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Effects of Improving Infrastructure Quality on Business Costs:

Evidence from Firm-Level Data

Atsushi Iimi

The World Bank
Finance, Economics and Urban Development Department
Economics Unit
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Abstract

Economic development is affected by infrastructure services in both volume and quality terms. However, the quality of infrastructure is relatively difficult to measure and assess. The current paper, using firm-level data collected by a business environment assessment survey in 26 countries in Europe and Central Asia, estimates the marginal impacts on firm costs of infrastructure quality. The results suggest that the reliability or continuity of services is important for business performance. Firm costs significantly increase when electricity outages occur more frequently and the average outage duration becomes longer. Similarly, increased hours of water supply suspensions also reduce firms' competitiveness. In these countries, it is found that the total benefit for the economy from eliminating the existing electricity outages ranges from 0.5 to 6 percent of gross domestic product. If all water suspensions are removed, the economy could receive a gain of about 0.5 to 2 percent of gross domestic product. By contrast, the quality of telecommunications services seems to have no significant impact.

This paper—a product of the Economics Unit, Finance, Economics and Urban Development Department—is part of a larger effort in the department to explore the linkage between infrastructure quality and economic growth. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted ataiimi@worldbank.org.

EFFECTS OF IMPROVING INFRASTRUCTURE QUALITY ON BUSINESS COSTS:

EVIDENCE FROM FIRM-LEVEL DATA

Atsushi Iimi [¶]

Finance, Economics and Urban Finance (FEU)
The World Bank
1818 H Street N.W. Washington D.C. 20433
Tel: 202-473-4698   Fax: 202-522-3481
E-mail: aiimi@worldbank.org

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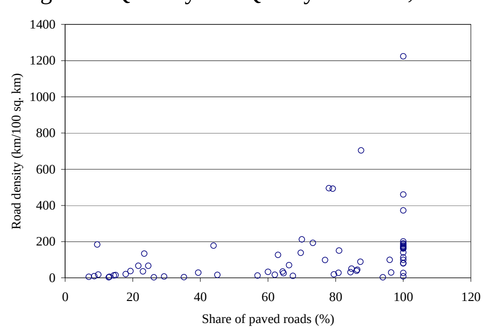
I. INTRODUCTION

Infrastructure is one of the most important driving forces for economic development. A strong correlation between growth and infrastructure stocks is usually expected (e.g., World Bank, 1994; Canning, 1998; Fay and Yepes, 2003). The reason is that accumulated public infrastructure is conducive to increasing productivity of individual firms, whence enhancing overall efficiency of the economy.

Importantly, however, not only the quantity but also the quality of infrastructure is essential for increasing firm competitiveness. High coverage of infrastructure is no doubt necessary, but it is not sufficient. For instance, many transition countries have well-established infrastructure networks; therefore, the access to services is granted. However, it does not necessarily guarantee the quality or reliability of service provision. Without proper maintenance, infrastructure services remain unreliable in some transition countries. A traditional example is this; there is no clear correlation between quantity and quality of roads at least on a cross-country basis (Figure 1). High road density does not always mean low transportation costs unless the quality of road surfaces is maintained. In this regard, the share of paved roads may be a better proxy for the quality of infrastructure.

Figure 1. Quantity and Quality of Roads, 2003

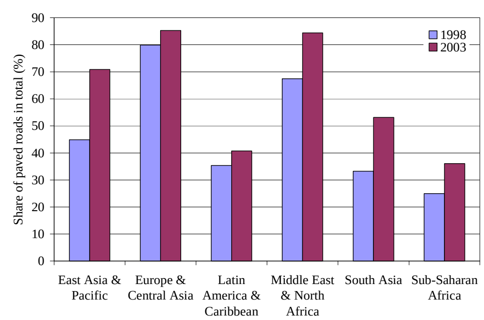


Source: *World Development Indicators.*

However, the quality of public infrastructure services is not always easy to measure in an objective manner. In general, quality data are thin, as often pointed out (e.g., Fay and Morrison, 2005). Among the existing aggregate data, several measurements of infrastructure quality cover most countries in the world: the share of paved roads in total roads, the rate of telephone faults per mainline, and the rate of electricity transmission and distribution losses (e.g., Calderón and Servén, 2004). The last indicator may not represent the quality of electricity supply services perceived by consumers, because it measures technical losses unobserved by consumers.

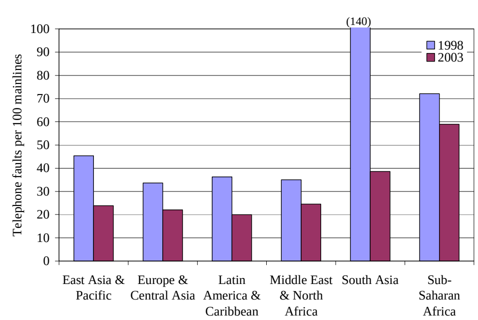
The share of paved roads is clearly one dimension of quality in the road sector. By region, East Asian countries considerably improved the road quality in recent years, while Latin American and Sub-Saharan African countries seem to be lagging behind in this area (Figure 2). The rate of telephone faults per fixed line represents the reliability of telecommunications services. Sub-Saharan Africa, again, had the highest fault rate in 2003. It is more than twice as high as other regions except South Asia (Figure 3). If the quality of electricity supply is measured by the transmission and distribution losses, the quality in East Asia is considered twice as high as South Asia and Sub-Saharan Africa (Figure 4).

