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The Role of Electricity Prices in Structural Transformation: Evidence from the Philippines*

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ABSTRACT

The Philippines provides an extreme example of Rodrik's observation that late developing countries experience deindustrialization at lower levels of per capita income than more advanced economies. Previous studies point to the role of protectionist policies, financial crises, and currency overvaluation as explanations for the shrinking share of the industry sector. We complement this literature by examining the role of electricity prices in the trajectory of industry share. We make use of data at the country level for 33 countries over the period 1980-2014 and at the Philippine regional level for 16 regions over the period 1990-2014. We find that higher electricity prices tend to amplify deindustrialization, causing industry share to turn downward at a lower peak and a lower per capita income, and to decline more steeply than otherwise. In a two-country comparison, we find that power-intensive manufacturing subsectors have expanded more rapidly in Indonesia, where electricity prices have been low, whereas Philippine manufacturing has shifted toward less power intensive and more labor-intensive subsectors in the face of high electricity prices.

Keywords: electricity prices, structural transformation, deindustrialization

JEL codes: O10, O14, Q40, Q41

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The Role of Electricity prices in Structural Transformation: Evidence from the Philippines

1. INTRODUCTION

One of the arguments for making power more affordable is that cheaper power may help to ameliorate premature deindustrialization, i.e. the peaking of industry's share in employment and value added at substantially lower levels of per capita income than historically observed in developed countries (Dasgupta and Singh 2007; Rodrik 2016). Premature deindustrialization can have adverse productivity effects and slow development generally. For example, deindustrialization in Latin American and African countries has been accompanied by growth of low productivity informal and non-traded goods sectors and increased rural-to-urban migration (Rodrik 2016).

While it is not difficult to imagine why high power-prices could be disadvantageous to manufacturing, empirical analysis of the relationship between electricity prices and industry is wanting, as is understanding of the mechanisms by which electricity prices influence structural change. The high cost of power may act as a deterrent to investment in power-intensive industries thereby biasing growth towards more labor-intensive sectors as well as industrial subsectors. Some manufacturing industries, e.g. electronics assembly lines, can also be sensitive to the quality of power. A few seconds of fluctuating electric current may waste a whole batch, substantially increasing costs.

From 1991 to 2000, the power industries in Indonesia, Malaysia, Thailand, and the Philippines were all vertically integrated and highly subsidized. With the Philippines' passage of the Electric Power Industry Reform Act (EPIRA) in 2001, the power industry went through a major restructuring. Generation was privatized and a transition to more competitive retailing was mandated. [1] Transmission and distribution were left as regulated monopolies. Due to implementation delays and the loss of subsidies, however, industrial electricity prices remain high, although the rate of price increase has slowed significantly (Ravago et al. 2018c).

Electricity prices have been high in the Philippines relative to its ASEAN neighbors (International Energy Agency 2016). Philippine residential rates in 2015 were \$0.19/kWh versus \$0.16/kWh in Singapore, \$0.13/kWh in Thailand, \$0.12/kWh in Indonesia, and \$0.08/kWh in Malaysia. Industrial rates were also higher in the Philippines (\$0.12/kWh) than in the rest of ASEAN with the exception of Singapore (at \$0.13/kWh).

There are many reasons why electricity prices have been high in the Philippines, including governance failures in the form of red tape (Clarete 2018), onerous licensing requirements (Escresa 2018), and local–central government standoffs, e.g., the Redondo case (Fabella 2018). These have dampened the appetite of investors (Alonzo and Guanzon 2018) resulting in a paucity of new generation capacity in the face of growing demand (Abrenica 2014). Taxes and subsidies (Clarete 2018), sub-optimal fuel mix (Ravago et al. 2018a), feed-in-tariffs, and missionary charges also contribute to the high cost of electricity (Ravago and

[1] As of 2018, implementation of EPIRA has experienced delays and the competitive retail sector has not fully materialized. See also Alonzo and Guanzon (2018) on the evolution of Philippine electricity policy and Ravago et al. (2018c) for further discussion of EPIRA implementation and timeline.

Roumasset 2018). Lack of competitiveness and possible transfer pricing from generation companies to affiliated distribution utilities may also increase prices (Ravago et al 2018b, Abrenica 2014). While transmission costs are slightly higher in an archipelago, high prices persist even in large population clusters on the major islands, e.g., within the National Capital Region and surrounding areas.

In this paper, we seek to illuminate how high electricity prices can exacerbate premature deindustrialization. High prices of an input tend to discourage the growth of sectors that use that input more intensively. Specifically, we illustrate the role that electricity prices play in the growth and composition of industry in the Philippines. We show that the composition of Philippine manufacturing shifted in favor of subsectors that use power less intensively (e.g. machinery). This is in contrast to Indonesia's experience, where manufacturing growth has been largely driven by more power-intensive subsectors. We adapt Rodrik's (2016) analysis to capture the relationship between electricity prices and the share of industry in total output. We then simulate how industry's share changes with electricity prices.

In cross-country analysis, we find that higher electricity prices are associated with a downward shift in the share of industrial gross value added (GVA) and the peaking of industry shares at lower per capita incomes. In analysis of Philippine data at the regional level, we similarly find higher electricity prices being associated with the industry share in output peaking at substantially lower levels of per capita income and declining at a much faster rate. While data limitations constrain definitive conclusions about causality, it appears that structural transformation is not independent of electricity prices, particularly in the Philippines.

The paper is organized as follows: Section 2 documents some stylized facts about electricity prices and structural transformation in the Philippines and neighboring countries. The Philippine development path displays Rodrik's rule with a vengeance; the share of manufacturing turned downwards at a relatively low maximum and descended faster. Comparing the Philippines with its higher per-capita income Southeast Asian neighbors, the shares of the industrial sectors are inversely correlated with electricity prices. With the exception of Singapore, Philippine electricity prices are highest and industry shares lowest. Controlling for subsector, the electricity cost shares tend to be higher in the Philippines than in Indonesia. The descriptive analysis helps motivate further analysis of premature deindustrialization and its relationship to electricity prices. Section 3 outlines the empirical methodology adapted from Rodrik (2016) to examine the issue more formally. It then presents the estimation results of the cross-country analysis and for regions of the Philippines. Section 4 provides conclusions and policy implications.

2. STRUCTURAL TRANSFORMATION AND ELECTRICITY PRICES: STYLIZED FACTS

There are several mechanisms through which electricity prices can influence growth in industry and hence the structural development of an economy. One mechanism operates through business investment, since higher electricity prices increase the marginal cost of production according to the cost share of electric power. The demanded quantities of energy intensive goods will also decline. Using National Income and Product Account data from the U.S. Bureau of Economic Analysis, Edelstein and Kilian (2007) analyzed how energy price shocks influence non-residential fixed investment and concluded that while the estimated negative response of business fixed investment to energy price shocks tends to be small, it satisfies conventional statistical significance criteria.

