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How and Why Does the Quality of Infrastructure Service Delivery Vary?

George R. G. Clarke

Access to infrastructure and the quality of services are very poor in many developing countries. This is a problem because studies have found that poor-quality service and weak access to infrastructure can slow development and impede growth.[1] Improving access and quality would therefore benefit many people in developing countries. However, when many sectors (power, water, telecommunications, and transportation) have problems—as they often do in developing countries—it is not clear how governments should focus their efforts.

This chapter seeks to answer two questions. The first concerns how the availability, quality, and price of infrastructure vary across countries. To answer, we first look at the correlation between different measures of infrastructure services

The data used in this chapter come from various sources, including the International Telecommunication Union, the International Energy Agency, and the World Bank's World Development Indicators, Doing Business Indicators, Logistic Performance Indicators, World Governance Indicators, and Enterprise Surveys (World Bank 2012). I would like to thank Ahmed M. Abdel Aziz, Karin Brandt, and Gregory Ingram for helpful discussions and comments on earlier drafts. Responsibility for all errors, omissions, and opinions rests solely with me.

1. See, for example, Straub (2008) for a recent review of the literature on infrastructure and growth. In a survey of 64 empirical papers, Straub concludes that close to two-thirds of the studies found a positive and significant link between various measures of infrastructure and economic growth. For the three sectors with the greatest number of studies (electricity, roads, and telecommunications), positive links were found in about 70 percent of the studies between physical measures of infrastructure and economic growth. See also World Bank (1994).

across countries. This chapter updates information from the 1994 *World Development Report: Infrastructure for Development* (World Bank 1994), which made similar comparisons using data from the mid-1990s.[2]

Access is highly correlated within countries for different infrastructure services (water, electricity, mobile phones, fixed-line phones, roads, and rail). So, for example, more people have electricity in countries where access to fixed-line and mobile phone service is higher and where road and rail networks are more dense. This is partly because per capita income and population density strongly affect all measures of access. That is, access to most infrastructure services is higher in countries where income is higher and population density is higher.[3]

In contrast, service quality and price are not highly correlated within countries. Countries with poor service in one sector do not necessarily have poor service in other sectors. For example, countries in which power outages are common do not necessarily have more unpaved roads. Similarly, although prices are often positively correlated across services (e.g., when per-minute charges for mobile phones are high, power prices are also high), the correlations are lower than for access.

The second question addressed here is how infrastructure affects the operations and growth of firms. The chapter shows that firm managers are more concerned about electricity than about transportation and that the strength of their concern is strongly related to the reliability of electricity service. In contrast, managers' perceptions about transportation are not strongly associated with measures of availability, service quality, or price. The most robust correlations are related to the cost and time associated with importing materials. Managers said transportation was a more serious problem in countries where it costs more to import a 20-foot container, where it takes longer for goods to clear customs, and where connections to international trade routes are worse.

Data

This section describes the main variables in the empirical analysis. For each type of infrastructure (transportation, electricity, telecommunications, and water), the measures are assigned into categories related to access, price, and quality of service. The data are country-level, cross-sectional, and mostly for 2009–2010.

The data come from a variety of sources: the World Bank's World Development Indicators database (World Bank 2011b), the International Telecommunication Union's World Telecommunication Indicators database (International

2. World Bank (1994) preceded—and indeed encouraged—the large increase in private sector participation in infrastructure that occurred in the 1990s and early 2000s. For a review of the literature on privatization, including in the infrastructure sector, see Megginson (2005), Megginson and Netter (2001), and Shirley and Walsh (2000).

3. This is consistent with results from the early 1990s from World Bank (1994).

Telecommunication Union 2012), the World Bank's Logistics Performance Indicators database (Arvis et al. 2012), the International Energy Agency's Energy Prices and Taxes database, and the World Governance Indicators database (Kaufmann, Kraay, and Mastruzzi 2009).

Additional data come from the World Bank's Doing Business Indicators (World Bank 2011a) and Enterprise Surveys database (World Bank 2012). Data from these two sources apply to formal firms in the economy. The Doing Business Indicators make various assumptions about the type of enterprise involved. For the most part, however, the Doing Business Indicators are calculated for medium-size or large formal enterprises.[4] Similarly, the Enterprise Survey only covers formal firms in manufacturing, retail trade, and services with at least five employees.[5] Because of the World Bank's focus on development, almost all Enterprise Survey data are for low- and middle-income countries. The indicators from these two sources might not represent the experiences and perceptions of informal microenterprises. Full descriptions and sources for each of the variables are included in appendix 14.1.

Correlations of Different Measures of Infrastructure Performance

This section looks at the correlation between different measures of infrastructure access, price, and quality. As in the 1994 *World Development Report*, we are interested in the extent to which measures of performance are correlated at the country level. That is, do the same countries tend to have better infrastructure services over a range of performance measures?

Although looking at simple correlations can be informative, it is possible that correlations between the different measures might reflect the effect of income, population density, or other macroeconomic variables on the availability, price, and quality of infrastructure. We therefore also look at the correlations after controlling for these differences, which is done by estimating an ordinary least-squares (OLS) model allowing macroeconomic factors and institutional quality to affect the availability, price, and quality of infrastructure services. We then look at the correlation of the residuals to see how highly correlated the performance of different infrastructure services is after controlling for these macroeconomic and institutional differences.

4. The Doing Business website provides detailed descriptions of how the indexes are constructed. See www.doingbusiness.org.

5. The surveys covered all manufacturing sectors (group D based on ISIC 3.1), construction (group F), retail and wholesale services (subgroups 52 and 51 of group G), hotels and restaurants (group H), transport, storage, and communications (group I), and computer and related activities (subgroup 72 of group K). Only formal firms with at least five employees are included. See World Bank (2009) for more detail.

DETERMINANTS OF INFRASTRUCTURE PERFORMANCE

To control for macroeconomic and institutional differences, the various measures of infrastructure are regressed on a set of macroeconomic control variables, and the residuals from each of the regressions are calculated.[6]

$$Infrastructure = \alpha + \beta\, macroeconomic\ controls + \gamma\, institutional\ quality + \varepsilon$$

The independent variables used here are similar to the variables used in Wallsten (2001), which looks at the telecommunications sector. Because the point is to identify things that might cause the high correlation between the various measures of access across sectors, the focus is on things that are likely to affect access in all sectors—not just telecommunications. Therefore, the institutional variables related to competition and regulation of telecommunications are not included. Area is included because population density is likely to be important for some forms of infrastructure. These are the variables used:[7]

- *Per capita income*. For the most part, infrastructure services could be expected to be affected by per capita income. For infrastructure services that government agencies provide (e.g., roads), countries with higher per capita income should generally find it easier to finance infrastructure needs. Moreover, to the extent that infrastructure services are normal goods, demand should be higher in wealthier countries.
- *Area*. We expect service availability, quality, and prices to be affected by population density. Because area is included in log-form and the regression also includes population in log-form, this variable essentially allows us to control for population density.[8]
- *Population*. If there are economies of scale in providing infrastructure services, then population size might affect infrastructure service. As discussed above, this variable also controls for population density given that (log of) area is also included among the regressors.
- *Urban population*. Especially in developing countries, infrastructure provision is limited in rural areas.[9] Moreover, the cost of network expansion and maintenance is generally higher in rural areas. It can therefore be

6. See table 14.17 for data sources for macroeconomic variables.

7. Long-term and short-term debt has been omitted because including these variables significantly reduces sample size.

8. The null hypothesis that population density alone affects infrastructure services can be tested by testing whether $\beta_1 = -\beta_2$, where β_1 is the coefficient on (log of) population and β_2 is the coefficient on (log of) area.

