Electricity Cost and Firm Performance: Evidence from India

Ama Baafra Abeberese*

August 8, 2012

PRELIMINARY DRAFT: PLEASE DO NOT CITE

Abstract

Although electrification rates in developing countries have increased, the price of electricity remains high especially for firms. This paper studies the extent to which high electricity prices affect firms' performance using data on Indian manufacturing firms and an instrumental variables strategy. Making use of India's reliance on coal for thermal generation of electricity, I construct an instrument for electricity price as the interaction between coal price and the share of thermal generation in a state's total electricity generation capacity. I find that firms reduce their electricity consumption and switch to less electricity-intensive production processes in response to an increase in electricity price. I argue that less electricity-intensive processes tend to be those that are less technologically advanced and show that switching to such processes has negative implications for firms' productivity growth.

JEL Classification Codes: H54, O13, O14, O33
Program Area: The Built Environment
Program Sub-Area: Infrastructure

* Department of Economics, Columbia University, New York, NY 10027. Email: aba2114@columbia.edu.

1 Introduction

Electricity has long been regarded as a catalyst for growth in developing countries. The availability of electricity can drive a country's growth by allowing firms to take advantage of productivity-enhancing technologies, the bulk of which are reliant on electricity. Such potential benefits of electricity have spurred investment in electricity projects in developing countries with the World Bank's lending for energy projects doubling from $3.9 billion in 2007 to $8.2 billion in 2011 (World Bank, 2011). Although the increased investment in energy has improved electrification rates in most developing countries, electricity costs remain high, especially for firms. In response to high electricity prices, firms may alter their product mix in favor of less technologically intensive products which require less electricity for production. Given the evidence in the literature on the positive relationship between technology and growth (see, for example, Isaksson (2007) for a review of the literature), a switch to low-technology goods in response to high electricity costs may negatively affect firms' productivity growth. Despite the perceived relevance of reliable and affordable provision of electricity for growth, there has been little empirical work on how firms' technology choices and, hence, growth are affected by electricity constraints.

In this paper, I attempt to fill this gap in the literature by studying the implications of high electricity prices for firms' product choice and productivity growth using data on manufacturing firms in India. In most developed countries, industrial users pay lower prices for electricity compared to other users (IEA, 2012). These lower prices reflect the lower cost of supplying electricity to industrial users as a result of their more stable demand patterns for electricity and their ability to use electricity at higher voltages without the power utility incurring the extra cost of stepping down the voltage. However, in developing countries like India the existence of cross-subsidies reduces electricity prices for domestic and agricultural users at the expense of industrial users.

For instance, in 2000, industrial users in India paid about 15 times the price paid by agricultural users for electricity (Government of India, 2002). In a 2006 World Bank survey, Indian manufacturing firms were asked to indicate which element posed the biggest constraint to their operations out of a list of 15 elements including electricity, access to finance, and corruption. Electricity was the most common major obstacle indicated, with more than 36 percent of firms listing electricity as their biggest constraint (World Bank, 2006). Although the Indian government has undertaken steps to reduce the extent of cross-subsidization, industrial users still pay high prices for electricity. As recently as 2011, the average prices (in rupees per kilowatt-hour) paid by agricultural and domestic users were estimated to be 1.23 and 3, respectively, compared to 4.78 for industrial users (Government of India, 2011). Despite being poorer than the average OECD country, India's average electricity price for industrial users, at about 11 cents per kilowatt-hour, is about the same as the OECD average electricity price for industrial users. On the other hand, at about 7 cents per kilowatt-hour, India's average electricity price for domestic users is less than half of the OECD average (IEA, 2012). As a result of the high cost of purchasing electricity, firms may reduce their electricity usage, which has implications for the types of technologies they are able to use and, ultimately, their growth.

The potential for other variables to move in tandem with electricity prices presents a challenge in establishing a causal link between electricity cost and firm outcomes. To address this challenge, I construct an instrumental variable (IV) for electricity price based on the characteristics of electricity provision in India. Most of the electricity generated in India comes from thermal plants which use coal as the source of fuel. Thus the price of coal affects the cost of generating electricity and, hence, its price. I therefore use the price of coal interacted with each Indian state's share of installed electricity generation capacity from coal-fired thermal power plants as an instrument for the electricity price faced by firms in that state. Using this instrument in an IV estimation, I find that firms switch to less electricity-intensive industries in response to increases in electricity prices. I argue that the less electricity-intensive industries are also those that are less technologically advanced and show that firms that operate in such industries experience lower productivity growth.

This paper is related to recent studies that have provided micro evidence on the impacts of inadequate provision of electricity on firm outcomes. Electricity shortages have been shown to reduce firm investment (Reinikka and Svensson, 2002) and to cause firms to reduce energy expenditures and increase material expenditures, suggesting an outsourcing of the production of intermediate goods (Fisher-Vanden, Mansur and Wang, 2012). Electrification has also been shown to raise female employment potentially via an increase in micro-enterprises (Dinkelman, 2011). Two recent papers, Rud (2012a, 2012b), also investigate the effects of electricity provision on firms in India. Rud (2012a) finds that an increase in rural electrification in Indian states starting in the mid 1960s led to an increase in aggregate manufacturing output in the affected states, while Rud (2012b) shows that more productive firms are able to adopt captive power generators to cope with electricity shortages and high electricity costs. Similarly, Alby, Dethier and Straub (2012) find that in countries with a high frequency of power outages, electricity-intensive sectors have a low proportion of small firms since only large firms are able to invest in generators to mitigate the effects of outages.

The contribution of this paper to this literature is twofold. First, to my knowledge, this is the first paper that studies how access to electricity can affect the types of products firms choose to manufacture. Understanding the impact of electricity on the types of products manufactured by firms and, hence, the technology used is important as this may have implications for firms' growth. Second, the existing firm-level studies, with the exception of Rud (2012b), have focused on the provision of electricity without emphasis on how the affordability of electricity may play a crucial role in firms' decisions and performance. In contrast, I analyze the extent to which, even with the availability of electricity, its cost may cause firms to change their production patterns in favor of less electricity-reliant technologies, which may have consequences for their productivity growth.

The findings of this paper also add to a recent strand of literature on the interplay between firm-level distortions, resource misallocation and productivity differences (see, for example, Restuccia and Rogerson, 2008; Hsieh and Klenow, 2009). For India, in particular, Hsieh and Klenow (2009) show that distortions cause significant resource misallocation across firms and a reallocation of resources could raise aggregate productivity by as much as 40 to 60 percent. While this strand of research has identified misallocation of resources as a cause of the productivity variation across firms, the exact sources of these distortions remains an open question in the literature. The results of this paper suggest that high electricity prices are a possible source of the distortions that result in resource misallocation in developing countries and making electricity more affordable could lead to aggregate productivity gains.

The rest of the paper is organized as follows. Section 2 presents a brief overview of the electricity sector in India. Section 3 outlines the empirical strategy while Section 4 describes the data. Section 5 presents the results and Section 6 concludes.

2 Electricity Sector in India

Each state in India is responsible for the generation, distribution and pricing of electricity for its residents. Electricity generation in India is mostly from thermal plants, which account for about 84 percent of the electricity generated in the country. Hydroelectric plants account for about 14 percent of electricity generation, while plants using nuclear energy, wind and other renewable resources account for the rest. The dominant fuel for the thermal power plants is coal which accounts for about 83 percent of installed thermal generation capacity (Government of India 2011, 2012). The electricity used by residents of a state comes from one or more of four sources. Power plants owned by the state's government provide the bulk of electricity used, with other states' power plants, the central government's power plants, and independent power producers providing the remainder. States' power plants produce about 60 percent of total electricity generated in the country. Each state determines the price paid for electricity by its residents. Electricity pricing in India is generally based on an incremental block tariff structure in which the marginal price of electricity increases with the amount consumed. Table A1 in the appendix provides an example of a state's electricity price list. For example, in Table A1, the first 100,000 kilowatt-hours of electricity consumed by industrial users cost 3.5 rupees per kilowatt-hour, while consumption above 100,000 kilowatt-hours costs a higher price of 3.75 rupees per kilowatt-hours.

The electricity sector in India is characterized by a system of cross-subsidization between agricultural and domestic users on one hand and industrial users on the other. The former group pays low prices for electricity at the expense of the latter group which faces high electricity prices, although the cost of supplying electricity to the latter group is lower. The pandering of politicians to farmers who form dominant voting blocs, and to a lesser extent the social objective of providing affordable services for the poor, has contributed to this system of cross-subsidization. Figure 1 shows the average electricity price paid by various categories of users in India between 1994 and 2008. The price paid by industrial users for electricity has consistently been much higher than that paid by agricultural and domestic users. In an effort to correct this price distortion, the government passed a law in 2003 that required states to set up electricity regulatory commissions whose main responsibility was to ensure fair pricing of electricity and to rid the price setting process of any political interference. Although most states have set up these commissions, a high level of cross-subsidization still exists. In the next section, I outline an empirical strategy to analyze the consequences of the high electricity prices faced by firms.