Figure 2. Road Quality by Region



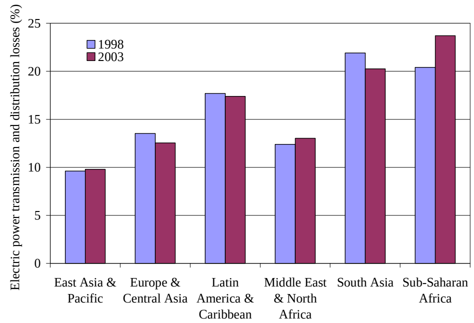
Source: *World Development Indicators.*

Figure 3. Telecommunications Service Quality by Region



Source: *World Development Indicators.*

Figure 4. Electricity Distribution Losses by Region



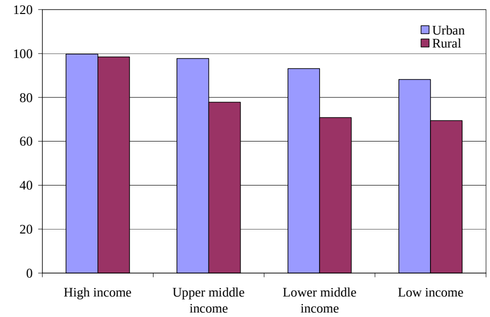
Source: *World Development Indicators*.

Based on these aggregate quality data, Calderón and Servén (2004) examines the growth impacts of infrastructure development in both volume and quality terms. Using a GMM technique, it is shown that growth is strongly affected by the infrastructure stocks and very weekly influenced by the quality of infrastructure.[1] The coefficient of infrastructure quality has been found statistically insignificant, possibly because of the dominant effects of infrastructure quantity. But they also show that the quality of telecommunications is likely to matter on a growth path, when only one infrastructure proxy is employed.

One important fact ignored by country-level analyses is that there is large heterogeneity in received infrastructure service quality within a country. Unfortunately, there are few indicators for the within-country heterogeneity that can be used for international comparison. However, it is intuitively obvious that the quality of infrastructure is often worse in rural areas, particularly in developing countries. Figure 5 reflects the access rates to improved water in urban and rural areas by income level. It is apparent that the quality infrastructure provision in the water sector tends to be uneven in lower income countries.

[1] Calderón and Servén (2004) creates an index of the quality of infrastructure services using the waiting time for telephone main lines, the rate of electricity transmission and distribution losses and the share of paved roads.

Figure 5. Access to Improved Water Facilities (%), 2004



Source: *World Development Indicators*.

Instead of these aggregate data, the current paper uses firm-level micro data. Therefore, the analysis can take into consideration the fact that the quality level of infrastructure services received by individual firms potentially differs, probably depending on their location. The data come from the 2005 Business Environment and Enterprise Productivity Survey (BEEPS) for 27 Europe and Central Asia (ECA) countries.[2] Our sample data include about 4,300 firms in 26 countries, of which the sufficient information is available for our analytical purposes.

The ECA region is of particular interest as far as the economic effects of infrastructure quality is concerned. As World Bank (2006) summarizes the recent infrastructure developments in the region, many transition economies have experienced sharp declines in the national incomes and outputs since the collapse of the Soviet Union. As a result the existing infrastructure facilities, which were constructed to provide almost universal access in the Soviet period, turned out excessive. Without appropriate maintenance and investment due to a lack of financial resources, the quality of infrastructure tends to deteriorate considerably in these countries.

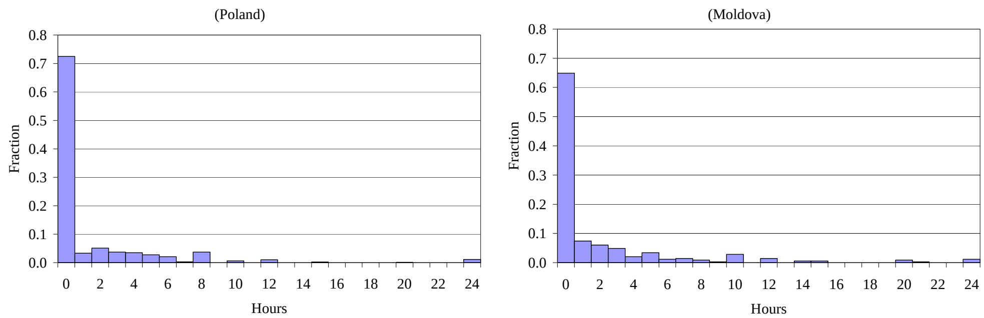
[2] It covers Albania, Armenia, Azerbaijan, Belarus, Bosnia, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyzstan, Moldova, Latvia, Lithuania, Macedonia, Poland, Romania, Russia, Slovakia, Slovenia, Tajikistan, Turkey, Ukraine, Uzbekistan, and Yugoslavia. One country, Azerbaijan, is excluded from our empirical model, because there is no firm cost information collected in the country.

The deterioration of public infrastructure is imposing a heavy burden on firms. About 68 percent of the survey respondents identified electricity as a major obstacle in 2005. Similarly, 72 percent of firms considered telecommunications as a constraint (World Bank, 2006). These subjective assessments by firms are also available in the BEEPS database. Using these subjective proxies, Carlin *et al*. (2006) estimates a production function with all the past BEEPS survey data over the world—not only ECA—and finds that manager's assessment of physical and institutional constraints in the economy explains the extent to which firm productivity would decline for these reasons. As far as the infrastructure is concerned, the low scores of telecommunications and electricity services are likely to decrease firms' sales significantly.

