Electricity prices and industry switching

Sun, Puyang; Zhu, Tong; Elliott, Robert

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Electricity Prices and Industry Switching: Evidence from Chinese manufacturing firms

Robert Elliott[1], Puyang Sun[2], and Tong Zhu[3]

[1]*University of Birmingham, UK*
[2]*Nankai University, China*
[3]*The Economic and Social Research Institute, Ireland*

Abstract

Energy is an essential input into a firm's production process. In this paper we investigate how electricity price changes across Chinese provinces affect the decision of firms to switch production from one industry to another. To address potential endogeneity between electricity prices and unobservable province level policies we construct an instrument from the interaction of regional coal production and thermal power generation capacity. Our instrumental variable results show that manufacturing firms are more likely to switch the industry of their main product to a less energy intensive industry as a result of rising electricity costs. More specifically, a 10% increase in the price of electricity leads to an increase in the probability of switching to a less energy intensive industry of around 2.3%. Our findings suggest that a well designed electricity price scheme can encourage firm behaviour than is consistent with reductions in energy use.

Keywords: L6, O13, O14
JEL Codes: Industry switching, Energy prices, Firm behaviour

1 Introduction

In recent years, environmental concerns in China have been growing. Widespread problems of smog and haze have resulted in calls to reduce air pollution (The Economist, 2015).[1] One reason that there has not been more progress is related to China's existing energy reserves and the structure of energy consumption. China is relatively rich in coal with total proven reserves totalling 114.5 billion tons at the end of year 2014 accounting for 12.8% of global reserves. In contrast, the proven reserves for oil and gas account for 1.1% and 1.8% of the global share respectively (British Petroleum, 2015). The endowment of coal in particular means there is less incentive for China to develop alternative energy strategies.[2] Besides uneven energy reserves, energy-hungry industries such as the smelting of ferrous and non-ferrous metals sectors were regarded as one of the major driving forces of growth during China's rapid industrialization process over the last 30 years. Given that energy consumption is one of the main causes of air pollution in China, an energy-centric approach to the problem is needed.

Energy is a fundamental input for manufacturing production and energy costs account for a significant part of operational costs. Electricity costs as a percentage of total production costs or value added for energy intensive sectors range from a low of 12-16% for blast/basic oxygen furnace steel production and textiles, to 20-25% for electric arc furnace steel and copper and 30-50% for aluminium and chemicals (BLS and Tractus, 2016). Since firms are an important engine of growth and energy is an essential input in the production process, identifying how firms change their main product in response to energy price changes is important for both academics and policymakers.

The purpose of this paper is to be the first, to the best of our knowledge, to study how changes in electricity prices in China affect the decision of firms to switch production between different sectors and industries taking into account possible endogeneity between energy prices and local government decision making.[3] Although existing research recognises the impact of energy prices on productivity and output there has been little discussion about the price impact on existing firms' product choice. Our approach is to combine a unique regional industrial electricity price dataset with a

[1] http://www.economist.com/news/china/21661053-new-study-suggests-air-pollution-even-worse-thought-mapping-invisible-scourge.

[2] According to Statistical Review of World Energy 2015 by British Petroleum, total proven reserves for oil, natural gas and coal in the United States are 2.9%, 5.2% and 26.6% respectively.

[3] In this paper we assume a firm to have switched its main product when this changes from one 4-digit level product to another. Our definition differs slightly from the definition in the literature that investigates the dynamic of multi-product firms, e.g., Bernard et al. (2010). See Section 2.1. for more details.

comprehensive firm-level dataset to investigate how changes in the electricity price affect firm switching behaviour across different provinces for the period 2005 to 2007. More specifically, we examine the impact of electricity prices on a firm's choice of industry for their main product controlling for firm and industry characteristics and initial intensity conditions. We address two main questions. First, everything else equal, does an increase in the electricity price encourage firms to shift production from high energy intensive goods and dissuade firms from switching from low to high energy intensity production. Second, does the gap between the energy intensity levels differ between these two groups of switchers. A further contribution is to address possible endogeneity concerns between electricity prices and local government policymaking.

In China, the electricity pricing scheme, originally designed in the 1960s, defined several categories of end users where each end user was assigned a specific energy price by province and local pricing bureaus under the guidance of the central government. The endogeneity concerns arise from the possible political influence under which low energy prices serve as a policy used by local officials to support industries in their jurisdictions. Hence, unobserved political influence might impact both local energy prices and firm performance with preferential treatment often targeted at firms that operate in energy intensive sectors (Lo, 2014; Chen, 2011; Zhou et al., 2010; US ITC, 2007). Our solution is to construct an instrumental variable from the interaction of regional coal production and thermal power generation capacity to isolate the exogenous variation in energy prices that allows us to observe how electricity prices affect firm behaviour only through the price variation.

A brief description of China's energy pricing policy helps to illustrate possible endogeneity concerns. The recent response of China's government to increasing environmental concerns was to launch a progressive energy pricing reform plan following the 12th Five-Year Plan. Starting in 2011 the plan promotes market-oriented competition in the energy markets. Prior to this period, for historical reasons, China's energy prices were highly regulated and the prices often set for political reasons rather than being market driven. As a political instrument, China has previously used energy prices, to subsidize energy consumption for the poor, and to encourage or restrict the development of specific industries depending on local governments' objectives (Ecofys et al., 2015). [4]

[4]Electricity pricing in China is controlled by the National Development and Reform Commission (NDRC) and province level government. Province-level officials set electricity prices taking account inflation, industrial support and social stability under the instruction of NDRC. For more information about energy pricing in China, see Fredrich Kahrl (2011); US ITC (2007); IEA and OECD (2006). As an example of how electricity prices have been used to incentivise or restrict certain industries, according to the differential electricity price scheme issued by the State Council in June 2004, firms operating in six energy-intensive sectors were classified into four categories: eliminated; restricted; permitted; and encouraged based on their products and manufacturing process. A punitive surcharge was imposed on

More recently, responsibility for energy pricing has been decentralized to the local level although this process has not been smooth as the policy was often in conflict with the primary interest of the local government to grow the economy. Moreover, the policy also tends to reduce the local tax revenue and the surcharge is levied directly by state-owned power companies. As a result, local governments would often evade the national policy or countered it with temporary preferential (reduced) electricity prices to support energy intensive industries in their jurisdictions (Zhou et al., 2010; Chen, 2011). [5]

The potential for electricity prices to be affected by firm behaviour also presents a challenge when it comes to identifying the causal link between electricity costs and switching behaviour. As a result, the endogeneity caused by both sources may induce a downward bias and an underestimation of the price effect. The endogeneity of the energy price is considered by Abeberese (2012), Ganapati et al. (2016) and Allcott et al. (2016). Abeberese (2012) interacts the coal price and the thermal power generation capacity to create an instrument for India electricity prices. Similarly, Ganapati et al. (2016) interact three types of fuel prices (coal, natural gas and petroleum) and the shares of fuel used to generate electricity respectively as instruments for U.S. state-level electricity prices. In a study of the impact of electricity shortages on India manufacturing firms, Allcott et al. (2016) use the average state level shortage of hydroelectric power availability as an instrument.

Turning to the existing literature, there are a small number of papers that have examined the determinants of firm switching behaviour. Redding et al. (2006) investigate the product switching of surviving firms using the quinquennial U.S. Manufacturing Censuses data and find that approximately two-thirds of firms altered their product mix of five-digit SIC products every five years and the change in output due to the adding and dropping of products by surviving firms accounts for approximately one-third of the aggregate change.[6] The prevalence of switching behaviour is also found among Japanese manufacturing firms (Kawakami and Miyagawa, 2010).

According to Goldberg et al. (2010), compared to US firms, product switching is far less common in large developing countries such as India. Although multi-product firms account for 47% of manufacturing firms over a 5 year period only 28% of firms

firms categorized as eliminated and restricted with an additional 0.05 yuan and 0.02 yuan per kWh imposed on consumed electricity. The tariff was adjusted in June 2010 and raised to 0.3 yuan and 0.1 yuan per kWh respectively.

[5] Such activity was particularly prevalent after the financial crisis when 22 provinces reinstated preferential electricity prices for firms producing aluminium even though such a policy response was first forbidden in 2004.http://www.gov.cn/jrzg/2010-08/07/content_1672969.htm

[6] Product switching in Redding et al. (2006)'s study is defined at 5-digit SIC level and consists of 1,848 products.

report a product switch compared to a 54 percent for US firms. However, common features for both Indian and US firms include that large and multi-product firms tend to be more likely to engage in switching behavior. Looking at Vietnamese data at the firm, sector and industry levels Newman et al. (2013) demonstrate that switchers have different characteristics and behave differently to newly established firms and exiting firms. Large firms with higher productivity involved in multi-product production tend to have a higher probability of switching into a new sector, while small firms with single products are more likely to switch out. There is also weak evidence that firm characteristics such as the capital-labour ratio and ownership play only a minor role in promoting switching. One type of supply shock, namely trade liberation, has been further investigated by Bernard et al. (2006) and shows that switching rates tend to increase with trade liberalization. As trade costs fall, firms' product scope shrinks and the least- productive product tends to be dropped by surviving exporters. When focusing on trade exposure to low-wage countries, the capital-labour ratio plays an important role in determining firms' switching behavior since labour-intensive firms are more susceptible to import from low-wage countries due to the comparative advantage (Bernard et al., 2007).

Studies that consider switching and energy prices are limited. The most relevant study is Abeberese (2012) who examines the electricity price effect on a series of Indian firm outcomes including industry choice, product mix, capital-labour ratio and productivity. The main finding is that a 1% increase in electricity price instrumented by generation conditions lead to approximately 1.6 to 1.8 percentage point change in the probability of a firm switching industries. Output, the capital labour ratio and labour productivity are also shown to decrease as a result of an increasing electricity price.[7]

To briefly summarise our results we show that higher electricity prices encourage surviving firms to change the 4-digit industry of their main product. In particular, we find that higher energy prices provide an incentive for firms to switch to a less energy intensive industry, and dampen a firm's desire to switch to a more energy intensive industry. Our preferred specification shows that a 10% electricity price increase leads to a 2.26% to 2.38% increase in the probability that a firm switches to a less energy intensive industry, and a 2.10% to 2.20% fall in the probability that a firm switches to a more energy intensive industry all else equal. We also find that the magnitude

[7] In related research Ganapati et al. (2016) develop a partial equilibrium methodology to estimate how the energy price changes are shared between U.S. manufacturers and consumers. They find that under the imperfect market competition environment, consumers bear about 70 percent of energy price-driven changes in input costs. In a more recent study Rentschler and Kornejew (2017) investigates the impact of regional energy price variation in Indonesia and finds that higher prices have a small but statistically significant negative impact on firms' long-term competitiveness.

of the dampening effect depends on a firm's initial energy intensity level. Our results also suggest that a degree of conflict between the central and local authorities in terms of the electricity pricing regime and that it is important to control for endogeneity between prices and local policies.

The reminder of the paper is organized as follow. Sections 2 and 3 describe the methodology and statistical description of the data. The empirical results are presented in Section 4 and the final section concludes and discusses the policy implications.

2 Empirical Strategy

2.1 Dependent variables

This study aims to analyze the impact of energy prices on a firm's switching decision. Our priors are that firms located in provinces with high energy prices are more likely to switch into less energy intensive industries compared to firms located in low energy cost provinces everything else equal. Following Newman et al. (2013), we define the switching behaviour as a firm whose main product in year t and main product in year $t+1$ are from different four-digit industries.[8] Table 1 provides an illustrative example of switching behaviour. The top row illustrates the case when a firm switches product in 2006 from CIC1311 to CIC1312 in 2007. Likewise, the middle row shows when a firm makes the same switch in 2005. The final row shows the example when there is no switching behaviour. A dummy variable $Switch$ is therefore defined as missing for all switchers for the year after a firm switches 4-digit industry.[9] In the Chinese industrial firm dataset a 4-digit sector code is assigned based on the product which accounts for the highest share of total revenue. No quantity or value information is provided for products other than the main product. There are variables for the firm's main product 1, main product 2 and main product 3. However, the records are imported in Chinese without a uniform codebook (but can be roughly translated at the 2 to 3 digit level).