9. See, for example, table 2.2 in Clarke and Wallsten (2003).

expected that coverage will be lower, quality will be lower, and prices will be higher in countries with large rural populations.

- *Exports*. Export orientation might also affect demand for infrastructure services. In particular, export-oriented firms might have greater demand for both transportation and communications infrastructure.[10] One concern about this variable is the potential for endogeneity. That is, it is possible that the availability of infrastructure affects export performance, rather than the reverse.
- *Corruption*. Given state involvement in regulating, financing, and implementing infrastructure projects, corruption might affect the availability, quality, and cost of infrastructure services. That is, it is likely that the cost of public infrastructure will be higher in countries where corruption is a problem.[11] In practice, this variable is likely to serve as an overall proxy for institutional development. As Langbein and Knack (2010) note, country-level measures of institutional development (e.g., related to the rule of law, regulatory quality, and corruption) tend to be very highly correlated.[12] As a result, it is difficult to isolate the effects of corruption from the effects of other aspects of institutional development.

AVAILABILITY OF INFRASTRUCTURE SERVICES

This chapter looks at six measures of access: (1) the percentage of the population that has access to electricity; (2) the percentage of the population that has access to improved water; (3) mobile phone subscriptions per 100 inhabitants; (4) fixed-line phone subscriptions per 100 inhabitants; (5) rail density (kilometers per 100 square kilometers [km per 100 sq. km]); and (6) road density (km per 100 sq. km). Higher values mean greater access for all measures. These are meant to capture the extent to which the population has access to or uses infrastructure services. Later, the chapter looks at similar regressions for the price and quality of infrastructure services.

For the most part, the measures of access and availability are strongly correlated with one another (table 14.1), and the average absolute correlation is 0.6.

10. For example, see Freund and Weinhold (2002, 2004) and Clarke and Wallsten (2006) for a discussion of the impact of Internet access on exporting. Similarly, Djankov, Freund, and Pham (2010) show that increasing the time to export has a large impact on trade. Each additional day that it takes to export a product, due to transportation and customs delays, reduces trade by more than 1 percent.

11. Consistent with this, Kenny (2007) notes that construction contractors are more likely to pay bribes than other firms, and they pay more as a percentage of sales when they do.

12. See also Kaufmann, Kraay, and Mastruzzi's (2010) response to Langbein and Knack (2010).

Table 14.1
Correlation of Access Indicators Before Controlling for Macroeconomic Regressors

	Access to Electricity	Access to Improved Water	Mobile Phone Subscriptions	Fixed-Line Phone Subscriptions	Rail Density	Road Density
Access to electricity	1.00					
Access to improved water	0.77*** *(0.00)*	1.00				
Mobile phone subscriptions	0.74*** *(0.00)*	0.64*** *(0.00)*	1.00			
Fixed-line phone subscriptions	0.77*** *(0.00)*	0.66*** *(0.00)*	0.63*** *(0.00)*	1.00		
Rail density	0.41*** *(0.02)*	0.52*** *(0.00)*	0.51*** *(0.00)*	0.57*** *(0.00)*	1.00	
Road density	0.27 *(0.13)*	0.58*** *(0.00)*	0.41*** *(0.00)*	0.63*** *(0.00)*	0.88*** *(0.00)*	1.00

***, **, * = statistically significant at 1%, 5%, and 10% significance levels.
Note: See appendix 14.1 for full variable descriptions. P-values in parentheses.
Source: See appendix 14.1 for data sources.

So, for example, access to improved water sources, mobile and fixed-line phone subscriptions, and rail density are higher, on average, in countries where access to electricity is higher. Most of the simple correlations are greater than 0.5, and all except one are statistically significant. This suggests that similar factors affect access for all types of infrastructure.

It seems plausible that the high correlation between the various measures of access could be due to some macroeconomic variable affecting all measures of access. One factor that might affect access across sectors is income. As shown in table 14.2, most measures of access increase as per capita income increases.

Table 14.3 shows the results from regressions in which the dependent variables are measures related to access and availability of infrastructure. Consistent with table 14.2, access to infrastructure is higher when per capita income is higher. The coefficients are statistically significant and positive in all six regressions. The coefficients imply that a 1-percent increase in per capita income would increase the population with access to electricity by 0.3 percent, the population with access to improved water by 0.1 percent, the number of mobile phone subscriptions by 0.3 percent, and the number of fixed-line phone subscriptions by

Table 14.2
Different Measures of Access by Income Level

	Low	Lower Middle	Upper Middle	High
Access to electricity	19.0	71.2	98.3	99.7
Per capita electricity consumption	130.8	755.6	2,282.3	6,693.1
Fixed-line phone subscriptions	0.9	8.0	21.5	41.7
Mobile phone subscriptions	31.2	59.8	98.6	117.6
Rail density	0.3	0.7	1.0	4.9
Road density	11.0	25.5	19.0	129.0

Note: See appendix 14.1 for full variable descriptions. Income levels are based on classifications from the World Bank. Low-income countries have per capita income of $1,005 or lower; lower-middle-income countries have per capital income between $1,006 and $3,975. Upper-middle-income countries have per capita income between $3,976 and $12,275. High-income countries have per capita income of more than $12,275.
Source: See appendix 14.1 for data sources.

0.4 percent.[13] Rail and road density would increase by 2.6 percent and 0.2 percent, respectively.

Access also appears to be affected by population density. The coefficients on area are negative and statistically significant in all six regressions. This indicates that access is generally lower in countries that have greater area. In contrast, the coefficient on population is positive in all regressions and is statistically significant in four of the six regressions. Because access tends to be lower in countries that are larger in area but higher in countries with larger populations, access appears to be negatively correlated with population density. These results are consistent with the idea that it is easier, and potentially cheaper, to expand access in densely populated countries.[14]

Per capita income, population density, and, to a lesser extent, urban population and institutional quality (as proxied by control of corruption) explain a significant part of cross-country differences in access to infrastructure. The R-squared terms for the regressions are between about 0.64 and 0.82.

Controlling for per capita income, population density, and the other control variables reduces the correlation between the access indicators significantly

13. All elasticities are calculated at the mean values of the access indicators.

14. It is, however, important to note that we can reject the null hypothesis that the coefficients are equal in absolute value in all six regressions at a 5 percent significance level or higher. That is, area and population appear to affect the different services to different degrees for each type of service.