Abeberese (2017) looked at the impact of electricity prices on manufacturing productivity and found that firms switch to less power-intensive production in response to higher electricity prices. If less power-intensive industries involve lower technology products, then higher electricity prices could result in less product sophistication and consequently, lower productivity. Electricity rates can also influence national output. Alvarez and Valencia (2016) showed that in Mexico a 13% reduction in electricity prices due to substitution of fuel oil for natural gas could increase Mexico's manufacturing output by 1.4% to 3.6%.

High electricity prices can also have a negative effect on foreign direct investment (FDI). The literature is replete with studies illustrating how FDI can increase productivity and growth of the manufacturing sector (e.g., Arnold and Javorcik 2009). Nonetheless, few have looked at the impact of energy prices on FDI inflows. Bilgili et al. (2012) is one of the rare examples, which found that high-energy prices deterred FDI entry into Turkey, particularly at times when FDI inflow was high in other countries.

The Philippine experience has long puzzled development scholars. In the early 19th century, the Philippines was the third Asian country (and the first in Southeast Asia) to enter the so-called "5% industrial growth club"—those countries that had experienced industrial growth rates of at least 5% a year (De Dios and Williamson 2015). This continued until the early 1960s when the Philippines had the most developed manufacturing sector in Southeast Asia, albeit supported by import protection (Bautista and Power 1979; Power and Sicat 1971). However, industrialization stagnated from the late 1960s, with the Philippines thereby missing the East Asian Miracle which brought the dramatic ascent of newly industrialized economies across Asia in the 1970s through the 1990s (e.g., Vos and Yap 1996). With the relative decline of industry in the Philippines, in particular manufacturing, came the rise of services. Workers from rural and agricultural areas, in search of better living standards, often found themselves in low-skill, traditional service-oriented jobs or as contract workers overseas.

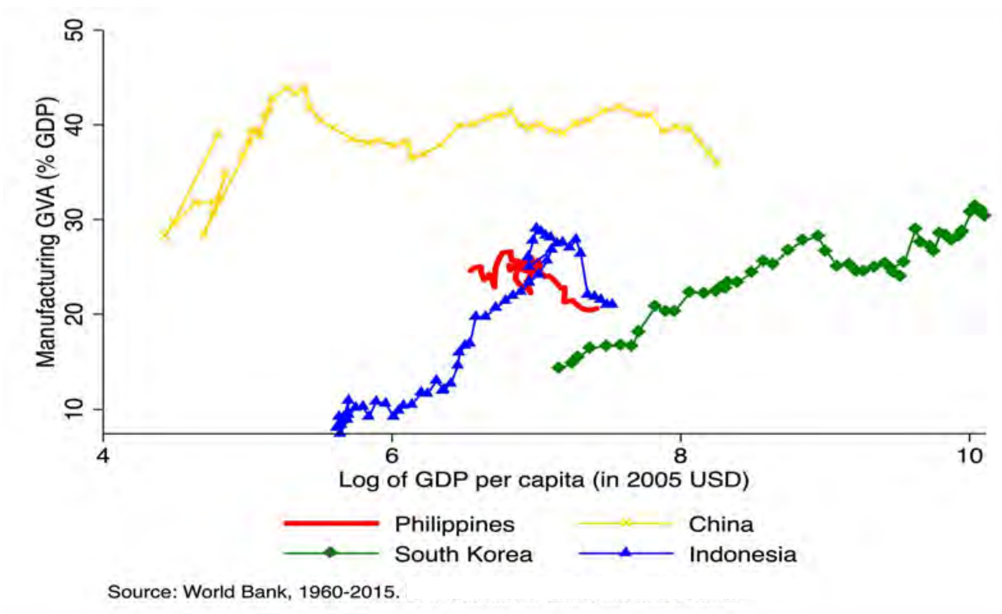
Daway and Fabella (2015) and de Dios and Williamson (2015) attribute the country's premature deindustrialization to decades of protectionism, political instability, insufficient export promotion, financial crises, and real exchange rate overvaluation. Recent anecdotal accounts, however, stress how higher electricity prices may have also stunted industrial growth. For instance, Rimando and Mercado (2013) and Deloitte (2014) assert that high power costs hampered the Philippines' ability to compete in the manufacturing sector. Philippine small and medium enterprises in particular are said to be hit hardest by high power costs (Remo 2014). For those manufacturing industries that did operate in the Philippines, the high cost of power is often cited as among the constraints to expansion. Unreliability of power supply further increases usage costs. Since 2006, the Philippines has ranked below Indonesia, Malaysia, and Thailand in terms of power quality according to the Global Competitiveness Report of the World Economic Forum (World Bank WEF 2018). In 2016-2017, out of the 138 countries surveyed, the

Philippines ranked 94th whereas Indonesia, Malaysia, and Thailand ranked 89th, 39th, 61st, respectively (World Bank WEF 2018).[2]

The Philippines is not unique in its industrial under-performance. Using data from the Groningen Growth and Development Center (Timmer et al. 2014) covering 42 countries, Rodrik (2016) observed that the vast majority of developing countries today are experiencing deindustrialization at lower levels of per-capita income. His analysis indicates that manufacturing employment shares in late peaking countries (after 1990) were about one-third that of earlier peaking countries.

To further motivate the discussion, we examine data on manufacturing output shares from the World Development Indicators (WDI) for China, Indonesia, South Korea, and the Philippines. Manufacturing is the largest component of the industrial sector, which also includes mining and quarrying, construction, and supply of electricity, gas, and water. Figure 1 shows the relationship between gross domestic product (GDP) per capita and the share of manufacturing gross value added (GVA) in GDP. Manufacturing share in the Philippines reached its peak at a low level of GDP per capita relative to its neighbors. As Figure 1 shows, the manufacturing share in the Philippines peaked at a lower level and at a lower GDP per capita compared to China, South Korea and Indonesia. The horizontal distance of each line reflects the growth of each economy from 1960 to 2015. For example, the percentage increase in South Korea's per capita GDP was an order of magnitude greater than that in the Philippines.

Figure 1. Manufacturing Share vs. GDP per capita, 1960-2015



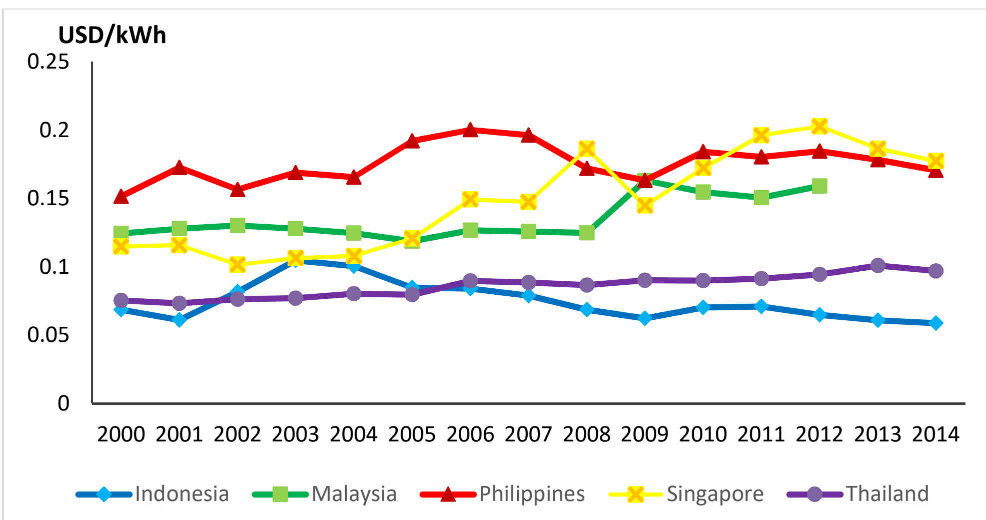
Manufacturing share in the Philippines fell fast and from a relatively low level.
Data source: World Development Indicators .