[Table 1 about here]

To measure whether a firm switches from a high to low or low to high energy intensive (hereafter, EI) industry, ideally we would have information on energy consumption at the 4-digit level. Unfortunately such information is unavailable for Chinese man-

[8] The 4-digit industry classification that we use is GB/T4754-2002.

[9] To investigate the characteristics of industries that firms switch out from, the switch dummy is defined as missing after the year of switching. This enables us to exclude the interface of industries that firms switch into. Strictly speaking, the dummy indicates a firm's switch-out behaviour.

ufacturing industries. Our solution is to consider energy inputs and fixed capital as complements. During our study period the correlation between 2-digit electricity consumption and 2-digit fixed capital is 0.845. Hence, we decompose industrial electricity consumption at the 2-digit level to create an estimate of electricity inputs at the 4-digit level using the proxy of total fixed capital.[10] Hence, we calculate equation (1) using sectoral electricity consumption disaggregated into industry electricity consumption.

$$\frac{FA_{4-digit,t}}{FA_{2-digit,t}} = \frac{EC_{4-digit,t}}{EC_{2-digit,t}}$$

$$EC_{4-digit,t} = \frac{FA_{4-digit,t}}{FA_{2-digit,t}} \times EC_{2-digit,t} \tag{1}$$

FA and EC represent the total fixed capital aggregated from firm-level data and electricity consumption respectively.

For our measure of electricity consumption, energy intensity at the 4-digit level is defined as electricity consumption at the 4-digit level over total industrial output aggregated from firm-level data.

$$EI_{4-digit,t} = \frac{EC_{4-digit,t}}{Y_{4-digit,t}} = \frac{FA_{4-digit,t} \times EC_{2-digit,t}}{FA_{2-digit,t} \times Y_{4-digit,t}} \tag{2}$$

From our 4-digit energy intensity estimates, we can now identify the direction of switching behaviour. A dummy variable $Switch\_HL$ is used to mark the switching behaviour from a high EI industry to a low EI industry; $Switch\_LH$ signals switching the other way around. Furthermore, we define the extent of the change in EI (or EI gap) as the absolute value of the EI difference between the current industry and the industry that a firm switches into. Hence, for switchers, the *EI gap* is given by:

$$EI\ gap_{ispt} = |EI_{isp,t} - EI_{isp,t+1}| \tag{3}$$

For non-switchers, *EI gap* is

$$EI\ gap_{ispt} = 0 \tag{4}$$

The dependent variable *EI gap* quantifies how large the energy intensity difference is between the current industry and the next industry. This can be considered as a measure of the degree to which price changes have encouraged firms to switch their

[10] The relationship of complementarity between energy and fixed capital has been studied extensively. For example, the E-K complementarity is found for manufacturing sectors in U.S. (Berndt and Wood, 1979), Canada (Fuss, 1977), Netherlands (Magnus, 1979) and New Zealand (Patterson, 1996). Recent studies include Apergis and Payne (2009), Mazzanti and Zoboli (2009) Pablo-Romero and Sánchez-Braza (2015), and Khayyat (2015) for a detailed literature review.

main good of production.

2.2 Independent variables

Our main variable of interest is the energy price. We measure local industrial electricity prices (IEP) at the province level. Due to data limitations, the time period for our industrial electricity price dataset covers the years 2005 to 2007. Other regional impact factors are assumed to be time invariant and proxied by province specific dummies.

Since firms evaluate their decisions and adjust future expectations on the basis of current production and capabilities (Newman et al., 2013), productivity plays a crucial role in the decision making process of the firm. We capture productivity using a measure of total factor productivity (TFP) using the LP method (Levinsohn and Petrin, 2003) and a measure of value added per worker ($Labor\ productivity$). We also include total fixed assets per worker ($KL\ ratio$) as a measure of sunk costs of production. Redding et al. (2006) find that within industries, labour intensive plants are more likely to be affected by international trade exposure and hence more likely to switch production relative to capital intensive plants. Newman et al. (2013) argue that the capital labour ratio plays a positive and significant role for new firms making the entry decision, while it is neutral or even obstructive for the decision to switch for incumbent firms.

Firm size and ownership structure are also considered important factors that may influence a firm's switching decision. Newman et al. (2013) point out that large firms may find it difficult to retrain workers if they plan to switch their industry of production. Redding et al. (2006) argue that young firms with small scale production have a higher tendency to drop products. As for ownership structure, state owned firms are often considered to be less efficient and less productive than private firms as the production decisions may be politically driven (Groves et al., 1994; Jefferson and Rawski, 1994). In contrast, firms with significant foreign investment are expected to be more flexible and utilize more advanced technologies (Dunning, 1988; Carr et al., 2001; Hu et al., 2005). Using the Chinese Industrial Census data, Li et al. (2001) suggest that domestic firms benefit from the presence of foreign investment but also from competition between foreign and local firms. To control for the influence of ownership structure, we include the state-own capital share (SOE) and the share that is from foreign, Hong Kong, Macao and Taiwan owners (FIE). [11]

[11] In further results we use an ownership dummy that is equal to one when the share of ownership exceeds 51%.

We also control for multi-product firms ($MULTI$), exports as a share of output (EXP) and investment in research and development as a share of output ($R\&D$). Multi-product firms are able to reallocate resources more efficiently than their single-product competitors (Redding et al., 2006). In contrast, Goldberg et al. (2010) find that product churning is far less frequent in developing countries due in part to complex industrial regulations. Hence, we separate single-product firms from multi-product firms. Bernard et al. (2006) indicates that trade liberalization can enhance firms' performance in terms of output per product and the total number of products since surviving firms reallocate resources and drop their less productive products as trade costs fall. Moreover, if firms export, they tend to export a series of goods to multiple destinations, and hence, the U.S. export market is occupied by a relatively small number of firms (Bernard et al., 2007). Likewise, firms with higher innovative capability are assumed to be able to switch production or produce more varieties as they adapt to customers' preferences (Abernathy and Utterback, 1978; Utterback and Abernathy, 1975). [12]

In addition to firm characteristics we also control for industry level controls that may affect a firm's switching decision. Our industry controls are aggregated from firm-level estimates of productivity, capital labour ratio, firm size, ownership structure, exports and R&D expenditure. We also control for the firm concentration ratio (CR) and industrial energy intensity (EI) to account for the degree of competition and the dependency on energy of an industry respectively. Industries that are highly dependent on energy resources are expected to be more sensitive to energy price changes. The existing literature that studies the effect of market concentration on firm survival tends to be inconclusive. For example, Audretsch (1991) find a positive impact of market concentration on the short-run survival rates at the industry level and no impact on the long-run scenario using U.S. manufacturing firms established in 1976. In contrast, Audretsch and Mahmood (1995) find limited evidence in a study of firm survival at the establishment level and find a negative impact of market concentration.[13]

2.3 Model specifications

Including a range of firm-level and industry-level characteristics our empirical specification is given by:

$$\begin{aligned} Pr(Switch_{ispt}) = & \alpha + \beta_1 IEP_{pt} + \beta_2 IEP_{pt} \times EI_{st} + \Phi + \Phi^{'} \\ & + \theta_s + \delta_p + \eta_t + \varepsilon_{ispt} \end{aligned} \tag{5}$$

[12] We also use export and R&D dummies that are equal to one if export or R&D expenditure is positive.

[13] For more literature on market concentration, see Mata and Portugal (2002) and Geroski et al. (2010).

$$\Phi = f\begin{pmatrix} Productivity_{ispt}, KL\ ratio_{ispt}, Size_{ispt}, SOE_{ispt} \\ FIE_{ispt}, EXP_{ispt}, R\&D_{ispt}, MULTI_{ispt} \end{pmatrix} \tag{6}$$

$$\Phi' = f\begin{pmatrix} Productivity^N_{st}, KL\ ratio^N_{st}, Size^N_{st}, SOE^N_{st} \\ FIE^N_{st}, EXP^N_{st}, R\&D^N_{st}, CR_{st}, EI_{st} \end{pmatrix} \tag{7}$$

The subscripts i, s, p, t represent firm, 4-digit industry, province and year respectively. Fixed effects at the industry, province and year are given by θ_s, δ_p, η_t respectively. Recall, our basic hypothesis is that firms located in provinces with costly electricity are expected to be more likely to adjust production away from high energy intensive goods. The impact of energy prices is captured by the coefficient on IEP_{pt} as well as the coefficient on the interaction term between IEP_{pt} and EI_{st}.

The industry-level variables with superscript N capture the characteristics of industry s that the firm has switched out of. Industry characteristics are calculated independently for each firm i by excluding firm i's information.[14] CR_{st} and EI_{st} are simple averages at the 4-digit industry level.

As previously discussed, a potential concern is that the electricity price in China may be endogenous to local firm behaviour. Firms located in regions with relatively high energy costs may make lower profits and hence, provide a low tax contribution to the authorities. With a policy-oriented pricing scheme, local governments have an incentive to lower the real electricity prices for the purpose of economic development through, for example, short-term preferential prices, subsidies and tax refunds.

For China, a significant proportion of the electricity generated comes from thermal power plants which use coal as the main source of fuel. During our period, electricity generation from coal accounted for around 80% of total electricity generation (World Bank, 2014). Although the coal price affects generation costs to a large extent, the electricity sales price does not capture the frequent fluctuations in coal prices. For example, coal prices increased by approximately 80% between 2007 and the middle of 2011, while electricity prices were only allowed to increase by 15%. As a result, we use the interaction between coal production and thermal power generation capacity as an instrument for provincial industrial electricity prices.

$$IV_{pt} = Coal\ production_{pt} \times Thermal\ power\ generation\ capacity_{pt} \tag{8}$$

$$Capacity_{pt} = \frac{Electricity\ generation\ from\ coal_{pt}}{Electricity\ generation\ from\ all\ types\ of\ fuel_{pt}} \tag{9}$$

[14] Strictly speaking, the subscripts for $Productivity^N_{st}$, $KL\ ratio^N_{st}$, $Size^N_{st}$, SOE^N_{st}, FIE^N_{st}, EXP^N_{st} and $R\&D^N_{st}$ are $ispt$ since the algorithm varies for each individual firm. For the consistency of expression, we use the subscript st for all industrial characteristics.

As before subscripts p, t signify that variables at the provincial level in year t. The instrument is expected to have a negative impact on energy prices.

3 Data

In this section we provide a brief introduction to the two main dataset that we use in the paper. The first is the Chinese Industrial Enterprises Dataset classified by the Chinese Industrial Classification (CIC) system. Complied and issued by NBSC, national economic activities are broken down by industry. At the 2-digit level the manufacturing sector is coded from 13 to 43. The annual survey provides detailed performance variables such as industrial output, export value, fixed assets and investments for all "above scale" industrial firms in China.[15]

To clean the data we follow Brandt et al. (2012). First we link firms from annual surveys with IDs and then match firms that might have changed their IDs as a result of restructuring, merger or acquisition using other information such as firms' name, legal person name, post code, phone number etc. Then we drop observations where key variables are negative and firm survival is less than two years between 2005 and 2007.[16]

Table 2 compares the output aggregates at the 2-digit level between the enterprise dataset and the NBSC website. The results show that our data capture over 90% of output for nearly all of our 2-digit products. Manufacture of tobacco (16) and Recycling and disposal of waste (43) are dropped because of insufficient coverage and a relatively small total industrial output. After dropping outliers following Brandt et al. (2012) the result is a dataset with 256,019 firms covering 28 2-digit manufacturing sectors. The top five industries for EI over our time period are CIC 33 (Smelting and processing of non-ferrous metals, CIC 31 (Manufacture of non-metallic mineral products), CIC 26 (Manufacture of chemical raw materials and chemical products), CIC 32 (Smelting and processing of ferrous metals) and CIC 42 (Manufacture of artwork and other manufacturing) . The energy intensity information and industry names at the 2-digit

[15]Until 2011 the Chinese Industrial Enterprise Dataset had no firms with annual sales of less than 5 million RMB after which the minimum size was increased to 20 million RMB. The unit of observation in the dataset is a firm defined as a legal unit with a legal unit number (faren daima). Subsidiaries belonging to a large Chinese enterprise may register with their own legal unit numbers and hence may be included in the dataset. In the survey, firms are asked how many establishments they have and in 2007 96.6% firms reported that they were single-plant firms (Brandt et al., 2014).

