)**	(3.12)**	(2.42)*	(3.88)**	–1.93	–0.24
Agriculture (% GDP)	0.081	0.296	0.07	–0.031	–0.124	–0.759	–0.864	0.114	0.231	0.265	0.344
	–1.88	(2.97)**	–0.47	–0.21	–0.63	(3.33)**	(3.52)**	–0.53	–1.57	–1.45	(2.13)*
Manufacturing (% GDP)	–0.064	0.04	0.142	–0.148	–0.193	–0.367	–0.428	0.014	0.089	0.035	–0.033
	–1.79	–0.47	–1.12	–1.17	–1.13	–1.86	(2.01)*	–0.07	–0.67	–0.24	–0.23
Constant	3.706	1.111	3.526	–6.44	–8.298	1.309	–0.262	–3.128	–1.791	–5.408	–2.015
	(9.19)**	–1.16	(2.41)*	(4.59)**	(4.39)**	–0.6	–0.11	–1.56	–1.35	(3.19)**	–1.34
Observations	94	92	82	95	95	94	94	98	84	98	97
R–squared	0.71	0.69	0.81	0.85	0.87	0.55	0.69	0.7	0.87	0.86	0.87

Note: * = significant at 5%; ** = significant at 10%. T-statistics are reported below coefficients. Parentheses denote that T-statistics have been reported in absolute value.

3 The impact of historical trends on infrastructure endowments

Variations over time

Africa's present-day infrastructure is strongly influenced by the endowment that the countries inherited at independence. Because infrastructure is costly to build, stocks usually change slowly over time. Hence, differences across developing regions will reflect differences in their history. The current dataset contains time series data going back as far as 1960 for roads, 1970 for fixed telephone lines, 1980 for generating capacity, and 1990 for water and sanitation. No consistent time series data are available for access to electricity. The data points from the 1960s and 1970s are of particular interest for Africa, since they describe the situation at around the time of independence.

Overall, the data show some evidence of worldwide convergence in infrastructure levels (table 3.1). They also reveal the divergent starting points and differing rates of infrastructure growth in world regions. Convergence requires, of course, that regions with a low starting point grow faster than regions with a high starting point. We computed correlation coefficients between starting levels and growth rates. These coefficients are uniformly negative and always smaller than –0.28, suggesting that convergence is underway. The strongest evidence of convergence is found for water and sanitation (with correlation coefficients between –0.6 and –0.7) and roads (with correlation coefficients between –0.45 and –0.55). The lowest is for generating capacity (with a correlation coefficient of –0.28).

Bucking the trend toward worldwide convergence, the infrastructure gap between Africa and other developing regions is larger today than it was some decades ago. Slow convergence has occurred for some forms of infrastructure. At the beginning of the data series for paved roads and access to water and sanitation, Africa had the lowest endowment of any developing region. The region managed to achieve relatively high growth rates in each category, but they were not great enough to compensate for the region's starting position. On the other hand, at the outset of the data series, Africa was doing significantly better than other developing regions with regard to overall road density, generation capacity, and fixed-line telephones. But growth rates in these categories have been slower than in other regions, so that by 2000 Africa had lost substantial ground relative to the other regions.

Africa's failure to converge with the rest of the developing world is most clearly illustrated by the comparison between Africa and South Asia. At the outset of the period under study, South Asia was ahead of Africa in all forms of infrastructure except for fixed-line telephones and electrical generating capacity (figure 3.1). Their positions have since been reversed. The record on generating capacity is particularly stark. In 1980, Africa had almost three times as much generating capacity (per million people) as South Asia. Since then, capacity in South Asia has expanded at an average annual rate of 9 percent, while in Africa it has stagnated. Consequently,

by 1990 South Asia had overtaken Africa; by 2000 it had almost twice the generating capacity (per million people) of Africa. Indeed, Africa had the slowest rate of growth in generating capacity of any region in the developing world. The story for telephone lines is similar, if less dramatic. In 1970, Africa had twice the teledensity of South Asia. However, with faster average annual growth rates in South Asia (9 percent against 6 percent in Africa), the two regions had converged by 2000. Africa has now fallen behind South Asia with respect to fixed-line telephones, but in mobile telephony and Internet connections Africa has been growing more rapidly than South Asia and currently maintains a lead.

Indexing infrastructure stocks in each region and plotting the evolution of the indexes over time sheds light on the sequencing and relative growth path of different aspects of infrastructure. In all regions, fixed-line telephones have been by far the fastest-growing component of infrastructure since the 1980s (albeit from low starting points), but the growth varies substantially across regions from around tenfold in Africa, Latin America, and the Middle East, to more than forty-fold in East Asia (figure 3.2). After telephone lines, paved roads generally have expanded most quickly, particularly in East Asia and Eastern Europe. Generating capacity (per million people) has grown only very slowly across all regions, except in South Asia in the late 1980s, when a significant expansion took place.

Within Africa, the SADC countries started with a larger infrastructure endowment than the other subregions and extended it more rapidly (table 3.2). At independence there already were substantial variations in infrastructure endowment across the continent—particularly with respect to paved roads, generating capacity, and telephone lines. By 1980, the SADC countries had more than three times the generating capacity of other subregions. By 1970, they had five times the teledensity. In the case of roads, ECOWAS was in a much stronger position than the other subregions in the 1960s, but was overtaken by SADC after 1980. In water and sanitation, the differences between subregions have been relatively small.

Table 3.1 Trends in infrastructure endowments, by world region, 1960–2000

	Region	1960	1970	1980	1990	2000 [a]	Average annual growth [b] (percent)
Density of paved road network (km/1,000 km^2)	SSA	6	8	21	26	39	5.0
	SAS	60	76	115	113	146	2.3
	EAP	12	21	37	39	54	4.0
	ECA	54	239	312	362	351	4.9
	LAC	132	185	59	274	361	2.6
	MNA	14	19	26	39	45	3.1
Density of paved road network (km/1,000 arable km^2)	SSA	71	120	544	652	1,037	7.1
	SAS	477	434	585	711	670	0.9
	EAP	239	392	563	453	556	2.2
	ECA	110	498	687	800	1,197	6.3
	LAC	472	808	527	1,973	3,958	5.6
	MNA	196	320	3,283	4,594	5,729	9.0
Density of total road network (km/1,000 km^2)	SSA	73	80	106	119	143	1.7
	SAS	104	145	204	204	303	2.8
	EAP	55	75	144	157	175	3.0
	ECA	298	576	567	630	620	1.9
	LAC	267	198	241	516	583	2.0
	MNA	45	50	77	92	104	2.2
Density of total road network (km/1,000 arable km^2)	SSA	1,525	1,577	2,106	2,343	2,556	1.3
	SAS	757	699	888	1,084	1,408	1.6
	EAP	3,064	2,671	3,244	3,063	3,252	0.2
	ECA	651	1,188	1,261	1,543	2,045	3.0
	LAC	1,962	2,138	2,743	4,929	7,021	3.3
	MNA	558	760	33,263	28,850	30,704	10.8
Density of fixed-line telephones (subscribers per 1,000 people)	SSA	—	4	7	11	22	5.6
	SAS	—	2	2	5	21	8.9
	EAP	—	5	10	21	58	8.9
	ECA	—	32	76	134	229	6.8
	LAC	—	24	44	75	155	6.4
	MNA	—	9	18	41	84	7.7
Electrical generating capacity (MW per 1 million people)	SSA	—	—	71	82	73	0.1
	SAS	—	—	26	127	137	8.6
	EAP	—	—	123	178	229	3.2
	ECA	—	—	587	786	1,022	2.8
	LAC	—	—	309	409	495	2.4
	MNA	—	—	207	421	413	3.5
Water (% of households with access)	SSA	—	—	—	51	63	1.0
	SAS	—	—	—	72	70	–0.2
	EAP	—	—	—	73	73	–0.03
	ECA	—	—	—	93	89	–0.4
	LAC	—	—	—	81	89	0.7
	MNA	—	—	—	83	83	–0.02

Sanitation (% of households with access)	SSA	—	—	—	30	35	0.4
	SAS	—	—	—	31	47	1.3
	EAP	—	—	—	57	53	–0.4
	ECA	—	—	—	86	80	–0.5
	LAC	—	—	—	64	76	1.0
	MNA	—	—	—	69	75	0.5

Sources: As for table 2.1.