[2] While the Philippines is ranked a respectable 29th in the world for "getting electricity" (well below Malaysia and Thailand and only slightly above Indonesia in the *Rankings and Ease of Doing Business Score,* World Bank 2018), this metric is presumably more about accessibility grid connections) than quality and reliability.

The Philippine growth path vis-à-vis its Asian neighbors is characterized by an early substitution away from manufacturing toward services at significantly lower levels of per capita income. With the Plaza Accord in 1985, Japanese firms sought to restore their competitive advantage by developing a regionally integrated supply chain of component and assembly plants. This impetus, and the competitive response of European and American firms, led countries in East and Southeast Asia to develop particular niches within their own manufacturing sectors according to their own comparative advantages. Thailand was the recipient of major Japanese investments and became a prime location for automotive manufacturing. South Korea and Taiwan became hubs of electronic and semiconductor production. Malaysia was able to boost its information technology industry, while Vietnam gained foreign attention as a promising new economy for low cost, labor intensive manufacturing. The Philippines, in contrast, seems to have failed to partake in this industrial renaissance, not only losing ground in manufacturing for much of the latter part of the 20th century but doing so at a comparatively rapid rate.[3]

Have electricity prices played a significant role in hampering Philippine industrialization? Since the 1990s, electricity rates in the Philippines have been consistently high relative to neighboring countries such as Indonesia, Malaysia, and Thailand, and this trend persisted throughout the 2000s (Figure 2).

Figure 2. Industrial electricity prices in Southeast Asian countries (constant 2010 USD/kWh)

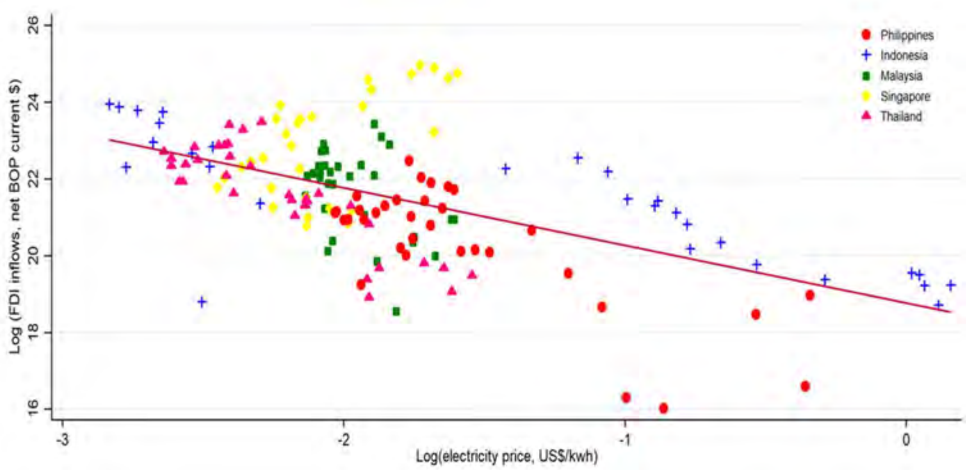


Electricity rates in the Philippines have been high, especially relative to Indonesia, Malaysia, and Thailand. The pronounced price declines for the Philippines and Singapore in 2009 were primarily due to the global financial crisis, which depressed demand and lowered input costs (NEMS 2009). *Data sources:* Aldaba (2003), Enerdata (various years), Meralco (various years), MEIH Statistics (various years), Singapore National Library Board (various years), Singapore Statistics (various years).

[3] Recently, however, the manufacturing sector has shown signs of resurgence (Deloitte 2014). From 2009 to 2013, the sector grew at 7.9% in value added terms, owing to greater competitiveness and an improved business climate in the country.

High electricity rates in the Philippines date back to the 1980 to early 1990 period when FDI inflows to East Asia were at record high levels. Indonesia, with its low industrial rates, remained competitive, as did Thailand. Power industries in these countries are vertically integrated and highly subsidized. Figure 3 shows a strong negative correlation between FDI inflows and industrial rates. In Indonesia, where average national electricity prices remained fairly flat at low levels, FDI inflows increased from the late 1980s up to 1997 and again after recovery from the Asian Financial Crisis from 2004 to 2010. In contrast, electricity prices in the Philippines have risen continuously and the amount of net FDI inflows has remained low. Anecdotal accounts of foreign business leaders cite both the prices and the quality of electricity to be major deterrents to investing in the Philippines (Enerdata 2014).

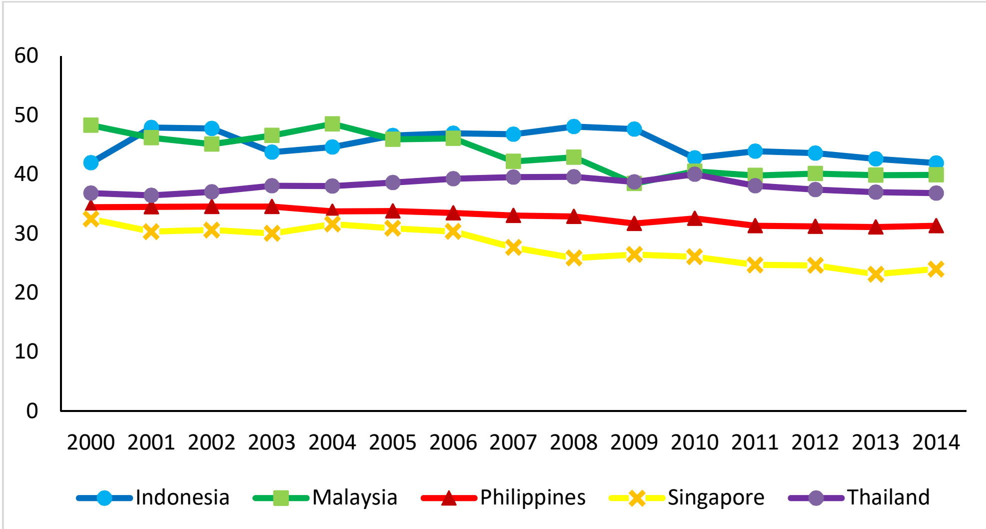
Figure 3. Correlation between FDI inflow and industrial electricity rates, 1984-1992



FDI inflow (Balance of payments, current million USD) is negatively correlated with industrial electricity rates (in US cents/kWh).

