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# The Impact of Electricity Shortages on Firm Productivity

## Evidence from Pakistan

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## Abstract

Power shortages present a significant challenge to manufacturers, who rely on power as a key input to production. In Pakistan, power shortages are commonplace, but empirical evidence on the impact of shortages is still lacking. Using a survey of 4,500 manufacturing firms for the year 2010–11, this paper estimates the impact of electricity shortages on firm productivity in Pakistan. The analysis finds that a 10 percent increase in the duration of outages on average leads to a 0.14 percent decrease in a firm's total revenue and a 0.36 percent decrease in the value added, all else being equal. There is heterogeneity in the impacts of shortages across sectors: the industries that are most energy-intensive, such as manufacturers of metal, wood, and paper, are affected the most severely by shortages.


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# The Impact of Electricity Shortages on Firm Productivity: Evidence from Pakistan[1]

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## 1. Introduction

In many developing countries, a significant barrier to economic growth is an unreliable supply of electricity. Electricity shortages in South Asia are especially widespread, with the average firm experiencing nearly an outage per day, lasting roughly 5.3 hours each. Within South Asia, Pakistan has the most severe power shortages where firms report 2.5 outages each day with an average duration of 13.2 hours. More than 75 percent of firms in Pakistan identifying lack of reliable electricity as a major constraint to their operation and growth (Figure 1).

Absent a reliable supply of electricity, manufacturing firms must substitute away from energy-intensive capital or divert investments toward diesel generators, and credit constraints and market imperfections can compound these inefficiencies. In the absence of alternative sources of electricity, particularly for unanticipated outages, firms must send workers home, which decreases the productivity of labor.

Several recent studies quantify the impacts of electricity shortages on various firm- and household-level outcomes. Allcott, Collard-Wexler, and O'Connell (2016) estimate the productivity impacts of large manufacturing firms in India. Grainger and Zhang (2017) follow a similar identification strategy but focus on micro-, small, and medium Indian enterprises, and they find much larger impacts on unit costs. Fisher-Vanden, Mansur, and Wang (2015) examine the productivity and environmental effects of electricity shortages in China. Foster and Steinbuks (2009), Alby, Dethier, Straub, et al. (2011) and Andersen and Dalgaard (2013) examine the impact of outages on firm size and technological adoption. Samad and Zhang (2016, 2017) analyze the effects of power outages on household welfare in India and Bangladesh. Chakravorty, Pelli and Marchand (2014) examine the effects of power supply reliability on the benefits of electrification.

Despite the wide recognition that electricity shortages result in substantial losses for the economy in Pakistan, empirical study that quantifies the impact is still lacking. In this paper, we study the impact of power shortages on manufacturing firms in Pakistan. We match firm-level data from the Census of Manufacturing Industry conducted by the Pakistan Bureau of Statistics with district-level power shortage data reported by distribution utilities. Using a sample of 4,500 manufacturing firms for 2011, we estimate the impact of electricity shortages on firm-level value-added and total product value while controlling for each firm's sector, labor costs, the costs of raw materials, the value of fixed capital assets, and the value of energy inputs. Our estimates suggest that a 10 percent increase in the total hours of outages on average leads to a 0.14 percent decrease in a firm's total value of output and a 0.36 percent decrease in the value added. There is also heterogeneity in the impact of outages on productivity across sectors: the most energy-intensive, technical manufacturers are impacted the most severely by shortages.

In what follows, we provide an institutional and economic background on Pakistan, focusing on electricity shortages and their causes. We then describe the firm-level data and power shortage data in Section 3, describe the empirical model in Section 4, and provide cross-sectional estimates in Section 5. Section 6 offers a discussion and concluding thoughts.

## 2. Background

Pakistan faces massive electricity shortages. Since 2006, nation-wide power shortages, the difference between projected demand and actual supply, have been steadily increasing each year and have risen to 26 percent of total demand, or 29 TWh in 2013 (Figure 2). To address supply shortfalls, utilities implement systematic rolling blackouts that can last 6 to 14 hours each day. In some areas of Pakistan summertime load shedding of 8 to 10 hours per day is typical, and in some areas up to 18 to 20 hours of load shedding happens on a regular basis.

Multiple price and institutional distortions have contributed to the current power crisis in Pakistan. On the pricing side, historically, electricity price has been set much lower the cost of supply. The gap is financed by direct budget support and cross-subsidization across consumer groups. Recent electricity tariff reforms have substantially lowered subsidy spending from more than 2 percent of gross domestic product (GDP) per year in the past decade to 0.8 percent of GDP in fiscal year 2014. However, the weighted average end-user tariff is still only about 50 percent of the average supply cost in fiscal year 2014. Underpricing of electricity undermines the incentives of power utilities to provide high-quality services, creating a so-called "subsidy trap" (McRae 2014).

When distributors were not fully paid through the combination of tariffs and subsidies, they in turn could not pay the generators. In Pakistan, accumulated arrears of distribution companies to suppliers, commonly known as circular debt, reached 280 billion rupees, or 1 percent of GDP, on March 31, 2015. Circular debt has caused up to 5 gigawatts (GW) to lie idle, accounting for almost 22 percent of the total installed capacity in Pakistan (World Bank, 2015). Furthermore, when capacity is used, it is substantially inefficient. For example, the average efficiency of gas power plants in

Pakistan is 30 percent as compared to the average efficiency of 43 percent for gas power plants in the United States.[2] Aging infrastructure and overloaded transmission and distribution systems also contributed to high losses in the network. In fiscal year 2014, average transmission and distribution losses reached about 21 percent of all the electricity generated.

Another cause for Pakistan's power shortages is upstream gas shortfalls. Gas plays an important role in power generation in Pakistan, constituting 25 percent of total electricity produced in 2014. Despite having large gas reserves, the low price of domestic gas has made gas supply increasingly fall short of demand in recent years. Specifically, natural gas was priced on average at 5 per million British Thermal Units (MMBTU) during 2009 and 2015 in Pakistan. In contrast, the price of liquefied natural gas was between USD 10 and 15 per MMBTU during the same period in the Asian market. Gas underpricing not only results in wasteful consumption, but also reduces investors' interest in upstream exploration and production. Meanwhile, there are huge losses in gas transmission and distribution. The amount of unaccounted-for-gas, the difference between gas available for sale and gas actually sold, has reached 12 percent of total supply in 2016.

