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Electricity Sector Constraints for Firms Across Economies: A Comparative Analysis

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What are the main types of electricity sector constraints and how do they vary across economies? How do power outages and electricity tariffs impact firms' demand for energy inputs? This note aims to provide insights into these questions using recent Doing Business data from the World Bank.

More than one billion people do not have access to electricity[1] and, according to the World Bank, an equal number receive electricity services that do not meet adequate reliability standards.[2] A lack of electricity negatively impacts welfare by undermining areas such as education (Khandker and others 2014) and healthcare (Adair-Rohani and others 2013). Firm performance is one area that is arguably the most affected by poor electricity services. Data from the World Bank Enterprise Surveys indicate that business owners in developing economies perceive a lack of reliable electricity supply as the biggest obstacle to the operation of their businesses, behind only access to finance, the informal sector and political instability.[3] However, obstacles to getting electricity vary. For a newly incorporated startup firm, for example, obtaining a new electricity connection may be difficult owing to a burdensome connection process. Or, once connected to the grid, a business may face blackouts that force it to halt production or resort to self-supply through generators, at a significant cost (Foster and Steinbuks 2010). Finally, firm performance may be hindered in economies where electricity tariffs are high relative to income levels.

This note explores electricity sector constraints across 190 economies by drawing on recent data from the *Doing Business* indicator set for getting electricity, which—in addition to measuring the process for obtaining an electricity connection for a firm—now includes electricity tariffs and power outages. Stylized facts are presented throughout. The data on tariffs and outages are collected directly from utilities and do not rely on firm surveys (as commonly used in the literature). Further adding to existing research, this note examines how power outages and electricity tariffs are related to firm demand for energy inputs.

Electricity reliability varies considerably across economies and regions

Infrastructure is one of the main pillars of competitiveness.[4] While it encompasses many types of facilities and systems, an economy's electricity supply is one of the main determinants of firm productivity (Escribano and others 2009). Furthermore, productivity is boosted by reliable electricity services (Fedderke and Bogetic 2006; Kirubi and others 2009; Grimm and others 2012). A weak power infrastructure, however, can act as a drag on economic growth. In Sub-Saharan Africa, economic growth is constrained by about two percentage points by a weak power infrastructure (Andersen and Dalgaard 2012).

To assess the impact of electricity infrastructure on firm performance, most studies use proxy measures of power outages. Some studies employ meteorological satellite data on lighting density, while others use firm-level data where businesses self-report outages over a period of time. *Doing Business*, however, collects two indices directly from distribution utilities for each economy's largest city:[5] the system average interruption duration index (SAIDI) and the system average interruption frequency index (SAIFI). SAIDI measures the average total duration (in hours) of outages, and SAIFI the average number of outages, experienced by a customer over the course of a calendar year. SAIDI and SAIFI include all types of outages, including load shedding or planned power cuts for maintenance.

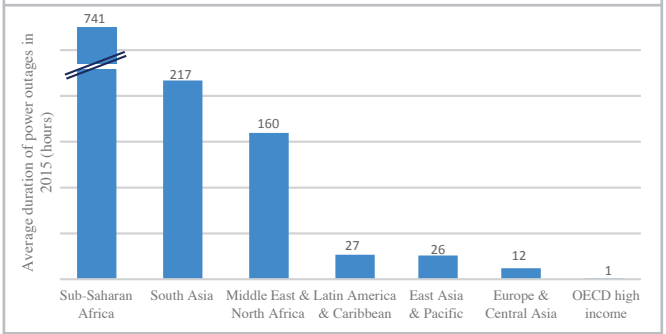
Looking at SAIDI and SAIFI data across economies, several observations can be made. First, the measures are highly correlated. Because SAIDI is a function of the number of service interruptions as well as the average disruption time, this is not surprising. Second, the data show a large variation in outages from one economy to another. In 2015, customers in the main cities of nearly 50 upper-middle-income and high-income economies experienced less than one hour of blackouts—including Costa Rica, Germany and Singapore. By contrast, power was interrupted for more than 1,000 hours in 2015 in Iraq, Nigeria, Pakistan and South Sudan, among others. Outages also fluctuate on a yearly basis; over a third of economies saw outages increase or decrease by 30% or more in 2015. In Zambia, for example, SAIDI and SAIFI more than doubled compared to the previous year as insufficient rainfall resulted in low water reserves at hydropower dams (Mutale 2015).

