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

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The Role of Power Prices in Structural Transformation:
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ABSTRACT

The Philippines provides a leading example of Rodrik's rule that developing countries experience deindustrialization at lower levels of per-capita income than did developed countries. Previous studies point to the role of protectionist policies, financial crises, and exchange rate overvaluation as explanations for the shrinking share of industry sector. We complement this literature by examining the role of power prices in industry share across countries and across regions of the Philippines. We find that higher power prices tend to augment the Rodrik rule, causing industry share to turn downward at a lower GDP per capita, a lower industry share, and to decline more steeply than otherwise. In a two-country comparison, we find a tendency for power-intensive manufacturing subsectors to expand more rapidly in Indonesia while the composition in the Philippines changes towards less power-intensive and more labor-intensive subsectors. The results suggest that that structural transformation is not independent of power prices, particularly in the Philippines.

Keywords: power prices; structural transformation; industrialization

JEL Classification: O10, O14, Q40, Q41

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

1. INTRODUCTION

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

While it is not difficult to think why power prices could be part of a cluster of factors disadvantageous to manufacturing, e.g., energy price can deter foreign direct investment (FDI) inflows to the sector (Bilgili et al. 2012), empirical analysis of the relationship between power prices and industry is wanting, as is understanding of the mechanisms by which power prices influence structural development. The high cost of power may act as a deterrent for power-intensive industries to invest in the industrial sector. In particular manufacturing may be skewed towards more labor-intensive 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 1991-2000, 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) of 2001, the power industry went through a major restructuring. Generation was privatized and 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 power prices remain high, although the rate of price increase has slowed significantly (Ravago et al. 2018c).

Relative to its neighbors, Philippine residential rates in 2015 were higher at \$0.19/kWh than ASEAN neighbors, Singapore (\$0.16/kWh), Thailand (\$0.13/kWh), Indonesia (\$0.12/kWh), and Malaysia (\$0.08/kWh). Industrial power rates were also higher in the Philippines (\$0.12/kWh) with the exception of Singapore, whose industrial rate is \$0.13/kWh (electricity price data from IEA 2016).

There are many reasons why prices are high in the Philippines, foremost of which are governance failures in the form of red tape (Clarete 2018), onerous licensing requirements (Escresa 2018), and local–central government standoffs e.g., Redondo case (Fabella 2018). These have dampened the appetite of investors (Alonzo and Guanzon 2018) resulting in a paucity of new generation capacities 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 Roumasset 2018). Lack of competitiveness and possible transfer pricing from generation companies to affiliated distribution utilities may be also adding to the cost (Ravago et al 2018b, Abrenica 2014). While transmission costs are slightly higher in an archipelago, we still see relatively high prices even within the Meralco franchise area.

In this paper, we seek to illuminate how high power prices can exacerbate premature deindustrialization. Specifically, we illustrate the role that power prices play in the growth and

[1] As of 2016, implementation of EPIRA has experienced delays and the competitive retail sector has not fully materialized.

composition of industry in the Philippines. We adapt Rodrik's (2016) analysis to capture the relationship between the share of industry in total output and power prices. We then simulate how industry's share changes with power prices.

We find that higher power prices are associated with a downward shift in the share of industrial gross value added (GVA) and lower per capita incomes at which industry shares peak. Using Philippine data at the regional level, we also find a similar result for the share of industry in total output, with higher power prices being associated with the output share of industry peaking at substantially lower levels of per capita income and declining at a much faster rate. While data limitations constrain more definitive conclusions about causality, it appears that structural transformation is not independent of power prices, particularly in the Philippines.

The paper is organized as follows: Section 2 provides the link between power prices and structural transformation. The descriptive analysis helps motivate the analysis of premature deindustrialization and its relationship to power prices. The stylized facts indicate how power prices may influence the growth of manufacturing and industry and the country's structural development. Section 3 presents the empirical methodology adapted from Rodrik (2016) to examine the issue more formally. Section 4 presents the results. and Section 5 provides the conclusion and policy implications.

2. STRUCTURAL TRANSFORMATION AND POWER PRICES

There are a number of mechanisms through which power prices can influence growth in industry and hence, the structural development of an economy. One mechanism operates through firms' investment, since higher power prices increase the marginal costs of production according to the cost share of electric power. The demanded quantities of energy intensive goods will also decline. Using US-BEA's National Income and Product Account, 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.