Note: SSA = Sub-Saharan Africa, SAS = South Asia, EAP = East Asia and Pacific, ECA = Europe and Central Asia, LAC = Latin America and Caribbean, MNA = Middle East and North Africa.

a. Water and sanitation data are from 2002.

b. Calculated over entire period available for each sector.

— = data not available.

Table 3.2 Trends in infrastructure endowments by African subregion, 1960–2000

		1960	1970	1980	1990	2000 [a]	Average annual growth [b] (percent)
Density of paved road network (km/1,000 km^2)	Central Africa	1	2	5	8	9	6
	EAC	3	6	12	13	8	3
	ECOWAS	11	14	21	24	38	3
	SADC	4	9	46	53	92	8
Density of paved road network (km/1,000 arable km^2)	Central Africa	19	75	156	161	159	6
	EAC	46	106	135	148	95	2
	ECOWAS	122	161	213	237	305	2
	SADC	64	123	1,715	2,015	3,649	11
Density of total road network (km/1,000 km^2)	Central Africa	57	60	82	94	101	1
	EAC	56	77	82	94	105	2
	ECOWAS	84	93	109	121	144	1
	SADC	81	90	140	154	211	2
Density of total road network (km/1,000 arable km^2)	Central Africa	2,101	1,720	1,776	1,677	1,587	–1
	EAC	1,053	1,201	1,073	1,124	1,297	1
	ECOWAS	1,137	1,259	1,391	1,319	1,300	0.3
	SADC	1,588	2,058	4,002	5,045	6,174	4
Density of fixed-line telephones (subscribers per 1,000 people)	Central Africa	—	1	2	4	7	5
	EAC	—	2	3	4	6	4
	ECOWAS	—	2	3	5	17	8
	SADC	—	10	18	32	56	6
Electrical generating capacity (MW per 1 million people)	Central Africa	—	—	49	57	48	–0.1
	EAC	—	—	21	20	23	0.4
	ECOWAS	—	—	38	34	31	–1
	SADC	—	—	177	204	185	0.2
Water (% of households with access)	Central Africa	—	—	—	46	56	1
	EAC	—	—	—	42	64	2
	ECOWAS	—	—	—	51	63	1
	SADC	—	—	—	60	73	1
Sanitation (% of households with access)	Central Africa	—	—	—	22	27	0.5
	EAC	—	—	—	44	45	0.1
	ECOWAS	—	—	—	28	35	1
	SADC	—	—	—	37	42	0.4

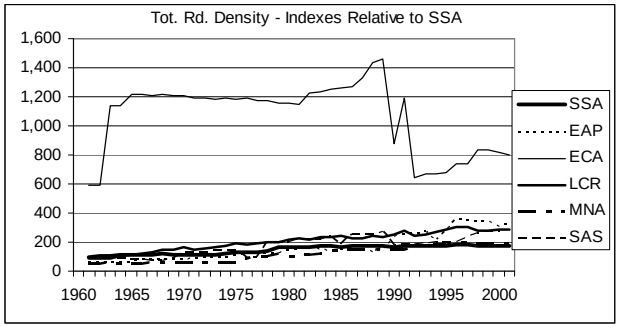
Sources: As for table 2.1.

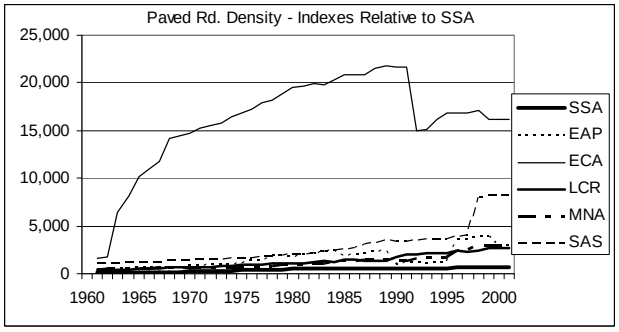
a. Water and sanitation data are from 2002.

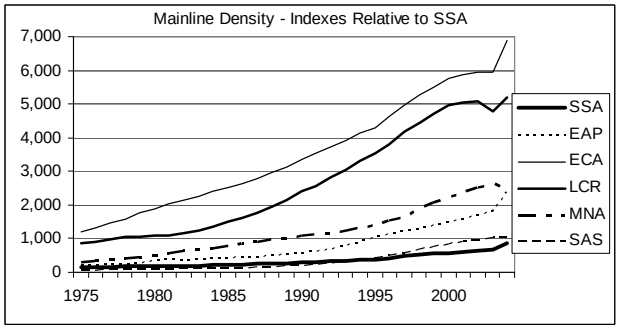
b. Calculated over entire period available for each sector.

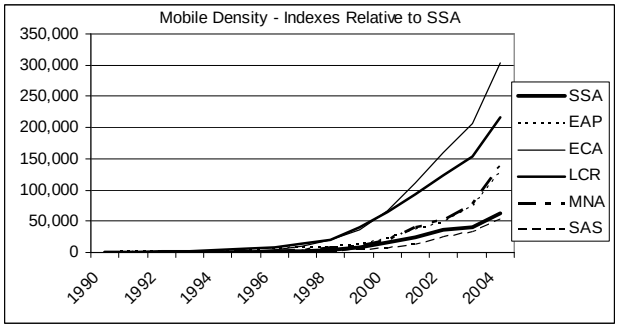
— = data not available.

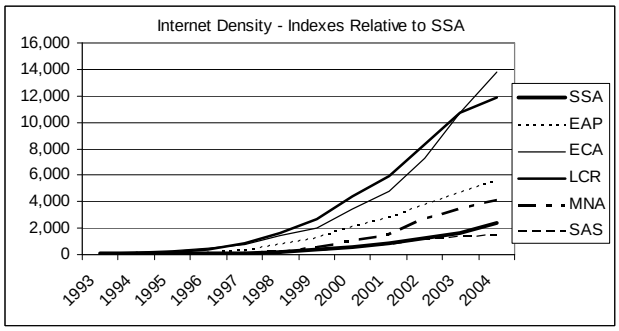
Figure 3.1 Index of infrastructure growth by sector and by region