As shown in Figure 4, the ordering of countries with respect to industry shares is opposite that of electricity prices. Indonesia, Malaysia, and Thailand have higher industry shares than the Philippines, even though they had higher per capita GDPs during the period. That Singapore's industrial share is even lower than that of the Philippines is not surprising given the country's much higher per capita income, high level of re-exporting, and large complementary service sector (e.g. finance).

Figure 4. Industry value added (% of GDP)



The share of industry is higher for Indonesia, Malaysia, and Thailand relative to the Philippines.
Data source: World Bank, World Development Indicators.

To further explore the link between electricity prices and economic development, we examine the changing composition of manufacturing in the Philippines and Indonesia, which had relatively high and low electricity rates respectively. Table 1 reports electricity cost shares in output value by manufacturing subsector for the two countries. For most subsectors electricity cost shares were higher in the Philippines than in Indonesia, in some cases roughly double or more. Cost share rankings of industries are similar in both countries. Chemicals and related products (ISIC 35) and basic metals (ISIC 37) rank at or near the top for both; wood and related products (ISIC 33) and other manufacturing (ISIC 39) rank at or near the bottom. Divergence in ranking for some subsectors may be due to different product composition within the subsectors.

Table 1. Electricity cost shares by manufacturing subsector, Philippines and Indonesia, 1998-1999

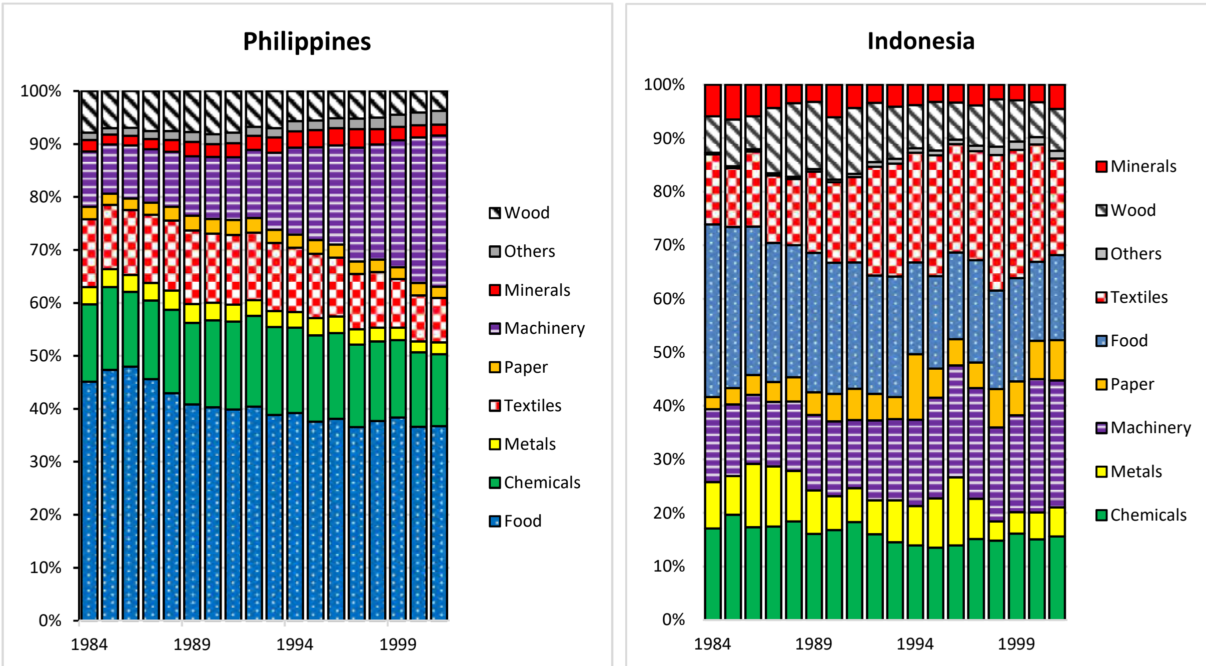
ISIC Code	Industry	Philippines		Indonesia	
		Electricity cost/ Output value	Rank	Electricity cost/ Output value	Rank
31	Manufacture of Food, Beverages, and Tobacco	0.048	1	0.023	5
35	Chemicals and Chemical, Petroleum, Coal, Rubber and Plastic Products	0.043	2	0.043	1
37	Basic Metal Industries	0.038	3	0.041	2

32	Textile, Wearing Apparel, and Leather Industries	0.035	4	0.019	6
34	Paper and Paper Products, Printing and Publishing	0.034	5	0.026	4
36	Non-Metallic Mineral Products, except Products of Petroleum and Coal	0.032	6	0.012	9
38	Fabricated Metal Products, Machinery and Equipment	0.032	6	0.032	3
39	Other Manufacturing Industries	0.028	8	0.015	7
33	Wood and Wood Products, Including Furniture	0.022	9	0.013	8

Data sources: Philippine Statistics Authority (PSA) (Annual Survey of Philippine Business and Industry (ASPBI)) and Badan Pusat Statistik – Statistics Indonesia (Industri Manufaktur - Census of Manufacturing).
Note: ISIC is International Standard Industrial Classification. The figures reflect averages for 1998-1999.

Figure 5 shows the changing shares of manufacturing subsectors for the two countries during the period 1984-2001. The composition of Philippine manufacturing shifted in favor of machinery and other subsectors with low electricity cost shares and away from food, chemicals, and other subsectors with high electricity cost shares. The fastest growing subsector in the Philippines was machinery, driven mainly by labor intensive assembly operations in semi-conductors and electronic products. The more power-intensive subsectors of textiles, metals, and chemicals grew at annual rates of just 0.4%, 0.7%, and 2.4%, respectively. In contrast, growth in Indonesian manufacturing has been driven by power-intensive subsectors, including metals, which grew at 15.3% annually and machinery, which grew at 19.4%. Compared with its ASEAN neighbors, Indonesia's electricity prices were both lower and flatter during the period, and its more power-intensive sectors were growing rapidly.

Figure 5. Manufacturing subsector shares, 1984-2001



Subsectors are ranked according to electricity cost share with the bottom subsector having the highest cost share. The composition of Philippine manufacturing has shifted toward subsectors with lower electricity cost shares (especially machinery) and away from higher cost subsectors (notably food). In contrast, shares of Indonesia's more power-intensive sectors were growing rapidly.
Data sources: Philippine Statistics Authority (PSA) 2010 Annual Survey of Philippine Business (ASBPI) and Industry and 1983-2001 Badan Pusat Statistik – Statistics Indonesia (Industri Manufaktur - Census of Manufacturing)
Note: ISIC codes are as follows: Food, 31; Textiles, 32; Wood, 33; Paper, 34; Chemicals, 35; Minerals, 36; Metals, 37; Machinery, 38; Others, 39.

The contrast between the Philippines and Indonesia also manifests in the growth of manufacturing in the aggregate. During the 1984-2001 period, manufacturing gross value added grew at annual rates of 2.8% in the Philippines versus 14.6% in Indonesia.