The current paper is complementary to this but relies on the objective indicators of infrastructure quality, such as the number of days with electricity outages a year and the average duration of water service suspensions per day. Hence, our analysis can explicitly quantify the possible impacts of improving or deteriorating the quality or reliability of infrastructure on business costs. Given the estimates, it will be examined how much cost could be saved as a whole economy by eliminating the existing infrastructure service interruptions. From the public investment point of view, this inference is important to assess the benefits from and costs of public infrastructure investment.

Three types of public infrastructure services are analyzed: electricity, water supply and telecommunications. For each sector, two dimensions are used to measure the level of service quality perceived by individual firms: annual frequency and daily duration of service suspensions. As mentioned above, it cannot be overemphasized that the perceived quality of infrastructure varies from firm to firm, depending on their location. For instance, the average duration of electricity interruptions ranges from 0 to 24 hours, though the majority of firms do not have any outrage (Figure 6).[3] Our empirical model accounts for this firm-level heterogeneity in service quality within a country.

Figure 6. Duration of Electricity Outages per Day



Source: BEEPS.

The following sections are organized as follows: Section II establishes our empirical model and describes our data uses. Section III provides the estimation results and some policy implications.

II. EMPIRICAL MODEL AND DATA

Based on the traditional industrial organization literature (e.g., Nerlove, 1963; Christensen and Greene, 1976), the following cost function is estimated by a seemingly unrelated regression (SUR) technique:

$$\begin{aligned}\ln C = {} & \beta_0 + \beta_Y \ln Y + \frac{1}{2}\beta_{YY} \ln Y \ln Y + \sum_i \beta_{W_i} \ln W_i + \frac{1}{2}\sum_i \sum_j \beta_{W_i W_j} \ln W_i \ln W_j \\ & + \sum_i \beta_{YW_i} \ln Y \ln W_k + \beta_Z \ln Z + \frac{1}{2}\beta_{ZZ} \ln Z \ln Z + \beta_{YZ} \ln Y \ln Z \\ & + \sum_i \beta_{W_i Z} \ln W_i \ln Z + \varepsilon\end{aligned} \qquad (1)$$

[3] These figures are unconditional. The conventional figures reported in BEEPS are the average number of hours needed to resume interrupted services on the condition that some interruptions happen. Thus, the observations without any service interruptions are usually excluded to compute the average duration of outages.

where C denotes total operating costs, Y is an output, and W_i is ith input price. Z represents an exogenous quality measure for infrastructure quality.

Two inputs are conceptually considered: labor and other cost, which is also referred to as capital in general. Unit labor price W_L is obtained by dividing total wage expenses by the number of employees. On the other hand, "capital" potentially consists of various costs, and the unit price of input capital (W_K) is computed by dividing the operating expenses other than wages by the amount of assets, more precisely total asset replacement costs.

Output is measured by total sales, because no physical output variable is available in the database. Since firms in the sample belong to various sectors, this is only the usable common proxy for output. To control for some possible heterogeneity among sectors, the empirical model incorporates the sector-specific dummy variables.

Three basic infrastructure services are examined: electricity, water supply and telecommunications. For each sector, two dimensions of service quality are adopted: the number of days without sufficient services (days per year) and the average duration of service interruptions (hours per day).

Note that these variables are in principle supposed to represent only the difference in quality, because the quantity effect caused by service interruptions should be accounted for by the dependent variable, operating costs, in our setting. However, if no utility meter is installed and some fixed monthly fees are collected regardless of actual service delivery, our infrastructure measurements may partially capture the quantity effect.

Given Equation (1), the following symmetry and homogeneity restrictions are imposed to have a well-behaved cost function:

$$\beta_{W_iW_j} = \beta_{W_jW_i}, \sum_i \beta_{W_i} = 1, \sum_i \sum_j \beta_{W_iW_j} = 0, \sum_i \beta_{YW_i} = 0, \sum_i \beta_{W_iZ} = 0 \tag{2}$$

In addition, from the Shephard's lemma, the following factor share equations are obtained:

$$S_i = \frac{\partial \ln C}{\partial \ln W_i} = \beta_{W_i} + \sum_j \beta_{W_iW_j} \ln W_j + \beta_{YW_i} \ln Y + \beta_{W_iZ} \ln Z \tag{3}$$

where S_i is the cost share of input i. Through the SUR model, the cost parameters are estimated in Equation (1) and one of the factor share equations (3).[4] The advantage of the SUR is that higher efficiency in estimation could be expected without wasting the degree of freedom (Christensen and Greene, 1976).

The marginal impact (elasticity) of infrastructure quality on firm costs is calculated by this:

$$\eta_Z = \hat{\beta}_Z + \hat{\beta}_{ZZ} \ln Z + \hat{\beta}_{YZ} \ln Y + \hat{\beta}_{W_LZ} \left(\ln W_L - \ln W_K \right) \tag{4}$$

The used data come from the 2005 BEEPS for 26 countries in the ECA region. The total sample size amounts to about 4,300. This excludes a number of observations of which the relevant cost data are not included.[5] The number of observations per country in our sample varies from 50 to 650, but mostly ranging between 100 and 200.