Facing supply shortfalls, domestic gas is being allocated to different sectors based on administrative orders. Although the economic benefit of using gas in power generation is expected to be among the highest in all sectors in Pakistan (USAID 2011), gas is diverted from power to other sectors such as fertilizer and transport. With gas resources waning, Pakistan has to increasingly rely on expensive imported fuel oil for power generation. Imported fuel oil is used for close to 40 percent of overall power generation in 2014, but the cost of this generation accounts for about 70 percent of the total energy cost. Reliance on oil-based power generation has resulted in higher cost of electricity and further worsened the circular debt issue.

Finally, although Pakistan has huge untapped hydropower and substantial wind and solar potential, development in renewable energy has been almost stagnant over the past decade.

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[2] United States Energy Information Administration. https://www.eia.gov/electricity/annual/html/epa_08_01.html

## 3. Data

Data for this study come from two sources. The first is the 2010-11 Census of Manufacturing Industries conducted by Pakistan Bureau of Statistics. The second data source is the distribution company performance evaluation report by National Electric Power Regulatory Authority (NEPRA). We describe these in turn.

### 3.1 Firm Data

The Census of Manufacturing Industries provides a thorough annual overview of firm-level activities, including detailed information on a variety of input costs, including labor, capital and electricity, as well as revenue data. The 2010-2011 census mainly covers firms in Punjab province.[3] Punjab in Pakistan has the largest economy of all provinces and the majority of the manufacturing activity is concentrated in this area.

The census covers 4,499 firms in 23 sectors at the 2-digit level of Pakistan Standard Industrial Classification (PSIC).[4] The distribution of firms by the 2-digit classification are shown in Table 1. Of the 23 divisions, number 13 (Manufacturing of Textiles) covers roughly 28 percent of our sample, division 10 (Manufacturing of Food Products) accounts for 15 percent, and division 32 (Other Manufacturing) is the third-largest with 11 percent of the sample. The 23 sectors can be further broken down into 236 subcategories at the 5-digit level of PSIC.

Firm-level characteristics are described in Table 2. The mean total product value at the firm level is about 523,000 rupees[5], whereas the mean value-added is 114,000 rupees. Average total employment costs are just over 17,000 rupees, whereas the average cost of raw materials is over 300,000 rupees. Firms have an average value of fixed assets of 150,000 rupees, which is notably half the value of the raw material costs for the average firm and less than a third of the value of the product output. The median number of employees at a firm in the census is 22 people, with an average of 103 and a standard deviation of 569.

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[3] There are four firms in the data set located outside Punjab province, including one in Karachi and three in Islamabad. Excluding these firms from the sample does not change the estimation results.

[4] A description of the PSIC and the relationship to ISIC is available at the following http://www.pbs.gov.pk/sites/default/files/other/PSIC_2010.pdf

[5] The Rupee-USD exchange rate was roughly 85:1 in June 2011.

### 3.2 Shortage Data

Power shortage data are reported annually by distribution companies (DISCO) to NEPRA and are published in the DISCO Performance Evaluation Report. The latest evaluation report includes shortage data at the DISCO level from year 2010-2011 to year 2014-2015. There are 11 distribution companies in Pakistan, among which 6 provide service in Punjab province. We identify service areas by district for each DISCO and match firm-level data with shortage data based on district-level identifiers in the census data for year 2010-2011. The providers (and corresponding number of firms) in our data are IESCO (120), GEPCO (1,517), FESCO (1,281), LESCO (1,159), and MEPCO (372).

Although power shortages are nationwide and systematic, there is large variation in shortages at the DISCO level, which is partially linked to differences in supply and demand for electricity and partially linked to differences in operating performance of DISCOs. In fiscal year 2014, for example, average transmission and distribution losses ranges from 9.4 percent to 38.2 percent, while collection rate ranges from 33 percent to over 100 percent across the 11 distribution companies.

Shortages are characterized by two reliability indices in the data: one represents the frequency of shortages, and the second represents the duration of shortages. The System Average Interruption Frequency Index (SAIFI) is the average number of interruptions that a customer experiences in a year. Specifically, SPAIFI is calculated as the total annual number of consumer supply interruptions divided by the total number of consumers that the distribution company serves in any a given year. The second measure, the System Average Interruption Duration Index (SAIDI), captures the outage duration (in minutes) that an average customer experiences in a year. Both SAIFI and SAIDI do not encompass outages caused by load shedding. However, there is still large variation in the value of SAIFI and SAIDI across regions. Among the distribution companies in our data, the SAIFI measure ranges from 0.41 (IESCO) to 185.5 (MEPCO) (Figure 3), while the SAIDI measure ranges from a minimum value of 22.6 minutes for IESCO to a maximum of 15,896 minutes (roughly 11 days) for PESCO (Figure 4). In our econometric analysis, we exploit regional variation in the reliability of power supply measured by SAIDI and SAIFI to identify the relationship between shortages and firm productivity.

For year 2010-11, these two measures of shortages have a correlation coefficient of -0.13 across the 11 distribution companies covered in the NEPRA report, but for the six distribution companies in Punjab Province, the correlation coefficient for the SAIDI and

SAIFI is about 0.54. We incorporate both measures of outages because they may have different impacts on manufacturing firms. The frequency of disruptions may have a smaller impact if load-shedding is anticipated, but we expect that longer durations will have a measurable impact regardless of regularity.

**4. Empirical Approach**

Given the data described above, we are interested in the impact of electricity shortages on firm-level value-added and revenues, holding constant costs of inputs and firm-specific characteristics. A regression of the following form is estimated as the baseline specification:

$$Y_i = \alpha + \beta * \ln(shortage_i) + \gamma * X_i + \delta S_i + \epsilon_i$$

where $Y_i$ is the outcome of interest (i.e. either the natural log of revenues or value-added) for firm *i*, $shortage_i$ is the shortage index experienced by firm *i*, $X_i$ are input costs and other firm-level characteristics, including firms' labor costs, raw material costs, fixed assets and total electricity costs. $S_i$ is sector fixed effects, capturing shocks that are common to all firms in a sector. $\alpha, \beta, \gamma$, and $\delta$ are parameters to be estimated. $\epsilon_i$ is the error term. Because the frequency and duration of shortages could have differential effects on firm productivity, we estimate alternative specifications to allow for alternative measures of the severity of shortages as described in the data section.

There could also be heterogeneous effects of shortages at the sector level. For example, energy-intensive sectors may be more vulnerable to power supply disruptions. In addition, sectors such as textile industry that are often equipped with gas-based captive power generators are likely to be less affected by power shortages. To test this hypothesis, we allow for heterogeneous impacts by two-digit PSIC groups. We note that there are tradeoffs in exactly how we implement this test. We could estimate the regression separately for each two-digit sector, but given the small data set, this will likely lead to few significant coefficients. Alternatively, we can include interaction terms for the PSIC dummy variable and shortages, assuming that the impacts for the other variables (labor costs, raw material costs, values of fixed assets, and energy costs) are the same across sectors as before. In next section, we report both results which are qualitatively similar in terms of coefficient magnitudes, but in the latter case we are able to get more precise estimates of the impact of outages.