Table 14.3
Impact of Macroeconomic Variables on Availability of Infrastructure

	Electricity	Water	Telecommunications		Transportation	
	Access to Electricity (% of Population)	Access to Improved Water (% of Population)	Mobile Phone Subscriptions	Fixed-Line Phone Subscriptions	Rail Density	Road Density
Observations	74	140	160	160	68	82
Per capita gross national income (log)	20.693*** (5.21)	9.760*** (6.89)	23.400*** (7.18)	7.918*** (6.93)	0.675*** (4.92)	0.736*** (4.83)
Area (log, sq. km)	–4.464** (–2.55)	–2.626*** (–4.17)	–3.895*** (–2.63)	–1.815*** (–3.50)	–0.630*** (–11.50)	–0.720*** (–10.38)
Population, total (log)	7.649*** (3.75)	1.055 (1.40)	1.046 (0.58)	2.014*** (3.19)	0.505*** (7.82)	0.507*** (6.84)
Urban population (% of population)	0.347** (2.05)	0.085 (1.35)	0.347** (2.38)	0.037 (0.72)	–0.014** (–2.21)	–0.010 (–1.45)
Exports of goods and services (% of gross domestic product)	–0.146 (–1.42)	–0.113*** (–2.90)	0.057 (0.66)	–0.051* (–1.69)	–0.008** (–2.65)	–0.004 (–1.03)
Control of corruption (high values mean less corruption)	–0.603 (–0.15)	–1.162 (–0.91)	–5.216* (–1.77)	5.756*** (5.57)	0.202* (1.82)	–0.017 (–0.14)
Constant	–191.906*** (–4.97)	15.916 (1.21)	–112.639*** (–3.58)	–60.876*** (–5.51)	–1.994 (–1.45)	–5.024*** (–3.20)
R-squared	0.70	0.64	0.65	0.75	0.82	0.76

Note: T-statistics in parentheses.
***, **, * = statistically significant at 1%, 5%, and 10% significance levels.
Source: See appendix 14.1 for data sources.

Table 14.4
Correlation of Access Indicators After Controlling for Macroeconomic Regressors

	Access to Electricity	Access to Improved Water	Mobile Phone Subscriptions	Fixed-Line Phone Subscriptions	Rail Density	Road Density
Access to electricity	1.00					
Access to improved water	0.50***	1.00				
	(0.00)					
Mobile phone subscriptions	0.37***	0.20**	1.00			
	(0.00)	*(0.02)*				
Fixed-line phone subscriptions	0.25***	0.05	0.06	1.00		
	(0.03)	*(0.53)*	*(0.43)*			
Rail density	0.01	0.08	–0.05	0.14	1.00	
	(0.97)	*(0.53)*	*(0.70)*	*(0.27)*		
Road density	–0.17	0.03	–0.02	0.31***	0.47***	1.00
	(0.38)	*(0.79)*	*(0.83)*	*(0.00)*	*(0.00)*	

***, **, * = statistically significant at 1%, 5%, and 10% significance levels.
Note: See appendix 14.1 for full variable descriptions. P-values in parentheses.
Source: See appendix 14.1 for data sources.

(table 14.4).[15] Although some correlations remain statistically significant (e.g., between rail and road density and between access to water and electricity), the point estimates of the correlations are significantly smaller—although they remain mostly positive—and most correlations are statistically insignificant, and the average value is 0.14. This suggests that the high correlations among the variables representing access to different types of infrastructure are largely due to access being higher in richer and more densely populated countries.

PRICE OF INFRASTRUCTURE SERVICES

Six measures of price are used: (1) the price per kWh for electricity for household users; (2) the cost of an electricity connection for a business; (3) the price of a three-minute peak-time local fixed-line call; (4) the price of a three-minute peak-time cellular call; (5) the cost of a fixed-line connection; and (6) the cost of importing a 20-foot container. No comparable cross-country data were available on the cost of water. Higher values mean more costly service for all variables.

15. These comparisons are made by calculating the residuals from each of the regressions in table 14.2 and calculating the correlations between them.

Table 14.5
Correlation of Price Indicators Before Controlling for Macroeconomic Regressors

	Price per kWh for Electricity (Household)	Cost of Electricity Connection (Business)	Price of 3-Min. Peak Call (Fixed Line)	Price of 3-Min. Peak Call (Cellular)	Price of Fixed-Line Connection (Business)	Cost of Importing 20-Foot Container
Price per kWh for electricity (household)	1.00					
Cost of electricity connection (business)	0.38*** *(0.02)*	1.00				
Price of 3-min. peak call (fixed line)	0.10 *(0.53)*	0.16*** *(0.05)*	1.00			
Price of 3-min. peak call (cellular)	0.44*** *(0.00)*	0.16*** *(0.06)*	0.22*** *(0.01)*	1.00		
Price of fixed-line connection (business)	0.39** *(0.02)*	0.30*** *(0.00)*	0.32*** *(0.00)*	0.03 *(0.77)*	1.00	
Cost of importing 20-foot container	–0.28 *(0.07)*	0.27*** *(0.00)*	0.03 *(0.69)*	0.21*** *(0.01)*	0.02 *(0.84)*	1.00

***, **, * = statistically significant at 1%, 5%, and 10% significance levels.
Note: See appendix 14.1 for full variable descriptions. P-values in parentheses.
Source: See appendix 14.1 for data sources.

As with the measures of access to infrastructure, the price variables are mostly positively correlated with one another, even across different services (table 14.5). For example, the price per kWh for electricity is positively correlated with the cost of an electricity connection for business, the price of a three-minute fixed-line phone call, and the cost of a three-minute cellular phone call. In contrast to the results from access, however, the correlations are generally smaller, and the average correlation is 0.18. Most correlations are between about 0.1 and 0.3—compared to between 0.4 and 0.7 for the indicators related to access. Given that the correlations are relatively modest, we would probably not expect the macroeconomic variables to be strongly and consistently correlated with the price variables. That is, if income or other variables explained most of the cross-country variation in prices, the price variables would be more highly correlated.

Table 14.6 shows the results from regressing measures related to the price of infrastructure services on macroeconomic and institutional variables. These are

Table 14.6
Impact of Macroeconomic Variables on Price of Infrastructure Services

	Electricity		Telecommunications		Transportation	
	Price per kWh (Household)	Cost of Connection (Business)	Price of 3-Min. Peak Call (Fixed Line)	Price of 3-Min. Peak Call (Cellular)	Price of Fixed-Line Connection (Business)	Cost of Importing 20-Foot Container
Observations	42	148	143	143	111	155
Per capita gross national income (log)	0.021 *(1.10)*	0.027 *(0.20)*	–0.031** *(–2.00)*	0.063 *(0.74)*	0.359** *(2.62)*	–0.117** *(–2.06)*
Area (log, sq. km)	–0.021** *(–2.68)*	0.009 *(0.14)*	0.015** *(2.19)*	0.006 *(0.18)*	–0.054 *(–0.94)*	0.102*** *(3.68)*
Population, total (log)	0.010 *(1.18)*	–0.060 *(–0.82)*	–0.009 *(–1.10)*	0.020 *(0.45)*	0.042 *(0.59)*	–0.129*** *(–4.08)*
Urban population (% of population)	–0.000 *(–0.43)*	0.002 *(0.27)*	–0.000 *(–0.12)*	0.003 *(0.79)*	–0.003 *(–0.58)*	–0.001 *(–0.41)*
Exports of goods and services (% of gross domestic product)	–0.001 *(–1.63)*	–0.007** *(–2.01)*	0.000 *(1.19)*	–0.006*** *(–2.96)*	–0.006 *(–1.62)*	–0.001 *(–0.99)*
Control of corruption (high values mean less corruption)	0.022 *(1.56)*	–0.102 *(–0.83)*	0.041*** *(2.95)*	0.139* *(1.85)*	–0.121 *(–1.02)*	–0.067 *(–1.29)*
Constant	0.067 *(0.38)*	10.774*** *(8.40)*	0.353** *(2.45)*	–0.222 *(–0.29)*	1.208 *(0.97)*	9.223*** *(16.89)*
R-squared	0.479	0.046	0.097	0.151	0.116	0.305