The summary statistics are shown in Table 1. Firms look different in size and labor intensity. The operating cost ranges from US$ 3,000 to 532 million U.S. dollars with a mean of about 3 million U.S. dollars. The average wage is around US$ 5,300 per annum. In the sample the labor cost amounts to 22 percent of total costs. The number of days without sufficient electricity supply reaches 10 days per year on average. For water, there are 4 days that do not

[4] One of the factor equations should be dropped to avoid the singularity problem.

[5] The original sample size of the BEEPS covering 27 countries is 9,655.

have sufficient water services. The average durations of electricity and water interruptions are 2.5 and 1.5 hours, respectively. The service suspensions in the telecommunications sector seem to be less crucial. Table 2 includes simple correlations between these variables.

Table 1. Summary Statistics

Variable		Obs	Mean	Std. Dev.	Min	Max
C	Operating cost	4370	3,270	15,675	3	532,544
Y	Output (total sales)	4370	3,757	17,636	7	585,000
W_L	Wage	4370	5.35	4.68	0.001	81.13
W_K	Capital price	4370	6.21	20.69	0	640.50
S_L	Cost share of labor expenses	4370	0.22	0.14	0.006	1.00
Infrastructure quality						
Z_{P1}	Days without electricity supply a year	4282	9.85	44.80	0	365
Z_{W1}	Days without water services a year	4197	4.10	31.14	0	365
Z_{T1}	Days without telephone services a year	4197	1.50	10.58	0	365
Z_{P2}	Duration of electricity suspension in hours	4281	2.56	3.98	0	24
Z_{W2}	Duration of water suspension in hours	4197	1.55	3.06	0	24
Z_{T2}	Duration of telecommunications suspension in hours	4196	1.91	4.10	0	24
Sector dummy						
	Mining	4370	0.01	0.11	0	1
	Construction	4370	0.10	0.30	0	1
	Manufacturing	4370	0.42	0.49	0	1
	Transport	4370	0.06	0.24	0	1
	Trade	4370	0.23	0.42	0	1
	Real estate	4370	0.07	0.26	0	1
	Hotels and restaurant	4370	0.05	0.22	0	1
	Other services	4370	0.04	0.21	0	1

Source: Author's calculation.

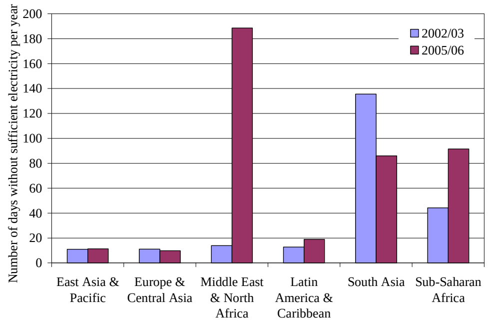
Table 2. Correlation

	C	Y	W_L	W_K	Z_{P1}	Z_{W1}	Z_{T1}	Z_{P2}	Z_{W2}
Y	0.998								
W_L	0.164	0.162							
W_K	0.101	0.100	0.028						
Z_{P1}	-0.002	0.002	-0.054	0.020					
Z_{W1}	-0.016	-0.015	-0.033	0.006	0.465				
Z_{T1}	-0.021	-0.021	-0.020	0.006	0.176	0.088			
Z_{P2}	-0.013	-0.013	-0.066	0.004	0.121	0.064	0.037		
Z_{W2}	-0.021	-0.021	-0.066	0.002	0.109	0.259	0.108	0.201	
Z_{T2}	-0.020	-0.020	-0.008	-0.006	0.117	0.044	0.294	0.170	0.138

Source: Author's calculation.

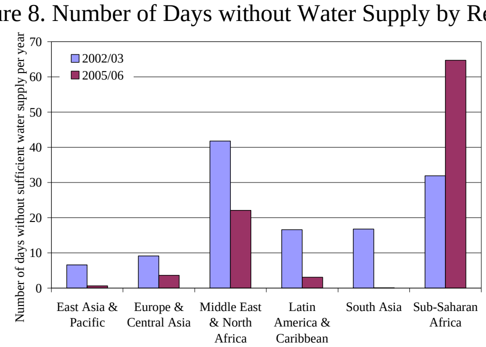
By region, the Europe and Central Asia region is providing the relatively good quality of infrastructure services to firms, along with East Asia and Pacific. The frequency of electricity outages is outstanding in South Asia and Sub-Saharan Africa. By contrast, the average outage in ECA was less than 10 days (Figure 7). The quality of water supply services was also relatively good for ECA countries, but when comparing with East Asia and Latin America, the frequency of water suspensions was higher at about 4 days. Notably, the service quality in Africa aggravated in the past three years (Figure 8). Telecommunications achieved marked improvements in service quality over the world (Figure 9). While Sub-Saharan Africa may have more than 10 days of service interruptions, the other regions have only several days on average. The ECA region has the lowest frequency of telecommunications unavailability.

Figure 7. Number of Days without Electricity by Region



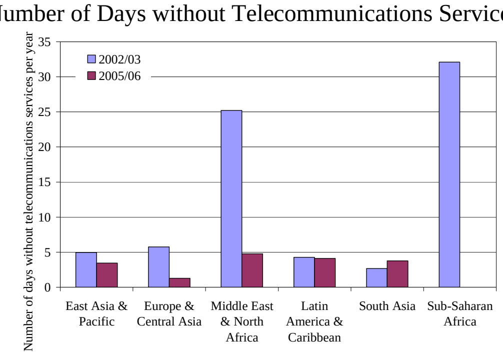
Source: BEEPS.