[16]Key variables include industrial output, sales, value added, intermediate, employment, fixed capital, depreciation, the share that is state-owned, Foreign or from Hong Kong, Macao and Taiwan, exports and R&D expenditure.

level can be found in Table A1 in the appendix.

[Table 2 about here]

Table 3 presents a summary of the switching behaviour of the firm in our dataset. On average, around 2.9% of firms change their main product in a given year.[17] We find that more switching occurs from high EI industries to low EI industries and the EI gap tends to be larger when the switch is from a high EI industry to a low EI industry. A F-test shows that the mean of the EI gap of group ”Switching to a low EI industry” is significantly different to the mean for the group ”Switching to a high EI industry”.[18]

[Table 3 about here]

The second dataset we use is the industrial electricity price dataset, released by the China Price Information Center (CPIC) under NDRC. It provides the retail price for industrial electricity of 35kV and above for 36 large and medium sized cities or province-equivalent municipal cities.[19] We use the average province price aggregated across the cities in that province to represent the industrial electricity price level of that province. This allows us to consider the role of the province level government in energy pricing.

Table 4 provides a brief description of province electricity prices and the relationship between the industrial electricity price, thermal power generation capacity and coal production for individual provinces. The average industrial electricity price is 636.5 yuan/MWH in 2005 prices. For our thermal power generation variable, we observe that Shanghai, Tianjin and Shandong have the electricity fully powered by coal. Shanxi produces on average 588 billion tons of coal and is the top producer in China. Figure 1 plots the industrial electricity price which we represent geographically in Figure 2. Figure 1 shows that the average electricity price increased relatively smoothly between 2005 and 2012 including during our period 2005 to 2007. After 2009 there is evidence of greater price dispersion across provinces. Figure 2 shows that the east and the southern areas of China have generally higher electricity costs than the north and the western areas. Figure 3 provides an overview of the inverse relationship between IEP and our instrument. The validity of instrument is checked later using post-regression tests. Definitions for all of our variables can be found in Table A2 in the appendix. Table A3 provides summary statistics for our control variables and Table

[17] Newman et al. (2013) finds that between 6 and 35 percent of Vietnamese manufacturing firms switched products between 2001 and 2008.

[18] The F-test F(1,11889)=198.72.

[19] The 36 large and medium size cities comprise 31 province-equivalent municipalities or provincial capitals, and 5 large non-capital cities including Qingdao (Shandong province), Ningbo (Zhejiang province), Dalian (Liaoning province), Shenzhen (Guangdong province) and Xiamen (Fujian province).

A4 presents a correlation matrix.

[Figure 1 about here]

[Figure 2 about here]

[Figure 3 about here]

4 Empirical Results

4.1 Switching and the electricity price

Our first estimations of the impact of energy prices on switching uses a simple pooled OLS approach and the results are presented in Table 5. The dependent variable is a switching dummy that is equal to 1 if a firm switches to a different main product at the 4-digit level. We include 4-digit industry fixed effects, province fixed effects and year fixed effects. Standard errors are clustered at the firm level. In terms of exposition, when a firm switches its "main product" it is assumed to have switched to that industry.

Column (1) in Table 5 presents the results including only IEP and fixed effects at different levels on the right hand side. Firm-level characteristics and industry-level characteristics are added in Columns (2) - (5). We include two measures of productivity (TFP and labour productivity) and two different measures of ownership, exports and R&D expenditure (share variables and dummies). The pooled OLS results show a statistically significant and positive impact of IEP on the probability that a firm switches the main product at the 4-digit level. A 10% increase in electricity prices increases the probability that a firm switches by approximately 0.51%. Results are highly consistent and statistically significant across different specifications. As shown in Table 4, the province with the highest annual industrial electricity price in our sample is Guangdong (790.6 Yuan/MWh) while Inner Mongolia has the lowest price level (450.8 Yuan/MWh). As a result, everything else equal, the switching probability of firms located in Guangdong is approximately 3.85 percentage points higher than firms from Inner Mongolia due to electricity cost differences.

Our results also show that the overall impact depends on the current EI level of an industry (Columns 2-5). The positive coefficient of the interaction term between IEP and EI shows that firms in originally energy intensive industries are more likely to be affected by high energy costs and hence are more likely to switch their main product. For example, from Table A1 we know that Sector 33-Smelting and processing of non-ferrous metals has an EI that is around ten times higher than Sector 40 which has the lowest EI. It implies that for two firms sharing similar characteristics, located in the same province but operating in these two sectors respectively, the probabilities of switching industries of these two firms differ by roughly 13%. Intuitively, for industries where energy costs are a large proportion of total costs, firms are more sensitive to electricity price changes.

Turning to the other right hand side variables, the coefficients and significance levels are relatively stable across different specifications. Both of our productivity measures, total factor productivity (Column 2) and value added per worker (Column 3), significantly increase the probability of the switching. A 10% increase in TFP increases the probability of switching by 0.026%. Our results are in line with but of a smaller magnitude to Newman et al. (2013) who show for Vietnam that firms with 10% higher TFP tend to increase the switching probability by 0.21 percentage points. The capital labour ratio is found to have a generally negative impact on switching and firm size shows a positive influence on the switching decision. One implication is that in our sample switchers tend to be the large labour intensive firms. Other results show that for multi-product firms, that account for nearly 30 percent of firms in our sample, as expected that firms producing more than one product are more likely to switch their main product when the electricity prices change.

Considering firm ownership we find that the greater the proportion of state ownership, the less likely firms are to switch products. The probability of industry switching falls by roughly 0.10 percentage points if there is a 10% increase in the share of state ownership. We find a similar result when we include a SOE dummy (Columns 4 and 5) which is assigned a value of 1 when the state owned investment share is greater than 51%. On average, a state owned firm is less likely to switch the main product by approximately 0.85 to 0.86 percentage points. For foreign ownership, Column (2) and column (3) show that on average a 10% increase in foreign investment share and a 10% increase in exports as a share of total output leads to an approximately 0.026 and 0.029 percentage point increase in the switching probability, respectively. However, in Columns (4) and (5) our FIE and export dummy variables are insignificant.[20] Finally, although R&D expenditure is considered to be an important factor that affects firm performance such as the entry and exit decisions (Klepper, 1996; Agarwal and Audretsch, 2001), we find no significant impact of R&D expenditure (share and dummy variables) on the switching decision at individual firm level.

We now turn to our industry controls. For average firm size of an industry we find a

[20]The inconsistency may be due to the less variation in our sample when both of the dependent and independent variables are measured by dummy variables.

negative coefficient suggesting that firms tend to keep producing their main product in those industries where the average firm size is relatively large. A possible explanation is the high sunk costs of establishing a market position in these industries that act as a barrier to exit as well as to entry as these costs will be hard to recover if a firm decides to leave an industry (Eaton and Lipsey, 1980). Hence, the sunk costs commit a firm to a certain industry which requires additional investment to continue to grow market share and hence profits (Cabral, 1995; Cabral and Ross, 2008). For our ownership variables, we find evidence that firms tend to switch out of industries with a significant degree of foreign presence. Given we know that at the individual level SOEs are less likely to switch industry, we can conclude that it is mainly private firms that tend to leave industries with a large share of foreign owed firms.[21] For exports, we observe that firms are less likely to switch out of export-oriented industries while for R&D we find that firms have a higher tendency to switch if that sector has a higher share of R&D expenditure over total output.[22] The concentration ratio and industrial EI levels have generally minor effect. The insignificance of EI when included separately may reflect the large sunk costs usually associated with energy intensive sectors that may deter firms from making the decision to switch.

[Table 5 about here]

4.2 Switching direction and the electricity price

In the previous section we find that the electricity price plays an significant role in a firm's switching decision. However, we did not consider whether the firm moved from a high to low or a low to high EI sector although intuitively one might assume that higher electricity prices encourages firms to switch from producing high EI products to low EI products. Tables 6 and 7 present the results on switching direction from high to low and low to high respectively. The dependent variable $Switch\_HL$ in Table 6 is a dummy that equals to one when a firm switches into a less energy intensive industry, and zero for non-switchers. Correspondingly, the dependent variable $Switch\_LH$ in Table 7 captures the switching behaviour from a less energy intensive industry to a more energy intensive industry.

[21] Existing foreign presence can also prevent new foreign entrants (Mitchell et al., 1994; Shaver et al., 1997; Mata and Portugal, 2002; Chang and Xu, 2008). For example, Mitchell et al. (1994) argues that both a low and a high foreign market share are not suitable for new foreign entrants due to the lack of market information and increasing congestion effects. According to Mitchell et al. (1994) Canadian entry in U.S medical sector is found to be highest when the existing foreign market share is between 13% and 24%. The phenomenon of crowding-out foreign investments has also been found among Chinese manufacturing firms (Chang and Xu, 2008).

[22] The inconsistency of the significance on R&D share and dummy variables may be due to the large amount of zero values of R&D expenditure in out dataset.

The positive and significant coefficients of IEP in Table 6 confirms our prediction that higher electricity costs drive firms away from producing energy intensive goods. Firms located in provinces with high IEP are more likely to switch to a less energy intensive industry everything else equal. The coefficient on IEP is approximately 0.073, which suggests that a 10% increase in the electricity price increases the probability of firm switching their main product into a less energy intensive industry by approximately 0.73%. The insignificant interaction term between IEP and EI shows that there is no additional incentive for firms in energy intensive industries to switch out merely because of high electricity costs. The EI variable by itself remains insignificant.

Table 7 presents the results for switching to a more energy intensive industry. Somewhat surprisingly, the results show that firms are more likely to switch to a high EI industry if they experience a high electricity price. The positive and significant coefficients on IEP suggest that with a 10% increase in IEP increases the probability that a firm switches to a more energy intensive industry by about 0.86% to 0.94%. This is not consistent with our priors as one would expect that firms located in provinces with costly electricity would be less likely to drop their current main product and switch to production of a good that relies more heavily on electricity as an input. The positive coefficients on IEP in Table 7 hint at a misspecification problem. Our concern is that the observable IEP is inappropriate for the evaluation of price effects. Potential bias occurs because we are ignoring the unobservable government impact on firm product choice and electricity prices. In the next section we show that intervention from local authorities can distort the price impact and hence reduce firms' incentive to switch to a low EI industry thereby encouraging firms to remain in their current high EI industry.

In terms of our other controls, we generally find results that are consistent with those in Table 5. Large multi-product firms with high productivity are more likely to switch to both more and less energy intensive industries. SOEs are generally less likely to switch their main products in both cases. However, we do find some differences in the determinants of switching behaviour. For example, negative coefficients on KL ratio in Table 6 suggest that labour intensive firms are more likely to switch to a low EI industry. In other words, capital intensive firms are more likely to stay within an industry producing energy intensive goods. A possible explanation could be the corresponding competitive advantage of capital intensive firms in energy intensive industries (Cole and Elliott, 2003; Cole et al., 2005). On the contrary, exporters are more likely to switch to low EI industry everything else equal. These features do not hold for switching behaviour to more energy intensive industries in Table 7. R&D expenditure has generally insignificant effect.

[Table 6 about here]

[Table 7 about here]

4.3 Controlling for endogeneity in electricity prices

As we have discussed previously, province energy prices may suffer from endogeneity due to electricity pricing being driven by political motives. Hence, we construct an instrument from the interaction between province level coal production and thermal power generation capacity. Thermal power generation capacity is not expected to have a direct impact on the production decision of local firms; the amount of coal production is determined by geographical factors and as a consequence, no immediate influence on firms location or production decisions are expected.