The OECD high-income economies had the lowest duration and frequency of interruptions in 2015, occurring on average less than once a year per customer. On the other hand, economies in Sub-Saharan Africa suffered the most blackouts in 2015, averaging almost 741 hours over 253 interruptions (Figures 1 and 2). South Asia and the Middle East and North Africa follow as the second and third regions, respectively, with the most power interruptions. Indeed, firms in the three regions mentioned above are most likely to own generators or report electricity as a major obstacle to doing business.[6] Electricity shortages are so chronic in some economies—including Afghanistan, Guinea-Bissau and Sierra Leone—that utilities advise new customers with moderate electricity needs to purchase their own generators instead of connecting to the grid (Geginat 2009).

Power outages are associated with an economy's income level—and economies that do not monitor outages tend to have more of them

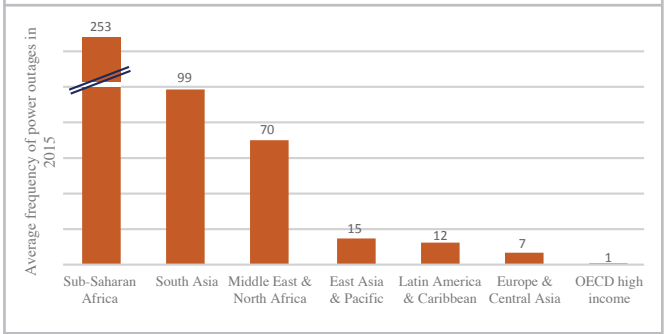
An economy's income level is associated with its infrastructure development (Calderon and others 2014). This holds true when infrastructure development is proxied by service reliability (Figure 3). A firm operating in a low-income economy in 2015 faced nearly 400 power cuts on average, while a firm in a high-income economy experienced about one such power cut. Moreover, the 42 economies where no SAIDI/SAIFI data are available have twice as many power outages on average[7] and significantly worse service reliability.[8] This is consistent with research suggesting that economies with poor service reliability often do not record or disclose data on the performance of public infrastructure (Alcott and others 2014).

Figure 1. Power outages have the longest duration in Sub-Saharan Africa and South Asia



Source: Doing Business database.
Note: The sample includes 142 economies. It excludes economies where SAIDI data are not available for 2015. Scale break is used on the average outage duration for Sub-Saharan Africa to illustrate an outlying value.

Figure 2. Power outages occur most frequently in Sub-Saharan Africa and South Asia



Source: Doing Business database.
Note: The sample includes 142 economies. It excludes economies where SAIFI data are not available for 2015. Scale break is used on the average outage frequency for Sub-Saharan Africa to illustrate an outlying value.

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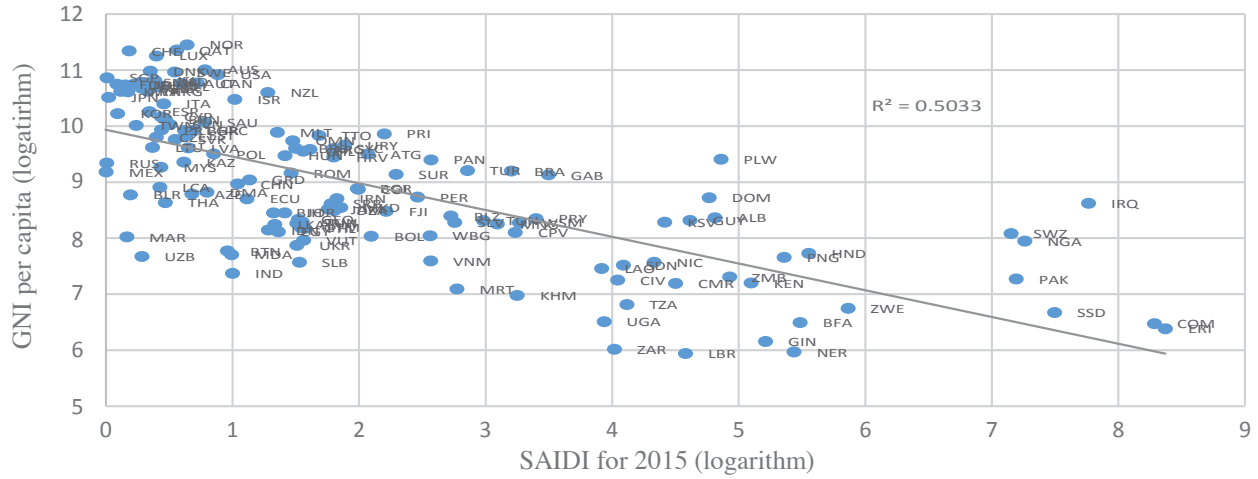
Figure 3. High-income economies have less outages in total duration