The descriptive analysis of this section gives an indication of how electricity prices may influence growth of the manufacturing sector and industry more broadly. We examine this issue more formally in the next section.

3. EMPIRICAL ANALYSIS

The descriptive statistics in Section 2 suggest that electricity prices may augment the premature deindustrialization described by Rodrik (2016). In this section, we examine this hypothesis more formally by adding electricity price as an explanatory variable to Rodrik's econometric model of industry shares in output. We follow Rodrik in emphasizing real measures (aggregation at constant prices) of output in order to keep quantities distinct from price movements for purposes of understanding structural change. Estimation using nominal shares is also included for completeness. We estimate the model using unbalanced panel data, first at the country level and then for regions within the Philippines.

3.1 Empirical model

To examine the relationship between the share of industry in output and electricity prices in conjunction with rising output per capita, we estimate the following equation:

$$S_{ct} = \alpha + \beta_0 P_{c,t} + \beta_1 GDP_{c,t} + \beta_2 GDP_{c,t}^2 + \beta_3 P_{c,t} GDP_{c,t} + \beta_4 P_{c,t} GDP_{c,t}^2 + \delta X + \varepsilon_{ct} \quad (1)$$

where S_{ct} is the share of industry in GDP (in real or nominal terms) of country or Philippine region c in year t; $P_{c,t}$ is the unit price of electricity; $GDP_{c,t}$ is GDP per capita; X' is a $k \times 1$ vector of other controls, including population, fixed effects by country or region to account for unobserved time-invariant heterogeneity in cross section (e.g., initial resource endowments, history), and decade dummies (i.e., 1980s, 1990s, and 2000s); and ε_{ct} is the error term. Electricity price, GDP per capita, and population are expressed in logarithms. GDP per capita and population are included in both levels and quadratic form, and GDP per capita and its quadratic form are both interacted with electricity price to account for the possibility that the relationship between industry share and GDP per capita is influenced by electricity prices.

An issue of concern in the estimation of equation (1) is the potential endogeneity of electricity prices. The estimated effect of electricity prices on industry shares will be biased if an omitted variable correlated with electricity price movements also affects a country's industrial trajectory. As Rodrik (2016), points out, adding period dummies captures the effects of common shocks on industrial share in each period relative to the excluded period (pre-1980 for the cross-country analysis and pre-1990 for the Philippine regional analysis). The period dummies used in the regression analysis help to control for any endogeneity of electricity prices. To check for the robustness of our results, we use one-period lagged values for electricity price and GDP per capita, which captures the sluggish response of macroeconomic variables to energy price shocks.

3.2 Data

For the cross-country analysis, we use annual data for 1980-2014 for 33 OECD and Southeast Asian countries. Industry share figures, reflecting gross value added of industry relative to GDP, are from World Bank WDI. Electricity price data come from various sources. For the OECD countries, data were obtained from the International Energy Agency, - OECD Library, and are expressed in USD/kWh in purchasing-power-parity terms. For the Southeast Asian countries data are from power distribution utility companies (Meralco, Malaysia Energy Information Hub, and Singapore Public Utilities Board) supplemented by data from Enerdata and individual country statistics offices. We also rely on Aldaba (2003) for earlier electricity prices from 1980 to 1991 for select Southeast Asian countries. Table 2 presents summary statistics for the cross-country data.

Table 2. Cross-Country Summary Statistics, 1980-2014

	Obs	Mean	St Dev	Min	Max
Industry share in GDP, real	947	28.38	8.00	10.72	49.20

Industry share in GDP, nominal	930	28.80	6.60	10.67	48.53
Electricity price (constant 2010 USD/kWh)	944	0.16	0.12	0.05	1.26
GDP per capita (constant 2005 prices, thousand USD)	1102	29.81	21.11	1.23	111.97
Population (million)	1155	42.46	59.91	0.36	318.56
Number of years (1980-2014)	35				
Number of countries	33				
Observations	1155				

Data sources: Aldaba (2003); Enerdata (various years); Meralco (various years); Malaysian Energy Information Hub Statistics (various years), Singapore National Library Board (various years), Singapore Statistics (various years), WDI (various years); International Energy Agency OECD (various years), International Labor Organization-Laborsta (various years)

For the Philippine regional analysis, we use annual data for 16 regions for 1990-2014 (the longest period for which comparable regions exist). Regional gross domestic product (RGDP) data are from the regional income accounts publications of the Philippine Statistics Authority (PSA). Electricity prices (PhP/kWh, measured in constant 2000 prices) are derived from revenue and sales data for distributional utilities (DUs) reported by the Philippine Department of Energy (DOE) with prices taken as the weighted averages. For the three regions covered by Meralco, the biggest DU which operates in Metro Manila and surrounding provinces, the shares of regional consumption compared to total consumption are used to weight each of three regions. As a check on the accuracy of our DOE-derived prices, we compute the simple correlation coefficient with the official electricity price indices reported by PSA. The two series are highly correlated (0.98 for the Philippines; 0.95 for Luzon; 0.92 for the Visayas; 0.95 for Mindanao; and 0.91 for the National Capital Region). Summary statistics are presented in Table 3.

Table 3. Philippine Regional Summary Statistics, 1990-2014

	Obs	Mean	St Dev	Min	Max
Average electricity price (PhP/kWh, weighted by sales, constant 2000 prices)	386	4.27	0.89	0.97	6.37
Industry share (% of RGDP)	386	25%	8%	4%	46%
Manufacturing share (% of RGDP)	386	14%	8%	1%	29%
RGDP per capita (constant 2000 prices, in thousand PhP)	386	587	1162	105	7983
Population (million)	400	5.03	3.07	1.15	16.22
No. of years (1990-2014)	25				
No. of regions	16				

Data sources: Philippine Statistics Authority; Department of Energy, Philippines.

3.3 Cross-country analysis and simulations

Results from estimating equation (1) using cross-country data are presented in Table 4. Period dummies are excluded in columns (1) to (3) and included in columns (4) to (6). Within each group, two different dependent variables are incorporated: industrial output share in real terms and industrial output share in nominal terms.[4]

In the specifications without period dummies, we find that holding other things constant, electricity price (in real terms) is negatively and significantly associated with the both the real output shares of industry. This relationship is not preserved using nominal variables however (columns 2). As suggested by Rodrik (2016), this may be due to the confounding effects of price movements.

Period dummies (1980s, 1990s, and 2000s) are included to capture time trends and to control for common shocks on industrial share in each decade relative to the years before 1980. The results in column (4) of Table 4 show a remarkable set of regularities. First, we find that there is a strong and statistically significant negative association between electricity prices and output shares of industry (in real terms). This finding empirically validates our descriptive analysis in the previous section. We find an inverted U-shaped relationship between industry shares and GDP per capita in that industry shares are related positively to GDP per capita and negatively to the square of GDP per capita. We also find a strong association between the electricity price interacted with GDP per capita variables and the industrial shares (in real terms). Our finding suggests that with higher electricity prices the rate of growth of industry shares is slower and, after a certain per capita GDP level, the rate of decline in industry shares is faster.