3 Empirical Strategy

A simple regression of a firm outcome on electricity price may yield inconsistent and biased estimates of the effect of electricity price due to the potential endogeneity of prices. This endogeneity may come from several sources. For instance, some firms may have managers who have the foresight to locate in states with low electricity prices and these may also be the firms that perform well along other dimensions. To the extent that the unobserved firm characteristics that affect both the electricity price firms pay and other outcomes are time-invariant, controlling for firm fixed effects in the regressions would alleviate any endogeneity from this source. Additionally, changes in the electricity price in a state may be correlated with changes in other unobserved state variables which also affect firm outcomes. If these state variables affect all firms in the same way, controlling for state-specific year effects may help address this issue. However, the unobserved firm characteristics that result in the endogeneity of electricity prices may not be time-invariant and unobserved state variables may affect firms in different ways, making the solutions described above insufficient for dealing with the endogeneity of electricity prices.

To circumvent this concern, I rely on an identification strategy that exploits the nature of electricity generation and the organization of the electricity sector in India. Since most of the electricity used in a state is generated by the state's own power plants, changes in the price paid by electricity users in the state will largely reflect changes in the cost of producing electricity in the state's power plants. As the primary mode of electricity generation in India is thermal generation using coal-fired power plants, the price of coal plays a critical role in the cost of electricity generation, and, hence, electricity prices. Given this reliance on coal for electricity generation, I construct a variable equal to the interaction between the price of coal in a given year and the initial coal-fired thermal share of a state's installed electricity generation capacity[1]. I then use this variable as an instrument for the electricity price paid by a firm in IV regressions of firm outcomes on electricity prices.

The validity of using this IV approach to establish a causal relationship between electricity

[1]The initial coal-fired thermal share of electricity generation capacity is the ratio of the installed generation capacity, in kilowatts, of a state's coal-fired thermal power plants to the total installed capacity of all of the state's power plants. With the exception of three states, Uttarakhand, Jharkhand and Chhattisgarh, this ratio is as of 1998, which precedes the first year of the data used in the analysis. There are no data on Uttarakhand, Jharkhand and Chhattisgarh prior to 2000 since these states were created in late 2000. Therefore, I use the earliest year of data on installed generation capacity available for these states which is 2003.

prices and firm outcomes hinges on the instrumental variable satisfying two conditions. The first is that the instrument, the interaction between coal price and thermal generation share, should be correlated with electricity price. As described, since coal price affects the cost of thermal electricity generation, it is plausible that this instrument is correlated with electricity price. I more formally demonstrate this correlation in the first-stage regression discussed in Section 5. Figure 2 shows how the coal price paid by power utilities has changed over time. Figure 3 shows the average electricity price paid by firms over time. Both coal and electricity prices follow similar upward trends. Coal prices increased sharply between 2001 and 2005, and became more stable afterward. This pattern is largely mirrored by the average electricity price which increased sharply between 2001 and 2005 and then slowed down between 2005 and 2007. The second condition is that the instrument should affect the firm outcome of interest only via its effect on electricity price. Although there is no way of formally testing this second condition, I present some evidence below that suggests that it holds.

The instrument consists of two parts: the price of coal paid by power utilities and the initial thermal share of a state's installed generation capacity. Almost all of the coal used in India is produced by two government-owned companies, Coal India (CIL), which produces about 80 percent of the coal consumed in the country, and Singareni Collieries Company Limited (SCCL), which produces about 8 percent (Government of India, 2008). These two companies set the price of coal and revise prices from time to time. Price revisions are driven mainly by cost pressures rather than changes in coal demand. The companies' reasons for revising prices have included offsetting inflationary pressures on their costs, offsetting increases in their wage bill and achieving parity between domestic and international coal prices, which are much higher than Indian domestic coal prices. Figure 4 shows the consumption of coal by thermal power plants over time. Comparing this chart to the chart of coal prices in Figure 2, the price setting of the coal companies does not appear to be in response to coal demand by the power utilities. For instance, as shown in Figure 4, although coal consumption increased substantially between 2006 and 2008, coal prices remained fairly stable over this period, as shown in Figure 2. The coal companies set separate prices for power utilities and for other categories of consumers. Since the price used in constructing the instrument is the price of coal paid by power utilities, arguably, other than through its effect on electricity prices, this price should not influence firm outcomes. Although some firms use coal as an input in their production, the price paid by firms for coal is different from the price paid by power utilities. Nonetheless, I have firm-level data on coal inputs and so I control for the value of coal used by the firm in all the IV regressions.

The second part of the instrument, the initial thermal share of a state's installed generation capacity, is determined in large part by a state's proximity to India's coal mines. As shown in the map in Figure 5, states that are located near coal mines are more likely to have a higher share of their installed generation capacity coming from thermal power plants. Given that a state's thermal capacity share is largely determined by geography, it should be plausibly exogenous to firm outcomes conditional on controlling for state fixed effects.

The system of equations I estimate are as follows.

$$y_{ist} = \beta_0 + \beta_1 log(electricity\, price)_{ist} + \beta_2 X_{ist} + \lambda_i + \eta_{rt} + \delta_s t + \epsilon_{ist} \quad (1)$$

$$log(electricity\, price)_{ist} = \alpha_0 + \alpha_1 log(thermal\, share_s * coal\, price_t) \quad (2)$$

$$+\alpha_2 X_{ist} + \lambda_i + \eta_{rt} + \delta_s t + \mu_{ijst}$$

Equation 1 is the outcome equation of interest where y_{ist} is an outcome for firm i in state s in year t, electricity $price_{ist}$ is the price in rupees paid by a firm per kilowatt-hour of electricity, X_{ist} is the value in rupees of coal used by a firm, λ_i is a firm fixed effect, η_{rt} is a region-year[2] effect, and $\delta_s t$ is a state time trend. Equation 2 is the first-stage regression equation in which the log of electricity price is regressed on the log of the interaction between coal price and thermal capacity share and all the other covariates in the outcome equation. All regressions include firm fixed effects to account for time-invariant firm characteristics which may simultaneously affect both the electricity price paid by firms and other firm outcomes. In the dataset, firms do not change the state in which they are located so the firm fixed effects also capture state fixed effects. I also control for region-year effects to absorb shocks that affect all firms in a particular region. The inclusion of state time trends controls for trends in other state variables that may be correlated with changes in electricity prices. Thus, the coefficient of interest, β_1, is an estimate of the

[2]The country is divided into the following regions: Northern comprising the states of Haryana, Himachal Pradesh, Jammu and Kashmir, Punjab, Rajasthan, Delhi and Chandigarh, Central comprising the states of Chhattisgarh, Uttarakhand, Uttar Pradesh and Madhya Pradesh, Eastern comprising the states of Bihar, Jharkhand, Orissa, and West Bengal, Western comprising the states of Goa, Gujarat, Maharashtra, Daman and Diu, and Dadra and Nagar Haveli, Southern comprising the states of Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Puducherry, and Northeastern comprising the states of Assam, Arunachal Pradesh, Manipur, Tripura, Mizoram, Meghalaya and Nagaland.

change in an outcome for a given firm given a change in the electricity price paid by the firm.

4 Data

My analysis is based on manufacturing firm-level panel data from the Indian Annual Survey of Industries (ASI) for the years 2001 to 2008[3]. The ASI is an annual survey of registered factories in India and covers about 30,000 firms each year. All factories are required to register if they have 10 or more workers and use electricity, or if they do not use electricity but have at least 20 workers. This population of factories is divided into two categories: a census sector and a sample sector. The census sector consists of all large factories and all factories in states classified as industrially backward by the government. For the 2001 to 2005 surveys, large factories were defined as those with 200 or more workers. From the 2006 survey onwards, the definition was changed to those with 100 or more workers. For the 2001 to 2004 surveys, twelve states were classified as industrially backward[4], while from the 2005 survey onwards, only 5 states were classified as industrially backward[5]. All the factories in the census sector are surveyed each year. The remaining factories make up the sample sector, of which a third is randomly selected each year for the survey. In the analysis, I use the sampling weights provided by the ASI to weight the observations. The survey includes data on firm-level electricity purchases, generation, and prices, products and inputs.

In the ASI, a firm's 5-digit industry[6] in a given year corresponds to the product that accounts for the highest share of the firm's total output in that year. There are 735 5-digit industries in the dataset corresponding to 127 4-digit industries and 61 3-digit industries. As an example of the level of detail in the industry classification, Table A1 in the appendix lists the 4- and 5-digit industries within the 3-digit industry code 151 "Production, processing and preservation of meat, fish, fruits, vegetables, oils and fats".

For constructing the instrument, I obtain data on coal prices from the Indian Ministry of Coal's Coal Directory of India publications and data on installed electricity generation capacity

[3]A year in the dataset corresponds to the Indian fiscal year which runs from April 1 to March 31. For instance, the year 2001 refers to the fiscal year beginning on April 1, 2000 and ending on March 31, 2001.