Source: Doing Business database; World Development Indicators database (http://data.worldbank.org/data- catalog/world-development-indicators), World Bank.
Note: The figure shows the average total duration of power outages over the course of 2015 for each customer served. There is a negative correlation coefficient of -0.71 between the natural logarithm of outages and the logarithm of GNI per capita. The relationship is significant at the 1% level. The sample includes 142 economies. It excludes economies where SAIDI are not available.

Electricity tariffs have decreased in the past three years

Business performance is sensitive to the cost of indirect inputs (Eifert and others 2008) and energy bills can constitute up to 30% of operating costs for an average company (Jewell 2006). A limited but growing body of research examines the impact of electricity tariffs on firm behavior. Abeberese (2016), for example, shows that manufacturing firms respond to exogenous tariff increases by reducing electricity consumption and switching to less energy-intensive industries. Boonzaaier and others (2015) find that electricity demand in South Africa is becoming more elastic in the wake of tariff surges and that eroding profits may lead to a change in investment decisions.

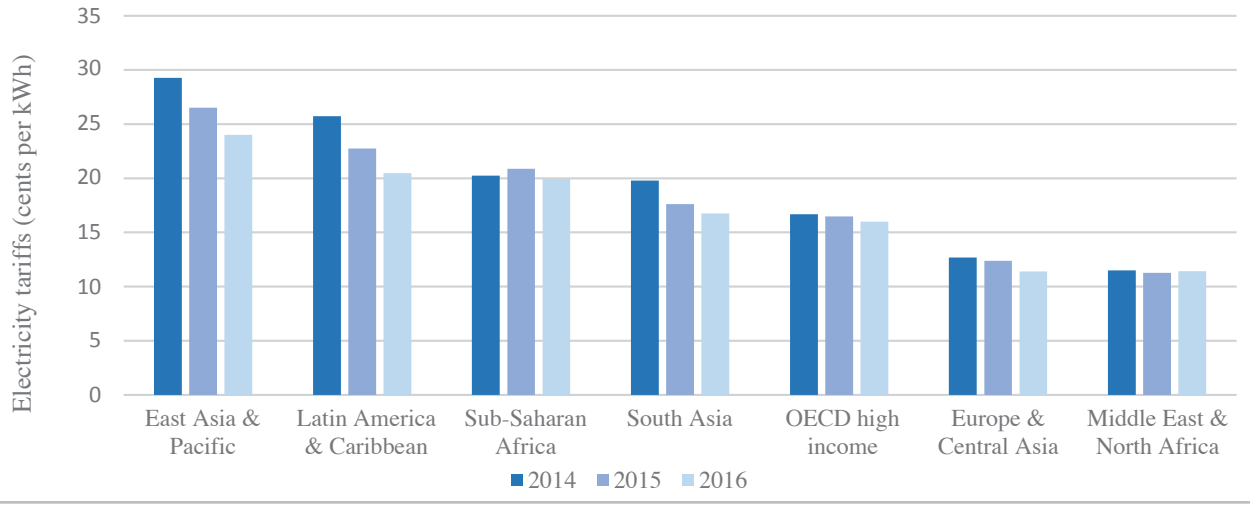
Doing Business measures electricity tariffs based on a set of assumptions and a hypothetical monthly consumption. On the basis of the assumptions about monthly consumption, a monthly bill for a commercial warehouse in the largest business city of the economy is computed. For comparability purposes, the price of electricity is measured in cents per kilowatt-hour (kWh). The data are collected from utilities and regulatory agencies and checked against sample bills sent by private sector professionals.