Figure 8. Number of Days without Water Supply by Region



Source: BEEPS.

Figure 9. Number of Days without Telecommunications Services by Region

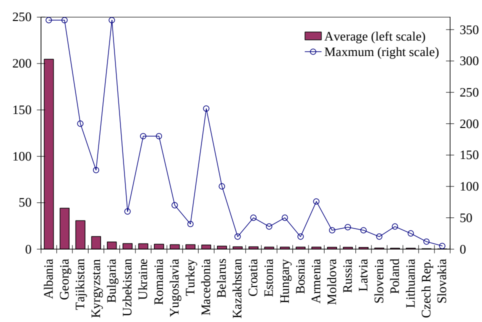


Source: BEEPS.

In the ECA region, Albania has the poorest quality of infrastructure services in all aspects (Figures 10 to 12). The number of days without sufficient electricity exceeds 200 days.

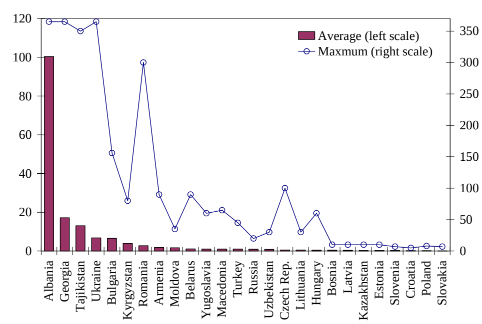
About 100 days have water supply interruption in Albania. Importantly, however, some firms in other countries *do* experience more service interruptions than Albania. The figures include the maximum days of service suspensions in each country. There is a trend that countries having the lower average would likely have the lower maximum. However, the figures indicate that there is a significant variation in service levels received by individual firms. In general, the quality problem in telecommunications is relatively modest in all countries.

Figure 10. Number of Days without Electricity in ECA



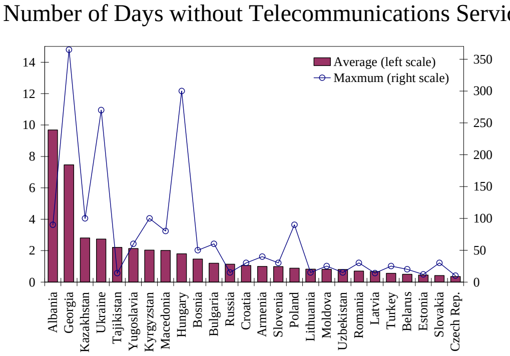
Source: BEEPS.

Figure 11. Number of Days without Water Supply in ECA



Source: BEEPS.

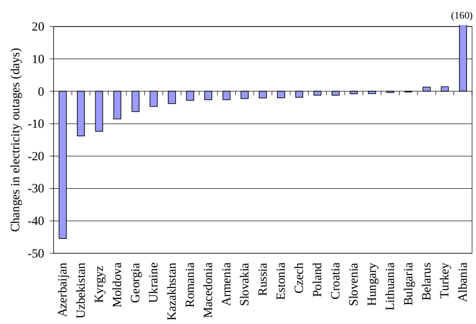
Figure 12. Number of Days without Telecommunications Services in ECA



Source: BEEPS.

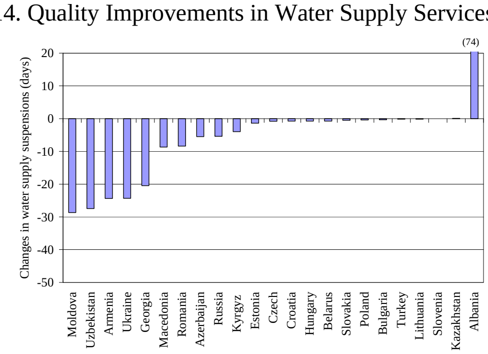
The extent to which the service quality of infrastructure has improved varies from country to country. Figures 13 to 15 show the difference between the 2002 and 2005 BEEPS results for each country. Obviously, more advanced countries tend to have experienced relatively moderate improvements simply because they already achieved the high level of quality and did not have much room for further improvement. Armenia, Georgia, Kyrgyz, Moldova and Uzbekistan are generally among the best performing countries in all sectors. Azerbaijan achieved the most spectacular change in electricity. Interestingly, however, the sector performances are not necessarily consistent with each other within a country. This must result from the difference in the development strategy and priority across countries.

Figure 13. Quality Improvements in Electricity in ECA



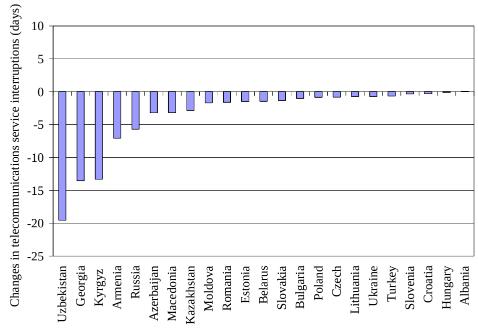
Source: BEEPS.

Figure 14. Quality Improvements in Water Supply Services in ECA



Source: BEEPS.

Figure 15. Quality Improvements in Telecommunications Services in ECA



Source: BEEPS.