[4]These twelve states are Himachal Pradesh, Jammu and Kashmir, Manipur, Meghalaya, Nagaland, Tripura, Puducherry, Andaman and Nicobar Islands, Chandigarh, Goa, Daman and Diu, Dadra and Nagar Haveli.

[5]These five states are Manipur, Meghalaya, Nagaland, Tripura, and Andaman and Nicobar Islands.

[6]The 5-digit industry codes are from India's National Industrial Classification (NIC) 1998. The NIC 1998 is identical to the ISIC Rev. 3 system up to the 4-digit level.

from the Indian Ministry of Power's annual reports. To reduce the influence of outliers, I "winsorize" the firm-level variables within each year by setting values below the 1st percentile to the value at the 1st percentile and values above the 99th percentile to the value at the 99th percentile. I deflate all monetary values using wholesale price indices from the Indian Ministry of Commerce and Industry.

Table 1 presents some summary statistics of the firm-level data separately for high and low electricity intensity industries. I define the electricity intensity of a 5-digit industry as the average kilowatt-hours of electricity consumed per rupee of output by firms in that industry. This corresponds to the standard measure of electricity intensity used by the International Energy Agency which is the ratio of electricity consumption in kilowatt-hours to the value of output. High electricity intensity industries are defined as those with electricity intensities above the average electricity intensity, while low electricity intensity industries are those with electricity intensities below or equal to the average. As shown in the table, not surprisingly, firms in high electricity intensity industries use more electricity. These firms also have higher output and employment. They are also more machine-intensive underscoring the idea that electricity-intensive industries tend to be those that are more technologically advanced. In addition, firms in high electricity intensity industries have higher labor productivity. These patterns suggest that the electricity intensity of a firm's industry and its productivity might be related. In the next section, I present results showing links between electricity prices, the type of industry firms choose to operate in and their productivity growth.

5 Results

The results of my analysis are presented in the following subsections. As discussed in Section 3, the strategy I use to show the existence of a causal link between electricity prices and firm outcomes makes use of the interaction between coal price and the thermal share of a state's generation capacity as an instrument for electricity price. Before proceeding to the IV results, I show in Section 5.1 that a relationship exists between the instrument and electricity price. Using IV regressions, I demonstrate in Section 5.2 that an increase in electricity price causes firms to reduce the quantity of electricity they use. I then present the main findings of this paper in Sections 5.3 and 5.4 where I show that firms switch to less electricity-intensive industries in response to high electricity prices and show that this change in production has negative implications for firm productivity growth. In Section 5.5, I explore other firm outcomes that may be affected by high electricity prices in line with firms switching to less electricity-intensive industries.

5.1 First Stage Regression

The results from the first stage regression in equation 2 are presented in Table 2. Since the instrument varies at the state level, all the standard errors in the IV regressions are clustered at the state level to allow for correlations across firms in the same state. Column 1 shows the results from the first stage regression without controlling for state time trends. The estimate of the coefficient on electricity price is positive and statistically different from zero at the one percent level. In Column 2, I control for state time trends. The coefficient remains positive and statistically significant with an F-statistic of 24.7 but is smaller than the estimate in Column 1. This suggests that the coal price trend is correlated with state-specific trends in other variables that vary with electricity prices. I, therefore, control for state time trends in all the regressions. In Column 3, I include a control variable for whether the firm is owned by the government to check if government-owned firms receive favorable electricity pricing. Government ownership does not appear to affect the electricity price paid by firms. The coefficient on the log of electricity price remains essentially the same with the inclusion of the government ownership variable. The results of the first-stage regressions indicate that as coal price rises, firms in states that rely on thermal electricity generation experience an increase in electricity price.

5.2 Effect on Electricity Consumption

Table 3 reports results on the effects of electricity prices on electricity consumption by firms. Column 1 presents estimates from OLS regressions of equation 1. All standard errors in the OLS regressions are clustered at the firm-level to allow for correlations across years within firms. All regressions control for firm fixed effects, state time trends and region-year effects. The statistically significant negative coefficient in Column 1 of Panel A suggests that firms reduce the quantity in kilowatt-hours of electricity purchased as electricity price increases. Because of the potential endogeneity of electricity prices discussed in Section 3, caution should be exercised in interpreting the result from the OLS regression as evidence of a causal relationship between electricity price and firm outcomes.

Column 2 presents the reduced form results while Column 3 presents the IV results correcting for the potential endogeneity of electricity prices. The result from the IV regression reiterates and permits a causal interpretation of the findings from the OLS regression. In response to high electricity prices, firms reduce the quantity of electricity they purchase. As indicated by the coefficient in Column 3 of Panel A, a one percent increase in electricity price leads to a 1.2 percent fall in the quantity of electricity consumed by firms. If firms are able to generate enough electricity to offset the reduction in the quantity of electricity purchased, then there may not be a reduction in the quantity of electricity they use. The following suggests that this may not be the case. The cost per kilowatt-hour incurred by a firm in generating its own electricity in India is generally much higher than the price per kilowatt-hour of purchasing electricity from power utilities. For instance, based on a firm-level survey, it is estimated that for Indian manufacturing firms the cost of generating their own electricity is 24 percent higher than the price paid for the electricity provided by power utilities (Bhattacharya and Patel, 2007). Firms therefore primarily use self-generation of electricity as a means of coping with electricity outages rather than with electricity prices.

In Panel B of Table 3 I regress the log of the total quantity of electricity used by the firm, both purchased and self-generated, on the log of electricity price. The coefficient on the log of electricity price is negative and statistically significant indicating that firms are not able to use self-generation to offset the reduction in the quantity of electricity purchased and therefore reduce their total electricity consumption. To further explore the effect, if any, of electricity price on the self-generation of electricity, Panels C and D of Table 3 present estimates from regressions of an indicator variable for self-generation and the generated share of electricity on the log of electricity price. The coefficients on the log of electricity price from the IV regressions are negative and statistically significant. This suggests that an increase in electricity price may impose financial constraints on firms that make it difficult to invest in the generation of electricity. In sum, the results in Table 3 indicate that an increase in electricity price has a significant negative effect on the total consumption of electricity by firms.

5.3 Effect on Industry Choice

The reduction in the consumption of electricity suggests that firms may be altering their production to rely less on electricity in order to mitigate the effects of high electricity prices. To become less dependent on expensive electricity, firms may change their production to focus on goods that are less electricity-intensive. To explore this, I define an indicator variable, *switch5*, equal to one if a firm's current 5-digit industry is different from its previous 5-digit industry and zero otherwise. Similarly, I define indicator variables, *switch3* and *switch4* corresponding to changes in firms' 3- and 4-digit industries, respectively.

Table 4 reports the results from the regressions of these indicator variables on the log of electricity price. These regressions have fewer observations than in Table 3 since I lose the first observation for each firm in constructing the switch variables. The results from the first-stage regression using this lower number of observations are shown in Column 1 of Table 4. The coefficient on the instrument remains positive and statistically significant but the F-statistic is lower than in Table 2 possibly due to the fewer number of observations used in this regression. Columns 2, 3 and 4 present the OLS, reduced form and IV results, respectively.

The coefficient on the log of electricity price in the regression with *switch3* as the dependent variable in Column 4 of Panel D is negative and statistically insignificant indicating that firms do not switch their 3-digit industry in response to changes in electricity price. This is perhaps not surprising since at the 3-digit level industries vary significantly in terms of the goods produced and processes used, making it more difficult and hence less likely for firms to switch between industries at this level. For instance, within the 2-digit industry Manufacture of Food Products and Beverages, the 3-digit industry code 151 refers to the production, processing and preservation of meat, fish, fruits, vegetables, oils and fats, while code 152 refers to the manufacture of dairy products. Within the 3-digit industry code 151, the 4-digit industry code 1511 refers to the production, processing and preserving of meat and meat products, while code 1512 refers to the processing and preserving of fish and fish products highlighting how the main inputs can differ even between two 4-digit industries in the same 3-digit industry. In light of this, it is again not surprising that the coefficient on the log of electricity price in the regression with *switch4* as the dependent variable in Column 4 is also statistically insignificant.

At the 5-digit level, industries within the same 4-digit industry exhibit similarities in terms of their main inputs and final products. Drawing on the food industry example again, in the 4-digit industry code 1512, the 5-digit industry code 15121 refers to the sun-drying of fish, while code 15122 refers to the artificial dehydration of fish, which requires the use of electrically powered drying machines. Both industries use the same primary input, fish, and have the same end product, dried fish, but differ in terms of the processes used, with industry 15121 using a less electricity-intensive process. Given the similarities between 5-digit industries within the same 4-digit industry, we might expect that firms can switch between 5-digit industries in response to changes in electricity price. This hypothesis is supported by the positive and statistically significant relationship between *switch5* and the log of electricity price shown in Column 4 of Panel B. The average probability of a firm switching its 5-digit industry is 29 percent. Therefore, the coefficient of 1.8 on the log of electricity price implies that a one percent increase in electricity price increases the probability of a firm switching its 5-digit industry by 1.8 percentage points or by about 6 percent from the average probability.