Table 4. Regression results for industry shares in GDP, cross country, 1980-2014

	(1) Real output	(2) Nominal output	(4) Real output	(5) Nominal output
Electricity price	-90.86***	-50.82	-83.50***	-42.33
	(24.03)	(31.48)	(25.36)	(33.28)
GDP/capita	86.13***	78.69***	78.72***	66.99***
	(14.77)	(18.22)	(15.06)	(16.31)
$(\text{GDP/capita})^2$	-4.32***	-4.10***	-3.85***	-3.32***
	(0.78)	(1.00)	(0.80)	(0.88)
Electricity price*(GDP/capita)	20.11***	10.44	18.37***	8.35
	(5.54	(6.72)	(5.85)	(7.18)
Electricity price*$(\text{GDP/capita})^2$	-1.10***	-0.54	-0.99***	-0.40
	(0.31)	(0.36)	(0.33)	(0.38)
Population	59.80**	63.30*	43.78	34.91

[4] Results using one-period lagged values for price and GDP per capita are shown in Appendix Table A1. The intent of using lagged values is to capture any potential sluggishness in the response of macroeconomic variables to energy price shocks. The signs on coefficients of key variables are consistent with the results in Table 4.

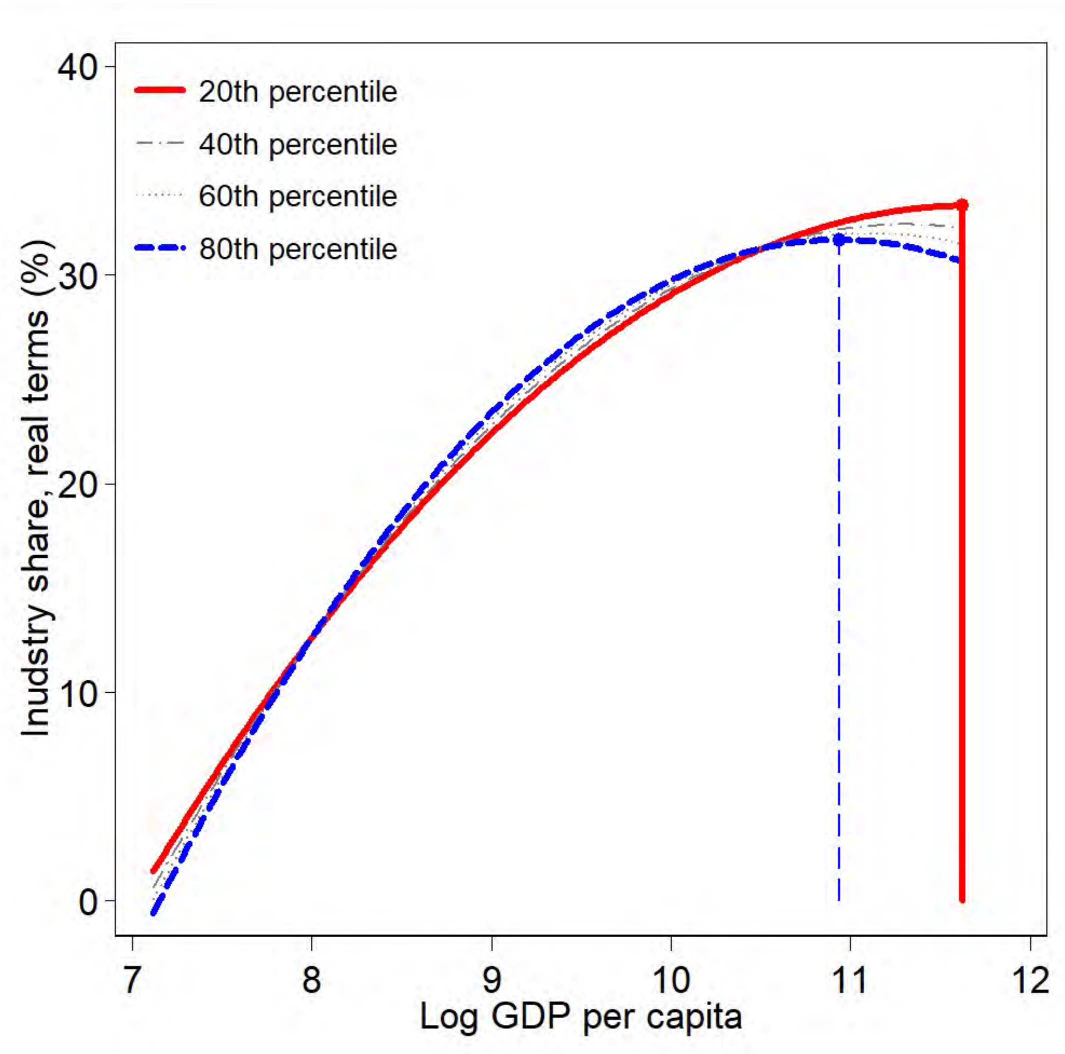
	(26.94)	(32.20)	(26.72)	(28.66)
Population^2	-2.32***	-2.23**	-1.79**	-1.29
	(0.82)	(0.96)	(0.83)	(0.85)
1980s			1.69**	3.79***
			(0.76)	(1.03)
1990s			1.59***	2.64***
			(0.50)	(0.55)
2000s			1.14***	2.15***
			(0.30)	(0.37)
Constant	-745.82***	-776.87**	-598.59**	-529.07*
	(249.06)	(320.88)	(243.30)	(279.44)
Country fixed effects	Yes	Yes	Yes	Yes
Observations	815	798	815	798
R^2 (adjusted)	0.48	0.38	0.51	0.45
R^2 (within)	0.49	0.39	0.52	0.46

Estimation results are from equation (1). Electricity price, GDP per capita, and population are expressed in logarithms. Real output shares are based on constant 2005 USD. Robust standard errors clustered by country are given in parentheses. *, **, *** correspond to 10, 5, and 1 percent significance levels, respectively.

To more vividly show how electricity prices influence the relationship between industry share and GDP per capita, we use the estimates from equation (1) under the specification with period dummies (column 4 of Table 4) to conduct simulations. We select four different electricity prices representing quantile values from the distribution of prices across the 33 countries and 35 years of our sample (see Appendix Figure A.1).

We plot the simulation paths in Figure 6 and provide key quantitative results in Table 5. Each curve in Figure 6 represents predicted industry share as a function of log GDP per capita at a different electricity price quintile. Higher energy prices increase the slope of the curve, implying an earlier turning point and a more rapid decline. The vertical lines indicate the level of GDP per capita at which the industry share reaches a maximum. The peak for an electricity price at the 80th percentile, as represented by the dashed vertical line, occurs at a lower per capita income than the peak for an electricity price at the 20th percentile, as represented by the solid vertical line.