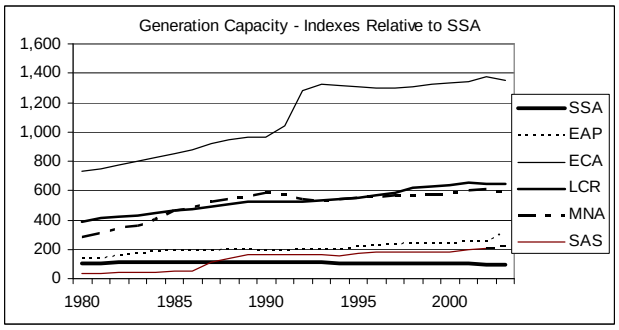


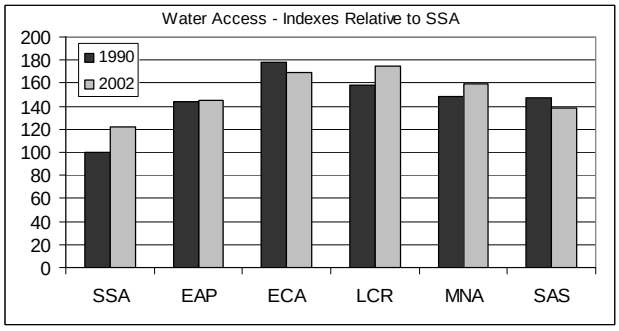


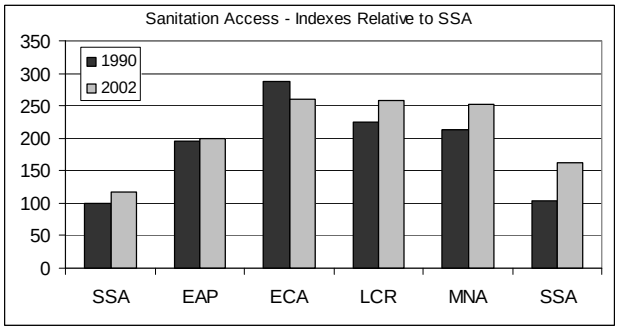






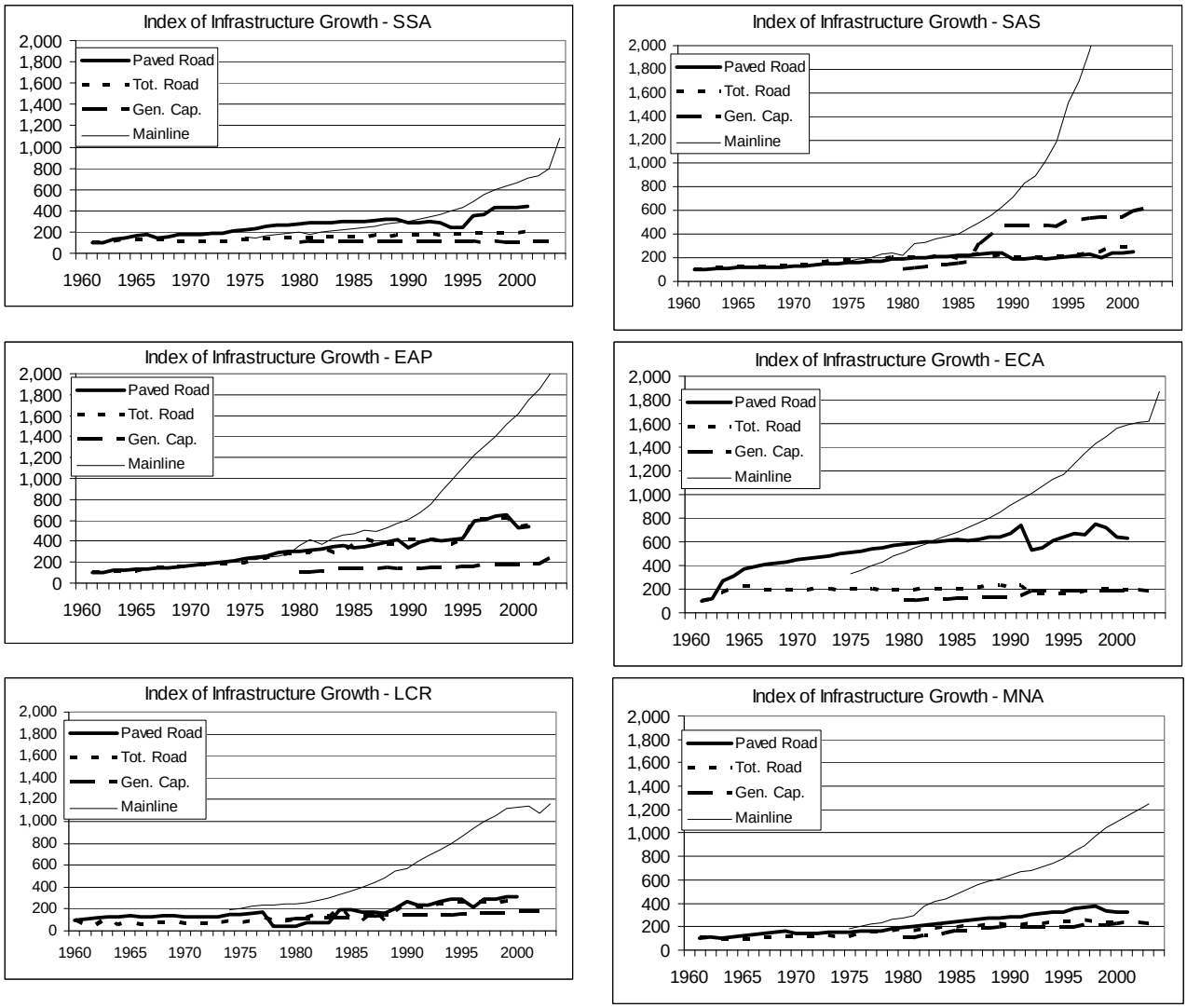






Sources: As for table 2.1.

Figure 3.2 Indexes of infrastructure growth by region, 1960–2003



Sources: As for table 2.1.

Panel data models

The preceding exploratory data analysis illustrated the importance of historical perspective in understanding countries' present-day infrastructure position. We use panel data models to integrate that perspective into our formal analysis. As described in the first section of this paper, two different panel model specifications are estimated: an OLS fixed effects model and an instrumental variables specification. Unfortunately, it is not possible to apply either of the panel data models to access to electricity, for which only a single cross-section is available. (However, we do apply a cross-sectional instrumental variables specification to the electricity access data so as to compare them to the OLS estimates. That comparison is reported in table 3.4.)

The fixed effects model confirms the importance of income, demography, and economic structure in driving stocks of household services and broader economic infrastructure (table 3.3).

The income and demographic variables that proved statistically significant in the cross-sectional OLS results were also statistically significant in the fixed effects panel results. To a greater extent than before, however, variables capturing the economic structure of the economy (export orientation, and shares of agriculture and manufacturing compared with services) become statistically significant in explaining infrastructure stocks, particularly in the case of roads and ICT. It is important to remember, however, that these results do not yet account for dynamics in infrastructure provision, nor have they been corrected for endogeneity.