Electricity tariffs per kWh varied significantly in 2016, from less than 1 cent in Kuwait to 96 cents in the Solomon Islands.[9] The global average was 18 cents per kWh in 2016. The data show that, unlike outages, end-user tariffs are not associated with the income-level of economies.[10] At the regional level (Figure 4), electricity tariffs are the lowest on average in the Middle East and North Africa (11 cents) as well as Europe and Central Asia (11 cents). They are highest in East Asia and the Pacific (24 cents). Electricity tariffs also fluctuate from year to year. In 2016, for example, tariffs decreased by 7% on average at the global level. Interestingly, the Middle East and North Africa was the only region where average commercial tariffs increased as several economies in the Gulf lowered subsidies on domestic electricity prices due to falling revenues from fossil fuel exports. In Kuwait, for example, electricity tariffs for commercial clients were raised for the first time in 30 years, with tariffs increasing over tenfold.[11]

Electricity tariffs are likely to be lower in resource-rich economies

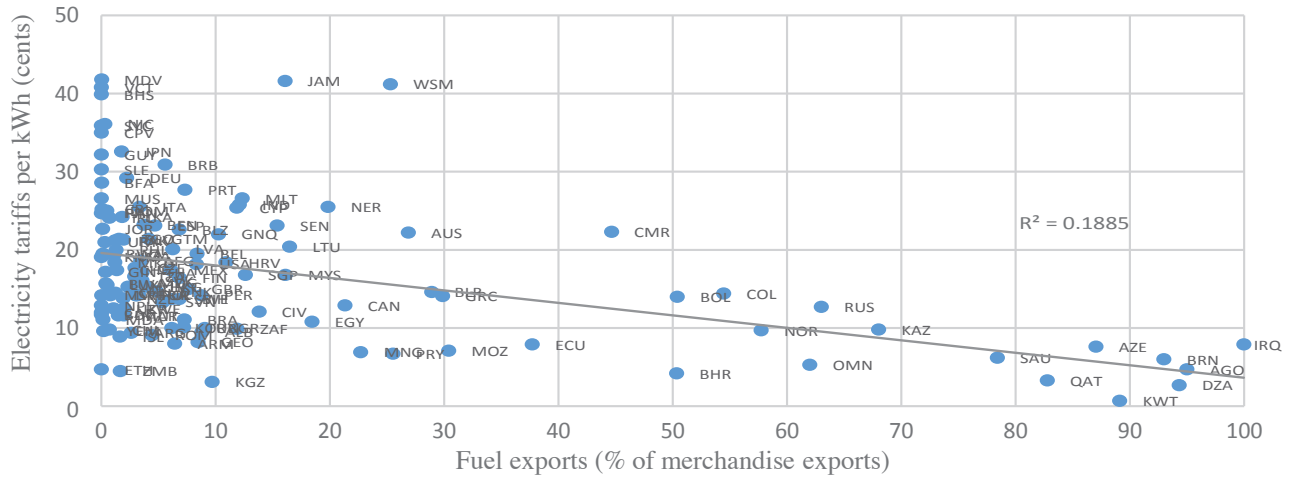
Resource-rich economies offer the lowest commercial electricity tariffs, while economies with low natural resource endowments—and relying on power generation using imported oil and gas—have the highest tariffs. The latter group includes several small island economies[12] such as the Solomon Islands (96 cents/kWh), Kiribati (46 cents) and Antigua and Barbuda (44 cents). These economies rely almost entirely on imported fossil fuels for power generation, making it expensive to produce electricity—and exposing them to oil price shocks. Economies with the lowest tariffs also tend to generate electricity through fossil fuel sources but they are able to subsidize domestic commercial tariffs thanks, in part, to oil and gas export revenues. These economies include Algeria (3 cents/kWh), Bahrain (5 cents) and Qatar (5 cents). Fuel exports as a percentage of total merchandise exports can be used as a proxy for natural resource endowment (Asiedu and others 2013). This measure shows a correlation with electricity tariffs; the relationship is even more pronounced for economies that export a large share of fuels (Figure 5).