We use the under-identification test (Kleibergen-Paap rk LM statistic) and the weak-identification test (Kleibergen-Paap Wald rk F statistic) to test the validity of our instrument. The null hypothesis is that the matrix is not full column rank and a rejection of the null indicates that the model is identified. The null hypothesis for weak-identification test is that the instrument is only weakly correlated with the endogenous variable and a large F statistic that exceeds the Stock-Yogo critical values eliminates the weak identification concern.[23] The rejection of the under-identification test and weak-identification test suggest that our instrument is valid. Coal production and thermal power generation capacity jointly play a significant role in determining regional electricity prices but are exogenous from a firm's decision to switch the industry of their main product.

Table 8 and Table 9 present the 2 stage least square (2SLS) results for switching to a less and a more energy intensive industry respectively. The coefficients on IEP remains highly significant at the 1% level for both switching directions. However, compared to the OLS results, the magnitudes of the 2SLS coefficients on IEP are larger for switching to a less energy intensive industry, and are now reassuringly negative for switching to a more energy intensive industry. The instrumented coefficients suggest that a 10% increase in IEP leads to a 2.26% to 2.38% increase in the probability of switching to a less energy intensive industry, and a 2.10% to 2.20% reduction in the probability of switching to a more energy intensive industry everything else equal. Furthermore, the negative and significant coefficients on the interaction term in Table 9 suggest that the dampening effect of IEP rises as the firm's initial EI level increases.

The IV results suggest that endogeneity of electricity prices not only lowers the

[23]The Stock-Yogo critical values for F statistics calculated after each 2SLS regression are available upon request. The F statistic in all specifications in our study pass the weak-identification test.

incentive of firms to switch to less energy intensive industries, but also reduces the ability of IEP to stop firms from switching to more energy intensive industries.

In terms of the firm-level characteristics, the parameters are similar to the OLS results in Tables 6 and 7 in terms of both statistical significance and magnitude. Switchers tend to be large, productive firms with a low capital-labour ratio (for firms switching to a less energy intensive industry) everything else equal. SOE firms are also found to be less likely to switch their main product. There is also a suggestion that firms with a high share of exports over total output are more likely to switch to a less energy intensive industry. R&D expenditure remains insignificant.

Likewise, for the industry level characteristics, the results are broadly similar to those in the OLS estimations. Firms with large competitors are less likely to switch out in either direction. In terms of ownership structure, industries with a large share of state-owned ownership are less likely to have firms switching to a low EI industry but more likely to have firms switching to a high EI industry. This may be due to the fact that most of the key energy-related heavy industries are state-owned. Firms that compete in industries with large share of foreign ownerships are also more likely to switch to a high EI industry but less likely to switch to a low EI industry. R&D expenditure is generally insignificant and the concentration ratio measured by the top 5% firms' output over total industrial output is insignificant in all specifications. Firms operating in energy intensive industries are more likely to switch to a high EI industry everything else being equal.

[Table 8 about here]

[Table 9 about here]

4.4 Switching distance

In the final stage of our analysis we investigate the relationship between IEP and the magnitude of the switch in EI. The dependent variable is the EI gap defined in Section 2.1 and is the absolute electricity intensity difference between the industry that the firm is currently located and the target industry for switchers, and zero for non-switchers. One way to think about this is as a measure of the difficulty a firm faces when switching its main product. As a reminder, referring to Table 3, the total number of firms switching to a low EI industry is almost the same as the number of firms switching to a high EI industry. However, the average EI gap of the former group of switchers is significantly larger than the average of the later. The larger EI gap indicates a greater effort made by firms to cut down their energy intensity through adjustments to their main good of production.

[Table 10 about here]

Table 10 presents the results on EI gap using a 2SLS approach. For simplicity we only present the results using ownership dummies. The first three regressions in Column (1) to (3) include switchers to low EI industries and non-switchers; the remaining three columns examine switchers to high EI industries and non-switchers.[24]

The results are highly consistent with those using $Switch\_HL$ and $Switch\_LH$ as dependent variables for both OLS and 2SLS estimations respectively. The price effects are positive and significant for promoting switching to a low EI industries. In our preferred method (Column (2) and (3) of Table 10), a 10% IEP increase leads to a 11.10% to 11.14% increase in the EI gap that a firm switches across to a low EI industry. In other words, an increase of 68 yuan/MWH in the real industrial electricity price will cause on average a drop of 99 KWH/10,000 yuan in the energy intensity. The magnitude of economic impact is relatively small because our sample includes a large amount of non-switchers.[25] As for switching to a more energy intensive industry, as indicted in Columns (5) and (6) of Table 10, a 10% increase in IEP means that the EI gap to a high EI industry is approximately 11.4% on average. This means a 64 KWH/10,000 yuan drop in the average EI gap. The results of other controls match those in earlier estimations.

To check the robustness of our results, we first limit the sample to single-product firms by excluding firms that produce more than one product as recorded in the dataset. In the full sample about 26% firms registered as a multi-product firm.[26] 5. This implies that single-product firms are more likely to switch when facing rising electricity prices while multi-product firms can partly adjust their product mix without switching.

We also recognize that electricity is not the only energy source that firms consume and that there are other alternative sources of energy such as coal and petroleum products. Based on the percentage of electricity consumption over total energy consumption,

[24]The results on EI gap using OLS method are available upon request. The results share a number of common features with those reported in Table 6 and Table 7 when using switching dummies as dependent variables.

[25]The average EI gap including non-switchers and switchers to a low EI industry is 889 KWH/10,000 yuan. The average EI gap including non-switchers and switchers to a high EI industry is 559 KWH/10,000 yuan.

[26]Remaining firms may produce multiple products but did not register the information of their additional products in the database. The information on additional products is entered in Chinese. Table A5 presents the results using OLS estimations and the results are highly consistent with those in Table 5. The coefficients of IEP are positive and significant at 1% level, with a larger magnitude compared to the coefficients in Table

we examine the price effect using firms from the top ten (and bottom ten) sectors that rely most (and least) on electricity as part of their energy mix. Table A6 presents the results with an estimation using the full sample also included for comparison. The coefficient of IEP for the top ten sectors is highly significant and is more than twice larger than that using all sectors. On the contrary, the coefficient is not statistically significant using the bottom ten sectors. The result implies that, as a policy tool, IEP tends to be effective only for sectors that consumes large amount of electricity.

Finally, other robustness checks we conducted include two series of regressions using switching dummies and EI gap as dependent variables. The first is based on a smaller sample that excludes all SOEs and the top 10% largest firms. The second are estimations with standard errors clustered at different levels including province-industry level, province-year level and industry-year level. The clustered standard errors allow for intra-group correlation and the observations within clusters can be correlated in this case. The results are consistent with our previous findings and confirm the association between IEP and firms' switching behaviour.[27]

5 Conclusions

In this paper we investigate how energy prices affect manufacturing firms' behaviour in Chinese provinces between 2005 and 2007. Specifically, we test the impact of industrial electricity price on firms' production choice under exogenous energy price changes. We take into account possible endogeneity arising from the policy-oriented pricing regime in China and show that industrial electricity prices act as an effective intervention that could be used to promote the shifting of the industrial structure towards a more energy efficient product range.

Our results show that more expensive energy not only provides a strong incentive for firms to switch into less energy intensive industries, but also reduces the probability of firms switching into a more energy intensive industry. A 10% increase in the electricity price is found to increase the probability of switching to a less energy intensive industry by approximately 2.26% to 2.38%, and reduce the probability of switching to a more energy intensive industry by 2.10% to 2.20%. The extent of the prevention effect depends on a firm's current energy intensity level. The higher the current energy intensity is, the less likely that a firm in a province with costly electricity will switch to a even more energy intensive industry. The price effect is statistically significant and robust under different specifications

[27]The results of the robustness checks are available upon request.

A number of firm and industry characteristics are also shown to have a significant impact on firms' switching decisions. Results suggest that switchers tend to be the larger and more productive firms. SOE firms are generally less likely to switch their main product. Labour intensive firms and exporters tend to switch out perhaps due to increased flexibility and more dynamic management systems. At the industry level, firms operating in industries with large competitors are less likely to switch generally, while firms in industries with large shares of state-owned and foreign ownerships are more likely to switch into high EI industries.

An important finding is the evidence of the preferential electricity price used by provincial and local authorities to support their jurisdictional energy intensive industries. Comparing OLS and 2SLS results, the prevention effect of costly energy is reversed as a result of endogenous linkages between firm performance and energy prices. This finding suggests that ignoring local protectionism and the conflict of interest between the central and local authorities in China could lead to a biased evaluation of national-wide policies. Our findings support the notion that local energy intensive industries may be protected by local governments by way of preferential energy prices. It is possible therefore that IEP has become a political tool for local authorities to promote the development of energy intensive industries. Preferential electricity prices and negotiated prices were prevalent across many Chinese provinces during the period of our study. Although NDRC instituted policies to increase electricity prices charged for energy intensive industries in 2004, significant resistance by local authorities to implementing these surcharges implies a general failure of these initial attempts. Province and local officials maintained a strong incentive to provide reduced utility fees to heavy industries operating within their localities because of the jobs, tax revenues and personal payoffs provided by these firms (US ITC, 2007; IEA and OECD, 2006; Zhang, 2011).

Furthermore, given that energy prices remained relatively stable until 2009 most of our provinces experienced steady price increases. Over time the IEP in the majority of provinces has continued to rise and the price differences between them has become smaller. Nevertheless, the price differences between provinces at the bottom of the ranking and the others has become larger, especially in the recent years. As a result, there is a larger price variation across Chinese provinces. For example, northern and western provinces such as Inner Mongolia and Shanxi experienced price falls relative to Southern and Eastern regions. Given the price impact on the industrial structure, these differences may cause energy intensive industries to shift from the south-east to the north-west. This mirrors the findings of Wu et al. (2017) who show a westward movement of energy intensive firms in China.

Finally, ongoing energy market reform aimed at fostering competition in the energy supply sectors is expected to reduce prices. Take the recent electricity transmission and distribution pricing reform as an example. The reform, first rolled out in Shenzhen in 2014, aimed to reduce the monopoly power of grid companies and allow room for the market to decide prices on both generation and consumption sides. Lower electricity prices may lead to an increase in energy consumption which may offset efficiency improvements and make it more challenging of improve energy efficiency. Along with energy pricing reforms, policies to promote energy diversification and investment in energy-saving technology may be further strengthened. As a result of high generation costs the market share of renewable energy is still limited. If the negative externalities of fossil energy were to internalized properly, unconventional energy would be expected to play a more important role in China's energy supply market accelerating the replacement of vintage production equipment and encouraging innovation.

One limitation with this current study is that we are not able to provide a detailed investigation into the mechanisms that are driving firms to switch their main product. This study has only investigated the switching of the main product rather than the dynamics of product mix. More precisely, if switching is observed, we are not able to distinguish whether a product has been dropped completely or merely experienced in relative fall in output and hence is no longer the main product. Consequently, we are not able to identify the distribution of products within the firm, and the dynamics of the intensive and extensive product margins. Furthermore, the relatively short period of our analysis means we must be cautious regarding the generalizability of our findings. However, despite these shortcomings we believe our research are a useful foundation for examining the industry dynamics in the context of China.