To check if the industries firms switch to in response to an increase in electricity price are less electricity-intensive, I run regressions of the electricity intensity of a firm's industry, as defined in Section 4, on electricity price. To check the reliability of the electricity intensities calculated from the Indian data, I compare them to the electricity intensities of industries in the UK. The most disaggregated level at which electricity intensities for comparable industries are available for other countries is the 4-digit level of the ISIC. The electricity intensities of the UK industries are obtained from data from the UK Department of Energy and Climate Change (Department of Energy and Climate Change, 2011) and the UK Annual Business Inquiry (Office of National Statistics, 2010). Since the UK data are available at the 4-digit industry level[7], I construct the Indian industry electricity-intensity at the 4-digit level for comparison purposes.

Figure 6 plots the log of the Indian industry electricity intensities at the 4-digit level against the log of the UK industry electricity intensities. The sizes of the circles in the graph represent the number of firms in the 4-digit industry in the Indian data and the fitted line is from a regression weighted by the number of firms. There is a strong positive and statistically significant relationship between the two sets of electricity intensities suggesting that the electricity intensities calculated from the Indian data are reliable. Since the electricity intensities at the disaggregated 5-digit industry level are only available from the Indian data, I rely on the Indian data for my analysis. Table 5 reports the estimates from regressions of the log of the electricity intensity of a firm's 5-digit industry on the log of electricity price. The coefficient on the log of

[7]The UK data are available at the 4-digit level of the SIC 2003 which is identical to the 4-digit level of the NACE Rev 1.1. I converted the SIC 2003 codes to the ISIC Rev. 3 codes (which are identical to India's NIC 1998 codes at the 4-digit level) using a concordance between the NACE Rev 1.1 and the ISIC Rev. 3 codes from the UN Statistics Office.

electricity price is negative and statistically significant supporting the idea that firms switch to less electricity-intensive industries as electricity price rises.

Is the electricity intensity of an industry related to its technological intensity? This question is an important one in understanding whether switching to less electricity-intensive industries in response to increases in electricity price has any dire consequences for firms. If electricity-intensive industries are indeed those that rely on advanced technology, then operating in a less electricity-intensive industry may affect firms' productivity growth. The literature has long recognized the important role of electricity in technology (see, for example, Schurr, 1984; Rosenberg 1982; Doms and Dunne, 1995). As most innovations in production processes are reliant on electricity, we would expect the electricity intensity of an industry to be positively associated with its technology use.

To check if this positive relationship exists, I look at the correlation between electricity intensity and a variable that has been used as a proxy for technology in the literature. This proxy is an index called PRODY which is a measure of the technological sophistication of a good that was developed in Hausmann, Hwang, and Rodrik (2007). This variable has been used in several papers including Mattoo and Subramanian (2009) and Wang, Wei, and Wong (2010). PRODY is defined as the weighted average of the per capita GDPs of countries exporting a given product, where the weights are the ratios of the share of the product in a country's exports to the sum of the shares for all countries exporting the product. The motivation for this measure is the assumption that richer countries produce more technologically sophisticated goods. The PRODY data are obtained from Hausmann, Hwang, and Rodrik (2006). The data are available for products at the 6-digit level of the Harmonized System (HS). Using a concordance between the HS codes and the ISIC Rev. 3 4-digit industry codes from the World Bank's World Integrated Trade Solution (WITS) system, I calculate the PRODY for each 4-digit industry as the average of the PRODY values for the HS products within that industry.

Figure 7 plots the log of electricity intensity at the 4-digit industry level for India against the log of PRODY. The sizes of the circles in the graph indicate the number of firms in the 4-digit industry in the Indian data. The fitted line in the figure is from a regression weighted by the number of firms. A positive relationship is discernible between the log of electricity intensity and the log of PRODY in the graph, and this relationship is statistically significant. This positive relationship between electricity intensity and a proxy for technology suggests that electricity-intensive industries rely on more technologically advanced processes. I also look at the relationship between electricity intensity and R&D intensity, a commonly used proxy for technology. R&D intensity is defined as R&D expenditure as a share of total industry sales at the 4-digit industry level using data from the U.S. Federal Trade Commission Line of Business Survey from Kugler and Verhoogen (2012). A positive relationship exists between the log of electricity intensity and the log of R&D intensity although this relationship is not statistically significant at conventional levels.

5.4 Effect on Firm Productivity Growth

I now analyze the relationship between the electricity intensity of a firm's industry and firm productivity growth. If an industry's electricity intensity is correlated with its technology intensity, then by operating in low electricity intensity industries, firms may be foregoing opportunities to increase their productivity. I define the productivity growth rate for a firm over the period 2001 to 2008 as

$$productivity\,growth\,rate_{is} = \frac{log(labor\,productivity_{is2008}) - log(labor\,productivity_{is2001})}{7} \qquad (3)$$

where labor productivity is output per worker. To test whether the type of industry a firm operates in matters for its growth, I regress the productivity growth rate on the log of the electricity intensity of the firm's initial 5-digit industry (the 5-digit industry in 2001). I also estimate regressions controlling for firm characteristics that have been shown in earlier work to affect firm productivity growth. Specifically, I control for the log of firm age and the log of firm size as measured by output. I also control for state fixed effects.

The results from the growth regressions are reported in Table 6. The estimate in Column 1 of Panel A illustrates a positive and statistically significant relationship between the electricity intensity of a firm's initial industry and its subsequent productivity growth. Controlling for firm characteristics in Column 2 leaves the estimate virtually unchanged. I also look at the relationship between a firm's electricity intensity and its output and employment growth. These results are shown in Panels B and C of Table 6, respectively. The output and employment growth rates are defined similarly to productivity growth rate. The results indicate that firms in electricity-intensive industries do not grow faster in terms of employment but experience faster output growth relative to firms in less electricity-intensive industries. In sum, the electricity intensity of a firm's industry may have implications for its productivity growth, highlighting the importance of making electricity affordable for firms such that they are not forced to switch to less electricity-intensive industries.

5.5 Effect on Other Firm Outcomes

In this section, I examine whether the effects of electricity prices on other firm outcomes are consistent with the result in Section 5.3 that firms switch to less electricity-intensive industries in response to high electricity prices. I run regressions similar to those in Table 3 of the following firm outcomes on the log of electricity price: log of output, log of employment, log of labor productivity, log of the value of machinery, and log of the machine-labor ratio. The estimates from these regressions are reported in Table 7. The IV results in Column 3 of Panel A imply that an increase in electricity price results in a reduction in output. On the other hand, changes in electricity prices do not appear to have a statistically significant effect on employment as shown in Panel B. Thus, as implied by the results in Column 3 of Panel C, labor productivity falls with an increase in electricity prices.

If the argument in Section 5.3 that an industry's electricity intensity is correlated with its technology intensity is valid, then we might expect the movement of firms to less electricity-intensive industries in response to high electricity prices to affect their use of machinery. Panels D and E of Table 7 present results of regressions of the log of the value of machinery and the log of the machine-labor ratio on the log of electricity price. In line with the above hypothesis, an increase in electricity price reduces the amount of firms' machinery and their machine-labor ratio.

6 Conclusion

Drawing on Indian firm-level data, this paper analyzes the effect of electricity price on the type of goods firms choose to produce and the implications of this choice for their productivity growth. Addressing the potential endogeneity of electricity prices by exploiting the nature of electricity generation in India, I show that firms respond to increases in electricity prices by focusing on the manufacturing of goods whose production are less electricity-intensive. I provide evidence that operating in low electricity-intensity industries, which I argue are less technologically advanced, has negative consequences on firm productivity growth.

While most papers on infrastructure constraints in developing countries have focused on the availability of infrastructure, this paper emphasizes the importance of considering the affordability of infrastructure as well. Even with the provision of infrastructure, high prices may instigate coping strategies that may have negative consequences.

The results of this paper also shed light on the literature on productivity growth in developing countries. The findings highlight a channel through which infrastructure constraints can affect firm productivity. Faced with infrastructure constraints, in this case high electricity prices, firms may use less efficient production processes in an attempt to become less reliant on that infrastructure. Although this paper addresses electricity specifically, one can imagine ways in which firms may change their processes to cope with other infrastructure constraints.

A limitation of my analysis is that I do not directly observe data on the technologies used by firms, which is generally absent from most firm-level datasets. Future data collection efforts could elicit such information from firms. Given the important role of technology in growth, such data would allow more in-depth analyses of the factors influencing firms' technology choices and how these choices shape productivity growth in developing countries.

References

Alby, Philippe, Jean-Jacques Dethier, and Stephane Straub. 2012. "Firms Operating under Electricity Constraints in Developing Countries." *World Bank Economic Review*, 2012. doi:10.1093/wber/lhs018

Bhattacharya, Saugata, and Urjit R. Patel. 2007. "The Power Sector in India: An Inquiry into the Efficacy of the Reform Process." *India Policy Forum*, 4(1): 211-283.

Dinkelman, Taryn. 2011. "The Effects of Rural Electrification on Employment: New Evidence from South Africa." *American Economic Review,* 101(7): 3078-3108.