Table 3.3 Results of OLS fixed effects panel data model

Data in logs

Variable	Density of roads	Density of roads (arable)	Density of paved roads	Density of paved roads (arable)	Access to water	Access to sanitation	Access to electricity	Generating capacity	Internet connections	Mobile telephones	Fixed-line telephones
Income	0.051	0.079	0.196	0.227	–0.022	0.126	0.371	0.247	1.768	2.059	0.633
	(3.25)**	(4.49)**	(10.60)**	(11.15)**	–0.47	–1.33	(2.52)*	(11.87)**	(7.73)**	(11.77)**	(27.68)**
Urbanization	0.244	0.131	0.477	0.365	0.664	0.141	1.096	0.504	2.316	3.158	0.986
	(3.52)**	–1.69	(5.90)**	(4.10)**	(3.30)**	–0.36	(5.11)**	(5.50)**	(2.88)**	(4.72)**	(10.98)**
Population density	0.366	0.094	0.587	0.312	0.103	1.01	0.119	0.062	21.884	16.909	1.524
	(6.43)**	–1.48	(8.76)**	(4.24)**	–0.64	(3.12)**	(2.18)*	–0.84	(26.44)**	(25.86)**	(20.14)**
Infrastructure aid (per capita)	–0.005	–0.011	–0.011	–0.017	–0.004	0.019	0.006	0.003	–0.019	0.08	–0.003
	–1.87	(3.90)**	(3.76)**	(5.08)**	–0.54	–1.25	–0.17	–0.96	–0.8	(3.98)**	–0.85
Exports (% GDP)	0.001	0	0.001	0.001	0.001	0	0.04	0.004	0.073	0.034	0.006
	–1.13	–0.35	(2.20)*	–1.82	–0.35	–0.01	–0.29	(5.98)**	(11.28)**	(6.85)**	(8.60)**
Agriculture (% GDP)	–0.004	–0.003	0.001	0.002	–0.001	0.009	0.188	–0.005	–0.112	–0.154	–0.01
	(3.40)**	(2.58)**	–0.95	–1.38	–0.49	–1.43	–1.17	(3.29)**	(7.11)**	(11.30)**	(5.69)**
Manufacturing (% GDP)	0.001	0.002	–0.001	0.001	–0.007	0.01	0.398	0.004	–0.151	–0.205	–0.002
	–0.85	–1.43	–0.37	–0.27	–1.56	–1.13	(2.85)**	(2.23)*	(7.55)**	(13.39)**	–0.99
Constant	–3.401	–0.185	–6.602	–3.424	4.764	–1.021	–0.22	–10.59	–92.962	–70.033	–5.856
	(11.67)**	–0.57	(19.38)**	(9.13)**	(5.72)**	–0.61	–0.15	(27.63)**	(23.72)**	(23.53)**	(14.93)**
Observations	1919	1910	1875	1866	167	165	85	2223	1100	1230	2323
Plant fixed effects	0.21	0.07	0.39	0.24	0.67	0.52	0.68	0.22	0.68	0.76	0.73

Sources: As for table 2.1.

The results from the instrumental variables estimation indicate endogeneity bias in the OLS specification. If—as suggested by Calderón and Servén (2004) and others that expansion of infrastructure is associated with higher levels of income and growth, then we would expect the OLS coefficient on per capita GDP to be upwardly biased. Indeed, the results of our instrumental variables estimation show that the magnitude of the coefficient on per capita GDP decreased substantially once we controlled for endogeneity using the standard regressors from the growth literature, as discussed above. The traditional Hausman test of the exogeneity of our instruments indicates that they are appropriate in most infrastructure sectors. The exception is in the estimates for access to water and sanitation, where the limited number of observations (from just two years of data) may have affected the results. But it is clear that addressing the endogeneity of per capita GDP is critical to obtaining consistent coefficient estimates.

Table 3.4 Fixed effects with instrumental variables (data in logs)

Variable	Density of roads	Density of roads (arable)	Density of paved roads	Density of paved roads (arable)	Access to water	Access to sanitation	Access to electricity	Generating capacity	Internet connections	Mobile telephones	Fixed-line telephones
Income	–0.065	0.0002	0.00002	0.0002	0.001	0.003	0.001	0.0000001	0.004	0.103	0.03
	–1.15	–1.43	(3.35)**	(2.91)**	–0.23	–1.11	–0.3	(8.70)**	(8.12)**	(10.97)**	(12.32)**
Urbanization	0.042	6.246	–0.041	3.011	40.797	–12.423	57.96	0.0002	–7.384	–30.302	31.93
	–0.46	(5.32)**	–0.57	(4.96)**	–1.02	–0.32	(2.12)*	(2.09)*	–0.67	–0.18	–1.16
Population density	–0.145	0.00001	0.001	0.0002	–0.002	0.093	0.01	–0.0000002	–0.076	–1.312	–0.128
	–0.8	–0.01	(4.75)**	–0.23	–0.04	(2.04)*	–0.51	–1.35	(3.28)**	(4.23)**	(2.97)**
Infrastructure aid (per capita)	0.0003	–0.0005	0.00005	–0.0004	–0.256	–0.018	–0.047	0.0000003	–0.007	0.222	0.009
	–0.09	–0.22	–0.37	–0.34	(2.05)*	–0.14	–0.16	–1.74	–0.54	–1.16	–0.18
Exports (% GDP)	–0.001	0.001	0.0002	0.001	0.016	0.037	–0.03	2.92E–06	0.228	3.58	0.699
	–0.64	–0.3	–0.67	–0.69	–0.12	–0.25	–0.22	(8.16)**	(8.43)**	(8.05)**	(7.15)**
Agriculture (% GDP)	–0.006	–0.008	0.001	0.001	–0.213	0.097	–0.791	0.000002	0.224	5.128	–0.011
	(2.38)*	–0.82	–1.47	–0.26	–1.03	–0.49	(2.20)*	(2.80)**	(2.83)**	(3.67)**	–0.05
Manufacturing (% GDP)	0.009	0.025	0.0004	0.011	–0.27	0.206	2.369	0.000002	0.204	1.001	–0.384
	(4.38)**	(2.47)*	–0.65	(2.08)*	–0.89	–0.69	(5.60)**	(2.85)**	(2.58)**	–0.75	–1.63
Constant	–1.186	–0.382	–0.006	–1.046	63.256	46.968	6.852	–0.0001	–9.948	–243.622	–25.85
	–1.19	–0.53	–0.13	(2.85)**	(3.07)**	(2.09)*	–0.39	(2.43)*	–1.37	(2.06)*	–1.59
Observations	1,247	1,299	1,308	1,296	119	116	78	1,474	765	892	1,525
Plant fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Hausman p–value	0.0523	0.0405	0.0001	0.0000	0.7338	0.7772	N/A	0.0000	0.0000	0.0000	0.0000

Sources: As for table 2.1.

When we model our data using the instrumental variables estimation, per capita GDP, urbanization, population density, and certain structural variables continue to explain the most country-to-country variance in infrastructure stocks (table 3.4), although the magnitude of their coefficients changes from the basic fixed effects specification. For the most part, per capita GDP remains highly significant in explaining national variations in infrastructure, although the magnitude of the coefficients decreased from the simpler model. Urbanization becomes slightly less important, with significance in only four sectors, compared to eight under the first fixed effects specification. Population density, too, loses significance in several sectors. The significance of structural variables varies by sector, but export share of GDP is highly significant with respect to generating capacity and ICT.

Benchmarking

The main objective of the regression models is to predict expected levels of infrastructure stocks for the purposes of benchmarking. As described in the first section of the paper, benchmarking is done by comparing the infrastructure stock in each country with the value predicted by the regression model and calculating the deviation. The value predicted by the model takes into account the effect of each country's history and environment in determining the level of infrastructure stocks the country might be expected to have. A negative deviation indicates that the country has performed below the benchmark, while a positive one indicates the opposite. The deviations are averaged across countries to produce unweighted average deviations at the regional and subregional level. For the purposes of sensitivity analysis, deviations are calculated for each of the two model specifications described above. Following Bogetic (2006), a deviation of less than 10% in absolute value is considered not to constitute a major divergence from the benchmark. Hence, attention focuses on larger deviations of more than plus or minus 10% that are taken to be indicative of a substantial degree of over or underachievement.