Figure 6. Simulated paths of industry share by electricity price, country level



Each curve represents the simulated path of industry share at a different electricity price quintile. The vertical lines point to the log GDP per capita levels at which industry shares peak, the solid line for an electricity price at the 20th percentile, the dashed line for an electricity price at the 80th percentile.

Table 5 shows quantitative magnitudes for the simulation exercises. Electricity prices range from 0.10 USD/kWh at the 20th percentile to 0.19 USD/kWh at the 80th percentile. For an electricity price at the 80th percentile, the turning point comes at a relatively low GDP per capita, about USD56,184 (in 2005 USD) with the industrial share peaking at 31.7% of GDP. By contrast, for an electricity price at the 20th percentile, the turning point comes at a much higher US$111,968 (in 2005 USD) with a peak in the industrial share of 33.3%.

Table 5. Simulated GDP per capita turning points of industry share by electricity price, country level

Electricity price		GDP/capita turning points (USD thousand)		Industry shares at peak (%)	
Percentile	USD/kWh	Real output	Nominal output	Real output	Nominal output
80	0.19	56.2	22.7	31.7	29.7
60	0.15	67.3	22.7	32.0	29.6
40	0.13	81.6	22.5	32.4	29.4
20	0.10	111.6	22.2	33.3	29.2

The table pertains to the simulated GDP per capita where industry share peaks using parameter estimates from Table 4, columns (4) and (5). Electricity prices are in constant 2010 USD and GDP per capita values in constant 2005 prices.

In sum, our results imply that a higher electricity price tends to shift the inverted U relationship between industrial share and GDP per capita down and to the left. This suggests that high electricity prices amplify premature deindustrialization, i.e., deindustrialization occurs sooner in terms of GDP per capita and at lower industry shares.

The Philippines represents an extreme version of premature deindustrialization. Comparing the Philippines with its higher per capita income Southeast Asian neighbors, we find, with the exception of Singapore, [5] a lower industry share and, higher electricity prices. Higher electricity prices in the Philippines appear to have exacerbated premature deindustrialization.

3.4. Philippine regional analysis and simulations

We now turn to the influence of electricity prices on industry shares across Philippine regions. We estimate equation (1) using panel data for 16 regions of the Philippines over the years 1990-2014. The dependent variable is the share of industry GVA in RGDP in real terms. To mitigate the effects of measurement error associated with electricity price data in small regions we weight observations by population using the maximum population over the sample time frame for each region. Such population weighting ensures that our regression results are driven by data points that are deemed more accurate by giving them more influence in estimating parameters. This increases the efficiency of the estimation compared to unweighted regression.[6] We then use the resulting estimates to simulate the path of industry share with respect to RGDP per capita holding electricity price constant at different levels.

Table 6 presents regression results for equation (1). Annual dummies are included to capture year effects for the years 1990-2014. The results show a negative and statistically

[5] The Singapore exception is consistent with its high per capita income and high transshipment and intermediary trade, all of which contribute to a large services sector.

[6] Cooperatives distributing electricity in small regions generally charge higher prices but offer subsidies supported by the National Electrification Administration that may not be reflected in reported price data.

significant association between electricity prices and industry share. As with the cross-country analysis, higher electricity prices appear to reduce the share of industry in RGDP.[7]

Table 6. Regression results for industry share, Philippine regions, 1990-2014

	Real output
Electricity price	-2.183*
	(1.082)
RGDP/capita	0.820
	(0.580)
(RGDP/capita)^2	0.058
	(0.043)
Electricity price*(RGDP/capita)	-0.676*
	(0.325)
Electricity price*(RGDP/capita)^2	-0.051*
	(0.024)
Population	2.751*
	(1.465)
Population^2	-0.076*
	(0.040)
Constant	-21.304
	(13.352)
Year dummies	Yes
Observations	350
R^2	0.380

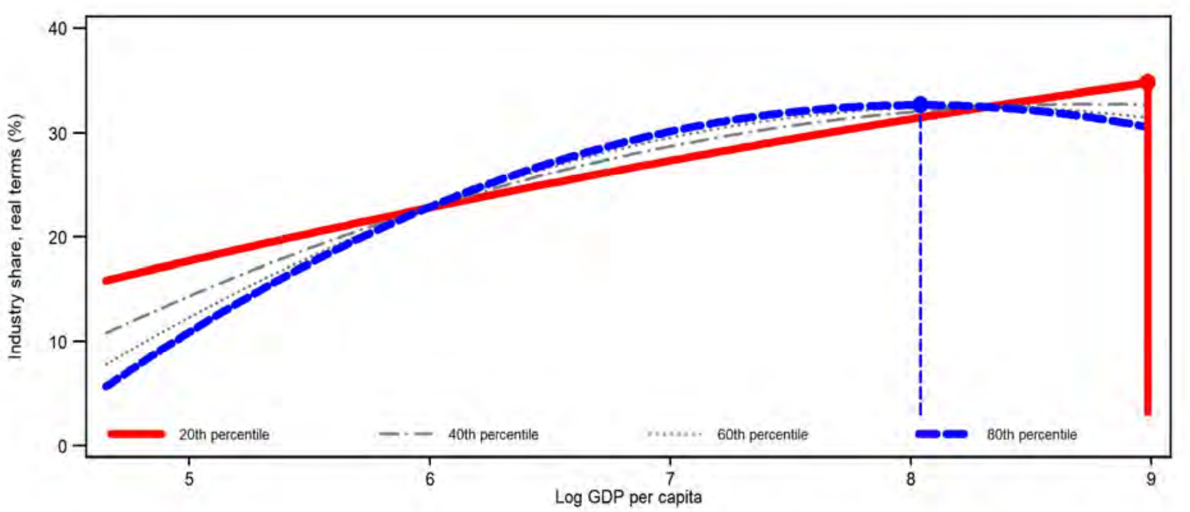
Estimation results are from equation (1). Electricity price, RGDP per capita, and population are expressed in logarithms. Electricity prices and industry shares are based on constant 2000 PhP prices. Robust standard errors clustered by region are in parentheses. *, **, *** correspond to 10, 5 and 1 percent significance levels, respectively.

We use the estimates in Table 6 to simulate the path of industry share with respect to RGDP per capita with results depicted in Figure 7 and key magnitudes reported in Table 7. Figure 7 shows that higher electricity prices are associated with an earlier and lower peak in industry share. For an electricity price at the 20th percentile, we do not see a turning point in industry share; it rises to the upper limit of RGDP per capita used in the simulation exercise. For electricity prices at higher quantiles, however, industry share reaches turning points within the

[7] Another way to examine the influence of electricity price on structural change is to estimate services share as a function of GDP per capita and electricity price. We estimated equation (1) using services share as the dependent variable for the Philippine regional database. The resulting coefficient for the electricity price variable is positive albeit not statistically significant. A similar finding holds for the agriculture sector.

simulation range. For an electricity price at the 40th percentile, the turning point is 6,425 PhP per capita while for an electricity price at the 80th percentile it falls to 3,105 PhP per capita.