Figures and tables

Figure 1: Industrial electricity price trend in China (2005-2012)

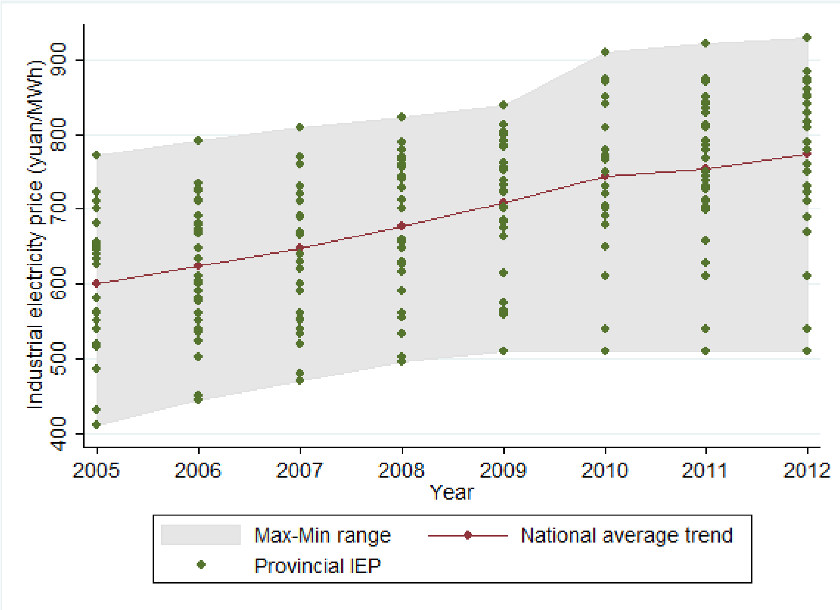

Figure 2: Annual average electricity price in China (2005-2007)

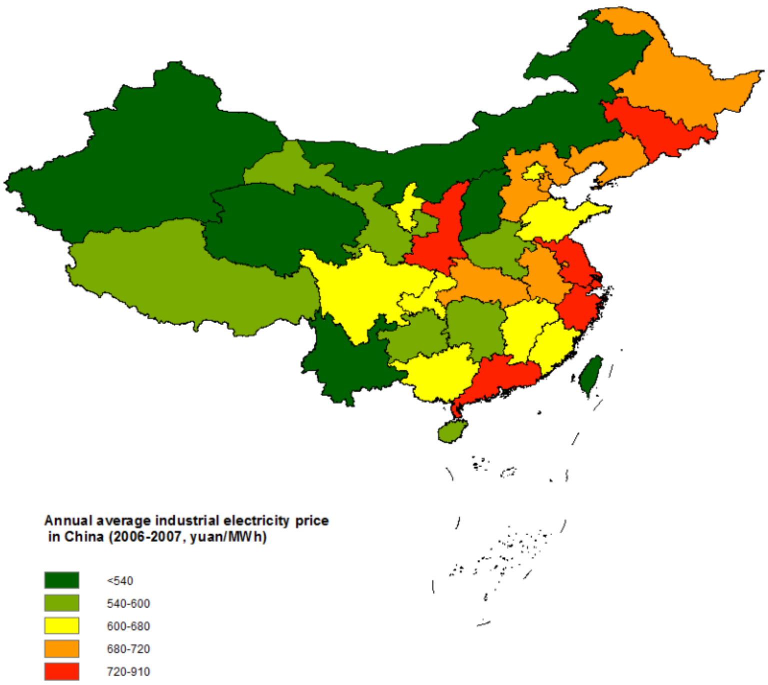

Figure 3: Industrial electricity price and the instrument (2005-2007)

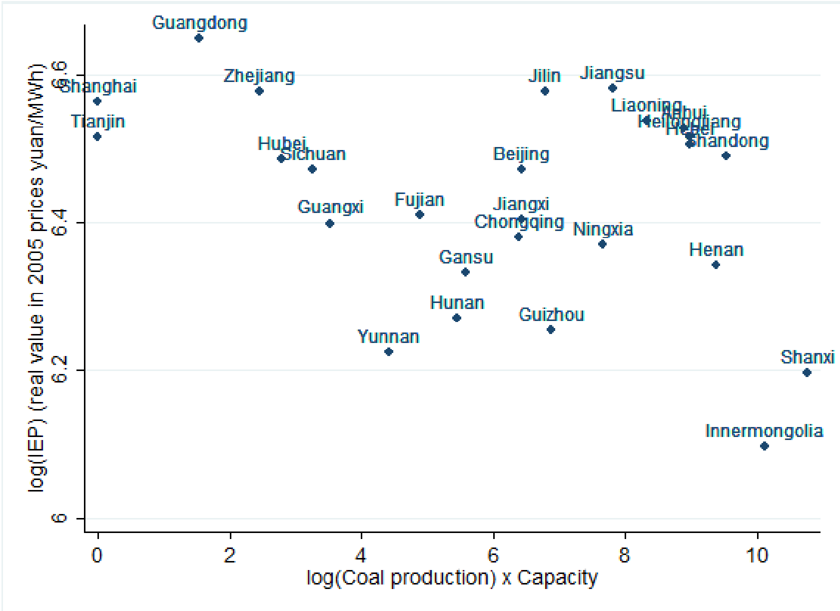

Table 1: An illustrative example of switching behaviour

Year 2005	Year 2006	Year 2007
Edible vegetable oil processing (CIC 1311) *Switch = 0*	Edible vegetable oil processing (CIC 1311) *Switch = 1*	Non-edible vegetable oil processing (CIC 1312) *Switch = .*
Edible vegetable oil processing (CIC 1311) *Switch = 1*	Non-edible vegetable oil processing (CIC 1312) *Switch = .*	Non-edible vegetable oil processing (CIC 1312) *Switch = .*
Edible vegetable oil processing (CIC 1311) *Switch = 0*	Edible vegetable oil processing (CIC 1311) *Switch = 0*	Edible vegetable oil processing (CIC 1311) *Switch = 0*

Table 2: Sectoral output comparison from different data sources

CIC2	Sector output from NBSC	Aggregated output from firm level	Percentage	CIC2	Sector output from NBSC	Aggregated output from firm level	Percentage
13	13695	12538	91.55	28	3312	3173	95.83
14	4855	4512	92.94	29	2797	2659	95.07
15	4024	3786	94.09	30	6523	6047	92.7
16	3277	2497	76.19	31	12159	11198	92.1
17	15573	14692	94.34	32	26859	25338	94.34
18	6245	5846	93.61	33	12969	11738	90.51
19	4255	4016	94.38	34	8844	8207	92.79
20	2592	2347	90.52	35	14254	13466	94.47
21	1912	1760	92.06	36	8210	7613	92.72
22	5174	4851	93.76	37	21082	19761	93.73
23	1756	1643	93.57	39	18695	17628	94.29
24	1780	1689	94.9	40	33099	31547	95.31
25	15000	9732	64.88	41	3543	3392	95.76
26	21202	19395	91.47	42	2652	2454	92.53
27	5210	4953	95.05	43	464.6	412.6	88.8

[a] 2005-2007 annual average. 16-Manufacture of tobacco and 43-Recycling and disposal of waste are dropped because of insufficient coverage and relatively small total industrial output.

Table 3: Summary of switching behaviour (2005-2007)

	2005	2006	Total
Number of firms	206,146	250,783	256,019
Switchers	6,540	6,493	13,033
Percentage of all firms (%)	3.17	2.59	5.09
	Numbers of firms	Mean of EI gap	
Switching to a low EI industry	6,813	356	
Switching to a high EI industry	6,220	289	

Note: EI gap unit in this table is KWH/10000 yuan.

Table 4: Summary of the energy variables by province (2005-2007)

Province	Industrial electricity price (Yuan/MWH)	Thermal power generation capacity	Coal production (10,000 tons)
Guangdong	790.6	0.780	127.8
Jiangsu	735	0.984	2782
Shanghai	726.7	0.996	0
Jilin	725.3	0.847	3024
Zhejiang	711.9	0.789	24.78
Liaoning	710.0	0.946	6704
Anhui	690	0.979	8695
Heilongjiang	681.7	0.976	9950
Tianjin	680	0.997	0
Hebei	679.4	0.991	8556
Hubei	672.5	0.398	1070
Sichuan	670	0.358	8761
Shandong	667.5	0.998	14206
Beijing	647.8	0.975	732.6
Fujian	634.6	0.646	1935
Jiangxi	610.6	0.811	2782
Chongqing	605	0.771	3968
Ningxia	600	0.948	3218
Guangxi	590	0.539	700.8
Henan	580.0	0.950	19194
Gansu	576.7	0.677	3840
Hunan	550	0.626	5967
Guizhou	536.1	0.737	11159
Yunnan	523.9	0.497	7185
Shanxi	502.5	0.981	58863
Innermongolia	450.8	0.982	30268
Average	636.5	0.81	8220

Note: Data source China Energy statistical Yearbooks and China Price Information Center. Thermal power generation capacity is defined as the share of electricity generated by coal over electricity generated by all types of fuels. Shaanxi and Qinghai provinces are dropped as outliers in terms of coal production and industrial electricity price. These two provinces account for approximately 0.94% of total number of firms.

Table 5: Effect of industrial electricity price on switching (Pooled OLS)

VARIABLES	(1) Switch	(2) Switch	(3) Switch	(4) Switch	(5) Switch
Log(IEP)	0.0641***	0.0498***	0.0497***	0.0523***	0.0523***
	(0.0115)	(0.0121)	(0.0121)	(0.0121)	(0.0121)
Log(IEP)×EI		0.1393**	0.1398**	0.1341**	0.1346**
		(0.0575)	(0.0575)	(0.0575)	(0.0575)
		Firm-level controls			
TFP		0.0026***		0.0026***	
		(0.0004)		(0.0004)	
Log(Labour productivity)			0.0024***		0.0024***
			(0.0004)		(0.0004)
Log(KL ratio)		-0.0008	-0.0028***	-0.0010	-0.0030***
		(0.0005)	(0.0005)	(0.0005)	(0.0005)
Log(Size)		0.0020***	0.0036***	0.0022***	0.0038***
		(0.0005)	(0.0004)	(0.0005)	(0.0004)
Multi		0.0069***	0.0069***	0.0068***	0.0068***
		(0.0009)	(0.0009)	(0.0009)	(0.0009)
SOE share		-0.0095***	-0.0096***		
		(0.0021)	(0.0021)		
FIE share		0.0026**	0.0026**		
		(0.0012)	(0.0012)		
EXP share		0.0029**	0.0029**		
		(0.0012)	(0.0012)		
R&D share		-0.0048	-0.0049		
		(0.0064)	(0.0064)		
SOE dummy				-0.0085***	-0.0086***
				(0.0020)	(0.0020)
FIE dummy				0.0009	0.0009
				(0.0011)	(0.0011)
EXP dummy				0.0006	0.0006
				(0.0009)	(0.0009)
R&D dummy				-0.0001	-0.0001
				(0.0008)	(0.0008)
		Industry-level controls			
TFP^N		0.0073		0.0078	
		(0.0086)		(0.0086)	
$\text{Log(Labour productivity)}^N$			0.0047		0.0056
			(0.0088)		(0.0088)
Log(KL ratio)^N		0.0228	0.0182	0.0151	0.0099
		(0.0130)	(0.0136)	(0.0134)	(0.0140)
Log(Size)^N		-0.0657***	-0.0616***	-0.0616***	-0.0571***
		(0.0125)	(0.0128)	(0.0127)	(0.0130)
SOE share^N		-0.0179	-0.0195		
		(0.0596)	(0.0595)		
FIE share^N		0.1772***	0.1773***		
		(0.0465)	(0.0465)		
EXP share^N		-0.1168***	-0.1173***		
		(0.0305)	(0.0305)		
$\text{R\&D share}^N$		0.0093***	0.0093***		
		(0.0034)	(0.0034)		
SOE dummy^N				0.0170	0.0153
				(0.0548)	(0.0547)
FIE dummy^N				0.1632***	0.1635***
				(0.0407)	(0.0407)
EXP dummy^N				-0.0970***	-0.0974***
				(0.0241)	(0.0241)
$\text{R\&D dummy}^N$				0.0036	0.0037
				(0.0207)	(0.0207)
CR^N		-0.0310	-0.0316	-0.0358**	-0.0364**
		(0.0178)	(0.0177)	(0.0178)	(0.0178)
EI^N		-0.6808	-0.6884	-0.6492	-0.6561
		(0.3695)	(0.3697)	(0.3692)	(0.3695)
Constant	-0.4082***	0.0489	0.0609	0.0375	0.0475
	(0.0744)	(0.1168)	(0.1191)	(0.1168)	(0.1190)
Observations	451,156	451,156	451,156	451,156	451,156
Adjusted R-squared	0.0302	0.0312	0.0312	0.0311	0.0311
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes	Yes	Yes
No. of clusters	255,853	255,853	255,853	255,853	255,853

Note: Standard errors clustered at firm level are reported in parentheses. Siginificant at **5%, ***1%. All monetary values are deflated to 2005 prices via provincial CPI. Year, province and 4-digit industry dummies are included in all specifications.