Note: T-statistics in parentheses.
***, **, * = statistically significant at 1%, 5%, and 10% significance levels.
Source: See appendix 14.1 for data sources.

meant to capture the cost of infrastructure service. In contrast to the previous results for access to infrastructure, most of the coefficients on the macroeconomic and institutional variables are statistically insignificant. Moreover, they do not, generally, show a consistent relationship with price. For example, the coefficient on per capita income is statistically significant in only three of the six regressions. Moreover, even when significant, the sign on the coefficient on income varies. The coefficient on income is positive in the regression for a fixed-line phone call with the point estimate indicating that the cost of a fixed-line phone call would be about 0.05 higher if income were increased by 1 percent. However, the reverse is true for the price of getting a fixed-line connection and the cost of importing a 20-foot container; in those cases, higher income appears to be correlated with lower prices.

Although it seems that access might be more limited in countries where population density is lower because it might be more expensive to serve spread-out rural customers, this does not seem to be the case. Neither urban population share nor population density (i.e., area and population) are consistently negatively correlated with the price indicators. Although the price of fixed-line phone calls is higher in geographically larger countries, the price of electricity is negatively correlated with area. The cost of importing a 20-foot container is higher in larger countries, possibly reflecting the greater inland transportation costs.

One plausible explanation for the insignificant relationship between population density and infrastructure service prices is that the price of infrastructure services is less than the cost of provision. In many countries, prices are set in consultation with government-appointed regulators. In this respect, the lower levels of access observed in large countries might reflect rationing due to regulated prices rather than high prices per se.

After controlling for the macroeconomic and institutional variables, the correlation between the different measures of the price of infrastructure services falls further (table 14.7). Although most remain positive, the correlations are mostly statistically insignificant and are smaller in absolute value; the average value is 0.16. The relatively modest drop is probably not surprising given that the macroeconomic variables are not consistently correlated with the price measures.

QUALITY OF INFRASTRUCTURE SERVICES

For all of the variables, high values represent poor service quality. For example, high values of transmission and distribution losses, power and water outages, and losses during transportation all suggest poor-quality services. The simple correlations between the quality variables are mostly positive (table 14.8). While this suggests that the same countries generally have quality problems across infrastructure services, the point estimates are mostly small—less than 0.25 in most cases—and statistically insignificant; the average correlation is 0.15.

Table 14.9 shows the results from regressing various measures related to the quality of infrastructure services on macroeconomic and institutional variables. The dependent variables are as follows: (1) the number of outages that firms

Table 14.7
Correlation of Price Indicators After Controlling for Macroeconomic Regressors

	Price per kWh for Electricity (Household)	Cost of Electricity Connection (Business)	Price of 3-Min. Peak Call (Fixed Line)	Price of 3-Min. Peak Call (Cellular)	Price of Fixed-Line Connection (Business)	Cost of Importing 20-Foot Container
Price per kWh for electricity (household)	1.00					
Cost of electricity connection (business)	0.20 *(0.22)*	1.00				
Price of 3-min. peak call (fixed line)	–0.13 *(0.43)*	0.13 *(0.12)*	1.00			
Price of 3-min. peak call (cellular)	0.29*** *(0.07)*	0.20*** *(0.02)*	0.25*** *(0.00)*	1.00		
Price of fixed-line connection (business)	0.20 *(0.28)*	0.25*** *(0.01)*	0.12 *(0.20)*	0.16 *(0.10)*	1.00	
Cost of importing 20-foot container	0.05 *(0.76)*	0.24*** *(0.00)*	0.14 *(0.10)*	0.22** *(0.01)*	0.16 *(0.10)*	1.00

***, **, * = statistically significant at 1%, 5%, and 10% significance levels.
Note: See appendix 14.1 for full variable descriptions. P-values in parentheses.
Source: See appendix 14.1 for data sources.

face in a month; (2) electricity transmission and distribution losses; (3) faults per 100 fixed-line telephones; (4) losses due to breakage and spoilage during shipping; (5) percentage of roads that are unpaved; and (6) number of water service interruptions and shortages in a month.

For the most part, service quality is higher in countries with higher per capita income. In particular, there are fewer power outages, lower transmission and distribution losses, fewer water service interruptions, and a lower percentage of unpaved roads in wealthier countries. This suggests that the higher coverage in high-income countries does not come at the expense of worse service quality.

Population density has a mixed effect on service quality. Although power outages and water service interruptions are more common in densely populated countries (i.e., the coefficient on area is negative and the coefficient on population is positive), densely populated countries have lower distribution and transmission losses and fewer unpaved roads.

After controlling for macroeconomic and institutional variables, the correlation between different quality indicators falls further (table 14.10). Although most remain positive, they generally become smaller, and almost all correlations are statistically insignificant; the average correlation is 0.10. Once again, given

Table 14.8
Correlation of Quality Indicators Before Controlling for Macroeconomic Regressors

	No. of Power Outages per Month	Electric Power Transmission and Distribution Losses	Faults per 100 Fixed-Line Telephones	Losses to Breakage or Spoilage During Shipping	Percentage of Roads That Are Unpaved	No. of Water Shortages per Month
No. of power outages per month	1.00					
Electric power transmission and distribution losses	0.18 *(0.11)*	1.00				
Faults per 100 fixed-line telephones	0.04 *(0.77)*	0.04 *(0.79)*	1.00			
Losses to breakage or spoilage during shipping	0.19 *(0.13)*	0.03 *(0.83)*	0.20 *(0.39)*	1.00		
Percentage of roads that are unpaved	0.20 *(0.24)*	0.21 *(0.14)*	0.12 *(0.54)*	0.27 *(0.23)*	1.00	
No. of water shortages per month	0.72*** *(0.00)*	0.18 *(0.13)*	–0.24 *(0.17)*	0.01 *(0.94)*	0.04 *(0.84)*	1.00

***, **, * = statistically significant at 1%, 5%, and 10% significance levels.
Note: See appendix 14.1 for full variable descriptions. P-values in parentheses.
Source: See appendix 14.1 for data sources.

the lack of strong and consistent correlations in the regressions, it is not surprising that the correlations do not fall greatly after controlling for the macroeconomic variables.

Effect of Infrastructure Services on Firm Performance

The results of the analysis suggest that although infrastructure access is mostly better in richer and more densely populated countries, the price and quality of infrastructure services are not consistently correlated with the macroeconomic control variables. In addition, the price and quality of service are not highly correlated across different infrastructure subsectors. For example, countries with high-quality telecommunications service do not necessarily have high-quality power or water service. This section discusses how the availability, price, and quality of infrastructure services affect firm behavior and performance.