III. Estimation Results and Policy Implications

Six seemingly unrelated regressions (SUR) are performed; the results are shown in Table 3. The coefficients are broadly consistent with economic theory. The coefficient of output Y is positive and significant, and the operating cost increases with unit labor costs (wages). Note that each model includes only one proxy of infrastructure quality, because the infrastructure variables in the sample tend to be correlated with each other.[6] In addition, by construction it makes little sense to include two dimensions, i.e., annual frequency and hourly duration of service interruptions, in the model. The reason is that the numbers of hours needed to resume suspended services are unconditional in our data, meaning that they include zero hours if firms do not experience any outages. Hence, no annual experience of interruptions means that the average interruption per day is zero hours, and vice versa.

From the industrial organization point of view, one interesting implication of the estimated cost function is economies of scale in production. The output elasticity evaluated at the sample means is about 0.8, regardless of the selection of infrastructure variables. The estimate is strongly significant in a statistical sense. This means that the estimated cost function exhibits economies of scale; firms could expect more production at relatively small additional operating costs.

[6] Estimating the similar model with more than one infrastructure variable has been found to generate theoretically unreliable results.

Table 3 also suggests that there are systematic differences in operating costs among sectors. The mining sector is used as a baseline in our estimation. In fact, mining is found among the most costly industries, along with manufacturing. The service industries, such as trade and real estate, require less operating costs to produce the same level of output.

Table 3. Estimated Cost Function by SUR

	Days with interruptions a year			Duration of suspensions per day		
	Electricity	Water	Telecom	Electricity	Water	Telecom
	Z_{P1}	Z_{W1}	Z_{T1}	Z_{P2}	Z_{W2}	Z_{T2}
β_Y	0.595 ***	0.555 ***	0.572 ***	0.610 ***	0.603 ***	0.589 ***
	(0.030)	(0.031)	(0.032)	(0.030)	(0.030)	(0.031)
β_{YY}	0.032 ***	0.033 ***	0.035 ***	0.033 ***	0.033 ***	0.035 ***
	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.005)
β_{WL}	0.754 ***	0.751 ***	0.747 ***	0.751 ***	0.750 ***	0.746 ***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
β_{WLWL}	0.008 ***	0.008 ***	0.007 ***	0.008 ***	0.008 ***	0.008 ***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
β_{WLWK}	-0.032 ***	-0.033 ***	-0.033 ***	-0.032 ***	-0.033 ***	-0.033 ***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
β_{YWL}	-0.012 ***	-0.012 ***	-0.012 ***	-0.012 ***	-0.012 ***	-0.012 ***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
β_Z	0.071 ***	0.095 ***	0.033 *	0.156 ***	0.289 ***	0.084
	(0.011)	(0.016)	(0.017)	(0.041)	(0.062)	(0.057)
β_{ZZ}	0.007 **	-0.001	0.000	0.022	-0.016	-0.010
	(0.003)	(0.004)	(0.006)	(0.023)	(0.037)	(0.030)
β_{YZ}	-0.008 ***	-0.013 ***	-0.005 *	-0.020 ***	-0.035 ***	-0.011
	(0.002)	(0.002)	(0.003)	(0.005)	(0.008)	(0.007)
β_{WLZ}	0.001	0.001	0.000	-0.002	-0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.002)	(0.003)	(0.003)
Construction	-0.130	-0.162 *	-0.172 *	-0.130	-0.164 *	-0.173 *
	(0.091)	(0.093)	(0.094)	(0.091)	(0.093)	(0.094)
Manufacturing	0.127	0.096	0.096	0.120	0.092	0.097
	(0.087)	(0.089)	(0.090)	(0.087)	(0.089)	(0.090)
Transport	-0.048	-0.067	-0.071	-0.045	-0.071	-0.070
	(0.094)	(0.096)	(0.097)	(0.094)	(0.096)	(0.097)
Trade	-0.303 ***	-0.329 ***	-0.334 ***	-0.306 ***	-0.331 ***	-0.334 ***
	(0.089)	(0.091)	(0.091)	(0.089)	(0.091)	(0.092)
Real estate	-0.425 ***	-0.449 ***	-0.446 ***	-0.429 ***	-0.453 ***	-0.445 ***
	(0.093)	(0.095)	(0.096)	(0.093)	(0.095)	(0.096)
Hotels & restaurant	-0.088	-0.129	-0.117	-0.081	-0.132	-0.116
	(0.095)	(0.098)	(0.098)	(0.095)	(0.098)	(0.098)
Other services	-0.292 ***	-0.330 ***	-0.310 ***	-0.287 ***	-0.327 ***	-0.310 ***
	(0.098)	(0.100)	(0.100)	(0.098)	(0.100)	(0.101)
Cons	0.566 ***	0.899 ***	0.702 ***	0.434 ***	0.547 ***	0.585 ***
	(0.134)	(0.148)	(0.152)	(0.135)	(0.136)	(0.137)
Obs.	4280	4195	4195	4279	4195	4194
R-squared						
Cost equation	0.624	0.627	0.631	0.625	0.628	0.631
Share equation	0.125	0.124	0.124	0.125	0.124	0.124

Note that the dependent variable is thelogarithmic operating cost. The standard errors are shown in parentheses. *, ** and *** represent the 10%, 5% and 1% level significance, respectively.

Source: Author's calculation.