Figure 4. Electricity tariffs have been declining since 2014



Source: Doing Business database.
Note: The sample includes 188 economies. República Bolivariana de Venezuela is excluded as it is an outlier. Somalia is also excluded as no data for 2014 are available.

Figure 5. Low electricity tariffs are associated with high natural resource endowment



Source: Doing Business database (tariffs are for calendar year 2015); World Bank staff estimates using data from the UN Comtrade database for 2016 (https://comtrade.un.org/), United Nations.
Note: The figure compares the share of fuel exports as a percentage of merchandise exports with electricity tariffs. The sample includes 127 economies for which data are available. The correlation coefficient between tariffs and fuel exports is -0.43. The relationship is significant at the 1% level.

A burdensome connection process is associated with utility corruption

The performance of infrastructure services is associated with the quality and efficiency of regulatory institutions (Kirkpatrick and others 2002; Cubbin and Stern 2006; Andres and others 2008). *Doing Business* measures the process of getting electricity based on the time, cost and interactions required to obtain a new connection to the grid.

The process of getting an electricity connection varies significantly across economies and regions (Geginat and Ramalho 2015). For example, in South Asia it takes on average 138 days to obtain a new connection—the most of any region—compared to an average of 66 days in Latin America and the Caribbean. The number of procedures varies widely: in the United Arab Emirates it takes three procedures to obtain a new connection compared to nine procedures in Nigeria. Furthermore, it takes significantly longer to get connected to the electrical grid in economies where a higher number of procedures are required. On average, it takes a customer 67 days to get connected to the grid in economies where three procedures are required; this number rises to 245 days in economies where nine procedures are required.

Comparing estimates on the procedures, time and cost to connect,[13] it can be observed that the higher the income group, the easier the connection process. The OECD high-income economies, for example, have the simplest connection process. Another finding is that utility corruption is associated with more complex connection processes; there is a higher likelihood of utility corruption in economies where there is more interaction between the utility and customers, both in terms of time and procedures (Figure 6).

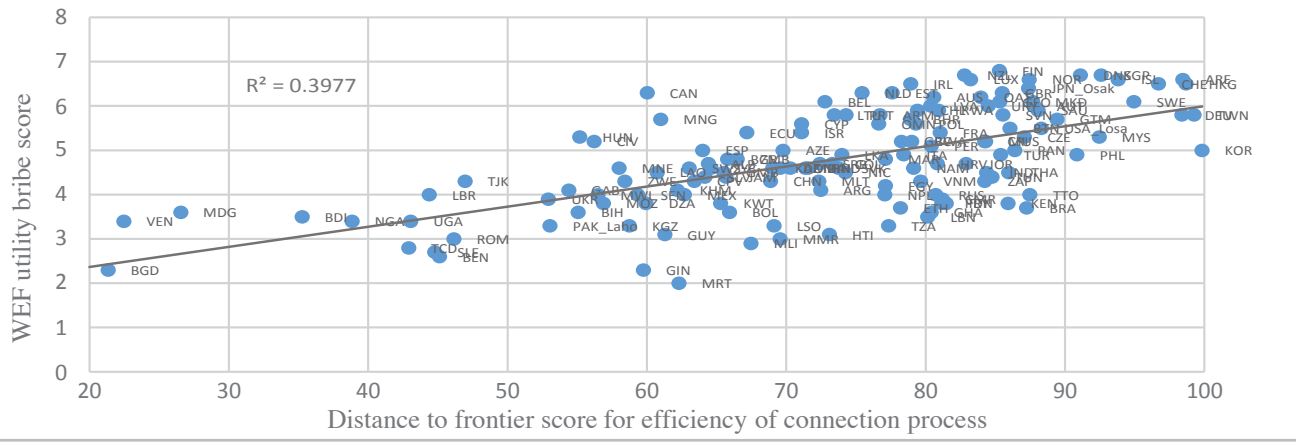
Power outages are correlated with a difficult connection process, while electricity tariffs are not associated with either measure