Abeberese (2017) looked at the impact of power prices on manufacturing productivity and found that firms switch to less power-intensive production in response to higher power prices. If less power-intensive industries are correlated with technologically-backward products, then this could indicate the impact of power prices on product sophistication and consequently, on productivity among firms. Power rates can also influence national output. Alvarez and Valencia (2016) showed that a 13% reduction in power prices can increase Mexico's manufacturing output by 1.4% to 3.6%. The reduction in power prices is due to the policy of substituting fuel oil for natural gas.

Another channel is through the negative effect of high power prices on FDIs. The literature is replete with studies illustrating how FDIs can increase productivity and growth of the manufacturing sector (e.g., Arnold and Javorcik 2009). Nonetheless, very few have looked at the impact of energy prices on FDI inflows. Bilgili et al. (2012), is one of the rare examples, who 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 first in Southeast Asia) to enter the so-called "5% industrial growth club"—those countries that had experienced at least 5% industrial growth (De Dios and Williamson 2015; Appendix Table A.1). This continued until the early 1960s when the Philippines had the most developed manufacturing sector in Southeast Asia, albeit via import protection (Bautista and Power 1979; Power and Sicat 1971). However, industrialization stagnated from the late 1960s through the 1990s, thereby missing the East Asian Miracle that occurred in the 1970s through the 1990s (e.g., Vos and Yap 1996), which helped lead the dramatic ascent of newly-industrialized economies across Asia. With the relative decline of industry, 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 (where productivity and wages were low) 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 power prices may have also stunted industrial and manufacturing 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.[2] For those manufacturing industries that have been operating in the Philippines, the high cost of power is often cited as among the constraints to expansion. Reliability of power supply further increases 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, Philippines ranked low at 94 whereas Indonesia, Malaysia, and Thailand ranked at 89, 39, 61, respectively (World

[2] Philippine small and medium enterprises (SMEs), in particular, are said to be hit hardest by high power costs (Remo 2014).

Bank WEF 2018).[3] Foreign business leaders often cite the high cost and reliability issues of power as the primary deterrents to investing in the Philippines (Enerdata 2014).

The Philippines is not unique. Using data from 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.

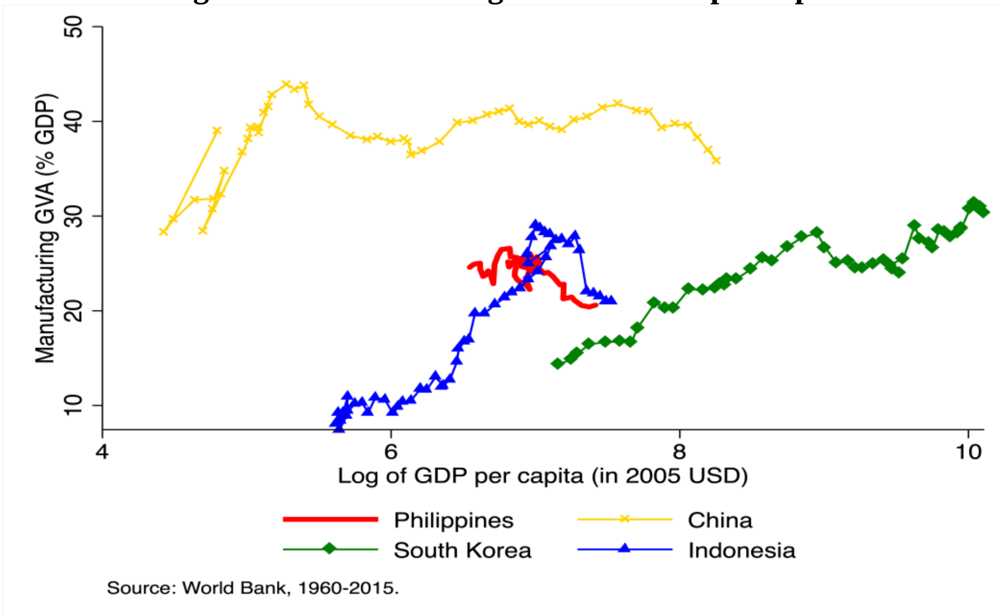
To further motivate the discussion, we used data from the World Development Indicators (WDI) for China, Indonesia, South Korea, and the Philippines. Industrial output is comprised of manufacturing, mining and quarrying, construction, and electricity gas and water supply, with manufacturing having the largest share. Figure 1 shows the relationship between the shares of manufacturing GVA and gross domestic product (GDP) per capita.