Doms, Mark, and Timothy Dunne. 1995. "Energy Intensity, Electricity Consumption, and Advanced Manufacturing-Technology Usage." *Technological Forecasting and Social Change*, 49(3): 297-310.

Fisher-Vanden, Karen, Erin T. Mansur, and Qiong (Juliana) Wang. 2012. "Costly Blackouts? Measuring Productivity and Environmental Effects of Electricity Shortages." NBER Working Paper No. 17741.

Department of Energy and Climate Change. 2011. "Energy Consumption in the UK: Industrial Data Tables - 2011." Department of Energy and Climate Change. http://www.decc.gov.uk/publications/ (accessed June 11, 2012).

Government of India. 1999 - 2011. *Annual Report on the Working of State Electricity Boards and Electricity Departments.* New Delhi: Government of India, Planning Commission.

___. 2008. *Annual Report 2007-2008.* New Delhi: Government of India, Ministry of Coal.

___. 2012. *Energy Statistics 2012.* New Delhi: Government of India, Ministry of Statistics and Programme Implementation.

Hausmann, Ricardo, Jason Hwang, and Dani Rodrik. 2007. "What You Export Matters." *Journal of Economic Growth*, 12(1): 1-25.

___. 2006. "What You Export Matters: Dataset." http://www.hks.harvard.edu/fs/drodrik/research.html (accessed May 1, 2012).

Hsieh, Chang-Tai, and Peter J. Klenow. 2009. "Misallocation and Manufacturing TFP in China and India." *Quarterly Journal of Economics*, 124(4): 1403-1448.

IEA. 2012. *Energy Prices and Taxes, Quarterly Statistics, Second Quarter 2012.* Paris: IEA.

Isaksson, Anders. 2007. "Determinants of Total Factor Productivity: A Literature Review." Research and Statistics Branch, United Nations Industrial Development Organization (UNIDO).

Karnataka Electricity Regulatory Commission. 2002. *Tariff Order - 2002.* Karnataka: Karnataka Electricity Regulatory Commission.

Kugler, Maurice, and Eric Verhoogen. 2012. "Prices, Plant Size, and Product Quality." *Review of Economic Studies,* 79(1): 307-339.

Office for National Statistics. 2010. "Annual Business Inquiry 1995-2007 - Section D: Manufacturing." Office for National Statistics. http://www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcm%3A77-235505 (accessed June 11, 2012).

Mattoo, Aaditya, and Arvind Subramanian. 2009. "Criss-Crossing Globalization: Uphill Flows of Skill-Intensive Goods and Foreign Direct Investment." Center for Global Development Working Paper 176.

Reinikka, Ritva, and Svensson, Jakob. 2002. "Coping with Poor Public Capital." *Journal of Development Economics*, 69(1): 51-69.

Restuccia, Diego, and Richard Rogerson. 2008. "Policy Distortions and Aggregate Productivity with Heterogeneous Establishments." *Review of Economic Dynamics*, 11(4): 707-720.

Rosenberg, Nathan. 1982. *Inside the Black Box: Technology and Economics.* Cambridge: Cambridge University Press.

Rud, Juan Pablo. 2012a. "Electricity Provision and Industrial Development: Evidence from India." *Journal of Development Economics,* 97(2): 352-367.

___. 2012b. "Infrastructure Regulation and Reallocations within Industry: Theory and Evidence from Indian Firms." *Journal of Development Economics,* 99(1): 116-127.

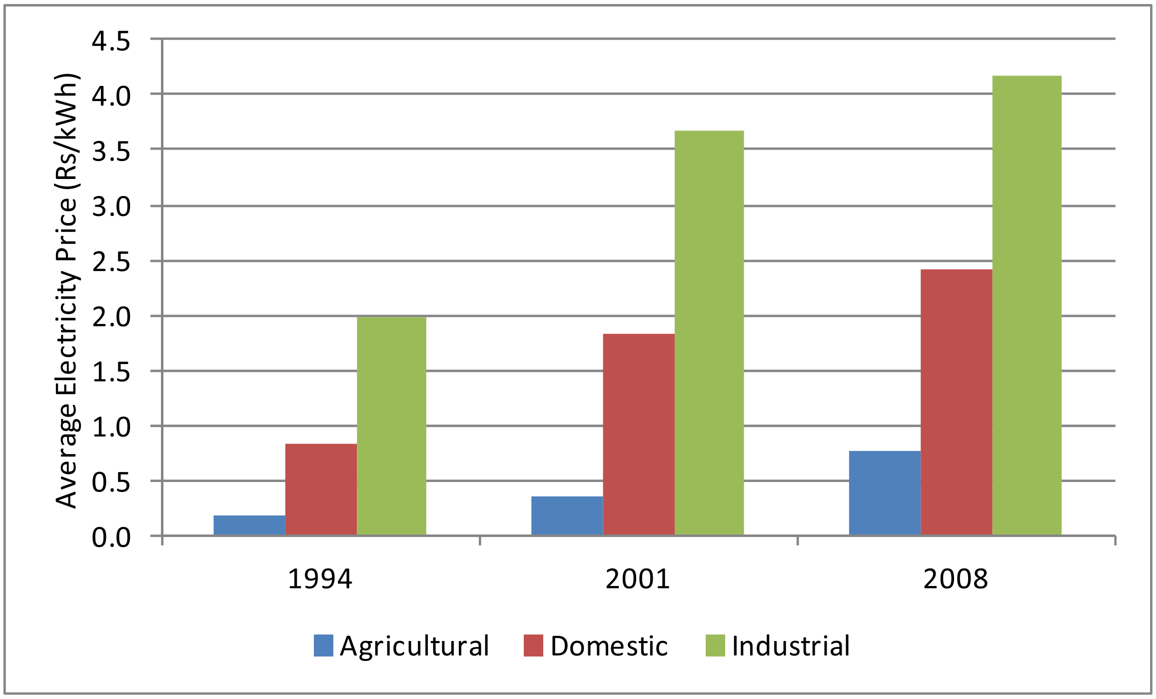
Schurr, S. H. 1984. "Energy Use, Technological Change, and Productive Efficiency: An Economic-Historical Interpretation." *Annual Review of Energy*, 9(1): 409-425.

Wang, Zhi, Shang-Jin Wei, and Anna Wong. 2010. "Does a Leapfrogging Growth Strategy Raise Growth Rate? Some International Evidence." NBER Working Paper No. 16390.

World Bank. 2006. "Enterprise Surveys." World Bank. http://www.enterprisesurveys.org (accessed July 12, 2012)

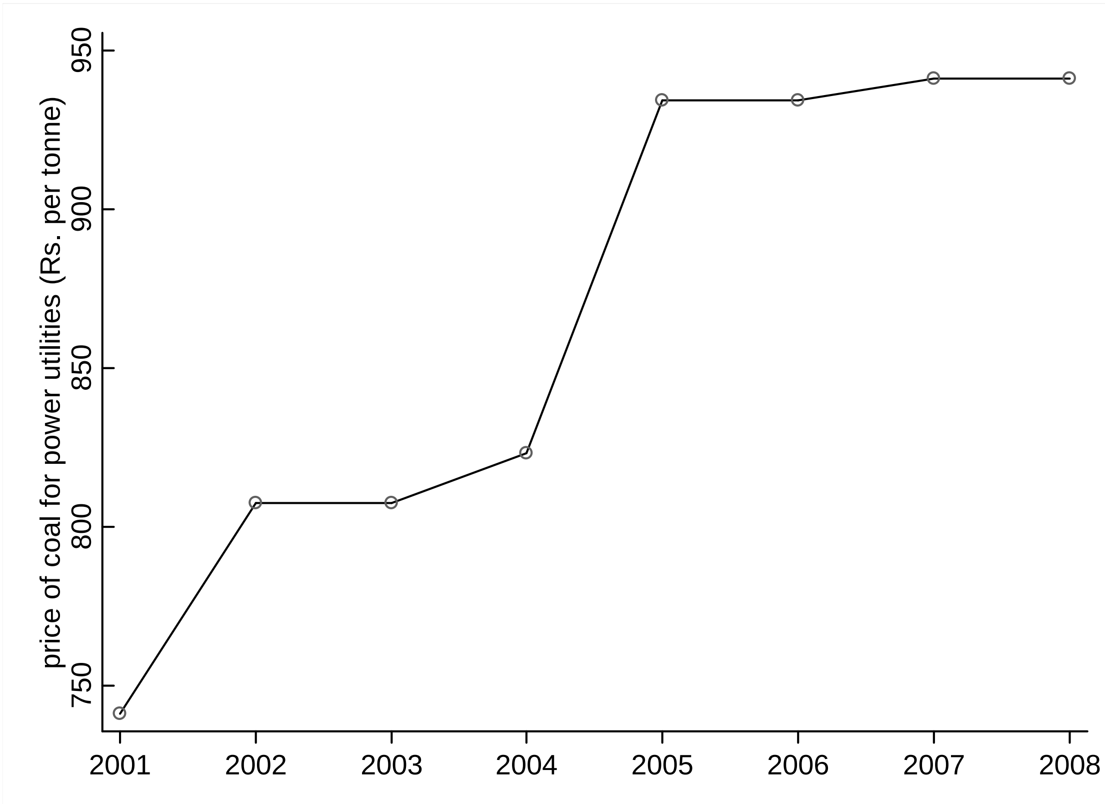
___. 2011. "World Bank Group Energy Portfolio." World Bank. http://go.worldbank.org/ERF9QNT660 (accessed July 12, 2012)