Because we rely on cross-sectional data for the estimation, there are challenges to causal identification of the impact of shortages on firm-level revenues or value-added. First, there is likely unobserved firm-level heterogeneity, which can affect both firm performance and shortages experienced by the firm. For example, more productive firms may be attracted to less shortage-prone districts. More productive firms are also more likely to acquire self-generators. Second, shortage is likely to be endogenous to growth and business climate at the district level. For example, areas that provide more friendly business environment and experienced faster economic growth can have higher demand for electricity. This will in turn result in worse power shortages (Allcott, Collard-Wexler, and O'Connell 2016; Grainger and Zhang, 2017). Finally, there is likely measurement error in our measurement of shortages, because we only capture district-level average outages, but not actual outage experienced by each firm. In the following, we present our estimation results while recognizing the above caveats of the identification strategy.

## 5. Empirical Results

Following the approach outlined in Section 4, we first estimate the impact of electricity shortages on firm-level product revenues, and then we assess the impact of shortages on firm-level value-added.

### 5.1 Product Revenues

Table 3 presents the results of our product revenue regressions in which the dependent variable is the natural log of product revenues at the firm level. There are 3,105 observations in the data with observations for all of the variables included in the regressions. Columns (1) and (2) include the duration index (SAIDI) as the shortage variable, while (3) and (4) include the frequency measure (SAIFI). The fifth column includes both.

The control variables for firms' labor costs, raw material costs, fixed assets and total electricity costs all have positive, significant impacts on product revenues, as expected. Furthermore, the regressions explain a significant amount of variation in product revenues with Adjusted R-squared values around 0.96 across specifications.

In the first two columns, we find that a 10 percent increase in the average total duration of outages decreases firm-level revenues by between 0.14 and 0.28 percent. Since column (2) includes two-digit PSIC fixed effects, this is our preferred specification, with an elasticity estimate of -0.014.

In columns (3) and (4), the estimates indicate that a 10 percent increase in the frequency of outages is associated with a decrease in revenues of between 0.1 percent and 0.2 percent, though the effect is insignificant when including PSIC sector fixed effects. Finally, in the fifth column we include both the duration and frequency indices. The duration index is significant, with an elasticity of -0.02, whereas the frequency index is insignificant and positive. It shows that when controlling for frequency of power shortages, a 10 percent increase in the duration of outages is on average associated with a 0.2 percent reduction in firm revenue.

### 5.2 Value-Added

In Table 4 we show estimates analogous to those for the product revenue regressions in Table 3, but with the dependent variable being the natural log of value-added. Overall the regressions explain less of the variation than in the product revenue regressions, but the adjusted R-squared values are still high at around 0.70. There are 3,274 observations in each regression.

In the first two columns, we see that the duration of outages has a negative, significant impact on a firm's value-added. In our preferred specification, which includes two-digit PSIC indicators, the elasticity is -0.036. This means that a 10 percent increase in the average total duration of outages leads to a 0.36 percent decrease in a firm's value-added. The effect of outages on value added is more than twice as large as that on revenue. This result suggests that even though firms can rely on self-generators to reduce the impact of shortages on output loss, the impact of shortages on value-added is more difficult to be mitigated because self-generators are in general less efficient and much more expensive than grid electricity.

As with the product revenue regressions, the frequency index leads to smaller and less significant coefficients, suggesting that the duration is potentially more important than the frequency of outages. In the fifth column, we see that a 10 percent increase in the duration of shortages leads to a 0.7 percent decrease in value-added, all else being equal. The coefficient associated with the frequency of outages is positive, suggesting that holding constant the total duration of outages in a year, more frequent shortages have an offsetting effect on revenue decrease due to power shortages. When the total duration of outages is holding constant in a year, more frequent outages means shorter duration of outages each time. This result suggests that firms on average would prefer shorter, more frequent shortages than fewer, long-lasting outages.

### 5.3 Heterogeneity by Sector

Figures 5 and 6 show the impacts of the duration of outages on firm's total output value and value-added by sector, respectively.  Figures 7 and 8 show impact of the frequency of outages on firm's output value and value-added, respectively. All results are based on sector-by-sector regressions.

The results indicate significant heterogeneity in impacts by sector. In the duration regressions, sector 16 (i.e. the manufacture of wood and products of wood and cork, except furniture) has the largest effect in absolute value, with an elasticity of roughly -0.24 in Figure 5, but it is imprecisely estimated, due to a small sample of observations. In the frequency regressions, sector 18 (printing and reproduction of recorded media) has the largest effect, with an elasticity of -0.4, again imprecisely estimated.

Of the significant impacts we estimate, sector 15 (manufacture of leather and related products) has an elasticity of roughly -0.15, and sector 17 (manufacture of paper and paper products) has a precisely estimated effect close to the overall average, with an elasticity of -0.06. Sectors 24 and 25, both of which deal with the manufacturing of metal products, have larger than average elasticities in the range of -0.15 to -0.20.

## 6. Discussion

Pakistan faces severe power shortages, but the question remains as to what impact shortages have on the national economy. Using a survey of 4,500 manufacturing firms in Punjab for 2011, we provide new empirical evidence on the impact power shortages have on firm productivity in Pakistan. Though the data in this study are limited to a cross-section, results in the paper suggest that there is indeed a strong negative correlation between electricity shortages and manufacturing revenues and value-added in Pakistan.

We use two measures of the reliability of power supply: the duration and frequency of power outages. Our baseline estimates suggest that the elasticity of the value of output to total duration of outages is roughly -0.014. That is, a 10 percent increase in the duration of outages on average leads to a 0.14 percent decrease in a firm's total value of output. On the value-added side, the elasticity is more than twice as large; a 10 percent increase in the total duration of outages on average leads to a 0.36 percent decrease in a firm’s value added.

There is also heterogeneity in the impact of outages on productivity across sectors; the most energy-intensive, technical manufacturers are impacted the most severely by shortages. The corresponding elasticities for manufacturers of various metal products are closer to -0.2, indicating that shortages can have a serious deleterious impact on firm productivity for energy-intensive manufacturing firms.

In the absence of outages, firms would likely behave very differently, including producing at different times during the day, employing different mixes of capital and labor, and even engaging in different activities altogether. Therefore, we believe our estimates to be conservative and underestimates of the actual losses due to the frequent outages experienced by firms in Pakistan.