Table 3.5 Mean deviations from predicted values, OLS

Region	Density of roads	Density of roads (arable)	Density of paved roads	Density of paved roads (arable)	Access to water	Access to sanitation	Access to electricity	Generating capacity	Internet connections	Mobile telephones	Fixed-line telephones
Subregions of Africa											
Central	–6	–6	–12	–13	2	4	–7	–18	–62	–39	–10
EAC	–12	–10	–55	–52	5	–13	–26	–11	–117	–57	–72
ECOWAS	–7	–14	–13	–20	–0.1	–1	–10	–9	–143	–30	–4
SADC	9	12	13	16	0.2	–3	–11	–21	9	7	–17
World regions											
SSA	–4	–5	–6	–8	1	–1	–11	–17	–78	–25	–15
SAS	24	25	13	14	–0.4	16	30	29	–36	35	35
EAP	–7	–6	–4	–4	–2	–1	9	–2	–33	–20	11
ECA	6	9	–6	–3	0.02	–0.5	N/A	–7	75	95	–18
LAC	–7	–7	–0.3	0.4	–0.1	–1	3	16	–11	30	9
MNA	0.1	3	1	4	–3	–3	10	4	–2	–2	5

Note: SSA = Sub-Saharan Africa, SAS = South Asia, EAP = East Asia and Pacific, ECA = Europe and Central Asia, LAC = Latin America and Caribbean, MNA = Middle East and North Africa.

Table 3.6 Mean deviations from predicted values, instrumental variables

Region	Density of roads	Density of roads (arable)	Density of paved roads	Density of paved roads (arable)	Access to water	Access to sanitation	Access to electricity	Generating capacity	Internet connections	Mobile telephones	Fixed-line telephones
Subregions of Africa											
Central	57	–57	–63	–93	–11	–48	–58	–81	–110	–79	–44
EAC	11	106	–87	20	–7	–20	–39	–77	–48	–54	–60
ECOWAS	21	–4	–50	–59	–11	–37	–24	–81	–12	–49	–64
SADC	6	84	–18	85	–1	–20	–69	–38	–76	–89	–38
World regions											
SSA	44	0.3	–61	–7	–10	–34	–41	–66	–50	–72	–64
SAS	–31	–53	–11	215	20	–42	–8	–51	–108	–118	40
EAP	32	31	–47	–42	–8	–1	24	–29	–29	–24	–34
ECA	–25	–43	173	57	12	38	81	167	–10	27	105
LAC	14	–34	–62	–62	1	34	–1	16	–14	–26	26
MNA	29	9	–14	–45	5	36	42	–11	–11	–10	29

Note: SSA = Sub-Saharan Africa, SAS = South Asia, EAP = East Asia and Pacific, ECA = Europe and Central Asia, LAC = Latin America and Caribbean, MNA = Middle East and North Africa.

Relative to the levels predicted by the instrumental variables model, Africa performs well in total road density (paved and unpaved). In the remaining sectors, it performs significantly below the levels predicted based on the region's economic, demographic, and structural characteristics. In fact, it is the worst-performing world region (that is, the region with the largest negative deviation as shown in table 3.6) in access to electricity, electrical generating capacity, and density of fixed-line telephones. Africa also exhibits large negative deviations in paved road density, sanitation access, mobile telephone density, and Internet density.

Once historic and environmental factors are taken into account and steps are taken to control for the endogeneity of per capita GDP, the relative standing of Africa's subregions is not as clear cut as it first appeared. The initial comparison of infrastructure stock indicators by subregions (see table 1.3) revealed a very clear ranking: SADC was the top performer on all dimensions and EAC the worst performer on nearly all dimensions, with Central Africa and ECOWAS somewhere in between. The picture is more nuanced once the regions are compared in terms of the magnitude of their deviation from benchmarks.

Except in road density (paved and unpaved densities and arable paved density), every African subregion underperformed relative to its expected value in every infrastructure sector. This underachievement is most severe in Central Africa, which exhibits the largest average negative deviation in Africa in water access, sanitation access, electricity generation capacity, and Internet density. While SADC—like the other African subregions—performs worse than predicted by the model in nearly every sector, its deviation from expectations is less great than that of other subregions, with the exception of electricity access and mobile telephone density, where it ranks last. ECOWAS and ECA generally fall somewhere between SADC and Central Africa, although ECOWAS exhibits the largest negative deviation in density of fixed-line telephones and ECA ranks last in paved road density.

History has a large influence. Deficiencies present at the beginning of our time series have become more pronounced over time. The historical data show that at the outset of the series, Africa was behind all other regions with respect to paved road density, water, and sanitation, but was doing significantly better than other regions in terms of road density, generating capacity, and telephone lines. Over time, Africa has lost ground, so that today it is the lowest-performing region in all areas except ICT. The most dramatic loss of ground has come in electrical generating capacity, which has largely stagnated since 1980. Comparing subregions within Africa reveals that most SADC countries started with a larger infrastructure endowment and have extended it more rapidly than other subregions on the continent.

Given the importance of historical trends, panel models provide the appropriate analytical framework for a benchmarking exercise. The OLS fixed effects specification underscores the importance of income and demographic variables in driving infrastructure endowments. The importance of these variables is confirmed by the instrumental variables model, which controls for potential endogeneity of per capita GDP. When Africa's actual infrastructure levels are compared to those predicted by the instrumental variables model, it is clear that Africa underperforms relative to its benchmark in nearly every sector. In fact, Africa tends to have the largest magnitude of underachievement relative to other regions in many sectors, with the most severe underachievement found in Central Africa.

4 Conclusions

We have tried to shed light on the status of infrastructure in Sub-Saharan Africa by benchmarking the region against other developing countries and against the level of development predicted by our models based on the region's income, demography, and economic structure. Our analysis has shown that with but one exception Africa has the worst infrastructure endowment of any developing region today, particularly with respect to electrical generating capacity. (The exception is the modern ICT sector.) African countries even perform poorly compared with their peers in the same income group in other parts of the world. Part of the explanation seems to lie in difficult environmental factors that complicate the development of infrastructure services, in particular low rates of urbanization. The region's very low level of infrastructure at the time of independence a half centry ago is another explanation for today's results.

Today, the SADC countries are far ahead of the rest of Sub-Saharan Africa—their infrastructure situation is more similar to that of East Asia than to other African subregions. EAC has the weakest infrastructure situation today; its position, like that of Central Africa and ECOWAS, most closely resembles that of South Asia.

When controlling for income, demographic, and structural variables, Central Africa misses its benchmark level of predicted infrastructure achievement by the largest margin of any African subregion, while SADC comes closest, despite generally falling below the predicted values.

References

Arellano, Manuel and Bond, Steven (1991), "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Questions," *Review of Economic Studies* 76 (1991), pp. 277–297.

Battese, G.E. and Coelli, T.J., "A Stochastic Frontier Production Function Incorporating a Model for Technical Inefficiency Effects," Working Papers in Econometrics and Applied Statistics, University of New England, 1993.

Blundell, Richard, and Steven Bond. 1998. "Initial Conditions and Moment Restrictions in Panel Data Models." *Journal of Econometrics* 87, pp. 115–143.