Table 6: Effect of industrial electricity price on switching to a less energy intensive industry (Pooled OLS)

VARIABLES	(1) Switch_HL	(2) Switch_HL	(3) Switch_HL	(4) Switch_HL	(5) Switch_HL
Log(IEP)	0.0733***	0.0732***	0.0731***	0.0733***	0.0733***
	(0.0174)	(0.0175)	(0.0175)	(0.0176)	(0.0176)
Log(IEP)×EI		0.0052	0.0054	0.0033	0.0036
		(0.0554)	(0.0554)	(0.0552)	(0.0553)
		Firm-level controls			
TFP		0.0007***		0.0007**	
		(0.0003)		(0.0003)	
Log(Labour productivity)			0.0006**		0.0006**
			(0.0003)		(0.0003)
Log(KL ratio)		-0.0011***	-0.0016***	-0.0011***	-0.0016***
		(0.0004)	(0.0004)	(0.0004)	(0.0004)
Log(Size)		0.0009***	0.0013***	0.0009***	0.0013***
		(0.0003)	(0.0003)	(0.0003)	(0.0003)
Multi		0.0030***	0.0030***	0.0030***	0.0030***
		(0.0005)	(0.0005)	(0.0005)	(0.0005)
SOE share		-0.0020	-0.0020		
		(0.0012)	(0.0012)		
FIE share		0.0008	0.0008		
		(0.0007)	(0.0007)		
EXP share		0.0023***	0.0023***		
		(0.0008)	(0.0008)		
R&D share		-0.0065	-0.0066		
		(0.0034)	(0.0034)		
SOE dummy				-0.0021	-0.0021
				(0.0012)	(0.0012)
FIE dummy				0.0001	0.0001
				(0.0006)	(0.0006)
EXP dummy				0.0014**	0.0014**
				(0.0006)	(0.0006)
R&D dummy				0.0001	0.0001
				(0.0005)	(0.0005)
		Industry-level controls			
TFP^N		0.0005		0.0013	
		(0.0100)		(0.0100)	
Log(Labour productivity)^N			0.0012		0.0021
			(0.0100)		(0.0101)
Log(KL ratio)^N		0.0183	0.0176	0.0125	0.0111
		(0.0144)	(0.0152)	(0.0151)	(0.0157)
Log(Size)^N		-0.0267**	-0.0262	-0.0214	-0.0203
		(0.0132)	(0.0140)	(0.0136)	(0.0142)
SOE share^N		-0.0982	-0.0981		
		(0.0652)	(0.0652)		
FIE share^N		-0.0869	-0.0871		
		(0.0506)	(0.0506)		
EXP share^N		0.0074	0.0074		
		(0.0330)	(0.0330)		
R&D share^N		0.0059	0.0059		
		(0.0040)	(0.0040)		
SOE dummy^N				-0.0696	-0.0695
				(0.0605)	(0.0605)
FIE dummy^N				-0.0600	-0.0602
				(0.0436)	(0.0436)
EXP dummy^N				-0.0240	-0.0241
				(0.0280)	(0.0279)
R&D dummy^N				-0.0162	-0.0161
				(0.0224)	(0.0224)
CR		-0.0197	-0.0197	-0.0210	-0.0209
		(0.0200)	(0.0201)	(0.0201)	(0.0202)
EI		0.0220	0.0212	0.0330	0.0326
		(0.3505)	(0.3509)	(0.3496)	(0.3499)
Constant	-0.4766***	-0.3329**	-0.3360**	-0.3536**	-0.3578**
	(0.1119)	(0.1521)	(0.1550)	(0.1523)	(0.1552)
Observations	451,156	451,156	451,156	451,156	451,156
Adjusted R-squared	0.0170	0.0174	0.0174	0.0173	0.0173
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes	Yes	Yes
No. of clusters	9,248	9,248	9,248	9,248	9,248

Note: Standard errors clustered at province-industry level are reported in parentheses. Siginificant at **5%, ***1%. All monetary values are deflated to 2005 prices via provincial CPI. Year, province and 4-digit industry dummies are included in all specifications.

Table 7: Effect of industrial electricity price on switching to a more energy intensive industry (Pooled OLS)

VARIABLES	(1) Switch_LH	(2) Switch_LH	(3) Switch_LH	(4) Switch_LH	(5) Switch_LH
Log(IEP)	0.0935***	0.0861***	0.0861***	0.0877***	0.0877***
	(0.0187)	(0.0195)	(0.0195)	(0.0196)	(0.0196)
Log(IEP)×EI		0.0821**	0.0822**	0.0830**	0.0832**
		(0.0326)	(0.0326)	(0.0325)	(0.0325)
		Firm-level controls			
TFP		0.0007***		0.0007***	
		(0.0002)		(0.0002)	
Log(Labour productivity)			0.0007***		0.0007***
			(0.0002)		(0.0002)
Log(KL ratio)		0.0007**	0.0002	0.0006	0.0001
		(0.0003)	(0.0003)	(0.0003)	(0.0003)
Log(Size)		0.0006**	0.0010***	0.0007**	0.0012***
		(0.0003)	(0.0003)	(0.0003)	(0.0003)
Multi		0.0024***	0.0024***	0.0024***	0.0024***
		(0.0005)	(0.0005)	(0.0005)	(0.0005)
SOE share		-0.0039***	-0.0039***		
		(0.0011)	(0.0011)		
FIE share		0.0006	0.0006		
		(0.0007)	(0.0007)		
EXP share		-0.0003	-0.0003		
		(0.0009)	(0.0009)		
R&D share		0.0010	0.0010		
		(0.0038)	(0.0038)		
SOE dummy				-0.0029***	-0.0029***
				(0.0011)	(0.0011)
FIE dummy				0.0002	0.0002
				(0.0006)	(0.0006)
EXP dummy				-0.0004	-0.0004
				(0.0006)	(0.0006)
R&D dummy				-0.0008	-0.0008
				(0.0005)	(0.0005)
		Industry-level controls			
TFP^N		0.0019		0.0019	
		(0.0115)		(0.0115)	
Log(Labour productivity)^N			0.0018		0.0020
			(0.0121)		(0.0121)
Log(KL ratio)^N		0.0052	0.0037	0.0035	0.0019
		(0.0168)	(0.0185)	(0.0179)	(0.0198)
Log(Size)^N		-0.0247	-0.0234	-0.0215	-0.0202
		(0.0148)	(0.0154)	(0.0153)	(0.0161)
SOE share^N		0.1352**	0.1349**		
		(0.0595)	(0.0593)		
FIE share^N		0.1340***	0.1340***		
		(0.0482)	(0.0483)		
EXP share^N		-0.0009	-0.0011		
		(0.0396)	(0.0395)		
R&D share^N		0.0008	0.0008		
		(0.0035)	(0.0035)		
SOE dummy^N				0.1156**	0.1153**
				(0.0541)	(0.0540)
FIE dummy^N				0.1095**	0.1095**
				(0.0443)	(0.0443)
EXP dummy^N				-0.0003	-0.0004
				(0.0281)	(0.0281)
R&D dummy^N				-0.0269	-0.0269
				(0.0273)	(0.0273)
CR		0.0177	0.0177	0.0159	0.0158
		(0.0186)	(0.0186)	(0.0187)	(0.0187)
EI		-0.5323**	-0.5333**	-0.5332**	-0.5339**
		(0.2141)	(0.2146)	(0.2130)	(0.2136)
Constant	-0.6005***	-0.4190**	-0.4190**	-0.4412***	-0.4421**
	(0.1203)	(0.1671)	(0.1726)	(0.1702)	(0.1756)
Observations	451,156	451,156	451,156	451,156	451,156
Adjusted R-squared	0.0150	0.0155	0.0155	0.0154	0.0154
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes	Yes	Yes
No. of clusters	9,248	9,248	9,248	9,248	9,248

Note: Standard errors clustered at province-industry level are reported in parentheses. Siginificant at **5%, ***1%. All monetary values are deflated to 2005 prices via provincial CPI. Year, province and 4-digit industry dummies are included in all specifications.

Table 8: Effect of industrial electricity price on switching to a less energy intensive industry (2SLS)

VARIABLES	(1) Switch_HL	(2) Switch_HL	(3) Switch_HL	(4) Switch_HL	(5) Switch_HL
Log(IEP)	0.1714**	0.2266***	0.2261***	0.2376***	0.2370***
	(0.0753)	(0.0806)	(0.0805)	(0.0818)	(0.0817)
Log(IEP)×EI		-0.1771	-0.1769	-0.1804	-0.1801
		(0.1493)	(0.1493)	(0.1492)	(0.1491)
		Firm-level controls			
TFP		0.0007***		0.0007***	
		(0.0002)		(0.0002)	
Log(Labour productivity)			0.0006***		0.0006***
			(0.0002)		(0.0002)
Log(KL ratio)		-0.0010***	-0.0016***	-0.0011***	-0.0016***
		(0.0003)	(0.0003)	(0.0003)	(0.0003)
Log(Size)		0.0008***	0.0013***	0.0008***	0.0013***
		(0.0002)	(0.0002)	(0.0002)	(0.0002)
Multi		0.0031***	0.0031***	0.0030***	0.0030***
		(0.0005)	(0.0005)	(0.0005)	(0.0005)
SOE share		-0.0020	-0.0020		
		(0.0012)	(0.0012)		
FIE share		0.0007	0.0007		
		(0.0006)	(0.0006)		
EXP share		0.0022***	0.0022***		
		(0.0006)	(0.0006)		
R&D share		-0.0067	-0.0068**		
		(0.0034)	(0.0034)		
SOE dummy				-0.0021	-0.0021
				(0.0012)	(0.0012)
FIE dummy				-0.0000	-0.0000
				(0.0006)	(0.0006)
EXP dummy				0.0013***	0.0013***
				(0.0005)	(0.0005)
R&D dummy				0.0000	0.0000
				(0.0004)	(0.0004)
		Industry-level controls			
TFP^N		-0.0002		0.0005	
		(0.0077)		(0.0077)	
Log(Labour productivity)^N			0.0010		0.0019
			(0.0079)		(0.0079)
Log(KL ratio)^N		0.0147	0.0142	0.0080	0.0069
		(0.0111)	(0.0120)	(0.0115)	(0.0122)
Log(Size)^N		-0.0221**	-0.0219**	-0.0159	-0.0152
		(0.0105)	(0.0108)	(0.0108)	(0.0110)
SOE share^N		-0.1107**	-0.1103**		
		(0.0503)	(0.0502)		
FIE share^N		-0.1012**	-0.1013**		
		(0.0405)	(0.0405)		
EXP share^N		0.0148	0.0147		
		(0.0259)	(0.0259)		
R&D share^N		0.0057	0.0056		
		(0.0031)	(0.0031)		
SOE dummy^N				-0.0820	-0.0816
				(0.0468)	(0.0467)
FIE dummy^N				-0.0677**	-0.0679**
				(0.0344)	(0.0344)
EXP dummy^N				-0.0233	-0.0234
				(0.0204)	(0.0204)
R&D dummy^N				-0.0194	-0.0194
				(0.0177)	(0.0177)
CR		-0.0212	-0.0210	-0.0223	-0.0222
		(0.0159)	(0.0159)	(0.0159)	(0.0158)
EI		1.1809	1.1815	1.2001	1.2008
		(0.9522)	(0.9525)	(0.9508)	(0.9512)
Constant	-1.1086**	-1.3368**	-1.3397**	-1.4301***	-1.4335***
	(0.4848)	(0.5320)	(0.5327)	(0.5400)	(0.5408)
Observations	451,156	451,156	451,156	451,156	451,156
Adjusted R-squared	0.0169	0.0170	0.0170	0.0169	0.0169
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes	Yes	Yes
Underidentification (p-value)	0.0000	0.0000	0.0000	0.0000	0.0000
Weakidentification (F statistic)	8,699	4,341	4,350	4,216	4,225
No. of clusters	255,853	255,853	255,853	255,853	255,853

Note: Standard errors clustered at firm level are reported in parentheses. Siginificant at **5%, ***1%. All monetary values are deflated to 2005 prices via provincial CPI. Year, province and 4-digit industry dummies are included in all specifications. Instrument tests include the under-identification test (Kleibergen-Paap rk LM statistic) and weak-identification test (Kleibergen-Paap Wald rk F statistic). The null hypothesis is that the matrix is not full column rank, a rejection of the null indicates that the model is identified. Null hypothesis for weak-identification test shows that the excluded instruments are correlated with the endogenous regressor but only weakly. Large F statistic that exceeds the Stock-Yogo critical values eliminates the weak identification concern.