On the other hand, the impact of frequency of outages has a small negative impact on firm output value or value-added, but the effects are not statistically significant. When holding constant total hours of outages in a year, more frequent shortages even have an offsetting effect on revenue decrease due to power shortages, suggesting that firms on average would prefer shorter, more frequent shortages than fewer, long-lasting outages.

There are a few caveats worth discussing. First, as discussed earlier, there are likely unobserved firm characteristics that affect our results through omitted variables bias, perhaps due to the locational decisions of the more- and less-productive firms. Second, we are unable to account for self-generation in the data. Though we have information on other fuel use, the effects (which are not shown) are virtually the same for firms that report purchasing other fuels, but this measure is imperfect. Third, outages are likely to be endogenous to economic growth at the district level. Endogeneity of shortages at the firm and district levels could both lead to an underestimation of the impact of power shortages on firm productivity. Therefore, our estimated impact of power shortages is likely to be a lower bound of the true effect. Future work will incorporate panel data as well as more precise measures of outages at the firm location, which will help us come closer to a true causal effect.

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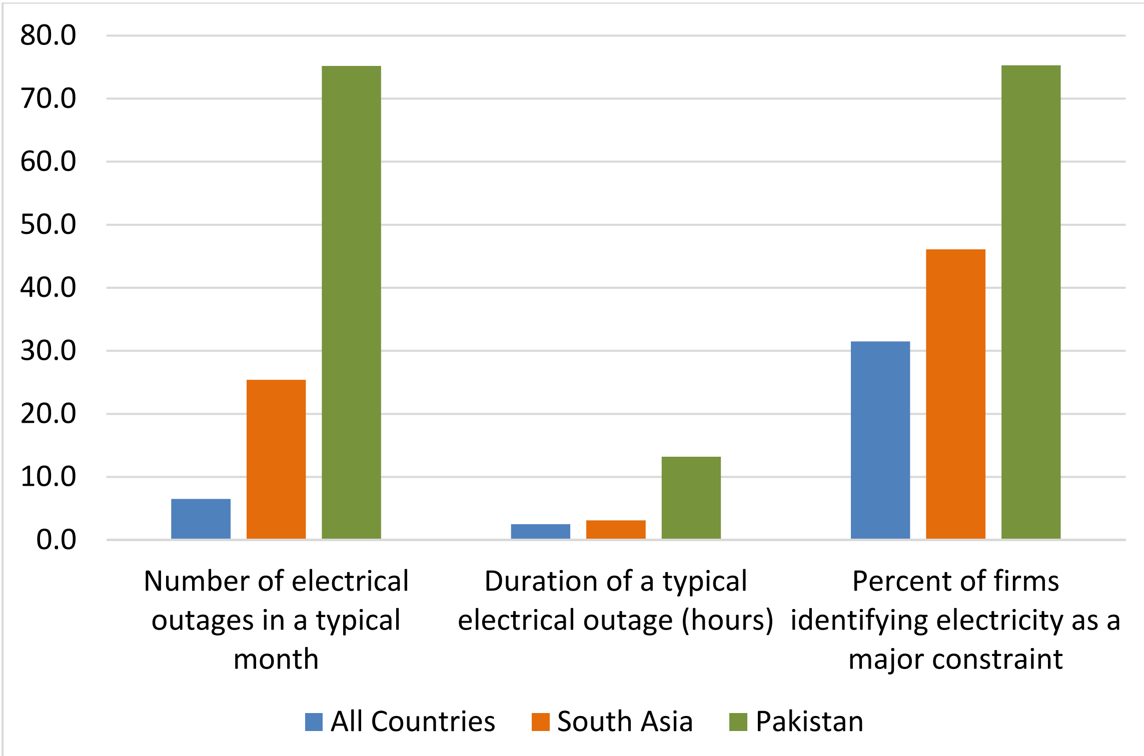
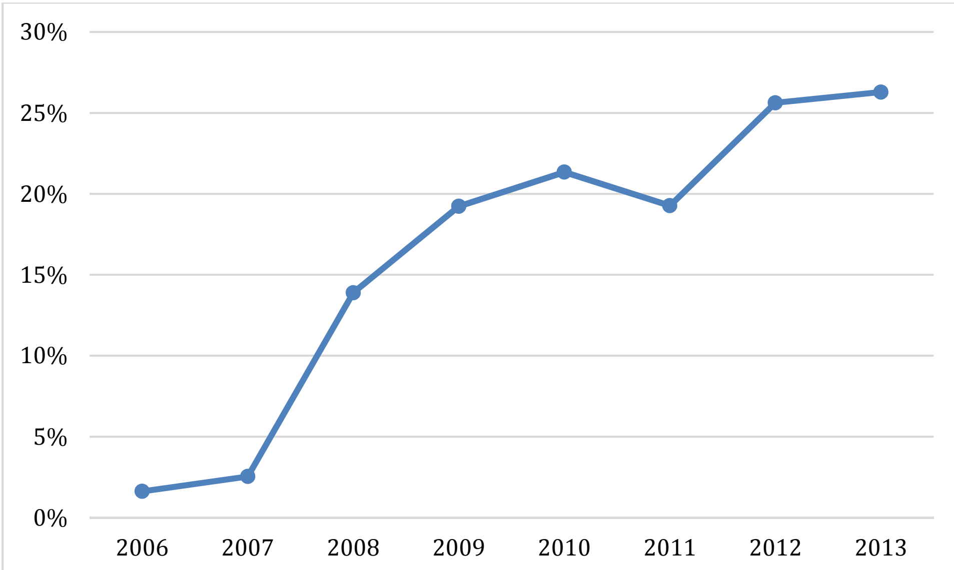
## Figures