The quality of infrastructure has been found to matter, particularly in the electricity and water sectors. Table 4 calculates the elasticity of operating costs with respect to each infrastructure variable. It is evaluated at sample means and estimated by the delta method. The table shows that the models with sector dummy variables could produce more significant estimates, because of the sectoral differences in costs as mentioned above. As to the frequency measurements of service interruptions, the elasticity with respect to electricity outages is significant and positive, meaning that a reduction in days without sufficient power could decrease firm costs. On the other hand, the water and telecommunications coefficients are statistically insignificant.

The duration of electricity and water service suspensions has a significant effect to improve firm performance. In these two sectors, the elasticities of the service interruption duration are significantly positive. An elimination of all the existing duration of electricity outages would lead to a 4 percent reduction in firms' operating costs.[7] The equivalent number for water suspensions is estimated about 7 percent.

The measured quality of telecommunications services seems to have little role to play in influencing firm costs. This is possibly because telecommunications services, particularly in the mobile telecommunications segment, are now generally reliable in the region, except for rural and remote areas. Moreover, the dependency of business on telecommunications may become lower because of the alternative communication measures, such as the Internet.

Table 4. Elasticity of operating costs with respect to infrastructure quality

	w/o sector dummy	With sector dummy
Number of days with insufficient services		
Electricity	0.0083 *	0.0086 **
	(0.0043)	(0.0039)
Water supply	0.0127	0.0176
	(0.0146)	(0.0132)
Telecommunications	0.0148	0.0030
	(0.0160)	(0.0145)
Avg. duration of service interruptions		
Electricity	0.0093	0.0393 **
	(0.0185)	(0.1681)
Water supply	0.0264	0.0683 *
	(0.0457)	(0.0416)
Telecommunications	-0.0317	0.0173
	(0.0387)	(0.0352)

Source: Author's calculation.

[7] That is, this is considers a 100 percent improvement of infrastructure quality.

The above elasticities look rather small. For instance, the table indicates that a 1 percent reduction in electricity outages in terms of hours could save only 0.04 percent of operating cost. But it is worthy recalling that the majority of firms do not suffer from any service interruptions in our sample (see Figure 6). While some firms claimed a 365-day or 24-hour service suspension, the average number of interruption days or hours is relatively small (Table 1). Therefore, no economically meaningful impact is expected to be generated by a 1 percent improvement in infrastructure quality.

Rather, Table 5 may provide more understandable estimates of the impact of quality infrastructure. It considers a one-day reduction of service suspensions per year and a one-hour cut in service interruption per day. A one-day reduction of power outages seems to have a minimal effect. On the other hand, firms could save their operating costs by 1.5 percent if the hourly power interruption shortens by one hour. The one-hour improvement in water supply services is expected to have a much greater impact; it would save 4.4 percent of operating costs.

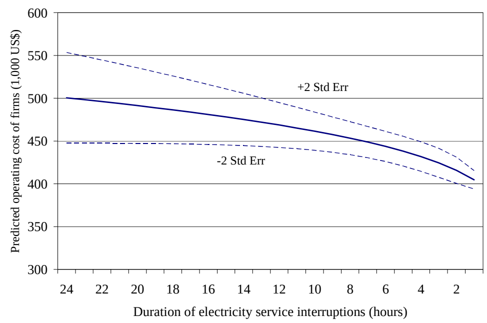
Table 5. Estimated cost savings from infrastructure quality improvements

	Estimated cost savings per operating cost (%)
Reducing service interruptions by 1 day	
Electricity	0.087 **
	(0.040)
Water supply	0.430
	(0.323)
Telecommunications	0.200
	(0.969)
Making service recovery faster by 1 hour	
Electricity	1.533 **
	(0.655)
Water supply	4.410 *
	(2.684)
Telecommunications	0.907
	(1.841)

Source: Author’s calculation.

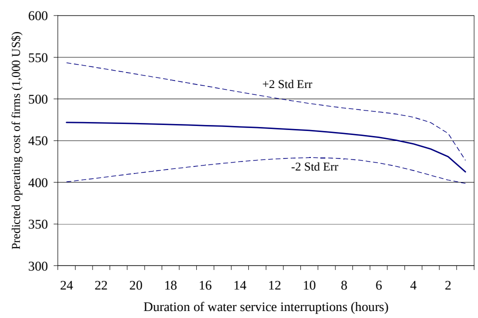
While the benefits from improving the quality of electricity services are relatively proportional to the reduction in interrupted service hours, the expected benefits from the water service reliability would concentrate on the last four hours of eliminating the existent suspensions. Figures 16 and 17 depict the predicted operating cost over the duration of service interruptions, holding other conditions constant. The “average firm” can expect to monotonically reduce the cost from US$ 500,000 to US$ 400,000 when electricity outages decrease from 24 hours to zero. By contrast, the operating cost may not be elastic to the decline in water suspensions from 24 hours to 5 hours. The benefits would be realized if the 24-hour service provision is achieved. It is a really important task for water operators to cut the service interruptions from 4 hours to zero.

Figure 16. Predicted Operating Cost Associated with Power Outages



Source: Author's calculation.

Figure 17. Predicted Operating Cost Associated with Water Suspensions



Source: Author's calculation.