Table 14.9
Impact of Macroeconomic Variables on Quality of Infrastructure Services

	Electricity		Telecommunications	Transportation		Water
	No. of Power Outages per Month	Electric Power Transmission and Distribution Losses	Faults per 100 Fixed-Line Telephones	Losses to Breakage or Spoilage During Shipping	Percentage of Roads That Are Unpaved	No. of Water Shortages per Month
Observations	113	122	61	60	54	94
Per capita gross national income (log)	–3.618* *(–1.78)*	–3.364** *(–2.00)*	2.108 *(0.65)*	0.187 *(0.26)*	–24.141*** *(–3.91)*	–2.494** *(–2.53)*
Area (log, sq. km)	–2.869*** *(–2.65)*	0.853 *(1.15)*	2.102 *(1.28)*	–0.538 *(–1.57)*	9.450*** *(–3.77)*	–1.266** *(–2.57)*
Population, total (log)	3.088** *(2.52)*	–2.418*** *(–2.84)*	–2.973 *(–1.43)*	–0.192 *(–0.42)*	–10.912*** *(–3.56)*	1.611*** *(2.79)*
Urban population (% of population)	0.005 *(0.05)*	0.049 *(0.64)*	–0.277* *(–1.82)*	0.039 *(1.33)*	0.191 *(–0.65)*	0.019 *(0.43)*
Exports of goods and services (% of gross domestic product)	–0.045 *(–0.59)*	0.005 *(0.13)*	0.054 *(0.65)*	–0.036 *(–1.28)*	0.164 *(1.20)*	–0.039 *(–1.00)*
Control of corruption (high values mean less corruption)	–4.065* *(–1.81)*	–2.048 *(–1.47)*	–4.030 *(–1.25)*	–1.686** *(–2.12)*	8.982 *(1.67)*	–1.168 *(–1.08)*
Constant	23.789 *(1.25)*	70.056*** *(4.09)*	31.037 *(0.87)*	8.396 *(1.08)*	300.771*** *(2.90)*	16.185* *(1.72)*
R-squared	0.25	0.22	0.18	0.19	0.51	0.31

Note: T-statistics in parentheses.
***, **, * = statistically significant at 1%, 5%, and 10% significance levels.
Source: See appendix 14.1 for data sources.

Table 14.10
Correlation of Quality Indicators After Controlling for Macroeconomic Regressors

	No. of Power Outages per Month	Electric Power Transmission and Distribution Losses	Faults per 100 Fixed-Line Telephones	Losses to Breakage or Spoilage During Shipping	Percentage of Roads That Are Unpaved	No. of Water Shortages per Month
No. of power outages per month	1.00					
Electric power transmission and distribution losses	0.17 *(0.12)*	1.00				
Faults per 100 fixed-line telephones	–0.05 *(0.76)*	–0.18 *(0.20)*	1.00			
Losses to breakage or spoilage during shipping	0.15 *(0.26)*	0.04 *(0.79)*	0.20 *(0.40)*	1.00		
Percentage of roads that are unpaved	0.22 *(0.21)*	–0.16 *(0.26)*	–0.03 *(0.90)*	0.37 *(0.12)*	1.00	
No. of water shortages per month	0.63 *(0.00)*	0.27 *(0.02)*	0.01 *(0.94)*	–0.11 *(0.42)*	–0.02 *(0.92)*	1.00

Note: See appendix 14.1 for full variable descriptions. P-values in parentheses.
Source: See appendix 14.1 for data sources.

MANAGERS' PERCEPTIONS ABOUT INFRASTRUCTURE SERVICES

How large an impact does the quality and availability of infrastructure have on firm performance? One common way of assessing how seriously different aspects of the investment climate constrain firm growth is to ask managers what they see as the biggest obstacles that they face. For example, the World Bank's Enterprise Survey asks managers to rank a series of investment climate constraints on a five-point scale ranging from "no obstacle" to "very severe obstacle" and also to say which of these are the biggest constraints. Two of the obstacles that the Enterprise Survey asks about relate to infrastructure: electricity and transportation.[16]

Figure 14.1 shows the seven constraints that the greatest number of firm managers identified as their biggest problem. By far the most common concerns are electricity (top constraint in 25 countries with available data) and access to finance (top constraint in 23 countries). Tax rates and competition with informal firms also ranked among the top concerns in more than 15 countries. In contrast, transportation did not rank as the top constraint in any of the countries with available data.[17]

The analysis in the previous section suggests that access to infrastructure is a greater problem in low-income countries than in middle- and high-income countries, although quality and price are much less strongly related to income. Firm managers are generally more concerned about electricity in low-income countries. In 16 of 38 mostly low-income countries in sub-Saharan Africa, electricity was ranked as the top constraint (Clarke and Dinh 2012). In comparison, it was ranked as the top constraint in only one of 16 mostly middle-income countries in Latin America.

Consistent with this, Gelb and colleagues (2006) find that firms in the poorest countries in Africa tend to be most concerned about basic services and stability: macroeconomic stability, electricity, and access to finance typically rank among the top concerns.[18] As income increases, firms tend to become more concerned about the quality of governance and the capability of the state; corruption, tax rates, tax administration, and regulation become increasingly binding.[19]

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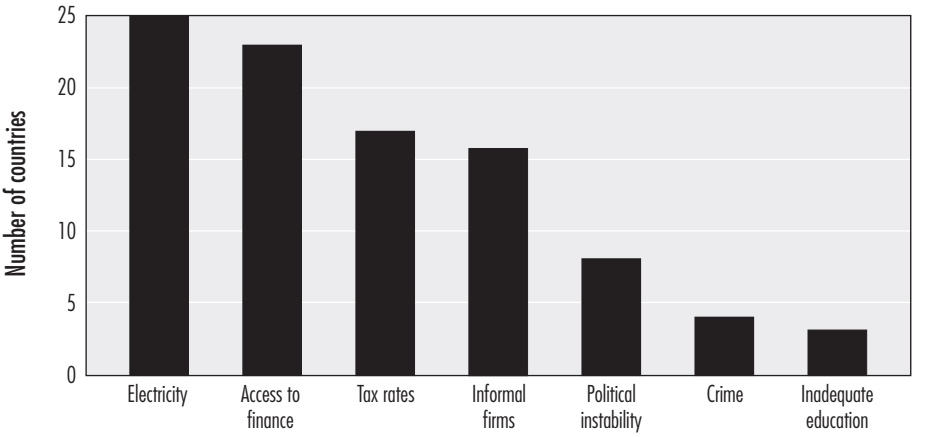
16. Questions about telecommunications are only asked to information-technology firms and firms in retail trade and so are ignored here.

17. It ranked as the second-greatest constraint in three countries: Gabon, Guinea, and Malawi.

18. Carlin, Schaffer, and Seabright (2010) also show that concern about physical infrastructure, including power and transportation, tends to be greater in low-income countries.

19. For example, the two countries where crime ranked as the top constraint—South Africa and Namibia—are both middle-income countries. During the middle of the 2007–2008 Enterprise Survey in South Africa, a serious power crisis hit the country. Since South African firms were used to cheap and reliable power, this was a shock to managers. Before the crisis hit, firm managers were most likely to say that crime was a serious problem. After the crisis, they were most likely to say that electricity was a problem (Clarke 2011a).