Bogetic, Zeljko, and Johannes W. Fedderke. 2006. "International Benchmarking of Infrastructure Performance in the Southern African Customs Union Countries." Policy Research Working Paper 3987, World Bank, Washington, DC.

Calderón, Cesar, and Luis Servén. 2003. "Infrastructure Compression and Public Sector Solvency in Latin America." In William Easterly and Luis Serven, eds., *The Limits of Stabilization: Infrastructure, Public Deficits and Growth in Latin America* (119–138). Palo Alto, CA: Stanford University Press.

———. 2004. "The Effects of Infrastructure Development of Growth and Income Distribution." Central Bank of Chile Working Papers 270. Santiago de Chile.

Canning, David. 1998. "A Database of World Stocks of Infrastructure, 1950–1995," *The World Bank Economic Review*, No. 3, Vol. 12, pp. 529–47.

Easterly, William and Luis Serven, eds. (2003), *The Limits of Stabilization: Infrastructure, Public Deficits and Growth in Latin America*, Stanford University Press and the World Bank, 119–38.

Estache, Antonio and Goicoechea, Ana. 2005. "A 'Research' Database on Infrastructure Economic Performance", World Bank Policy Research Working Paper No. 3643, available at SSRN: http://ssrn.com/abstract=757364.

Shleifer, Andrei, "A Theory of Yardstick Competition," *The RAND Journal of Economics*, 16 (1985) pp. 319–327.

United Nations. 2007. "UN Millennium Development Goals." http://www.un.org/millenniumgoals/.

World Bank. Annual since 2000. *Doing Business*. Private Sector Development Vice Presidency, World Bank, Washington DC.

World Bank (2004), *Colombia: Recent Economic Developments in Infrastructure*, Finance, Private Sector and Infrastructure Department, Latin America and Caribbean Region, World Bank, Washington DC.

World Bank (2005a), *El Salvador: Recent Economic Developments in Infrastructure*, Finance, Private Sector and Infrastructure Department, Latin America and Caribbean Region, World Bank, Washington DC.

World Bank (2005b), *Costa Rica: Country Economic Memorandum*, Poverty Reduction and Economic Management Department, Latin America and Caribbean Region, World Bank, Washington DC.

Annex A Alternative regression models

Annex table A.1 Blundell and Bond Dynamic Panel Estimator

Variable	Density of roads	Density of roads (arable)	Density of paved roads	Density of paved roads (arable	Generating capacity	Internet connections	Mobile telephones	Fixed-line telephones
Lagged dependent variable	1.006	1.004	1.034	1.004	1.167	1.186	1.255	1.098
	(119.55)**	(54.94)**	(52.45)**	(102.82)**	(17.17)**	(23.45)**	(43.17)**	(48.39)**
Income	0	0	0	0	0	0	0.007	–0.002
	–0.59	–1.23	–0.13	–1.19	–0.9	–1.57	–1.65	–0.81
Urbanization	–0.004	–0.33	–0.005	–0.203	–0.0001	–0.785	–21.369	–7.481
	–0.54	–1.33	–0.66	–1.3	(2.01)*	–1.16	–1.25	(2.42)*
Population density	0	0	0	0	0	0.001	–0.011	0
	–0.05	–0.27	–0.81	–1.42	–0.69	–1.41	–1.28	–0.12
Fractionalization	0.005	–0.015	0.001	0.008	0	–0.063	3.153	–1.167
	–1.56	–0.32	–0.2	–0.28	–0.5	–0.28	–0.74	–1.01
Governance	0	0.005	0	–0.009	0	–0.004	–1.476	–0.058
	–0.72	–0.58	–0.38	–1.62	–0.4	–0.13	(2.53)*	–0.29
Infrastructure aid (per capita)	0	–0.003	0	0	0	–0.001	–0.043	0.003
	–0.47	–0.75	–0.24	–0.39	–0.55	–0.33	–0.49	–0.33
Exports (% GDP)	0	0.001	0	0	0	0.007	0.028	–0.032
	–0.28	–0.5	–0.37	–0.03	–1.81	–1.82	–0.55	–1.3
Agriculture (% GDP)	0	0.003	0	0.002	0	0.005	0.083	–0.077
	–0.85	–1.23	–0.46	–1.21	–1.03	–0.52	–0.4	–1.08
Manufacturing (% GDP)	0.0004	0.003	0	0.003	0	0.005	–0.004	–0.069
	(2.37)*	–0.27	–1.36	–1.67	–1.59	–0.41	–0.03	–0.8
Constant	–0.008	–0.075	0	–0.044	0	–0.196	8.932	7.611
	–1.03	–0.45	–0.04	–0.66	–1.67	–0.38	–1.15	–1.8
Observations	1889	1880	1848	1839	2186	995	1128	2308
Hansen J-test (p–value)	0.299	0.322	0.15	0.203	0.055	0.064	0.062	0.003
AB test for AR(1) (p–value)	0.008	0.288	0.129	0.004	0.000	0.013	0.377	0.023
AB test for AR(2) (p–value)	0.163	0.302	0.42	0.356	0.268	0.357	0.412	0.576

Annex B Country-specific deviations from regression models

Annex table B.1 Country deviations, OLS

Percent

	Country	Density of roads	Density of roads (arable)	Density of paved roads	Density of paved roads (arable)	Access to water	Access to sanitation	Access to electricity	Generating capacity	Internet connections	Mobile telephones	Fixed-line telephones
Central Africa	Burundi	42	48	1	7	0	0	—	24	93	–58	31
	Cameroon	–65	–55	–1	9	1	22	5	–3	–9	117	–16
	Central African Republic	–4	2	14	21	0	0	—	–15	78	150	26
	Chad	–2	–1	–50	–50	20	–7	–55	–40	46	12	3
	Comoros	–8	–2	–8	–1	0	0	–3	–32	–12	0	32
	Congo, Rep.	0	–4	–5	–10	0	0	–3	–55	–17	–45	–127
	Equatorial Guinea	0	2	—	—	—	—	—	–2	—	—	–6
	Eritrea	–5	–11	–6	–12	0	0	39	—	177	0	13
	Ethiopia	0	0	0	0	—	—	—	0	—	—	0
	Gabon	–7	–4	5	8	0	0	–16	–15	–107	–9	–56
	Madagascar	–3	–1	–19	–17	–4	29	–20	–33	–177	8	–59
	Mauritania	–12	–19	–18	–24	3	6	16	–23	–210	–117	66
	Mayotte	—	—	—	—	—	—	—	—	—	—	—
	Mozambique	–12	–13	–16	–17	0	0	–33	–45	–206	–115	–78
	Rwanda	–18	–30	14	1	2	0	–34	–27	–405	–426	–92
	Sao Tome and Principe	–4	–15	–6	–17	0	0	10	–31	–57	4	5
	Somalia	0	1	–83	–82	—	—	—	9	—	—	16
	Sudan	–2	–7	–13	–18	0	0	15	–6	–62	–70	70
	Average	**–6**	**–6**	**–12**	**–13**	**2**	**4**	**–7**	**–18**	**–62**	**–39**	**–10**
EAC	Kenya	–12	–12	–70	–69	1	–8	–37	–13	–67	–53	–105
	Tanzania	–1	–2	–24	–26	15	–20	–17	–4	–57	–25	–53
	Uganda	–23	–15	–70	–62	0	–12	–25	–15	–226	–93	–59
	Average	**–12**	**–10**	**–55**	**–52**	**5**	**–13**	**–26**	**–11**	**–117**	**–57**	**–72**
ECOWAS	Benin	–42	–65	–9	–33	–3	36	–9	61	–370	–26	–45
	Burkina Faso	8	–5	–2	–14	3	–18	9	–8	–165	–13	6
	Cape Verde	–28	–22	30	36	0	0	–23	–53	–351	–250	7
	Cote d'Ivoire	–11	–22	–8	–18	1	4	–2	–62	–117	–127	–14
	Gambia, The	23	3	11	–8	0	0	–34	9	–36	82	44
	Ghana	8	–19	28	–1	12	7	18	–34	8	–2	18
	Guinea	–6	–9	–7	–10	2	–28	–38	9	11	81	1
	Guinea–Bissau	–11	–2	–5	4	0	0	–26	5	–83	0	–43
	Liberia	12	20	14	24	0	0	—	–11	0	0	–39
	Mali	–13	–55	–41	–84	3	3	–11	40	–361	–226	–4