Table 9: Effect of industrial electricity price on switching to a more energy intensive industry (2SLS)

VARIABLES	(1) Switch_LH	(2) Switch_LH	(3) Switch_LH	(4) Switch_LH	(5) Switch_LH
Log(IEP)	-0.2488***	-0.2197***	-0.2195***	-0.2082***	-0.2082***
	(0.0729)	(0.0744)	(0.0743)	(0.0755)	(0.0754)
Log(IEP)×EI		-0.2558***	-0.2557***	-0.2542***	-0.2540***
		(0.0837)	(0.0837)	(0.0836)	(0.0836)
Firm-level controls					
TFP		0.0007***		0.0007***	
		(0.0002)		(0.0002)	
Log(Labour productivity)			0.0006***		0.0007***
			(0.0002)		(0.0002)
Log(KL ratio)		0.0008***	0.0003	0.0007***	0.0002
		(0.0003)	(0.0003)	(0.0003)	(0.0003)
Log(Size)		0.0005**	0.0009***	0.0006***	0.0011***
		(0.0002)	(0.0002)	(0.0002)	(0.0002)
Multi		0.0024***	0.0024***	0.0024***	0.0024***
		(0.0004)	(0.0004)	(0.0004)	(0.0004)
SOE share		-0.0039***	-0.0040***		
		(0.0011)	(0.0011)		
FIE share		0.0006	0.0006		
		(0.0006)	(0.0006)		
EXP share		-0.0004	-0.0004		
		(0.0006)	(0.0006)		
R&D share		0.0017	0.0017		
		(0.0037)	(0.0037)		
SOE dummy				-0.0030***	-0.0030***
				(0.0011)	(0.0011)
FIE dummy				0.0002	0.0002
				(0.0006)	(0.0006)
EXP dummy				-0.0004	-0.0004
				(0.0005)	(0.0005)
R&D dummy				-0.0006	-0.0006
				(0.0004)	(0.0004)
Industry-level controls					
TFP^N		0.0015		0.0016	
		(0.0073)		(0.0073)	
Log(Labour productivity)^N			0.0009		0.0011
			(0.0073)		(0.0073)
Log(KL ratio)^N		0.0167	0.0158	0.0152	0.0142
		(0.0109)	(0.0109)	(0.0113)	(0.0113)
Log(Size)^N		-0.0357***	-0.0348***	-0.0329***	-0.0320***
		(0.0106)	(0.0105)	(0.0109)	(0.0107)
SOE share^N		0.1518***	0.1514***		
		(0.0464)	(0.0463)		
FIE share^N		0.1739***	0.1739***		
		(0.0393)	(0.0393)		
EXP share^N		-0.0172	-0.0173		
		(0.0265)	(0.0265)		
R&D share^N		0.0014	0.0014		
		(0.0024)	(0.0024)		
SOE dummy^N				0.1303***	0.1300***
				(0.0432)	(0.0431)
FIE dummy^N				0.1307***	0.1308***
				(0.0335)	(0.0335)
EXP dummy^N				-0.0045	-0.0046
				(0.0195)	(0.0195)
R&D dummy^N				-0.0165	-0.0165
				(0.0171)	(0.0171)
CR		0.0177	0.0176	0.0157	0.0156
		(0.0146)	(0.0146)	(0.0147)	(0.0147)
EI		1.6444***	1.6422***	1.6370***	1.6352***
		(0.5370)	(0.5371)	(0.5360)	(0.5361)
Constant	1.6042***	1.5918***	1.5942***	1.5073***	1.5095***
	(0.4693)	(0.4941)	(0.4948)	(0.5016)	(0.5022)
Observations	451,156	451,156	451,156	451,156	451,156
Adjusted R-squared	0.0131	0.0134	0.0134	0.0135	0.0135
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes	Yes	Yes
Underidentification (p-value)	0.0000	0.0000	0.0000	0.0000	0.0000
Weakidentification (F statistic)	8,699	4,341	4,350	4,216	4,225
No. of clusters	255,853	255,853	255,853	255,853	255,853

Note: Standard errors clustered at firm level are reported in parentheses. Siginificant at **5%, ***1%. All monetary values are deflated to 2005 prices via provincial CPI. Year, province and 4-digit industry dummies are included in all specifications. Instrument tests include the under-identification test (Kleibergen-Paap rk LM statistic) and weak-identification test (Kleibergen-Paap Wald rk F statistic). The null hypothesis is that the matrix is not full column rank, a rejection of the null indicates that the model is identified. Null hypothesis for weak-identification test shows that the excluded instruments are correlated with the endogenous regressor but only weakly. Large F statistic that exceeds the Stock-Yogo critical values eliminates the weak identification concern.

Table 10: Effect of industrial electricity price on EI gap (2SLS)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Switch to a less energy intensive industry			*Switch to a more energy intensive industry*		
Log(IEP)	0.7885	1.1144**	1.1099**	-1.4334***	-1.1443***	-1.1407***
	(0.4264)	(0.4824)	(0.4818)	(0.3343)	(0.3481)	(0.3476)
Log(IEP)×EI		-0.8960	-0.8942		-1.2032***	-1.2033***
		(1.0600)	(1.0599)		(0.4065)	(0.4064)
Firm-level controls						
TFP		0.0050***			0.0026**	
		(0.0014)			(0.0011)	
Log(Labour productivity)			0.0044***			0.0025**
			(0.0014)			(0.0011)
Log(KL ratio)		-0.0048***	-0.0086***		0.0043***	0.0023
		(0.0017)	(0.0016)		(0.0013)	(0.0013)
Log(Size)		0.0033**	0.0064***		0.0032***	0.0049***
		(0.0014)	(0.0013)		(0.0012)	(0.0010)
Multi		0.0173***	0.0173***		0.0105***	0.0105***
		(0.0026)	(0.0026)		(0.0020)	(0.0020)
SOE dummy		-0.0123	-0.0125		-0.0131***	-0.0132***
		(0.0067)	(0.0067)		(0.0050)	(0.0050)
FIE dummy		0.0020	0.0020		-0.0026	-0.0026
		(0.0033)	(0.0033)		(0.0026)	(0.0026)
EXP dummy		0.0059**	0.0059**		-0.0034	-0.0034
		(0.0029)	(0.0029)		(0.0023)	(0.0023)
R&D dummy		-0.0009	-0.0009		-0.0020	-0.0020
		(0.0025)	(0.0025)		(0.0020)	(0.0020)
Industry-level controls						
TFP^N		-0.0382			0.0496	
		(0.0457)			(0.0357)	
$Log(Labour productivity)^N$			-0.0267			0.0367
			(0.0473)			(0.0364)
$Log(KL ratio)^N$		0.0927	0.1176		-0.0040	-0.0373
		(0.0677)	(0.0739)		(0.0532)	(0.0546)
$Log(Size)^N$		-0.1254	-0.1472**		-0.1092**	-0.0803
		(0.0652)	(0.0675)		(0.0497)	(0.0506)
SOE $dummy^N$		-0.5169	-0.5088		0.8027***	0.7927***
		(0.2737)	(0.2728)		(0.1996)	(0.1994)
FIE $dummy^N$		-0.1634	-0.1643		0.4405***	0.4415***
		(0.1885)	(0.1885)		(0.1619)	(0.1619)
EXP $dummy^N$		-0.1350	-0.1339		-0.0270	-0.0289
		(0.1171)	(0.1171)		(0.0927)	(0.0928)
R&D $dummy^N$		0.0132	0.0130		-0.1255	-0.1252
		(0.1018)	(0.1018)		(0.0783)	(0.0783)
CR		-0.2091**	-0.2068**		0.1756***	0.1726**
		(0.0917)	(0.0916)		(0.0682)	(0.0681)
EI		6.8832	6.8902		7.4180***	7.3959***
		(6.7523)	(6.7551)		(2.6007)	(2.6016)
Constant	-5.0989	-6.2667**	-6.2859**	9.2324***	7.7928***	7.8237***
	(2.7466)	(3.1867)	(3.1922)	(2.1534)	(2.3234)	(2.3277)
Observations	446,013	446,013	446,013	443,272	443,272	443,272
Adjusted R-squared	0.0199	0.0201	0.0201	0.0100	0.0108	0.0108
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Underidentification (p-value)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Weakidentification (F statistic)	8,643	4,181	4,190	8,588	4,162	4,171
No. of clusters	253,011	253,011	253,011	251,143	251,143	251,143

Note: Standard errors clustered at firm level are reported in parentheses. Siginificant at **5%, ***1%. All monetary values are deflated to 2005 prices via provincial CPI. Year, province and 4-digit industry dummies are included in all specifications. Instrument tests include the under-identification test (Kleibergen-Paap rk LM statistic) and weak-identification test (Kleibergen-Paap Wald rk F statistic). The null hypothesis is that the matrix is not full column rank, a rejection of the null indicates that the model is identified. Null hypothesis for weak-identification test shows that the excluded instruments are correlated with the endogenous regressor but only weakly. Large F statistic that exceeds the Stock-Yogo critical values eliminates the weak identification concern.

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Appendix A

Table A1: 2-digit manufacturing sectors electricity intensity ranking

Manufacturing	CIC	2005	2006	2007	mean
Smelting and processing of non-ferrous metals	33	1856	1414	1330	1533
Manufacture of non-metallic mineral products	31	1544	1429	1193	1389
Manufacture of chemical raw materials and chemical products	26	1302	1193	1037	1177
Smelting and processing of ferrous metals	32	1188	1196	1086	1157
Manufacture of artwork and other manufacturing	42	1354	1112	854.2	1107
Manufacture of rubber	29	952.8	868.5	759.8	860.4
Manufacture of paper and paper prod.	22	979.8	889.3	688.8	852.6
Manufacture of chemical fibers	28	894.1	763.7	672.0	776.6
Manufacture of metal products	34	773.6	710.2	591.5	691.8
Manufacture of textiles	17	649.9	674.0	600.2	641.4
Manufacture of plastics	30	636.2	556.6	469.2	554.0
Processing of timber, manufacture of wood, bamboo, rattan, palm, and straw products	20	577.6	524.2	422.7	508.2
Printing and recorded media	23	420.8	389.9	350.3	387.0
Manufacture of medicines	27	360.5	318.0	268.3	315.6
Manufacture of general purpose machinery	35	324.9	283.4	243.2	283.8
Manufacture of foods	14	303.8	284.6	250.0	279.5
Manufacture of special purpose machinery	36	300.6	260.6	216.4	259.2
Manufacture of articles for culture,education and sport activity	24	287.0	247.0	219.2	251.0
Processing of petroleum, coking,processing of nuclear fuel	25	261.2	235.9	229.5	242.2
Manufacture of beverages	15	247.8	229.4	199.1	225.4
Processing of food from agric. products	13	238.7	228.2	191.4	219.4
Manufacture of textile,apparel, footwear£¬and caps	18	176.1	176.6	163.8	172.2
Manufacture of transport equipment	37	191.4	169.5	153.9	171.6
Manufacture of electrical machinery and equipment	39	176.8	155.4	142.2	158.1
Manufacture of leather, fur, feather and related products	19	158.4	155.2	143.0	152.2
Manufacture of furniture	21	170.1	151.3	122.2	147.9
Manufacture of measuring instruments and machinery for cultural activity and office work	41	152.9	146.4	142.0	147.1
Manufacture of communication equipment, computers and other	40	121.5	121.5	122.3	121.8

Note: Data source China Energy statistical Yearbooks 2006-2008. Unit kWh/10,000 yuan.