**Figure 1  Power outages and their impact**



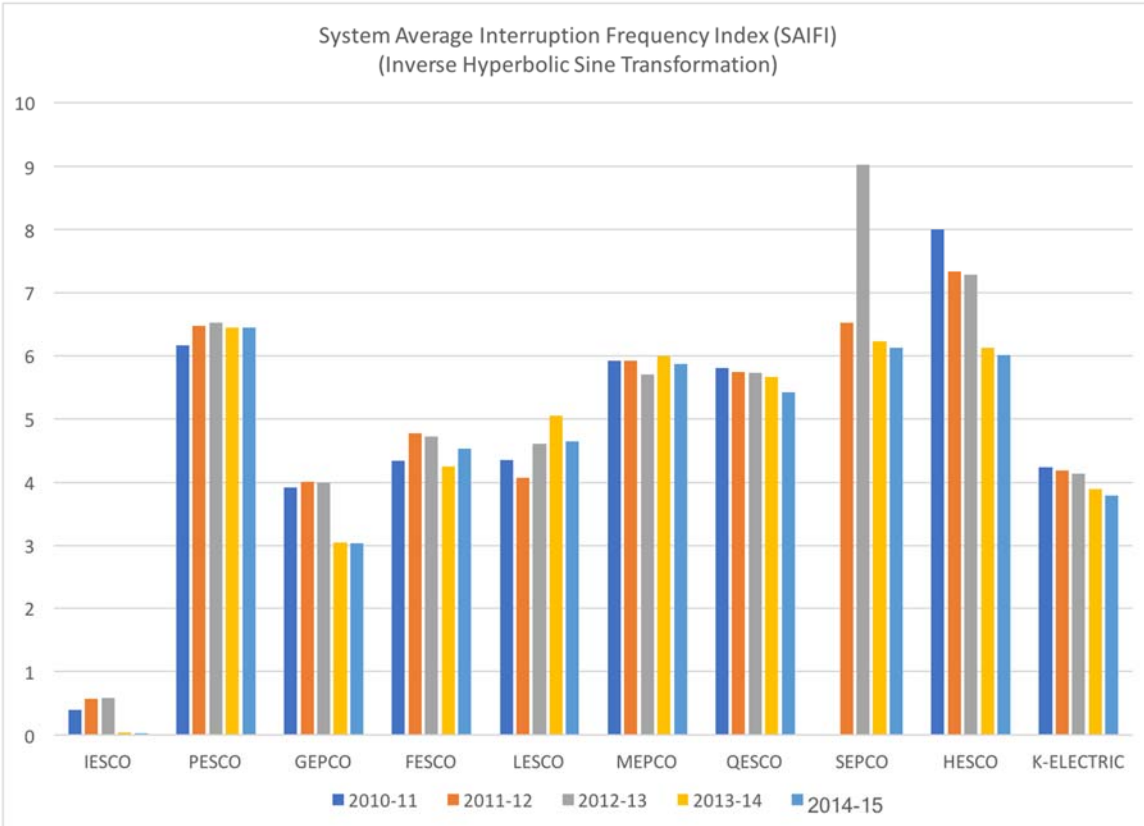

Source: World Bank Enterprise Survey for Pakistan (2013)

**Figure 2 Power shortages in Pakistan (%) (2006-2013)**




Source: Electricity Demand Forecast by Planning Power of National Transmission and Dispatch Company (NTDC) (2014).

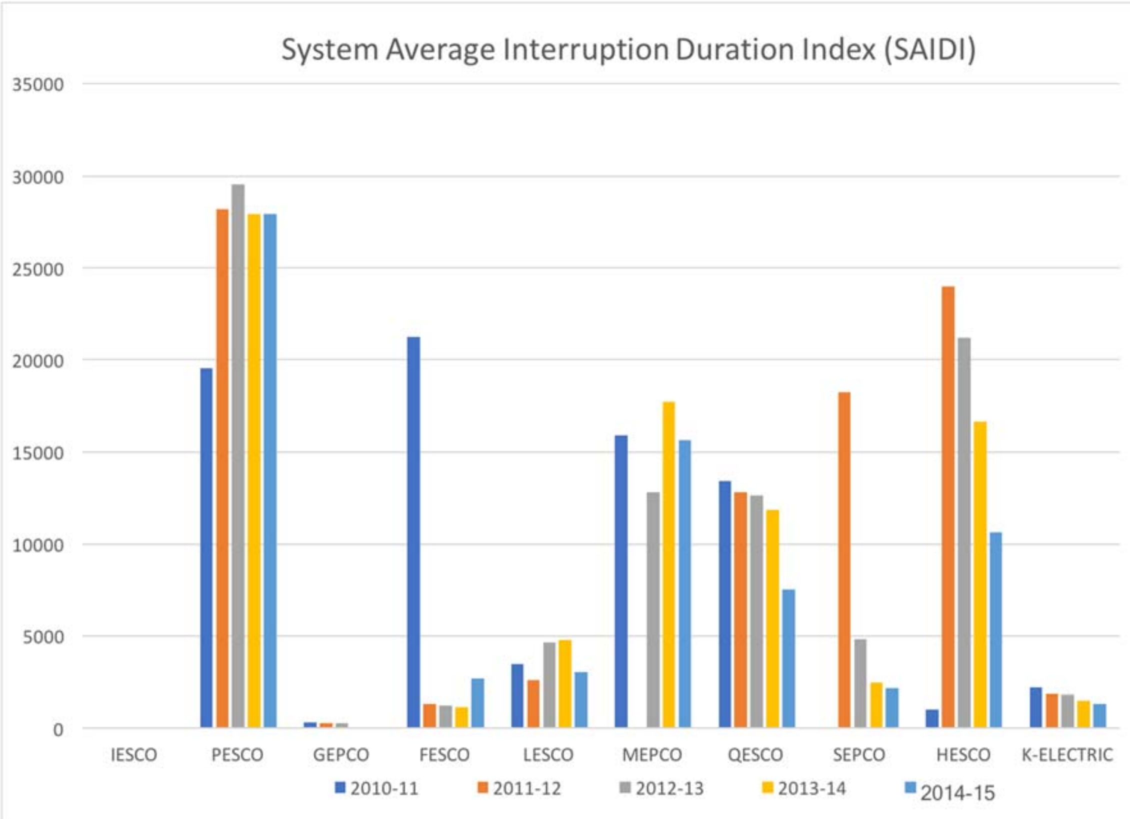
**Figure 3 System Average Interruption Frequency Index**




Source: DISCO Performance Evaluation Report 2014-2015 by NEPRA.