	Niger	–69	–70	–157	–157	–5	6	3	–5	–76	103	–47
	Nigeria	29	41	24	36	–1	–18	17	–35	–132	–19	–25
	Senegal	–15	–10	–16	–12	–5	8	–5	–37	–159	–114	33
	Sierra Leone	19	25	–57	–51	—	—	—	–3	107	0	–1
	Togo	–14	–21	–2	–8	–8	–14	–29	–16	–415	62	41
	Average	**–7**	**–14**	**–13**	**–20**	**0**	**–1**	**–10**	**–9**	**–143**	**–30**	**–4**
SADC	Angola	–44	–37	16	23	9	–10	–7	–42	–245	–217	–71
	Botswana	–19	–8	22	34	–7	–4	–6	–82	–56	–54	–13
	Congo, Dem. Rep.	5	15	27	36	–4	5	–	–1	329	231	–104
	Lesotho	4	6	24	26	0	–7	–43	–16	222	184	46
	Malawi	53	44	12	4	10	8	–20	6	–249	–117	–9
	Mauritius	–2	1	–5	–2	–2	–6	1	35	–3	–14	45
	Namibia	13	11	35	34	8	–7	8	—	–6	–34	–41
	Seychelles	4	6	10	12	0	—	–24	–34	–2	127	–4
	South Africa	39	45	11	16	–5	–14	–3	–12	–110	–18	–34
	Swaziland	–14	–12	11	11	0	0	–19	–42	–36	–51	–17
	Zambia	70	77	1	8	–5	4	–16	–29	–3	–54	–29
	Zimbabwe	–2	–5	–3	–5	0	0	4	–11	270	101	31
	Average	**9**	**12**	**13**	**16**	**0**	**–3**	**–11**	**–21**	**9**	**7**	**–17**

Annex table B.2 Country deviations, instrumental variables

Percent

	Country	Density of roads	Density of roads (arable)	Density of paved roads	Density of paved roads (arable)	Access to water	Access to sanitation	Access to electricity	Generating capacity	Internet connections	Mobile telephones	Fixed-line telephones
Central Africa	Burundi	–72	–472	–82	–117	44	–32	—	–80	–100	–100	–130
	Cameroon	32	–76	–84	–89	–16	–9	17	–76	–88	–64	–90
	Central Afr. Rep.	84	–22	–98	–89	–17	–46	–44	–94	–99	–99	–93
	Chad	123	6	–99	–104	–46	–85	–80	–98	–96	–97	–96
	Comoros	–60	–8	70	—	33	–69	—	–82	–108	–102	69
	Congo, Rep.	94	92	–63	–38	–50	–80	–89	–90	–94	–67	–96
	Equatorial Guinea	13	36	—	—	—	—	—	–80	—	—	–72
	Eritrea	85	16	–80	–139	–17	–83	–84	–100	–220	–61	–35
	Ethiopia	64	–348	–95	–107	—	—	—	–91	—	—	–138
	Gabon	106	–49	–94	–87	–10	–28	–92	–48	–88	–42	–86
	Madagascar	31	39	–76	—	–34	–37	–63	–88	–93	–88	–90
	Mauritania	237	–50	–92	–80	–30	–9	–19	–79	–89	14	–76
	Mayotte	—	—	—	—	—	—	—	—	—	—	—
	Mozambique	89	–51	–78	58	–40	–47	–84	–10	–85	–71	–90
	Rwanda	–66	–408	–82	–114	31	–50	–33	–139	–102	–106	–110
	Sao T&P	–48	139	129	—	3	–61	—	–53	–229	–136	12
	Somalia	62	289	–94	–218	—	—	—	–93	—	—	403
	Sudan	189	–95	–95	–83	–4	–33	–65	–85	–49	–86	–24
	Average	*57*	*–57*	*–63*	*–93*	*–11*	*–48*	*–58*	*–81*	*–110*	*–79*	*–44*
EAC	Kenya	12	–8	–76	36	–15	–12	–59	–75	68	–33	–74
	Tanzania	18	73	–93	128	6	–14	18	–83	–83	–76	–88
	Uganda	4	251	–92	–106	–11	–32	–74	–72	–129	—	–19
	Average	*11*	*106*	*–87*	*20*	*–7*	*–19*	*–39*	*–77*	*–48*	*–54*	*–60*
ECOWAS	Benin	40	–86	–79	–85	–9	–41	–5	–88	130	–60	–68
	Burkina Faso	59	–15	–87	–111	–19	–78	–61	–86	–82	–63	–50
	Cape Verde	–37	–25	159	86	11	–25	—	–92	–300	74	81
	Cote d'Ivoire	–2	–33	–73	–72	11	–28	–34	–78	–81	–59	–79
	Gambia, The	–68	78	–14	—	13	–12	–46	–86	227	54	–40
	Ghana	–21	–29	–26	73	10	0	73	–67	–49	–46	–61
	Guinea	8	252	–48	–488	–28	–75	–64	–65	314	–84	–92
	Guinea–Bissau	6	–1	–80	159	–2	–38	1	–94	–84	–100	–82
	Liberia	20	28	–88	–62	–18	–48	—	–42	–99	–100	–95
	Mali	144	–68	–96	–151	–33	–10	—	–84	–94	–85	–85
	Niger	173	–48	–98	–105	–30	–77	76	–90	–98	–96	–94
	Nigeria	–28	–66	–36	–49	–23	–38	3	–77	–151	–23	–87

	Senegal	36	–76	–53	–69	–10	0	–35	–87	296	9	–58
	Sierra Leone	–15	107	–85	65	—	—	–153	–84	–134	–95	–87
	Togo	–3	–79	–46	–12	–28	–42	–38	–95	25	–67	–69
	Average	*21*	*–4*	*–50*	*–59*	*–11*	*–37*	*–24*	*–81*	*–12*	*–49*	*–64*
SADC	Angola	83	6	–39	333	–37	–40	–82	–80	–91	–80	–92
	Botswana	153	–9	–84	55	8	–21	–79	–84	–85	–42	–59
	Congo, Dem. Rep.	37	163	–97	–200	–30	–45	–136	–71	–99	–95	–99
	Lesotho	–14	24	–41	381	11	–36	–88	–80	–78	–56	–60
	Malawi	–31	401	–65	–129	9	–25	–66	–73	–84	–79	–32
	Mauritius	–99	–34	122	64	41	–14	–45	17	–194	–384	152
	Namibia	69	359	–79	334	12	–43	–53	–100	–81	–67	–49
	Seychelles	–91	—	165	—	–7	—	—	–62	–34	–31	–14
	South Africa	–33	–34	–11	–60	1	21	–23	115	–57	–4	–24
	Swaziland	–6	–8	–45	56	–19	–20	–79	–73	–87	–78	–59
	Zambia	23	–9	–60	–48	–26	–9	–53	26	–41	–77	–80
	Zimbabwe	–25	66	18	147	20	5	–60	12	18	–75	–37
	Average	*6*	*84*	*–18*	*85*	*–1*	*–20*	*–69*	*–38*	*–76*	*–89*	*–38*

Source: As for table 2.1.