Figure 1: Average Electricity Price for Different Categories of Users



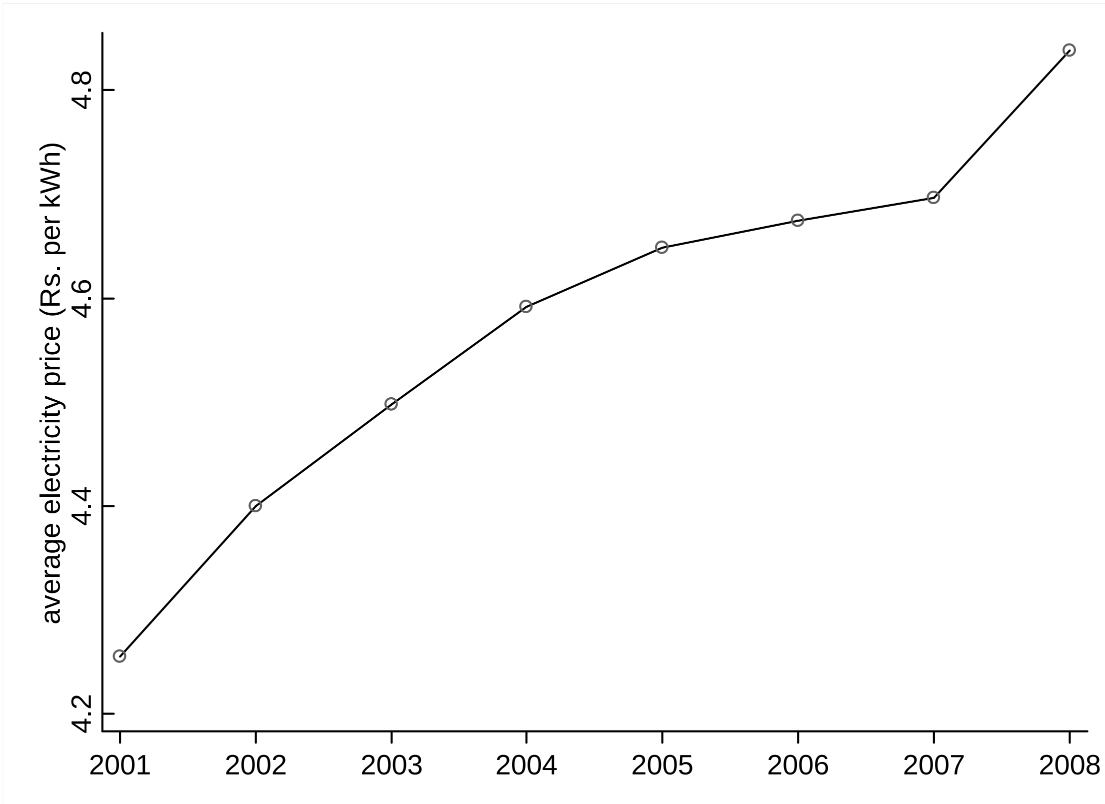
Notes: Data from Government of India (1999 - 2011).

Figure 2: Price of Coal for Power Utilities



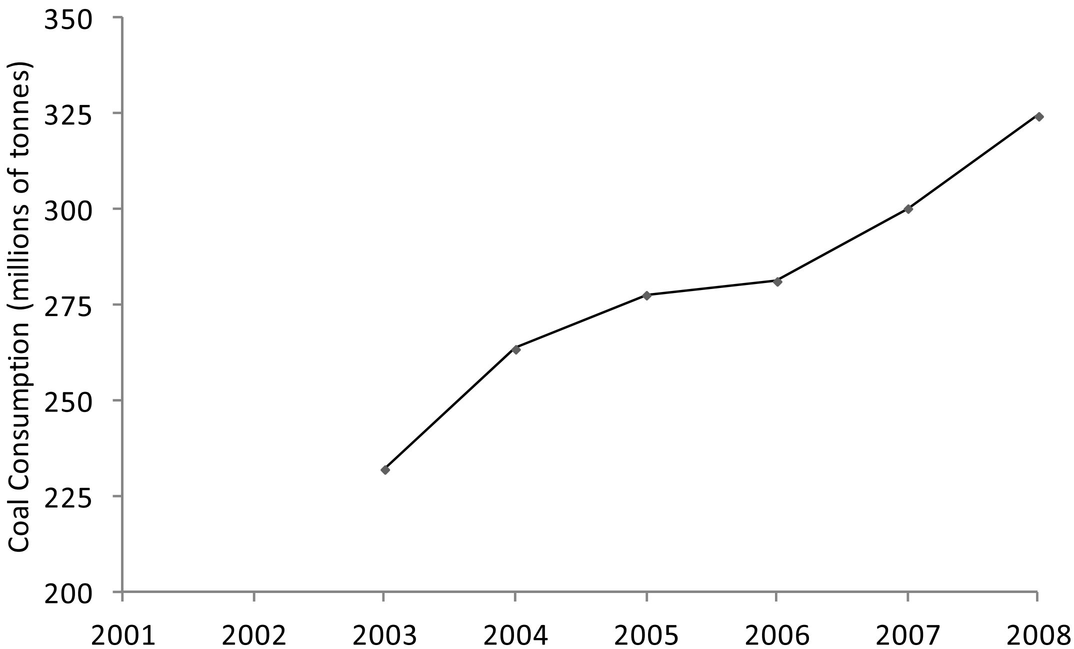
Notes: Data from Coal Directory of India 2010-2011, Government of India, Ministry of Coal.

Figure 3: Average Electricity Price



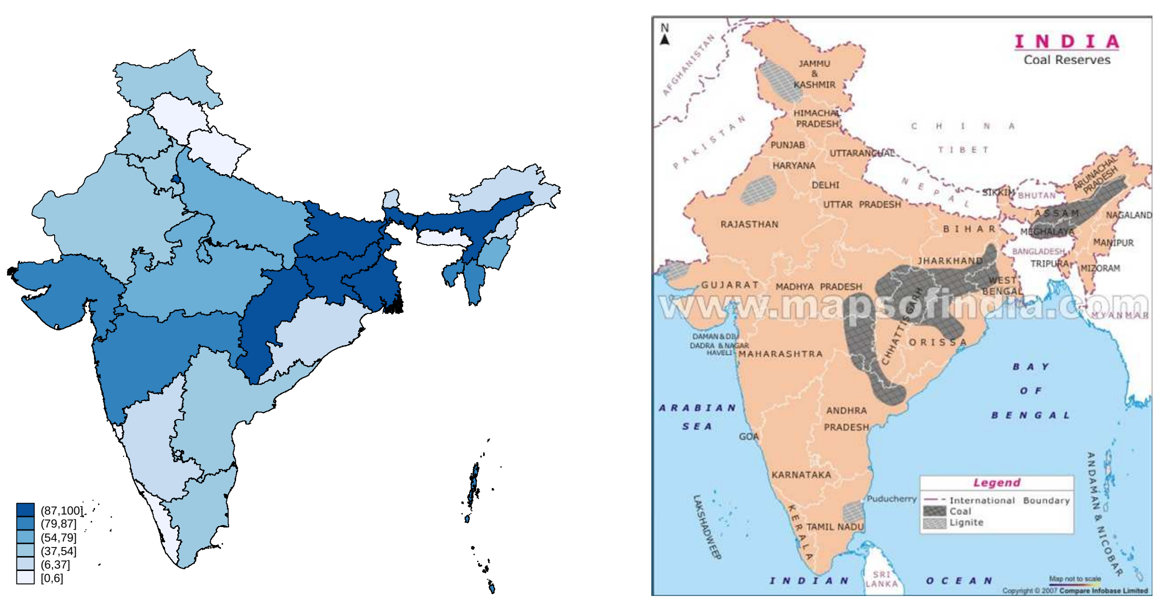
Notes: Averages are taken across all firms within each year using data from the ASI dataset.