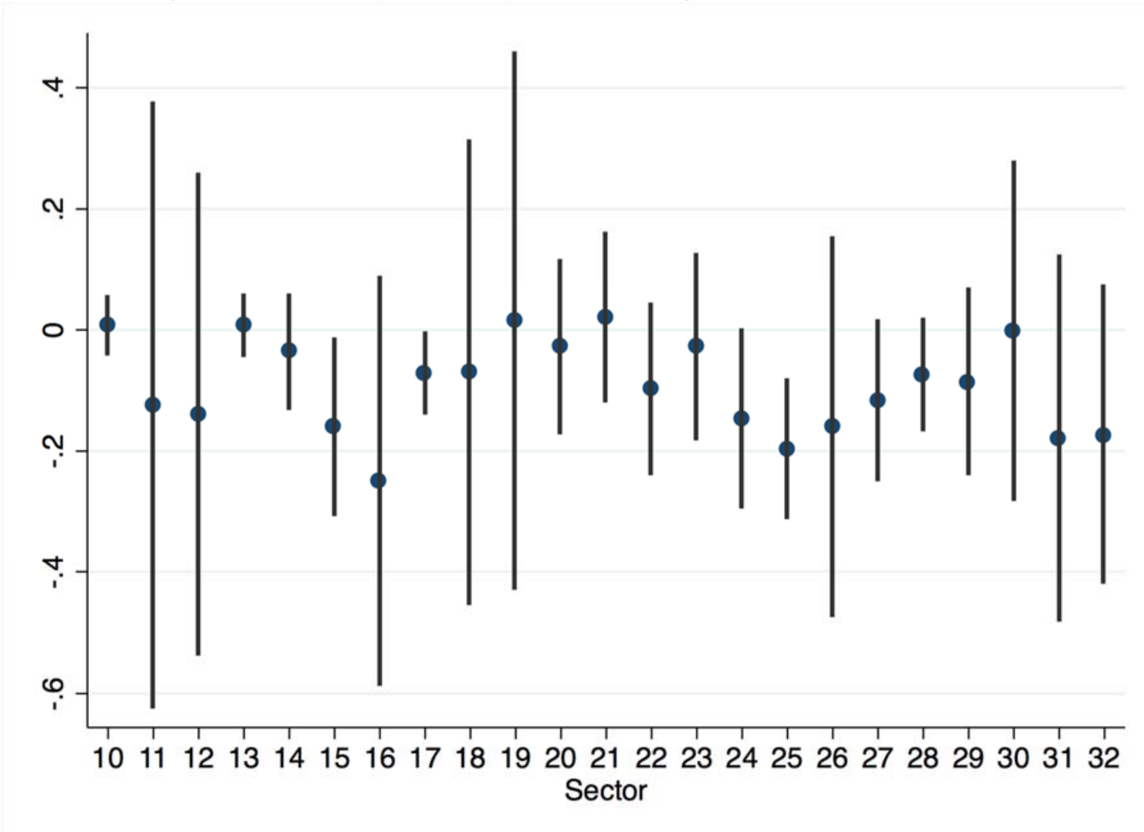
Notes: SAIFI is the average number of interruptions that a customer experiences in a year. Specifically, SPAIFI is calculated as the total annual number of consumer supply interruptions divided by the total number of consumers that the distribution company serves in any a given year. For the purposes of illustration, the index has been transformed using the inverse hyperbolic sine.

**Figure 4. System Average Interruption Duration Index**



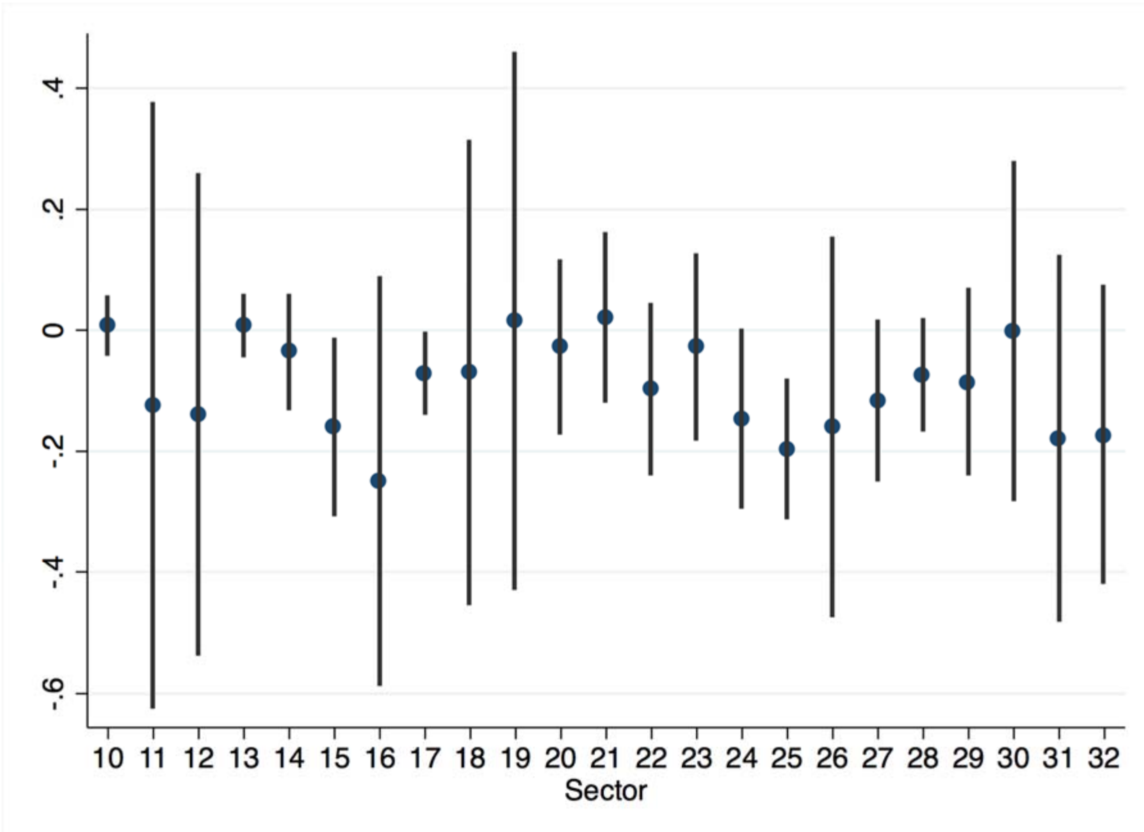

Source: DISCO Performance Evaluation Report 2014-2015 by NEPRA.
Notes: SAIDI is the outage duration (in minutes) that an average customer experiences in a year.