Note: Deviations larger than 500% or less than –500% have been dropped.

Annex C Regional infrastructure endowment

Region/ country	Infrastructure category										
	Transport				Information and communication technology			Energy		Water	Sanitation
	Density of paved road network		Density of total road network		Density of fixed-line phones	Density of mobile phones	Density of Internet connections	Electrical generating capacity	Access to electricity		
	km per 1,000 km², 2001				subscribers per 1,000 people, 2004		subscribers per 100 people, 2004	MW per 1 million people, 2003	% house-holds with access, 2004	% households with access, 2002	
	total	arable	total	arable							
ECOWAS	38	301	144	1,279	28	72	2.4	31	18	63	35
Benin	12	55	60	273	9	—	1.4	18	22	68	32
Burkina Faso	7	48	46	298	6	31	0.4	10	13	51	12
Cape Verde	213	2,047	273	2,625	148	133	5.3	21	20	80	42
Côte d'Ivoire	15	156	156	1,603	—	86	1.8	55	39	84	40
Gambia	85	338	496	1,982	—	118	3.4	21	5	82	53
Ghana	58	326	194	1,088	14	78	1.7	63	54	79	58
Guinea	20	565	124	3,427	—	—	5.8	35	5	51	13
Guinea-Bissau	13	117	122	1,138	—	—	2.0	13	8	59	34
Liberia	6	149	95	2,410	—	—	—	98	5	62	26
Mali	1	39	12	319	6	30	0.5	24	8	48	45
Niger	1	18	8	225	2	11	0.2	9	8	46	12
Nigeria	65	208	210	672	8	71	1.4	43	40	60	38
Senegal	22	170	74	579	—	90	4.7	23	30	72	52
Sierra Leone	13	187	158	2,263	—	—	0.2	22	5	57	39
Togo	42	91	132	287	—	—	4.4	8	9	51	34
EAC	8	93	105	1,286	6	54	2.1	24	7	64	45
Kenya	13	165	110	1,364	9	76	4.6	36	8	62	48
Tanzania	4	87	93	2,060	—	44	0.9	24	11	73	46
Uganda	8	29	113	436	3	42	0.7	12	4	56	41
SADC	92	3,636	214	6,164	74	180	5.5	175	21	71	43
Angola	15	638	41	1,712	—	61	1.2	50	12	50	30
Botswana	10	1,479	18	2,690	77	319	3.3	75	22	95	41
Congo, DR	2	55	67	2,262	—	—	—	48	7	46	29
Lesotho	36	329	196	1,796	21	88	2.4	45	5	76	37
Malawi	31	132	240	1,024	7	18	0.4	27	5	67	46
Mauritius	956	1,939	980	1,989	287	413	14.6	548	100	100	99
Namibia	10	983	76	7,619	64	142	3.7	—	34	80	30
Seychelles	700	31,532	829	37,337	253	589	24.7	359	30	87	—
South Africa	60	498	297	2,445	—	428	7.9	883	66	87	87
Swaziland	—	—	—	—	—	101	3.3	118	20	52	52

Zambia	10	141	121	1,716	—	26	2.1	172	12	55	55
Zimbabwe	48	575	252	3,025	25	31	6.3	150	20	83	83
Central Africa	41	416	132	1,790	13	74	1.7	44	18	58	28
Burundi	37	97	520	1,369	—	—	0.4	6	5	79	36
Cameroon	9	70	72	564	—	96	1.0	56	49	63	48
Cen. Afr. Rep.	1	34	38	1,233	3	15	0.2	10	5	75	27
Chad	0.2	7	26	910	1	13	0.7	3	3	34	8
Comoros	302	841	395	1,099	—	—	1.0	17	20	94	23
Congo, Rep.	4	670	37	6,905	4	99	0.9	32	21	46	9
Eq. Guinea	—	—	103	2,218	—	113	1.0	20	20	44	53
Eritrea	7	150	34	689	9	5	1.2	—	17	57	9
Ethiopia	4	33	29	268	—	3	0.2	10	13	22	6
Gabon	3	248	32	2,510	28	359	3.0	305	31	87	36
Madagascar	10	194	89	1,755	—	18	0.5	17	8	45	33
Mauritania	2	177	7	1,569	—	175	0.5	42	50	56	42
Mozambique	7	139	38	744	—	36	0.7	125	7	42	27
Rwanda	38	94	456	1,125	3	16	0.4	5	5	73	41
San Tome and Principe	227	3,633	333	5,333	—	—	12.2	64	20	79	24
Somalia	4	245	35	2,075	25	63	1.7	8	3	29	25
Sudan	2	25	5	70	29	30	3.3	23	30	69	34

— = data not available.

About AICD

This study is part of the Africa Infrastructure Country Diagnostic (AICD), a project designed to expand the world's knowledge of physical infrastructure in Africa. AICD will provide a baseline against which future improvements in infrastructure services can be measured, making it possible to monitor the results achieved from donor support. It should also provide a more solid empirical foundation for prioritizing investments and designing policy reforms in the infrastructure sectors in Africa.

AICD will produce a series of reports (such as this one) that provide an overview of the status of public expenditure, investment needs, and sector performance in each of the main infrastructure sectors, including energy, information and communication technologies, irrigation, transport, and water and sanitation. The World Bank will publish a summary of AICD's findings in November 2009. The underlying data will be made available to the public through an interactive Web site allowing users to download customized data reports and perform simple simulation exercises.

The first phase of AICD focuses on 24 countries that together account for 85 percent of the gross domestic product, population, and infrastructure aid flows of Sub-Saharan Africa. The countries are: Benin, Burkina Faso, Cape Verde, Cameroon, Chad, Democratic Republic of Congo, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mali, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, South Africa, Sudan, Tanzania, Uganda, and Zambia. Under a second phase of the project, coverage will be expanded to include additional countries.

AICD is being implemented by the World Bank on behalf of a steering committee that represents the African Union, the New Partnership for Africa's Development (NEPAD), Africa's regional economic communities, the African Development Bank, and major infrastructure donors. AICD grew from an idea presented at the inaugural meeting of the Infrastructure Consortium for Africa, held in London in October 2005.

Financing for AICD is provided by a multi-donor trust fund to which the main contributors are the Department for International Development (United Kingdom), the Public Private Infrastructure Advisory Facility, Agence Française de Développement, and the European Commission. A group of distinguished peer reviewers from policy making and academic circles in Africa and beyond reviews all of the major outputs of the study, with a view to assuring the technical quality of the work.

This and other papers analyzing key infrastructure topics, as well as the underlying data sources described above, will be available for download from www.infrastructureafrica.org. Freestanding summaries are available in English and French.

Inquiries concerning the availability of datasets should be directed to vfoster@worldbank.org.