Figure 14.1
Constraints Identified by Firm Managers as Most Difficult



Note: The biggest constraint is based on the percentage of managers who identified that constraint as their biggest problem among 15 different constraints. The other options were access to land, corruption, courts, customs and trade regulation, labor regulation, tax administration, and transportation.
Data source: Dinh, Mauvridis, and Nguyen (forthcoming).

RELIABILITY OF PERCEPTION-BASED INDEXES

To assess what influences managers' concerns about infrastructure, we regress aggregate measures of the percentage of firms that say infrastructure is a serious problem on the macroeconomic and institutional variables from the previous section and a vector of variables representing availability, price, and quality of infrastructure. The dependent variables come from the World Bank's Enterprise Surveys (2012).

Economists are often concerned about perception-based data (see, for example, Bertrand and Mullainathan 2001). Some researchers question whether managers have a good idea about binding constraints. One particular concern is that since only firms that exist can be interviewed—and by definition, these are firms that have managed to overcome any binding constraints—surveys of existing firms may underestimate the barriers caused by particularly binding constraints. Hausmann and Velasco (2005) illustrate this point with an analogy to camels and hippos. They note that the few animals found in the Sahara will be camels, which have adapted to life in the desert, rather than hippos, which depend heavily on water. Asking the camels about problems associated with life in the desert might not adequately represent the views of the missing hippos.

Although underestimating the binding constraints is true, it seems that managers can better assess the constraints to running their businesses than can

outsiders like academics, politicians, and policy advisers. This would seem to be particularly true for broad constraints (e.g., whether electricity is a problem) rather than specific policy questions (e.g., whether the electricity company should be privatized or should invest in hydroelectric power). Moreover, it is important to remember that objective data also have problems—particularly for sensitive and difficult questions.[20] In contrast, managers can easily answer questions about what they see as the biggest problems they face.

SIMPLE CORRELATIONS

As a first exercise, we look at the simple correlations between measures of availability, price, and quality of electricity and transportation services and the two measures of perceptions: the percentage of firms identifying electricity as a serious problem and the percentage of firms identifying transportation as a serious problem. As discussed earlier, although many firms rated electricity as a serious problem, few rated transportation as a serious problem. The data come from the World Bank's Enterprise Surveys, which, as noted, only include formal firms in manufacturing, retail trade, and services with at least five employees.[21] The views of these firms might not reflect the views of informal microenterprises.

Electricity All three measures of access are negatively correlated with firms' perceptions about electricity (table 14.11). The negative correlation suggests that firms are more likely to say that electricity is a major or very severe problem in countries where access is lower. This is consistent with results in Hallward-Driemeier and Aterido (2009), which show that the percentage of firms that complain about electricity is correlated with per capita electricity consumption.

The correlation between access and perceptions could reflect that in countries with the lowest access rates, the mostly small and medium-size enterprises in the Enterprise Survey samples find it more difficult or more expensive to get facilities with electricity connections. That is, although most small and medium-size formal urban firms in the Enterprise Surveys have utility service in most countries, this could reflect that they tend to purchase or rent properties that already have service.[22] Another possible explanation for the correlation is that it reflects omitted variable bias.

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20. For example, some work has shown that managers appear to find it difficult to answer questions that involve calculating percentages. Clarke (2011b) shows that when managers in sub-Saharan Africa report bribes as a percentage of sales, they report bribe payments that are between four and fifteen times higher than when they report them in monetary terms.

21. See footnote 5.

22. This does not mean that most enterprises in low-income countries have access to infrastructure services. For example, based on a nationally representative survey of microenterprises and small enterprises in Zambia, Clarke and others (2010) found that only 6 percent of microenterprises in rural areas and 24 percent in urban areas were connected to the public

Table 14.11
Correlations with Electricity Obstacles

	Percentage of Firms Saying Electricity Is Serious Problem
Access to electricity	–0.24**
	(0.04)
Per capita electricity consumption	–0.38**
	(0.00)
Per capita electricity production	–0.32**
	(0.00)
Cost of electricity connection	0.16*
	(0.06)
Price per kWh for electricity (household)	–0.38**
	(0.05)
Price per kWh for electricity (industrial)	0.01
	(0.97)
No. of required procedures to get electricity connection	–0.03
	(0.72)
No. of days to get electricity connection	0.26***
	(0.00)
Losses due to power outages	0.53***
	(0.00)
No. of power outages per month	0.56***
	(0.00)
Percentage of firms with generators	0.43***
	(0.00)
Electric power transmission and distribution losses	0.30***
	(0.00)

***, **, * = statistically significant at 1%, 5%, and 10% significance levels.
Note: See appendix 14.1 for full variable descriptions. P-values in parentheses.
Source: See appendix 14.1 for data sources.

grid. In contrast, all of the medium-size and large formal enterprises in the sample had both electricity connections and public water supply. The medium-size and large enterprises were more similar to the types of firms in the Enterprise Surveys. Indeed, firms in the Enterprise Surveys are not explicitly asked whether they have utility connections; it is implicitly assumed that they do when they are asked questions about infrastructure services.

In contrast to the access and availability indicators, the price indicators are much less strongly correlated with firms' perceptions about electricity. When measured in dollar terms, there is a weakly significant positive correlation between the price of a business connection and firms' perceptions about electricity.[23] That is, firms appear to be more concerned about power in countries where the price of a business connection is higher. In contrast, the price per kWh for business users is not correlated with perceptions about power, and the price per kWh for households has a counterintuitive negative sign (i.e., firms are less concerned about power in countries with high electricity prices for households). Although this could reflect that service is of poorer quality in countries that do not charge households a sustainable price, it is important to note that the correlation between price and service quality is weak and statistically insignificant in most cases.

Finally, there is a strong correlation between most measures of service quality and perceptions about electricity. Managers say that electricity is a greater problem in countries where it takes longer to get a new connection, where outages are more common and cause greater losses, where firms are more likely to have generators (a sign that reliability is a problem), and where transmission and distribution losses are higher.[24]

Transportation In contrast to the electricity-related variables, few of the transportation-related variables are significantly correlated with managers' perceptions about transportation (table 14.12). Of the two measures of access to infrastructure—rail density and road density—only rail density is significantly correlated with perceptions about transportation. Managers in countries with greater rail density were less likely to say that transportation was a major or very severe obstacle.

Similarly, most of the proxies for transportation costs are not significantly correlated with perceptions about transportation. In particular, the price of gasoline and diesel are uncorrelated with concerns about transportation. Moreover, the perception-based measures of costs from the Logistics Performance Index (i.e., the percentage of firms that said that rail, road, and port costs were high or very high) are also uncorrelated with the percentage of firms that said that transportation is a major or very severe obstacle. The only measure of cost that is correlated with perceptions about transportation is the cost of importing a 20-foot container. Managers were significantly more likely to say transportation was

23. In contrast, when measured as a percentage of gross national income, the correlation is strong and more highly statistically significant. This is the way the data are presented in the Doing Business indicators. This could reflect that the second measure, but not the first, is highly negatively correlated with income.