**Figure 5. Sector-Specific Impacts of Outage Duration on Revenues**



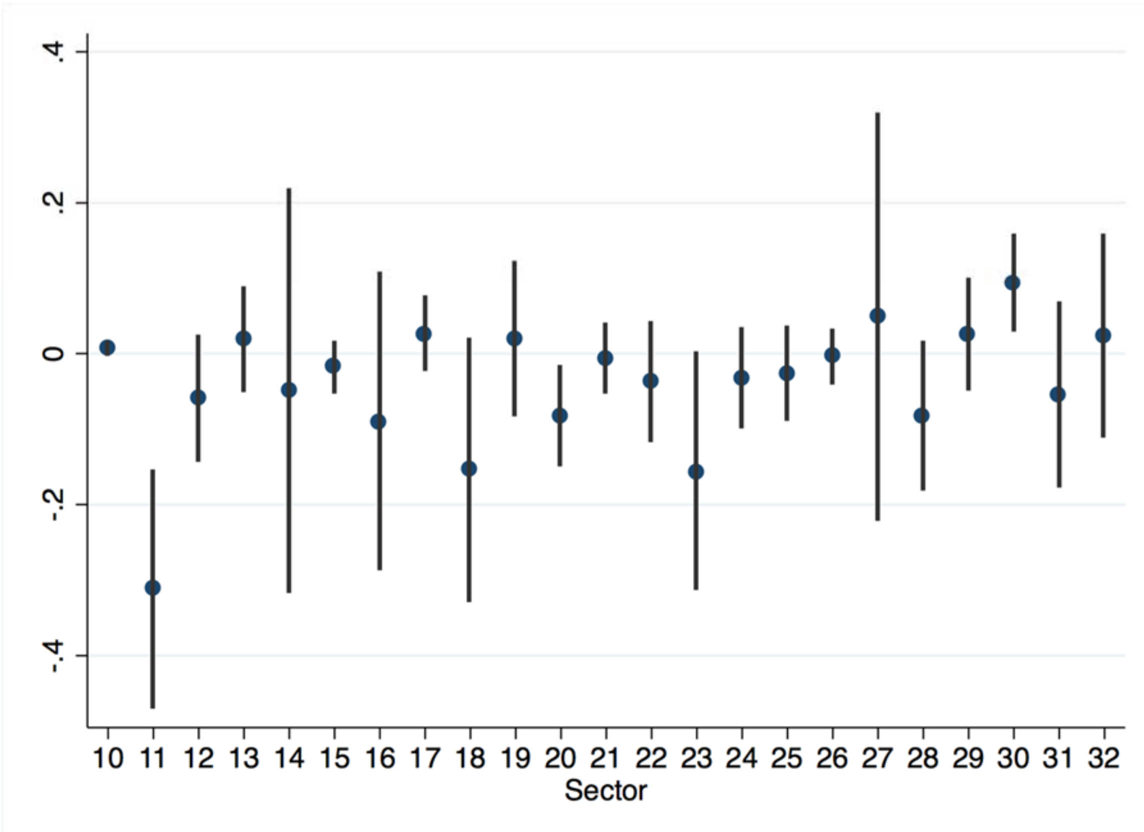

Notes: This figure shows the sector-specific effects of ln(SAIDI) on ln(product revenues). The independent variables include ln(SAIDI), sector-specific intercepts, sector-by-ln(SAIDI) interactions, as well as controls for ln(labor costs), ln(raw material costs), ln(fixed assets) and ln(total energy costs). The bars show the 95% confidence intervals.

**Figure 6. Sector-Level Impacts of Outage Duration on Value-Added**



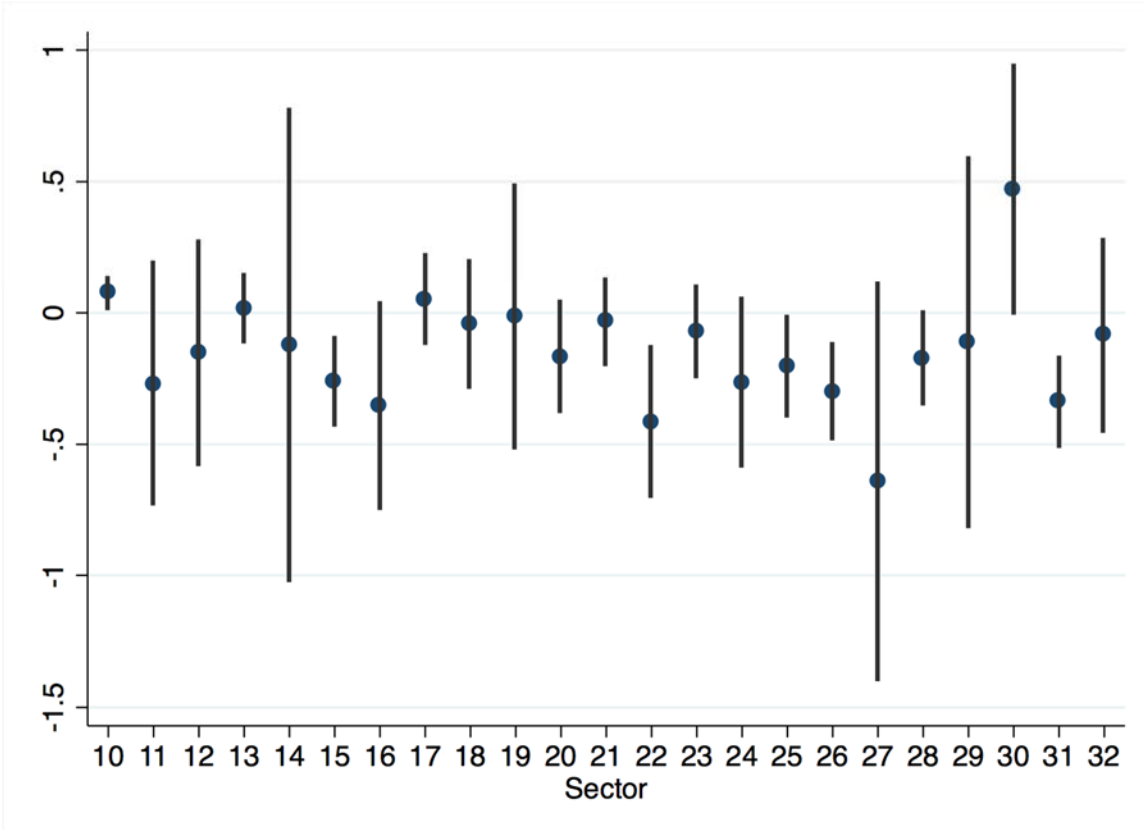

Notes: This figure shows sector-specific effects of ln(SAIDI) on ln(value-added). The independent variables include ln(SAIDI), sector-specific intercepts, sector-by-ln(SAIDI) interactions, as well as controls for ln(labor costs), ln(raw material costs), ln(fixed assets) and ln(total energy costs). The bars show the 95% confidence intervals.

**Figure 7. Sector-Level Impacts of Outage Frequency on Output Value**




Notes: This figure shows sector-specific effects of ln(SAIFI) on ln(output value). The independent variables include ln(SAIFI), sector-specific intercepts, sector-by-ln(SAIFI) interactions, as well as controls for ln(labor costs), ln(raw material costs), ln(fixed assets) and ln(total energy costs). The bars show the 95% confidence intervals.