Historical *Doing Business* data show that power outages are negatively associated with the efficiency of grid connections.[14] This is consistent with Geginat and Ramalho (2015), who suggest that utilities ensuring better customer service are more likely to ensure better service reliability. On the other hand, electricity tariffs are not associated with the number or duration of power outages.[15] Electricity tariffs are subject to myriad forces beyond the control of the utilities and, as such, they do not always act as efficient price signals (Viera and others 2016). On the demand side, market size and exogenous factors such as weather conditions have an impact on tariffs. On the supply side, tariffs are impacted by an economy's natural resource endowment as well as the regulations it has in place. Governments may choose to subsidize tariffs to make electricity consumption affordable for the population through public fund transfers or cross-subsidization between consumer groups. Given these factors, it is not surprising that end-user tariffs do not reflect an economy's ability to meet peak demand or carry out connections in an efficient manner.

Electricity sector constraints are negatively associated with measures of energy demand

Power outages, electricity tariffs and burdensome connection procedures can impact firms to varying degrees. Therefore, it is interesting to see how these variables are associated to firms' demand for energy inputs. The International Energy Agency (IEA) provides data on electricity consumption

Figure 6. The more complex the connection process, the higher the likelihood of utility corruption



Source: Doing Business 2017 data; World Economic Forum 2015.
Note: The sample includes 140 economies for which data are available. The correlation coefficient between the distance to frontier score for the ease of connecting (DB2017) and the WEF's Global Competitiveness Index (GCI) score for frequency of bribe payments for calendar year 2015 is 0.63. This relationship is significant at the 1% level. The GCI utility bribe index is based on survey results from businesses which are asked how common it is to make undocumented bribes to public utilities. The index is scored from 1 to 7; a score of 1=very common and a score of 7=never occurs.

Table 1. Robust regression analysis of the percentage of firms owning a generator (city level)

	(i) Generator ownership (%)	(i) Generator ownership (%) with income control
Outages (log of SAIDI)	**8.383*** **	**8.099*** **
	(1.021)	(1.254)
Electricity Tariffs (cents per kWh)	**0.618*** **	**0.610*** **
	(0.13)	(0.13)
Ease of connecting (DTF)	**-0.260** **	**-0.241***
	(0.13)	(0.12)
Income (log of GNI)	-	**(1.19)**
	-	(2.01)
Observations	96	96
R-squared	0.661	0.662
Standard errors in parentheses	*** p<0.01, ** p<0.05, * p<0.1	

Source: Doing Business database; Enterprise Surveys database (http://www.enterprisesurveys.org), World Bank.
Note: Sample excludes all World Bank Enterprise Surveys data prior to 2010.

per capita. A regression analysis of the IEA measure of firm consumption against the Doing Business electricity infrastructure measures shows that both power outages and electricity tariffs are negatively associated with consumption.[16] This may suggest that electricity demand is not inelastic and tariff levels impact the consumption levels of firms.

The percentage of firms using a generator, as reported by World Bank Enterprise Surveys data, is another measure of energy demand. It could be surmised that—where electricity services are unsatisfactory for businesses (including reliability of electricity supply, tariffs and efficiency of connection to the grid)—more firms rely on off-grid solutions; this is corroborated by regression results.[17] For example, when income is controlled for, a 1% increase in the level of outages is associated with an 8 percentage point increase in the share of businesses owning a generator. Similarly, a 1 cent increase in electricity tariffs is associated with an increase of 0.6% in the share of generator ownership, while a 1% increase in the efficiency of electricity connection is associated with a 0.26 percentage points decrease in the share of firms owning a generator. More burdensome connection procedures are associated with more firms having self-supply capacity.