Table A2: Independent variable definition

Variable	Definition	Source
Firm-level		
TFP	Total factor productivity (LP method)	Chinese Industrial Enterprises Dataset
Labour productivity	Real value added per worker, million yuan/1000 person in 2005 price	Chinese Industrial Enterprises Dataset
KL ratio	Real fixed assets per worker, million yuan/1000 person in 2005 price	Chinese Industrial Enterprises Dataset
Size	Total fixed asset stock, 10,000 yuan in 2005 price	Chinese Industrial Enterprises Dataset
SOE share	State-owned capital/Total capital	Chinese Industrial Enterprises Dataset
FIE share	Foreign, Hong Kong, Macao and Taiwan capital/Total capital	Chinese Industrial Enterprises Dataset
EXP share	Export value/Total output	Chinese Industrial Enterprises Dataset
R&D share	Expenditure in research and development/Total output	Chinese Industrial Enterprises Dataset
SOE dummy	=1 if SOE share>51%	Chinese Industrial Enterprises Dataset
FIE dummy	=1 if FIE share>51%	Chinese Industrial Enterprises Dataset
EXP dummy	=1 if EXP share>0	Chinese Industrial Enterprises Dataset
R&D dummy	=1 if R&D share>0	Chinese Industrial Enterprises Dataset
Multi	Dummy variable with value one if survey shows a firm produces multiple products (roughly defined at the 3-digit and 4-digit level)	Chinese Industrial Enterprises Dataset
Industry-level		
CR	Output of the top 5% of firms/Output of all firms in that industry	Chinese Industrial Enterprises Dataset
EI	Electricity consumption/Real output, KWH/yuan	China Energy statistical Yearbooks
Province-level		
IEP	Industrial electricity price, yuan/MWH	China Price Information Center
Coal production	Province-level coal production, 10,000 tons	China Energy statistical Yearbooks
Capacity	Electricity generation from coal to electricity generation from all types of fuel	China Energy statistical Yearbooks

Table A3: Summary statistics (2005-2007)

Variable	Obs	Mean	Std.Dev.	Min	Max
IEP	451,156	680.10	68.54	431.67	790.56
Coal production	451,156	4,997.10	7,577.14	0.00	58,141.91
Capacity	451,156	0.84	0.17	0.36	1.00
TFP	451,156	6.54	1.00	2.00	11.53
Labour productivity	451,156	99.20	122.45	4.66	1,034.34
KL ratio	451,156	78.57	108.47	0.70	1,000.00
Size	451,156	16,665.78	60,625.30	8	3,125,911
SOE share	451,156	0.03	0.16	0.00	1.00
FIE share	451,156	0.17	0.35	0.00	1.00
EXP share	451,156	0.18	0.35	0.00	1.00
R&D share	451,156	0.01	0.05	0.00	0.77
SOE dummy	451,156	0.03	0.17	0.00	1.00
FIE dummy	451,156	0.16	0.37	0.00	1.00
EXP dummy	451,156	0.30	0.46	0.00	1.00
R&D dummy	451,156	0.30	0.46	0.00	1.00
CR	451,156	0.43	0.10	0.11	0.93
EI industry	451,156	0.06	0.05	0.00	0.46

Table A4: Correlation matrix (obs = 451,156)

	IEP	Coal production	Capacity	TFP	Labour productivity	KL ratio	Size	SOE share	FIE share	EXP share	R&D share	SOE dummy	FIE dummy	EXP dummy	R&D dummy	CR	EI
IEP	1.00																
Coal production	-0.56	1.00															
Capacity	0.13	0.29	1.00														
TFP	-0.02	0.10	0.07	1.00													
Labour productivity	-0.05	0.11	0.10	0.59	1.00												
KL ratio	-0.04	0.05	0.04	0.12	0.31	1.00											
Size	-0.03	0.04	0.01	0.29	0.11	0.41	1.00										
SOE share	-0.10	0.06	-0.02	-0.01	-0.03	0.05	0.10	1.00									
FIE share	0.23	-0.16	-0.00	0.10	0.00	0.07	0.08	-0.07	1.00								
EXP share	0.19	-0.17	-0.05	0.03	-0.13	-0.10	0.01	-0.07	0.41	1.00							
RD share	-0.01	-0.01	0.01	-0.01	-0.01	0.06	0.06	0.09	0.02	-0.02	1.00						
SOE dummy	-0.10	0.06	-0.02	-0.02	-0.03	0.04	0.09	0.97	-0.07	-0.06	0.08	1.00					
FIE dummy	0.22	-0.15	-0.01	0.09	0.00	0.07	0.07	-0.07	0.97	0.38	0.02	-0.08	1.00				
EXP dummy	0.12	-0.10	-0.01	0.12	-0.07	-0.05	0.09	-0.05	0.38	0.80	0.00	-0.05	0.36	1.00			
RD dummy	0.07	-0.11	-0.02	0.12	-0.01	0.11	0.17	0.10	0.14	0.07	0.33	0.09	0.13	0.13	1.00		
CR	0.02	-0.00	0.04	0.02	0.10	0.07	0.07	0.01	-0.00	-0.10	0.04	0.01	0.00	-0.07	0.07	1.00	
EI	-0.14	0.10	-0.03	-0.02	0.03	0.10	0.08	0.02	-0.11	-0.13	-0.00	0.02	-0.11	-0.12	-0.04	0.01	1

Table A5: Effect of industrial electricity price on switching excluding multi-product firms (Pooled OLS)

VARIABLES	(1) Switch	(2) Switch	(3) Switch	(4) Switch	(5) Switch
Log(IEP)	0.0945***	0.0850***	0.0850***	0.0865***	0.0864***
	-0.0131	(0.0137)	(0.0137)	(0.0137)	(0.0137)
Log(IEP)×EI		0.0762	0.0765	0.0710	0.0713
		(0.0594)	(0.0594)	(0.0594)	(0.0594)
		Firm-level controls			
TFP		0.0025***	0.0025***		
		(0.0005)		(0.0005)	
Log(Labour productivity)			0.0024***	0.0024***	
			(0.0005)		(0.0005)
Log(KL ratio)		0.0001	-0.0018***	0.0000	-0.0019***
		(0.0006)	(0.0006)	(0.0006)	(0.0006)
Log(Size)		0.0014***	0.0030***	0.0015***	0.0031***
		(0.0005)	(0.0005)	(0.0005)	(0.0005)
SOE share		-0.0058**	-0.0058**		
		(0.0026)	(0.0026)		
FIE share		0.0032**	0.0032**		
		(0.0014)	(0.0014)		
EXP share		0.0024*	0.0024*		
		(0.0014)	(0.0014)		
R&D share		0.0038	0.0038		
		(0.0081)	(0.0081)		
SOE dummy				-0.0051**	-0.0051**
				(0.0026)	(0.0026)
FIE dummy				0.0012	0.0012
				(0.0013)	(0.0013)
EXP dummy				0.0005	0.0005
				(0.0011)	(0.0011)
R&D dummy				0.0017*	0.0017*
				(0.0009)	(0.0009)
		Industry-level controls			
TFP^N		-0.0020		-0.0015	
		(0.0102)		(0.0102)	
Log(Labour productivity)^N			-0.0032		-0.0020
			(0.0104)		(0.0104)
Log(KL ratio)^N		0.0067	0.0089	-0.0033	-0.0018
		(0.0150)	(0.0154)	(0.0154)	(0.0158)
Log(Size)^N		-0.0391***	-0.0408***	-0.0330**	-0.0341**
		(0.0143)	(0.0145)	(0.0146)	(0.0147)
SOE share^N		-0.0505	-0.0508		
		(0.0711)	(0.0710)		
FIE share^N		0.0939*	0.0942*		
		(0.0558)	(0.0558)		
EXP share^N		-0.0741**	-0.0740**		
		(0.0362)	(0.0362)		
R&D share^N		0.0142***	0.0143***		
		(0.0045)	(0.0045)		
SOE dummy^N				-0.0218	-0.0220
				(0.0663)	(0.0663)
FIE dummy^N				0.0911*	0.0912*
				(0.0482)	(0.0482)
EXP dummy^N				-0.0843***	-0.0843***
				(0.0285)	(0.0285)
R&D dummy^N				0.0191	0.0191
				(0.0247)	(0.0247)
CR^N		-0.0287	-0.0289	-0.0324	-0.0326
		(0.0208)	(0.0207)	(0.0209)	(0.0208)
EI^N		-0.3256	-0.3298	-0.3061	-0.3093
		(0.3816)	(0.3818)	(0.3813)	(0.3815)
Constant	-0.6070***	-0.2622**	-0.2550*	-0.2758**	-0.2723**
	-0.0846	(0.1321)	(0.1349)	(0.1324)	(0.1350)
Observations	332,582	332,582	332,582	332,582	332,582
Adjusted R-squared	0.0329	0.0335	0.0335	0.0335	0.0335
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes	Yes	Yes
No. of clusters	193,585	193,585	193,585	193,585	193,585

Note: Standard errors clustered at firm level are reported in parentheses. Siginificant at **5%, ***1%. All monetary values are deflated to 2005 prices via provincial CPI. Year, province and 4-digit industry dummies are included in all specifications.

Table A6: Effect of industrial electricity price on switching for top/bottom ten sectors relying most/least on electricity (Pooled OLS)

VARIABLES	(1) All sectors	(2) Top ten sectors	(3) Bottom ten sectors
Log(IEP)	0.0498***	0.1293***	-0.0217
	(0.0121)	(0.0271)	(0.0195)
Log(IEP)×EI	0.1393**	0.4320**	0.0805
	(0.0575)	(0.1789)	(0.0599)
	Firm-level controls		
TFP	0.0026***	0.0031***	0.0024***
	(0.0004)	(0.0008)	(0.0006)
Log(KL ratio)	-0.0008	-0.0022**	-0.0001
	(0.0005)	(0.0010)	(0.0009)
Log(Size)	0.0020***	0.0028***	0.0010
	(0.0005)	(0.0009)	(0.0008)
Multi	0.0069***	0.0054***	0.0069***
	(0.0009)	(0.0016)	(0.0014)
SOE share	-0.0095***	-0.0158***	-0.0061**
	(0.0021)	(0.0045)	(0.0028)
FIE share	0.0026**	0.0040*	0.0021
	(0.0012)	(0.0022)	(0.0023)
EXP share	0.0029**	0.0015	0.0069**
	(0.0012)	(0.0022)	(0.0029)
R&D share	-0.0048	-0.0111	0.0043
	(0.0064)	(0.0112)	(0.0104)
	Industry-level controls		
TFP^N	0.0073	0.0495***	-0.0148
	(0.0086)	(0.0162)	(0.0137)
Log(KL ratio)^N	0.0228*	0.0302	0.0059
	(0.0130)	(0.0291)	(0.0226)
Log(Size)^N	-0.0657***	-0.0957***	-0.0189
	(0.0125)	(0.0270)	(0.0203)
SOE share^N	-0.0179	0.0270	-0.1245
	(0.0596)	(0.1429)	(0.0817)
FIE share^N	0.1772***	0.1161	0.1528*
	(0.0465)	(0.0845)	(0.0858)
EXP share^N	-0.1168***	-0.1197**	-0.1416**
	(0.0305)	(0.0530)	(0.0709)
R&D share^N	0.0093***	0.0036	0.0045
	(0.0034)	(0.0052)	(0.0148)
CR^N	-0.0310*	-0.1113***	0.0245
	(0.0178)	(0.0344)	(0.0245)
EI^N	-0.6808*	-2.3974**	-0.5979
	(0.3695)	(1.1451)	(0.3875)
Constant	0.0489	-0.4323*	0.3482*
	(0.1168)	(0.2522)	(0.1816)
Observations	451,156	129,645	163,634
Adjusted R-squared	0.0312	0.0333	0.0340
Year fixed effect	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes
No. of clusters	255,853	73,602	92,911

Note: Standard errors clustered at firm level are reported in parentheses. Siginificant at **5%, ***1%. All monetary values are deflated to 2005 prices via provincial CPI. Year, province and 4-digit industry dummies are included in all specifications.