Figure 4: Coal Consumption by Thermal Power Plants



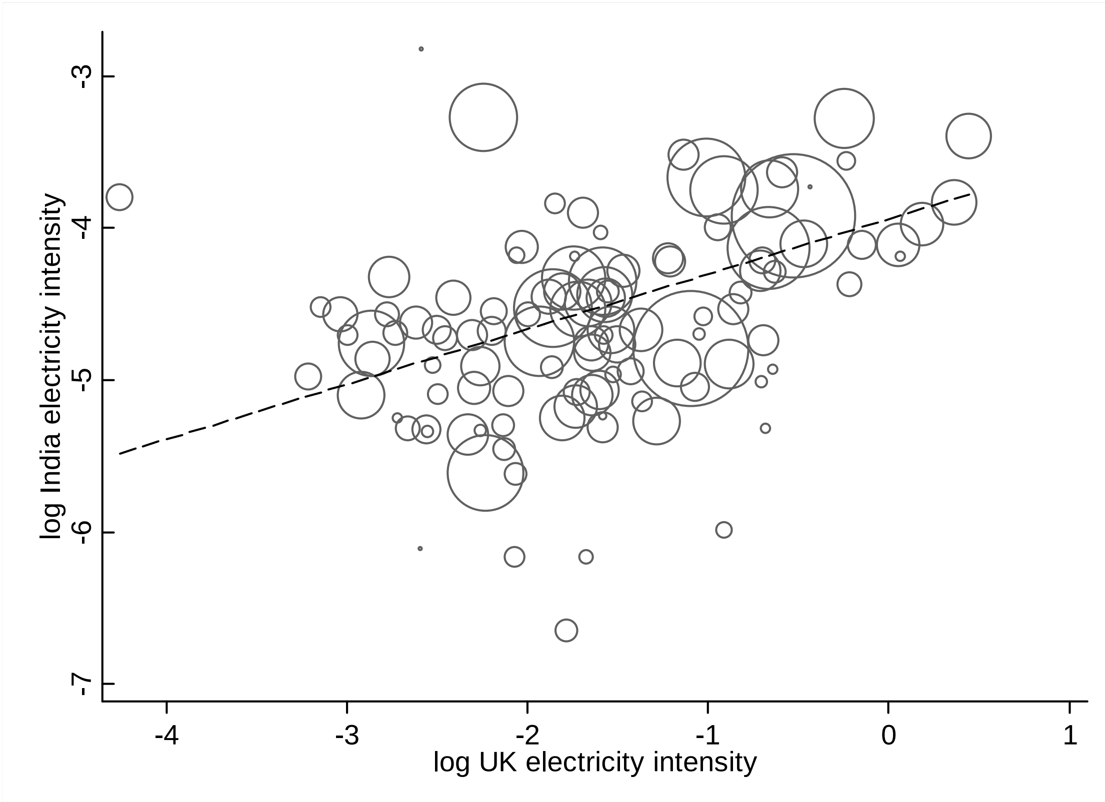
Notes: Data from Government of India, Ministry of Power, Central Electricity Authority Thermal Performance Review (various issues), and Indiastat database (www.indiastat.com).

Figure 5: States' Thermal Share of Generation Capacity and Indian Coal Reserves



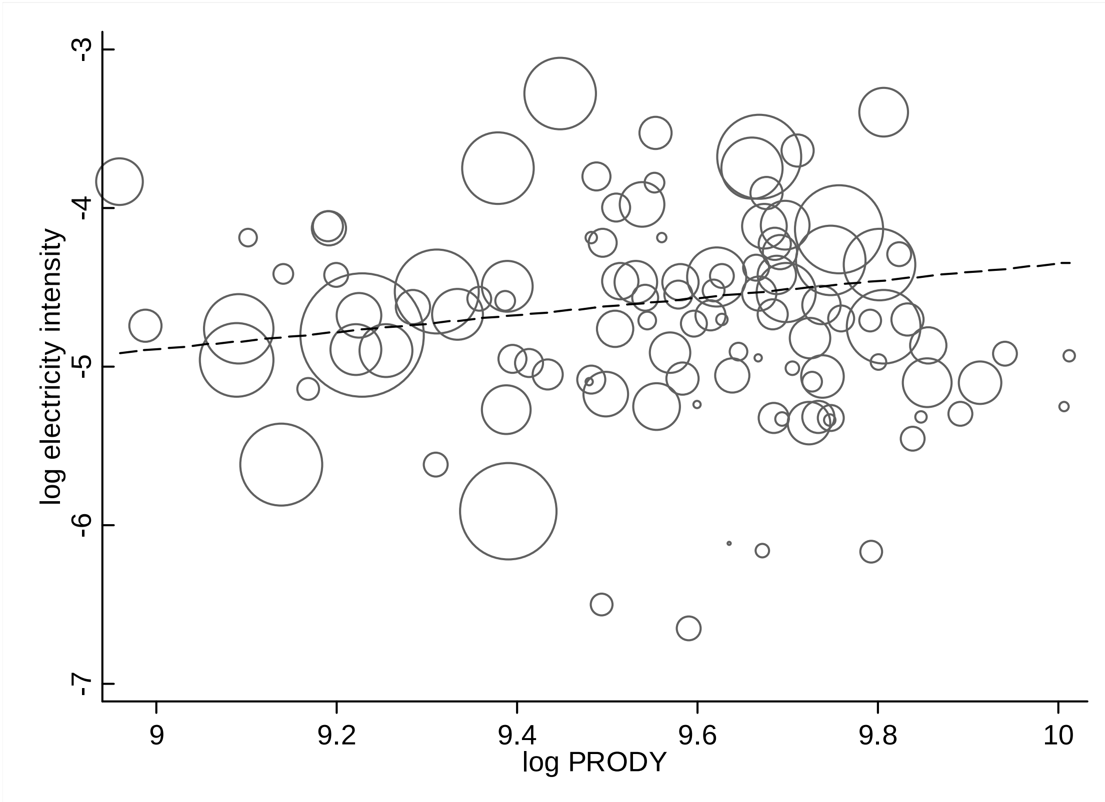
Notes: Data on installed generation capacity from the Indian Ministry of Power's annual reports. Map of coal reserves from MapsofIndia.com.

Figure 6: Indian and UK Electricity Intensities



Notes: Log India electricity intensity (in rupees per kilowatt-hour) is calculated for 4-digit industries using the 1999 ASI data. Log UK electricity intensity (in pounds sterling per kilowatt-hour) is calculated for 4-digit industries using data from Department of Energy and Climate Change (2011) and Office of National Statistics (2010). The fitted regression line is weighted by the number of Indian firms used to calculate electricity intensity in each 4-digit industry. The sizes of the circles indicate these weights. The slope of the line is 0.36 and is statistically significant at the one percent level.

Figure 7: Electricity Intensity vs. PRODY



Notes: Log electricity intensity is calculated for 4-digit industries using the 1999 ASI data. Log PRODY is calculated using data from Hausmann, Hwang, and Rodrik (2006). The fitted regression line is weighted by the number of firms used to calculate electricity intensity in each 4-digit industry. The sizes of the circles indicate these weights. The slope of the line is 0.54 and is statistically significant at the five percent level.

Table 1: Summary Statistics

	High Electricity Intensity Industries	Low Electricity Intensity Industries	All
Electricity used (GWh)	2.55	0.91	1.57
	(4.03)	(2.15)	(3.15)
Electricity bought (GWh)	2.35	0.80	1.43
	(4.03)	(2.01)	(2.98)
Electricity generated (GWh)	0.19	0.11	0.14
	(0.48)	(0.35)	(0.41)
Electricity generation dummy	0.46	0.43	0.44
	(0.50)	(0.49)	(0.50)
Electricity generated share	0.08	0.09	0.09
	(0.17)	(0.18)	(0.49)
Electricity price (Rs. Per kWh)	2.90	2.92	2.91
	(0.50)	(0.48)	(0.49)
Electricity intensity (kWh per Rs.)	0.02	0.01	0.01
	(0.02)	(0.003)	(0.02)
Output (millions of Rs.)	152.0	121.0	133.0
	(272.0)	(238.0)	(253.0)
Number of workers	176	153	162
	(231)	(212)	(220)
Output per worker (millions of Rs. per worker)	0.80	0.78	0.79
	(1.08)	(1.10)	(1.09)
Machinery (millions of Rs.)	39.70	21.10	28.60
	(77.00)	(54.30)	(65.10)
Machine-labor ratio (millions of Rs. per worker)	0.19	0.11	0.14
	(0.31)	(0.22)	(0.26)
No. of observations	62,429	92,421	154,850

Notes: High electricity intensity industries are defined as those with electricity intensities above the average electricity intensity, while low electricity intensity industries are those with electricity intensities below or equal to the average.. Standard deviations in parentheses.

Table 2: First Stage Regression

	Dependent Variable: log(electricity price)		
	(1)	(2)	(3)
log(thermal share x coal price)	0.599***	0.224***	0.224***
	<0.182>	<0.045>	<0.045>
government ownership dummy			0.005
			<0.010>
F-statistic (1st Stage Instrument)	10.80	24.70	24.65
No. of Observations	154,850	154,850	154,850
No. of Firms	45,703	45,703	45,703
Firm Effects	Yes	Yes	Yes
Region-Year Effects	Yes	Yes	Yes
State Time Trend	No	Yes	Yes

Notes: *** indicates statistical significance at the 1% level, ** at the 5% level, and * at the 10% level. Robust standard errors, in parentheses, are clustered at the state level. All regressions control for the value of coal used by the firm.