Manufacturing share in the Philippines reached its peak at a low level relative to the average of East Asian and Pacific (EAP) countries and also relative to its neighbors, China, Indonesia, and South Korea[4] which participated in the East Asian manufacturing renaissance in the latter half of 1980s and early 1990s. The WDI data shows that the highest share of industry to total output (Gross Domestic Product or GDP) occurred in 2000 for Indonesia at 45.4%, for Malaysia at 48.3%, and for Thailand in 2010 at 44.7%; in the Philippines, it occurred in the early 1980s at only 38.8% (see Appendix Table A.1).

[3] While the Philippines is ranked a respectable 29th in the world for "getting electricity," although 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 grid connection than quality and reliability.

[4] The manufacturing share in South Korea appears to be still increasing, although its employment share peaked in 1989 (Cowen 2016), due to a dramatic decrease in labor intensity.

Figure 1. Manufacturing GVA vs. GDP per capita

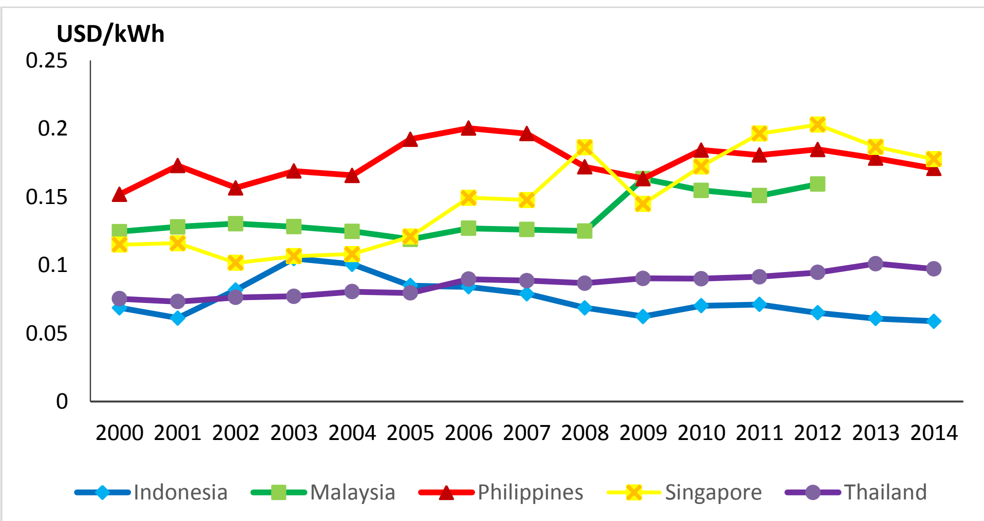


Note: Manufacturing share in the Philippines fell fast and from a relatively low level. Authors' calculations. *Sources of basic data:* World Development Indicators, 1960-2015.

The Philippine growth path vis-à-vis its Southeast and East 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 deeply 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 IT industry, while Viet Nam 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.[5]

Have power prices played a significant role in hampering Philippine industrialization? Since the 1990s, power rates in the Philippines have been consistently high relative to neighboring countries such as Indonesia, Malaysia, and Thailand, and this trend persisted throughout 2000s (Figure 2). It is interesting to note that we see an opposite ordering of countries when it comes to the share of industrial output in gross domestic product (Figure 3). Indonesia, Malaysia, and Thailand have higher shares than the Philippines.