24. This is consistent with the similar results reported by Gelb and others (2006), who note that firms complain more about power in countries where outages are more common.

Table 14.12
Correlations with Transportation Obstacles

	Percentage of Firms Saying Transportation Is Serious Problem
Rail density	–0.42**
	(0.00)
Road density	–0.15
	(0.33)
Cost of importing 20-foot container	0.29**
	(0.00)
Price of diesel	–0.09
	(0.33)
Price of gasoline	–0.15
	(0.11)
Rail transport rate	–0.04
	(0.73)
Road transport rates	0.09
	(0.40)
Port charges	–0.16
	(0.14)
Losses to breakage or spoilage during shipping	0.24**
	(0.05)
No. of days to complete import procedures	0.29***
	(0.00)
Quality of port services	0.14
	(0.18)
Quality of rail services	–0.12
	(0.27)
Quality of road services	0.11
	(0.31)
Percentage of roads that are unpaved	–0.04
	(0.81)
Liner shipping connectivity index (maximum value in 2004 = 100)	–0.32***
	(0.00)

***, **, * = statistically significant at 1%, 5%, and 10% significance levels.
Note: See appendix 14.1 for full variable descriptions. P-values in parentheses.
Source: See appendix 14.1 for data sources.

a serious problem in countries where the cost of importing a 20-foot container is high.

Finally, the measures of quality are also mostly uncorrelated with perceptions about transportation. The coefficients on the measures of perceptions about the quality of service (i.e., the percentage of firms that said that the quality of port services, rail services, and road services was low or very low) are statistically insignificant in all cases. Similarly, the coefficient on the percentage of unpaved roads is also statistically insignificant. The only two statistically significant coefficients are related to the ease of engaging in international trade. Managers were less likely to say that transportation was a major or very severe obstacle in countries with better shipping connectivity and in countries in which it takes less time to import goods.

Although these results might suggest that the main concern with respect to transportation is related to imported materials, it is important to note that these measures are highly correlated with similar measures related to exports (i.e., the cost of exporting a 20-foot container, the number of days to export a container).[25] Further, shipping connectivity will also affect ease of exporting as well as ease of importing. In this respect, although the results suggest that transportation issues related to international trade are important, it is not clear that importing dominates exporting in terms of the effect on managers' perceptions.

EMPIRICAL MODEL

For the main regressions, we regress the two measures of perceptions about infrastructure (perceptions about electricity and transportation) on a set of macroeconomic control variables and a set of variables related to the relevant infrastructure services.

$$Perceptions = \alpha + \beta\, macroeconomic\ controls + \gamma\, institutional\ quality + \delta\, infrastructure + \varepsilon$$

The macroeconomic and institutional dependent variables are described in the previous section. In addition, measures of access, price, and quality of electricity and transportation services are added.

In practice, including the infrastructure variables significantly reduces sample size: the different measures are not all available for all countries. Therefore, the focus is on those variables that are statistically significantly correlated with perceptions. When multiple measures are significantly correlated with perceptions within the same class of variables (e.g., price, quality of service, and access), the variables with the greatest coverage are generally selected. For example, per capita electricity consumption rather than access is used because the first vari-

25. The simple correlation between the two cost variables (import and export) is 0.94, and the simple correlation between the two time measures is 0.95.

able is available for significantly more countries. If access were included rather than per capita electricity consumption, the regression would only have about 61 rather than 82 observations.

ECONOMETRIC RESULTS

Table 14.13 presents results from the econometric analysis.

Table 14.13
Impact of Macroeconomic and Sector Variables on Perceptions About Infrastructure

Observations	Percentage of Firms Saying Electricity Is Problem		Percentage of Firms Saying Transportation Is Problem		
	120	82	120	90	44
Per capita electricity consumption		–0.001			
		(–0.63)			
No. of days to get electricity connection		0.077***			
		(3.32)			
Cost of electricity connection (business)		0.749			
		(0.36)			
No. of power outages per month		0.788***			
		(5.84)			
Cost of importing 20-foot container				0.006***	0.004
				(2.74)	(1.50)
Liner shipping connectivity index (high values mean better connected)				–0.166*	–0.136*
				(–1.81)	(–1.97)
Rail density					0.796
					(1.38)
Urban population	0.337**	0.504***	0.156**	0.172**	0.256**
	(2.40)	(3.40)	(2.03)	(2.04)	(2.46)
Area	–3.553**	–0.320	0.639	–1.087	2.563*
	(–2.06)	(–0.18)	(0.68)	(–0.87)	(1.77)
Population, total	1.494	–0.256	–1.918*	0.907	–1.444
	(0.80)	(–0.13)	(–1.89)	(0.61)	(–0.90)
Per capita gross national income	–10.366***	–5.400	–3.181*	–1.780	–1.933
	(–3.25)	(–1.34)	(–1.82)	(–0.91)	(–0.93)
Exports of goods and services	–0.093	–0.086	0.002	0.069	0.128*
	(–0.79)	(–0.74)	(0.03)	(0.93)	(1.98)

(continued)

Table 14.13
(continued)

Observations	Percentage of Firms Saying Electricity Is Problem		Percentage of Firms Saying Transportation Is Problem		
	120	82	120	90	44
Control of corruption (high values mean less corruption)	−4.634 (−1.39)	0.541 (0.14)	−3.376* (−1.84)	−2.222 (−1.03)	−5.360** (−2.45)
Constant	128.832*** (4.55)	45.562 (1.08)	61.969*** (3.99)	16.569 (0.78)	3.016 (0.12)
R-squared	0.216	0.488	0.146	0.250	0.668

Note: T-statistics in parentheses.
***, **, * = statistically significant at 1%, 5%, and 10% significance levels.
Source: See appendix 14.1 for data sources.

Macroeconomic Variables Before controlling for the quality and availability of infrastructure services, the coefficient on per capita income is negative and statistically significant in the regressions for both electricity and transportation. This suggests that managers are more likely to say that electricity and transportation are serious problems in low-income countries. After adding the infrastructure variables, however, the coefficients become smaller in absolute value and become statistically insignificant. In addition, the R-squared of the regressions increases, suggesting that managers' perceptions of sectoral problems are informed by objective measures of difficulties with access and quality; that is, managers do not believe service is poor just because they believe that low income always means poor service.

The coefficient on the percentage of the population living in urban areas is positive and statistically significant in both regressions. This suggests that managers are more concerned about electricity and power in countries with larger urban populations. For the most part, the quality and price of infrastructure service were not significantly correlated with the urban population share, as discussed earlier. Availability was higher in countries with larger urban populations, but since the Enterprise Surveys only cover urban areas in most countries, it is not clear that this should affect perceptions. For transportation, it is possible that this reflects congestion: countries with larger urban areas might be more likely to be congested. However, this would not explain the positive correlation between urban population share and the percentage of managers that identify electricity as a serious problem.

After controlling for income and other macroeconomic variables, firms appear to be more concerned about transportation in countries where corruption is a greater problem. The coefficient on the "control of corruption" variables—with higher values meaning less corruption—is negative and statistically significant.