Conclusion

Using recent *Doing Business* data, this note provides an analysis of electricity sector constraints across economies. The findings provide some interesting insights. Not surprisingly, service unreliability is a significant factor in low-income economies, where power outages fluctuate significantly from year to year. Furthermore, electricity tariffs are associated with an economy's natural resource endowment, while burdensome electricity connections are associated with utility corruption.

Consistent with the existing research, the data reveals that electricity sector constraints impact firm behavior in terms of demand for energy inputs. One major question, however, remains to be explored: how is the performance of firms impacted by specific electricity sector constraints, namely (i) power outages, (ii) electricity tariffs and (iii) the connection process? This is will be explored in an upcoming policy note.

NOTES

1 IEA 2016.
2 World Bank Group 2015.
3 According to World Bank Enterprise Surveys data, over 11% of business owners in developing economies perceive a lack of reliable electricity supply as their biggest obstacle, behind access to finance (15%), the informal sector (12%) and political instability (12%). For more, see the website at http://www.enterprisesurveys.org.
4 According to the World Economic Forum (WEF), infrastructure is one of four pillars that are "basic requirements" for global competitiveness.
5 Economies where two cities are measured are Bangladesh, Brazil, China, India, Indonesia, Japan, Mexico, Nigeria, Pakistan, the Russian Federation and the United States.
6 According to World Bank Enterprise Surveys, electricity is perceived as major constraint to doing business by 39% of firms in Sub-Saharan Africa, 41% in the Middle East and North Africa and 46% in South Asia. These represent the highest share of all regions.
7 Controlling for sample size and the city considered, and for 35 economies where no SAIFI data are available, there is an average of 131 outages a year, according to data from the World Bank Enterprise Surveys. For a sample of 103 economies where SAIFI is available, on average 53 outages a year are reported.
8 Controlling for sample size, and for 24 economies where no SAIFI data are available, the average World Economic Forum 2015 Global Competitiveness Index (GCI) score on the quality of electricity supply is 2.4. In contrast, for a sample of 116 economies where SAIFI data are available, the score is 4.9.
9 República Bolivariana de Venezuela is excluded from the sample.
10 The correlation coefficient between tariffs and GNI is 0.12. The relationship is not significant.
11 As of May 16, 2016, electricity tariffs for commercial users in Kuwait were raised from 2 fils/kWh (0.7 cents) to 25 fils/kWh.
12 Eleven of the 15 economies where commercial electricity tariffs are the highest are islands economies with less than one million in population. These are Antigua and Barbuda; Cape Verde; Dominica; Kiribati; Marshall Islands; Micronesia, Fed. Sts.; Samoa; Seychelles; Solomon Islands; Tonga; and Vanuatu.
13 The distance to frontier score is calculated. For each economy, the number of procedures, time and costs are normalized to a common unit from 0 to 100, where 0 represents the lowest performance and 100 represents the frontier. An average of these three scores is then computed and used for the analysis.
14 The correlation coefficient between the distance to the frontier ease of connection score (2014-2016 average) and SAIDI (2013-2015 average) is-0.52. This relationship is significant at the 1% level.
15 The correlation coefficient between electricity tariffs (2014-2016 average) and SAIDI (2013-2015 average) is-0.10.
16 While the IEA measures aggregate electricity consumption for households and businesses, according to the US Energy Information Association commercial and industrial customers account for 60% of electricity consumption. Using electricity consumption as the dependent variable, outages (log of SAIDI) and electricity tariffs are found to be negatively associated to consumption. These relationships are significant at the 1% level when controlling for income. A robust regression is used to minimize the impact of outliers.
17 The regression uses three-year averages for Doing Business data as the survey year for the World Bank Enterprise Surveys varies from economy to economy. World Bank Enterprise Surveys data prior to 2010 are excluded and the weighted aggregates for each major business city are selected. For outages, a logarithm of SAIDI is used to normalize data. The results presented below show little change when SAIFI is used. A robust regression is used to minimize the impact of outliers.

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