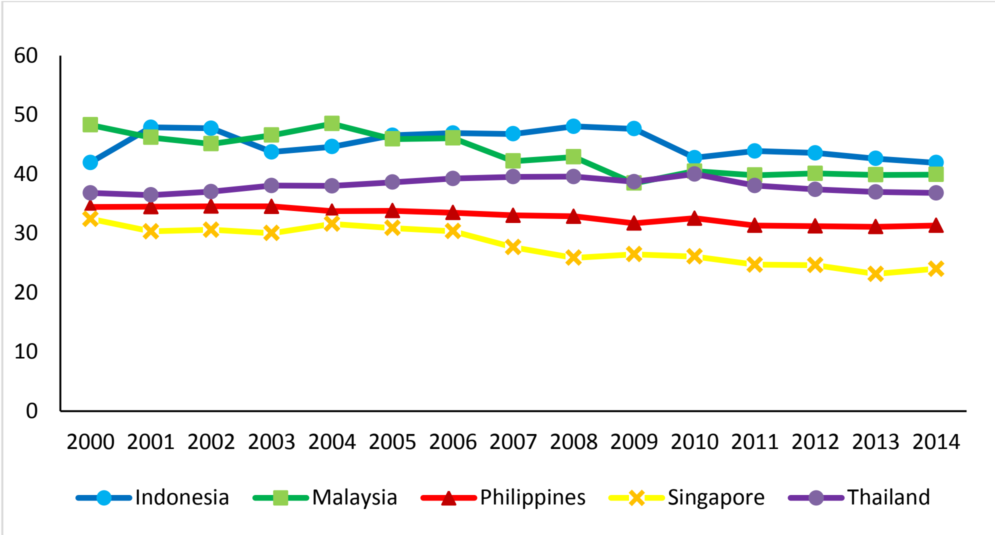
Figure 2. Industrial power prices in select Southeast Asian countries (constant 2010 USD/kWh)



Power rates in the Philippines have been consistently high relative to neighboring countries including Indonesia, Malaysia, and Thailand. The sharp declines for the Philippines and Singapore in 2009 are primarily due to global financial crisis, which affected both prices and demand (NEMS 2009).
Sources of basic data: Aldaba (2003), Enerdata (various years), Meralco (various years), MEIH Statistics (various years), Singapore National Library Board (various years), Singapore Statistics (various years).
Note: Data come from different sources and may not be entirely comparable.

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

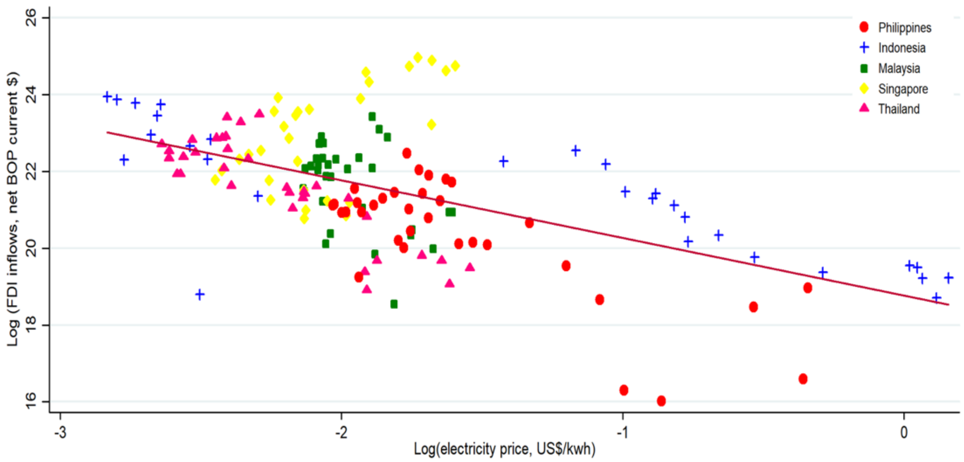
Figure 3. Industry value added (as % of GDP)



The share is higher for Indonesia, Malaysia, and Thailand relative to the Philippines. Industry is the sum of the shares of manufacturing, mining and quarrying, construction, electricity gas and water supply. Source of basic data: World Bank, World Development Indicators.

The high-power-rate regime occurred during the period when FDI inflows to East Asia were at record high levels during the 1980s and early 1990s. Indonesia, with its low industrial power rates, remained competitive, as did Thailand. Figure 4 shows a negative correlation between FDI inflow and industrial power rates. The correlation also provides a statistically significant elasticity of FDI with respect to power rates. Examining closely the trends, FDI net inflows have been increasing in Indonesia, where average national power prices remained fairly flat at low levels from the late 1980s up to 1997, and from 2004 up to 2010. In contrast, power prices in the Philippines have risen continuously and the amount of net FDI inflows has remained low. Anecdotal accounts of foreign business leaders see this as a main deterrent to investing in the Philippines (Enerdata 2014).