**Figure 8. Sector-Level Impacts of Outage Frequency on Value-Added**




Notes: This figure shows sector-specific effects of ln(SAIFI) on ln(value-added). The independent variables include ln(SAIFI), sector-specific intercepts, sector-by-ln(SAIFI) interactions, as well as controls for ln(labor costs), ln(raw material costs), ln(fixed assets) and ln(total energy costs). The bars show the 95% confidence intervals.

## Tables

**Table 1. Distribution of Firms in Census by Two-Digit PSIC**

| Two-Digit PSIC | Activity Description | Number Firms |
|---|---|---|
| 10 | Manufacture of food products | 669 |
| 11 | Manufacture of beverages | 21 |
| 12 | Manufacture of tobacco products | 3 |
| 13 | Manufacture of textiles | 1,235 |
| 14 | Manufacture of wearing apparel | 183 |
| 15 | Manufacture of leather and related products | 77 |
| 16 | Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials | 11 |
| 17 | Manufacture of paper and paper products | 177 |
| 18 | Printing and reproduction of recorded media | 53 |
| 19 | Manufacture of coke and refined petroleum products | 10 |
| 20 | Manufacture of chemicals and chemical products | 154 |
| 21 | Manufacture of basic pharmaceutical products and pharmaceutical preparations | 96 |
| 22 | Manufacture of rubber and plastics products | 150 |
| 23 | Manufacture of other non-metallic mineral products | 135 |
| 24 | Manufacture of basic metals | 165 |
| 25 | Manufacture of fabricated metal products, except machinery and equipment | 195 |
| 26 | Manufacture of computer, electronic and optical products | 15 |
| 27 | Manufacture of electrical equipment | 231 |
| 28 | Manufacture of machinery and equipment n.e.c. | 187 |
| 29 | Manufacture of motor vehicles, trailers and semi-trailers | 112 |
| 30 | Manufacture of other transport equipment | 89 |
| 31 | Manufacture of furniture | 39 |
| 32 | Other manufacturing | 480 |

Source: Authors' calculations using 2010-11 Census of Manufacturing Industries.

**Table 2. Descriptive Statistics of Manufacturing Firms**

| Variable | Obs. | Mean (thousands) | Std Dev (thousands) | Minimum | Maximum (thousands) |
|---|---|---|---|---|---|
| Product Value | 3,585 | 522.82 | 2,944.99 | 180 | 125,000.00 |
| Value Added | 4,444 | 113.69 | 1,021.25 | -4,429,910 | 32,400.00 |
| Total Employ. Cost | 4,488 | 17.57 | 98.60 | 36 | 3,430.71 |
| Raw Materials Cost | 3,841 | 316.02 | 2,146.54 | 25 | 114,000.00 |
| Value of Fixed Assets | 3,975 | 148.79 | 1,137.34 | 24 | 34,800.00 |
| Electricity Costs | 4,443 | 12.07 | 72.98 | 2 | 1,880.29 |

Notes: Authors' calculations from the 2010-11 Census of Manufacturing Industries.

**Table 3. Impact of Outages on Product Revenues**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| ln(Total Labor Cost) | 0.114*** | 0.109*** | 0.112*** | 0.108*** | 0.110*** |
| | (0.00798) | (0.00797) | (0.00806) | (0.00798) | (0.00800) |
| ln(Total Raw Materials) | 0.740*** | 0.755*** | 0.737*** | 0.755*** | 0.756*** |
| | (0.00881) | (0.00609) | (0.00872) | (0.00609) | (0.00609) |
| ln(Fixed Assets) | 0.0364*** | 0.0363*** | 0.0387*** | 0.0372*** | 0.0360*** |
| | (0.00662) | (0.00542) | (0.00664) | (0.00542) | (0.00543) |
| ln(Total Electricity Cost) | 0.109*** | 0.0979*** | 0.107*** | 0.0978*** | 0.0981*** |
| | (0.00791) | (0.00625) | (0.00798) | (0.00627) | (0.00626) |
| ln(SAIDI) | -0.0281*** | -0.0152*** | | | -0.0196*** |
| | (0.00440) | (0.00418) | | | (0.00618) |
| ln(SAIFI) | | | -0.0275*** | -0.0143** | 0.0101 |
| | | | (0.00958) | (0.00707) | (0.0104) |
| Constant | 1.347*** | | 1.278*** | | |
| | (0.0446) | | (0.0474) | | |
| Two-Digit PSIC FE | | X | | X | X |
| Observations | 3,104 | 3,104 | 3,104 | 3,104 | 3,104 |
| Adjusted R-squared | 0.967 | 0.961 | 0.966 | 0.961 | 0.961 |

Notes: The dependent variable is ln(product revenues). SAIDI is an index of the average duration of electricity shortages, and SAIFI is an index of the average frequency of shortages experience by firms for that distribution company. Heteroskedastic-robust standard errors are shown in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

**Table 4. Impact of Outages on Value-Added**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| ln(Total Labor Cost) | 0.503*** | 0.429*** | 0.496*** | 0.426*** | 0.433*** |
| | (0.0270) | (0.0239) | (0.0271) | (0.0239) | (0.0239) |
| ln(Total Raw Materials) | 0.376*** | 0.425*** | 0.374*** | 0.424*** | 0.424*** |
| | (0.0172) | (0.0174) | (0.0172) | (0.0175) | (0.0174) |
| ln(Fixed Assets) | 0.122*** | 0.116*** | 0.130*** | 0.119*** | 0.114*** |
| | (0.0200) | (0.0159) | (0.0197) | (0.0159) | (0.0160) |
| ln(Total Electricity Cost) | 0.00400 | 0.0213 | -0.00691 | 0.0202 | 0.0246 |
| | (0.0168) | (0.0179) | (0.0166) | (0.0180) | (0.0180) |
| ln(SAIDI) | -0.0652*** | -0.0364*** | | | -0.0703*** |
| | (0.0116) | (0.0125) | | | (0.0180) |
| ln(SAIFI) | | | -0.0445* | -0.00619 | 0.0816*** |
| | | | (0.0255) | (0.0216) | (0.0311) |
| Constant | 0.482*** | | 0.227 | | |
| | (0.131) | | (0.142) | | |
| Two-Digit PSIC FE | | X | | X | X |
| Observations | 3,274 | 3,274 | 3,274 | 3,274 | 3,274 |
| Adjusted R-squared | 0.705 | 0.684 | 0.702 | 0.683 | 0.684 |

Notes: The dependent variable is ln(value added). SAIDI is an index of the average duration of electricity shortages, and SAIFI is an index of the average frequency of shortages experience by firms for that distribution company. Heteroskedastic-robust standard errors are shown in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.