Figure 7. Simulated paths of industry share by electricity price, Philippine regional level



Each curve represents the simulated path of industry share at a different electricity price quintile. The vertical lines indicate the per capital RGDP levels at which industry shares peaked. The solid red line corresponds to the RGDP per capita for the (low) 20th percentile price. The dashed line shows the per capita RGDP where industry peaks for the case wherein electricity price is set at the 80th percentile.

Table 7. Simulated RGDP per capita turning points of industry share by electricity price, Philippine regional level

Electricity price (Percentile)	Electricity price (PhP/kWh)	RGDP/capita turning points (PhP)	Industry share at peak (%)
80	5.46	3,105	32.7
60	4.97	3,775	32.5
40	4.48	6,425	32.8
20	3.62	-	34.8

Note: For the 20th percentile, industry share is still rising at the end point of the simulation range (RGDP per capita = 8000 PhP). Electricity prices and industry shares are based on constant 2000 PhP prices.

4. CONCLUSIONS AND POLICY IMPLICATIONS

Motivated by the Philippine experience of deindustrialization at a low level of per capita income, we study the role of high electricity prices in the process of structural transformation using data at both country and Philippine regional levels.

High electricity prices can plausibly augment other factors that induce premature deindustrialization. We adapt Rodrik's (2016) model of deindustrialization to investigate how industry share moves in connection with GDP per capita and electricity prices. We estimate the model with respect to 33 countries for the period 1980-2014 and with respect to 16 regions of the Philippines for the period 1990-2014.

For both the country and Philippine regional estimations, we find that higher electricity prices are associated with industry share turning downward at lower peaks and at lower levels of GDP per capita. Moreover, the downtrend tends to be steeper the higher are electricity prices. Data limitations constrain definitive conclusions about causality, but it appears that structural transformation is not independent of electricity prices. Descriptive analysis of the Philippine case relative to other Southeast Asian nations provides further evidence of a connection.

Electricity prices can impact industry via several pathways, including business investment, manufacturing productivity, and foreign direct investment. Untangling the relative contributions of the various pathways is a promising agenda for further research.

The Philippine manufacturing sector still accounts for a 20% share of the country's output. The Philippine government has recently targeted a substantial increase in manufacturing's share. Several promising strategies have been identified—from increasing value added in the electronics sector to improving the competitiveness of paper mills. Realizing this potential may be difficult without lowering the price of electricity and improving its quality and reliability.

Lowering electricity prices by relaxing bureaucratic red-tape and increasing the competitiveness of generation and retailing would confer a win-win in terms of power market efficiency and enhancing manufacturing's ability to act as a growth engine. Whether electricity-rate subsidies are warranted to further augment externalities of investment coordination, knowledge and new-good creation remains an open question.

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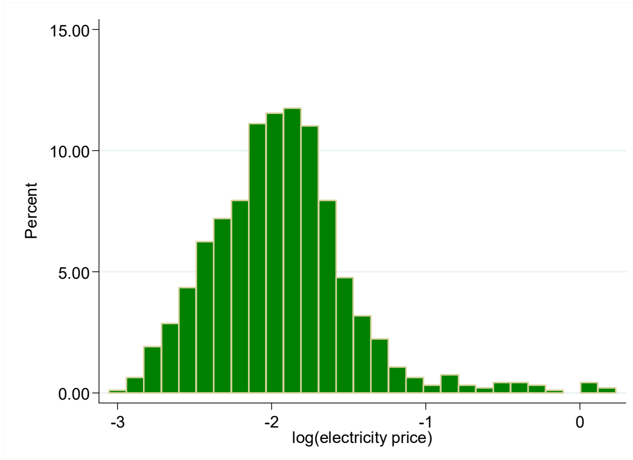
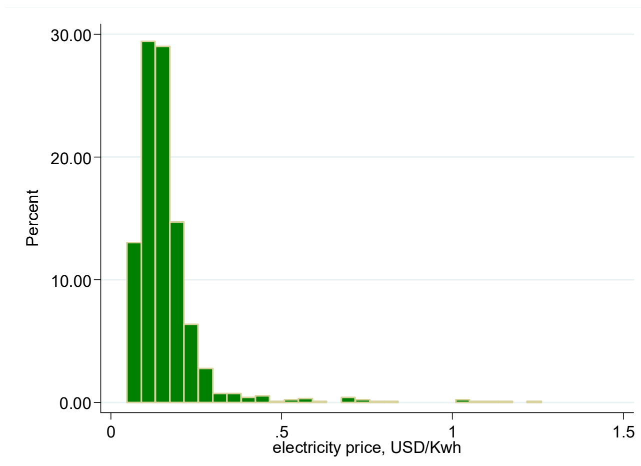
APPENDIX

Figure A1. Distribution of electricity prices, in log transformed and USD/kWh terms across 33 countries over 35 years





Distribution of Electricity price across 33 countries in 35 years	
Percentile	USD/kWh
80	0.19
60	0.15
40	0.13
20	0.10

Note: Prices are in constant 2010 USD.

Source: Data sources: Aldaba (2003); Enerdata (various years); Meralco (various years); Malaysian Energy Information Hub Statistics (various years), Singapore National Library Board (various years), Singapore Statistics (various years), International Energy Agency OECD (various years),

Table A1. Regression results for industry shares with lagged independent variables, cross country, 1980-2014

	(1) Output share, real	(2) Output share, nominal	(3) Employment share
Electricity price$_{t-1}$	-87.768***	-42.314	-48.768
	(24.615)	(31.142)	(30.211)
(GDP/capita)$_{t-1}$	81.385***	67.465***	90.491***
	(14.702)	(15.379)	(15.153)
(GDP/capita)$_{t-1}^2$	-4.050***	-3.421***	-4.791***
	(0.782)	(0.832)	(0.883)
Electricity price$_{t-1}$*(GDP/capita)$_{t-1}$	19.438***	8.466	10.750
	(5.692)	(6.758)	(6.632)
Electricity price$_{t-1}$*(GDP/capita)$_{t-1}^2$	-1.055***	-0.415	-0.576
	(0.321)	(0.364)	(0.356)
Population$_t$	43.802	36.358	-36.036
	(26.218)	(27.695)	(21.237)
Population$_t^2$	-1.770**	-1.289	1.050*
	(0.817)	(0.817)	(0.604)
1980s	1.318*	3.167***	6.473***
	(0.765)	(1.009)	(1.436)
1990s	1.427***	2.343***	5.040***
	(0.484)	(0.543)	(0.841)
2000s	1.113***	2.110***	3.331***
	(0.292)	(0.364)	(0.549)
Constant	-611.986**	-546.330*	-90.316
	(238.347)	(267.777)	(228.898)
Country fixed effects	Yes	Yes	Yes
Observations	798	783	896
R^2, adjusted	0.495	0.440	0.709
R^2, within	0.501	0.447	0.712

Note: Estimation results are from equation (1). Electricity price, GDP per capita, and population are expressed in logarithms. Real output shares are based on constant 2005 USD. Robust standard errors clustered by country are in parentheses. *p<0.10; **p<0.05; ***p<0.01.