Table 3: Effect of Electricity Price on Electricity Consumption

	OLS	**Reduced Form**	**IV**
	(1)	(2)	(3)
Panel A. Dependent Variable: log(electricity bought)			
log(electricity price)	-0.875***	-0.263***	-1.178***
	<0.024>	<0.056>	<0.209>
Panel B. Dependent Variable: log(electricity used(bought + self-generated))			
log(electricity price)	-0.837***	-0.374***	-1.672***
	<0.023>	<0.080>	<0.052>
Panel C. Dependent Variable: generation dummy			
log(electricity price)	0.030**	-0.244***	-1.090***
	<0.012>	<0.082>	<0.249>
Panel D. Dependent Variable: share of self-generated electricity			
log(electricity price)	0.033***	-0.083*	-0.369*
	<0.004>	<0.046>	<0.191>
No. of Observations	154,850	154,850	154,850
No. of Firms	45,703	45,703	45,703
Firm Effects	Yes	Yes	Yes
Region-Year Effects	Yes	Yes	Yes
State Time Trend	Yes	Yes	Yes

Notes: *** indicates statistical significance at the 1% level, ** at the 5% level, and * at the 10% level. Robust standard errors, in parentheses, are clustered at the state level except for the OLS regressions which cluster standard errors at the firm level. All IV regressions control for the value of coal used by the firm.

Table 4: Effect of Electricity Price on Industry Switching

	First Stage	OLS	Reduced Form	IV
	(1)	(2)	(3)	(4)
Panel A. Dependent Variable: log(electricity price)				
log(thermal share x coal price)	0.177**			
	<0.074>			
F-statistic (1st Stage Instrument)	5.71			
Panel B. Dependent Variable: switch5				
log(electricity price)		0.006	0.313**	1.772***
		<0.017>	<0.134>	<0.061>
Panel C. Dependent Variable: switch4				
log(electricity price)		-0.018	-0.002	-0.009
		<0.013>	<0.090>	<0.497>
Panel D. Dependent Variable: switch3				
log(electricity price)		-0.016	-0.176***	-0.996
		<0.011>	<0.057>	<0.647>
No. of Observations	104,517	104,517	104,517	104,517
No. of Firms	27,926	27,926	27,926	27,926
Firm Effects	Yes	Yes	Yes	Yes
Region-Year Effects	Yes	Yes	Yes	Yes
State Time Trend	Yes	Yes	Yes	Yes

Notes: *** indicates statistical significance at the 1% level, ** at the 5% level, and * at the 10% level. Robust standard errors, in parentheses, are clustered at the state level except for the OLS regressions which cluster standard errors at the firm level. All IV regressions control for the value of coal used by the firm. Switch5, switch4, and switch3 are indicator variables for whether a firm's 5-, 4-, or 3-digit industry, respectively, differs from the previous period's.

Table 5: Effect of Electricity Price on Industry Choice

	Dependent Variable: log(5-digit industry electricity intensity)		
	OLS	**Reduced Form**	**IV**
	(1)	(2)	(3)
log(electricity price)	-0.008	-0.065***	-0.290***
	<0.014>	<0.019>	<0.079>
No. of Observations	154,850	154,850	154,850
No. of Firms	45,703	45,703	45,703
Firm Effects	Yes	Yes	Yes
Region-Year Effects	Yes	Yes	Yes
State Time Trend	Yes	Yes	Yes

Notes: *** indicates statistical significance at the 1% level, ** at the 5% level, and * at the 10% level. Robust standard errors, in parentheses, are clustered at the state level except for the OLS regressions which cluster standard errors at the firm level. All IV regressions control for the value of coal used by the firm.

Table 6: Industry Electricty Intensity and Firm Productivity Growth (2001-2008)

	(1)	(2)
Panel A. Dependent Variable: productivity growth rate		
log(5-digit industry electricity intensity)	0.011***	0.012***
	<0.004>	<0.004>
log(output)		-0.013***
		<0.002>
log(age)		-0.003
		<0.004>
Panel B. Dependent Variable: output growth rate		
log(5-digit industry electricity intensity)	0.015***	0.015***
	<0.005>	<0.004>
log(output)		-0.011***
		<0.002>
log(age)		-0.030***
		<0.004>
Panel C. Dependent Variable: employment growth rate		
log(5-digit industry electricity intensity)	0.002	0.002
	<0.003>	<0.003>
log(output)		0.003***
		<0.001>
log(age)		-0.024***
		<0.003>
No. of Observations (Firms)	5,654	5,654
State Effects	Yes	Yes

Notes: *** indicates statistical significance at the 1% level, ** at the 5% level, and * at the 10% level. Robust standard errors, in parentheses, are clustered at the state level except for the OLS regressions which cluster standard errors at the firm level. All IV regressions control for the value of coal used by the firm.

Table 7: Effect of Electricity Price on Other Firm Outcomes

	OLS	Reduced Form	IV
	(1)	(2)	(3)
Panel A. Dependent Variable: log(output)			
log(electricity price)	-0.013	-0.763***	-3.408***
	<0.026>	<0.099>	<0.468>
Panel B. Dependent Variable: log(employment)			
log(electricity price)	0.009	-0.135	-0.603
	<0.015>	<0.129>	<0.478>
Panel C. Dependent Variable: log(output per worker)			
log(electricity price)	-0.023	-0.575***	-2.569***
	<0.024>	<0.056>	<0.653>
Panel D. Dependent Variable: log(machinery)			
log(electricity price)	0.01	-0.576***	-2.576***
	<0.044>	<0.115>	<0.131>
Panel E. Dependent Variable: log(machine-labor ratio)			
log(electricity price)	0.001	-0.423***	-1.889***
	<0.044>	<0.107>	<0.581>
No. of Observations	154,850	154,850	154,850
No. of Firms	45,703	45,703	45,703
Firm Effects	Yes	Yes	Yes
Region-Year Effects	Yes	Yes	Yes
State Time Trend	Yes	Yes	Yes

Notes: *** indicates statistical significance at the 1% level, ** at the 5% level, and * at the 10% level. Robust standard errors, in parentheses, are clustered at the state level except for the OLS regressions which cluster standard errors at the firm level. All IV regressions control for the value of coal used by the firm.

Appendix

Table A1: Electricity Prices Approved by Karnataka Electricity Regulatory Commission (2002)

Category of Consumer	**Electricity Price (Rupees per kWh)**	
Industrial	Up to 100,000 kWh	3.50
	100,001 kWh and above	3.75
Domestic	Up to 30 kWh	1.50
	31kWh to 100 kwH	2.55
	101kWh to 200 kwH	3.25
	201kWh to 300 kwH	3.75
	301kWh to 400 kwH	4.00
	401 kWh and above	4.25
Agricultural	All kWh	0.40

Notes: Data from Karnataka Electricity Regulatory Commission (2002).

Table A2: NIC 1998 Industry 151

3-Digit Industry	4-Digit Industry	5-Digit Industry	Industry Description
151	**Production, processing and preservation of meat, fish, fruits, vegetables, oils and fats**		
	1511	*Production, processing and preserving of meat and meat products*	
		15111	Mutton-slaughtering, preparation
		15112	Beef-slaughtering, preparation
		15113	Pork-slaughtering, preparation
		15114	Poultry and other slaughtering, preparation
		15115	Preservation of meat except by canning
		15116	Processing and canning of meat
		15117	Rendering and refining of lard and other edible animal fats
		15118	Production of flours and meals of meat and meat offals
	1512	*Processing and preserving of fish and fish products*	
		15121	Sun-drying of fish
		15122	Artificial dehydration of fish and sea food
		15123	Radiation preservation of fish and similar food
		15124	Processing and canning of fish
		15125	Manufacturing of fish meal
		15126	Processing and canning of froglegs
		15127	Processing and preserving of fish crustacean and similar foods
	1513	*Processing and preserving of fruit and vegetables*	
		15131	Sun-drying of fruit and vegetables
		15132	Artificial dehydration of fruit and vegetables
		15133	Radiation preservation of fruit and vegetables
		15134	Manufacturing of fruit/vegetable juices and their concentrates, squashes and powder
		15135	Manufacture of sauces, jams, jellies and marmalades
		15136	Manufacture of pickles, chutneys, murabbas etc.
		15137	Canning of fruit and vegetables
		15138	Manufacture of potato flour & meals and prepared meals of vegetables
		15139	Fruit and vegetables preservation n.e.c. (including preservation by freezing)
	1514	*Manufacture of vegetable and animal oils and fats*	
		15141	Manufacture of hydrogenated oils and vanaspati ghee etc.
		15142	Manufacture of vegetable oils and fats (excluding corn oil)
		15143	Manufacture of vegetable oils and fats through solvent extraction process
		15144	Manufacture of animal oils and fats
		15145	Manufacture of fish oil
		15146	Manufacture of cakes & meals incl. residual products, e.g. Oleostearin, Palmstearin
		15147	Manufacture of non-defatted flour or meals of oilseeds, oilnuts or kernels

Notes: Data from Indian 1998 National Industrial Classification.