This might suggest that the quality of transportation infrastructure is worse in countries with more corruption, perhaps because the quality of roads and other transportation infrastructure is worse or because the cost is higher in corrupt countries. If firms pay bribes to win government contracts, money will end up being diverted from the national treasury to the pockets of corrupt bureaucrats (Bardhan 1997).[26] Similarly, corruption can affect the quality of construction when firms are able to bribe inspectors and regulators to avoid meeting contract provisions or quality standards. Quality will also suffer if firms pay bribes to avoid meeting technical requirements specified in the bidding documents.[27]

Infrastructure Services In addition to the macroeconomic and institutional variables, several objective measures are included that relate to the availability, price, and quality of infrastructure services. As noted above, the inclusion of these variables tends to restrict sample size, so only a limited number of variables were selected, based on sample availability and whether the simple correlation was statistically significant. In addition, at least one variable representing quality, access, and price was selected in each case.

For electricity, per capita electricity consumption (availability), the cost of an electricity connection (price), the number of days to get an electricity connection (quality), and the number of power outages per month (quality) are included. While the R-squared more than doubles, the only statistically significant coefficients are on the variables representing quality: the number of days to get a connection and the number of power outages. These results suggest that the most important aspect of electricity service is quality and reliability.

For transportation, rail density (availability), liner shipping connectivity (quality), and cost of importing a 20-foot container (price) are included. Including rail density reduces sample size considerably, so results are presented with and without this variable (see table 14.13). The coefficients on the cost of importing a 20-foot container and the index of shipping connectivity are both statistically significant, while the coefficient on rail density is statistically insignificant.[28] Consistent with the previous results, this suggests that the most important aspect of transportation is the cost and ease of imports and exports.

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26. Also consistent with this, Kenny (2007) shows that construction contractors are more likely to pay bribes and spend more on them than other firms.

27. Consistent with this, Kahn (2005) shows that natural disasters lead to more deaths in countries with weak institutions. He suggests that this could be because corruption leads to poorly enforced building codes and low-quality infrastructure. Anecdotal evidence is consistent with this. After the 2010 earthquake in Haiti, Billam (2010) argued that "buildings had been doomed during their construction." The poor construction standards were attributed to corruption in procurement and building standards enforcement (Padget 2010; ScienceDaily 2010). Destruction during natural disasters in other countries has also been blamed on corruption (Kenny 2007).

28. When we include losses during transportation, all coefficients become statistically significant because including this variable significantly reduces sample size.

Conclusions

This chapter looks at two questions: (1) how do different aspects of infrastructure service—availability, quality, and price—vary across countries; and (2) what aspects of infrastructure service have the greatest impact on firms? It examines the correlation between various measures of infrastructure services and the correlation between objective (and some subjective) measures of infrastructure services and managers' perceptions about obstacles to firm performance imposed by poor-quality services. It also looks at the correlation between infrastructure services and macroeconomic variables.

The analysis shows that access is highly correlated within countries for different infrastructure services (water, electricity, mobile phones, fixed-line phones, roads, and rail). In contrast, prices and service quality are not highly correlated within countries. That is, countries with poor service in one sector do not necessarily have poor service in other sectors. Similarly, although prices are often positively correlated across services (e.g., when per-minute charges for mobile phones are high, power prices are also high), the correlations are lower than for access. And price and quality and price and access are not strongly correlated within sectors (see, for example, table 14.15 for electricity).[29] These results are broadly consistent with results in the 1994 *World Development Report* (World Bank 1994) for the 1990s.

Macroeconomic variables—per capita income and population density in particular—explain much of the cross-country variation related to access to roads, rail, electricity, water, and telecommunications services. Given the weak within-country correlations for price and quality, it is not surprising that macroeconomic variables like income and population density explain less of the cross-country variation for these variables.[30]

The strong correlation between income, population density, and access to infrastructure might suggest that income is destiny with respect to access: low-income and sparsely populated countries are destined to have low levels of access. This does not mean, however, that governments can do nothing to improve access to infrastructure other than promote economic growth. As noted earlier, there is some variation in access, and even more for service quality and price, even after controlling for income and other macroeconomic factors.

The recent experience with increased private sector participation in infrastructure supports this conclusion. Both cross-country econometric studies and individual country case studies show that governments can improve access and other aspects of service by introducing private sector participation, setting up in-

29. This, again, is broadly consistent with evidence from the 1994 *World Development Report* (World Bank 1994).

30. This is also consistent with results using data from the 1994 *World Development Report* (World Bank 1994).

dependent regulators, and, where possible, allowing competition.[31] For example, in 2006, the government of Kenya partially privatized the Kenya Electricity Generating Company (KenGen) and introduced a two-year management contract for the distribution company, Kenya Power and Lighting Company (KPLC). This, along with other reforms, resulted in connections increasing from 67,000 to 150,000 in two years (Public Private Infrastructure Advisory Facility 2010b). Similarly, starting in 2004, private and state-owned companies were allowed to bid for route-by-route contracts to provide bus service in Hanoi. This increased access to transportation and improved the quality of bus service in the city even though public subsidies were reduced (Public Private Infrastructure Advisory Facility 2010a).

Although population density is correlated with access to service, the relationship between population density and the price of infrastructure services is not consistent. Given that access might be low in countries with large, spread-out rural populations because of the high cost of serving rural areas, it seems plausible that the cost of service should be higher in these countries. The insignificant relationship between population density and price of infrastructure services might be because the price of infrastructure services does not reflect the cost of providing service. That is, if prices are set by state-owned enterprises or in consultation with government-appointed regulators, they might not reflect the cost of providing service.

The second part of the chapter shows that poor-quality infrastructure imposes substantial costs on firms. Enterprise managers in developing countries—and especially in low-income countries—were more likely to say that electricity is a serious obstacle than to say the same about any other area of the investment climate (e.g., access to finance, corruption, tax rates and administration, or regulation). Managers were less likely to say that transportation was a serious problem.

Firm managers are most concerned about the quality of service for electricity. In contrast, most price measures are only weakly correlated with managers' perceptions. Although managers tend to have worse perceptions about electricity in countries where access is poor, these correlations become statistically insignificant after controlling for the quality of service.

Managers' perceptions about transportation do not appear to be strongly associated with most measures of price, availability, or service quality in the transportation sector. Most of the objective indicators are not significantly correlated with managers' perceptions about transportation. The most robust correlations appear to be related to the cost and time associated with importing materials—and potentially exporting, given the high correlation between the time and cost of exporting and importing. Firms were more likely to complain about transportation

31. Kessides (2005) and Megginson (2005) provide two recent summaries of the experience with private sector participation in infrastructure.

in countries where the cost of importing a 20-foot container is higher and where connections to international trade routes are worse.

Previous studies have noted that managers appear more concerned about infrastructure in low-income countries than in middle-income countries (Carlin, Schaffer, and Seabright 2010; Gelb et al. 2006). Before controlling for quality of service, price, and access, we find similar results. The results from this study suggest that this mostly reflects that the quality of infrastructure is low in low- and middle-income countries. After controlling for this, the correlation between perceptions and per capita income becomes smaller and statistically insignificant. This might not be surprising given that, as noted above, many measures of access and service quality are positively correlated with per capita income.

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