Importantly, it must cost countries to improve infrastructure services. In order to assess the benefits of quality improvements on the national level, Table 6 calculates the share of predicted operating cost savings to GDP. Given the average elasticities (in Table 3), the cost savings of individual firms are calculated and the sum of those savings is divided by the sample coverage rate. Notably, the resultant figures should be interpreted carefully, because there is a general tendency that the magnitude of total cost savings by firms in the economy is upward biased when the population size of enterprises is large. Nonetheless, three samples of large, medium and small countries in the region, Poland, Romania and Moldova, are examined.[8]

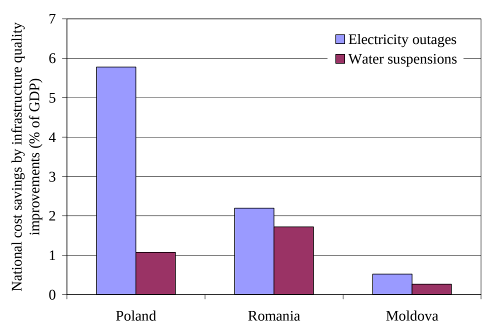
The total cost savings from eliminating existing power outages may range from 0.5 to 6 percent of GDP. The national benefits from removing all water suspensions would be equivalent to 0.5 to 3 percent of GDP (Figure 18). This justifies some government expenditures for infrastructure developments at the national account level. To improve the reliability and continuity of infrastructure services, the size of installed capacity may need to be augmented. Some technical inefficiency can be minimized by strengthening the utility networks. All the investment and maintenance costs should be accounted for in comparison with the above estimated benefits received by the economy as a whole. Residential consumer welfare gains are also additional.

Table 6. Estimated National Benefits from Infrastructure Quality Improvements

	No. of enterprises	Sample size	Total cost savings by sample firms (US$ '000)	National cost savings by firms per GDP (%)
Eliminating existing duration of electricity outages				
Poland	731,083	657	15,741	5.8
Romania	91,760	278	6,575	2.2
Moldova	4,182	86	319	0.5
Eliminating existing duration of water suspensions				
Poland	731,083	657	2,915	1.1
Romania	91,760	278	5,139	1.7
Moldova	4,182	86	163	0.3

Source: Author's calculation.

Figure 18. Estimated National Benefits from Infrastructure Quality Improvements

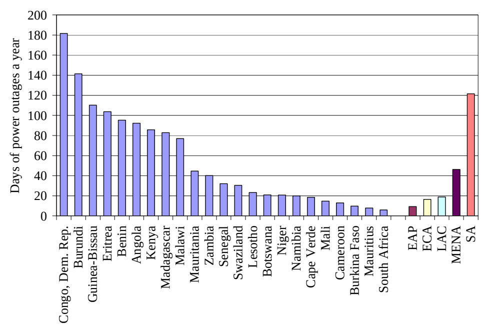


Source: Author's calculation.

[8] These three countries are selected based on a technical note on the BEEPS sampling (World Bank, 2007).

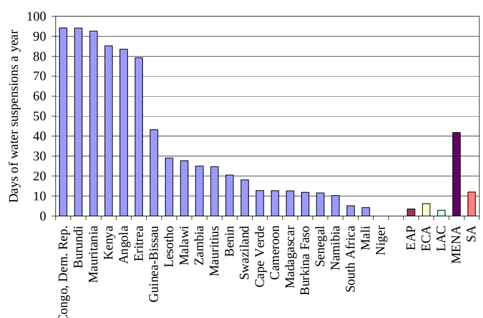
The applicability of these estimates to other regions is evident. Our sample analyzed above may represent relatively more developed developing countries. In Africa, for instance, the quality of infrastructure measured in the same way is much poorer than the ECA region. The frequency of power outages reaches as many as 80 days per year in several African countries (Figure 19). There is no such case in Europe and Central Asia, except for Albania. Similarly, many countries in Africa are suffering from more than 20 days of water suspensions a year (Figure 20). Again, these are fairly exceptional in other regions. Much greater efforts toward infrastructure quality improvements are called for in particular in Africa.

Figure 19. Quality of Electricity Infrastructure Services in Africa



Source: BEEPS.

Figure 20. Quality of Water Infrastructure Services in Africa



Source: BEEPS.

IV. CONCLUSION

Infrastructure is one of the most important factors for growth. Good quality infrastructure services are essential for firms to strengthen competitiveness. However, few studies have quantified the effects of improving the quality of infrastructure services, possibly due to the difficulty in measuring them.

The paper recast light on this problem, using large firm-level data collected by the business environmental assessments in 26 European and Central Asian countries. By a conventional seemingly unrelated regression technique, the cost function is estimated with several dimensions of infrastructure quality included.

The results generally reveal the importance of quality or reliability in providing infrastructure services. The paper found that a one-hour reduction in electricity outages could provide firms savings on operating costs of 1.5 percent on average. If the existing water supply suspensions are shortened by one hour, firms could save 4.4 percent of their operating costs. If all current electricity and water suspensions are removed, the benefits for firms would be equivalent to approximately 4 percent and 7 percent of their operating costs.

As per these estimates, the benefits that could be received by the economy as a whole are considered sizable. The total cost savings from quality improvements in infrastructure services may normally range from 0.5 to 2 percent of GDP. But it could reach more than 5 percent of GDP, depending on the country conditions. This level of public investment in infrastructure quality is justifiable. Governments need to ensure the high quality of infrastructure services to increase firm-level competitiveness, whence accelerating growth.

The applicability of these estimates to other regions is evident. Especially in Africa, the quality of infrastructure measured in the same way is far below the ECA region analyzed in the paper. Frequent suspensions of electricity and water supply services have been observed in Africa. In some countries, the frequency of power outage reaches as many as 80 days per year. Greater efforts toward infrastructure quality improvements are called for in these countries.

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