Figure 4. Correlation between FDI inflow and industrial power rates for select Asian countries, 1984-1992



Notes: The figure shows the correlation between FDI inflow (BOP, current Million USD) and industrial power rates (in US cents/kWh). All variables are converted in natural logarithms.

To further explore the link between power prices and economic development we now explore the changing composition of manufacturing in the Philippines and Indonesia, which had relatively high and low electricity rates respectively. Table 1 reports the relative electricity intensity across manufacturing subsectors for Indonesia and the Philippines. Intensity rankings are similar in both countries. The exception of food, beverage, and tobacco manufacturing may be due to the different compositions of that sub-sector in the two countries.

Table 1. Electricity intensities by manufacturing sub-sector, Philippines and Indonesia, 1998-1999.

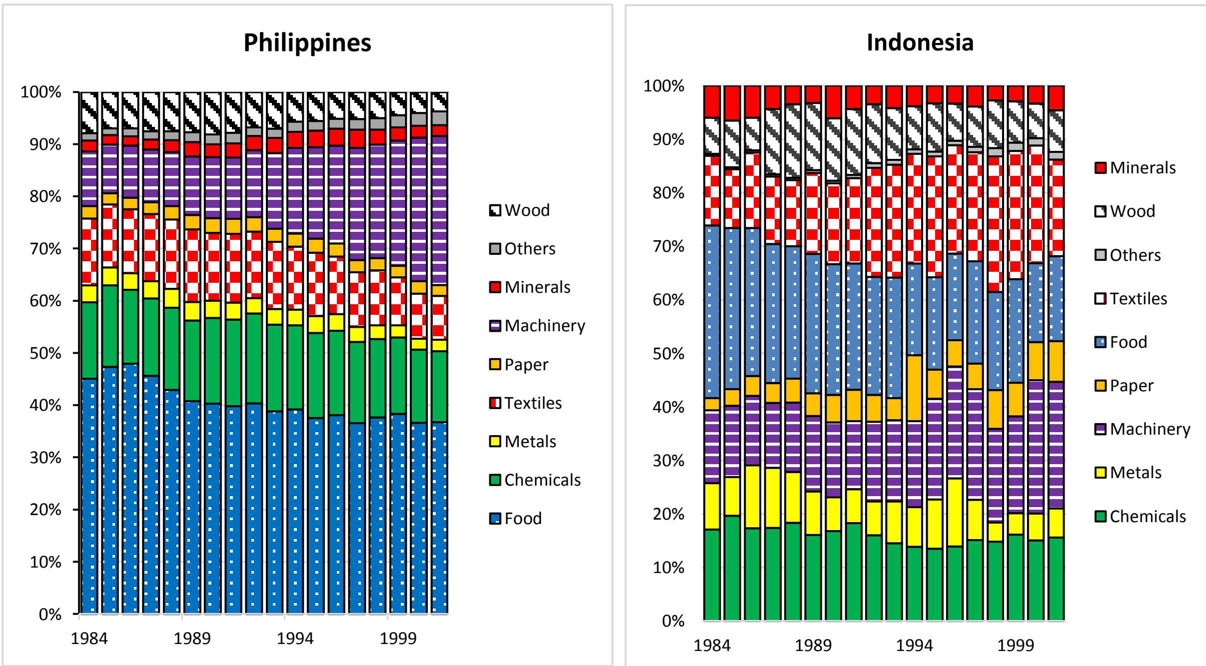
ISIC Code	Industry	Philippines		Indonesia	
		Electricity cost/ Value of output	Rank	Electricity cost/ Value of output	Rank
31	Manufacture of Food, Beverages, and Tobacco	0.048	1	0.023	5
32	Textile, Wearing Apparel, and Leather Industries	0.035	4	0.019	6
33	Wood and Wood Products, Including Furniture	0.022	9	0.013	8
34	Paper and Paper Products, Printing and Publishing	0.034	5	0.026	4
35	Chemicals and Chemical, Petroleum, Coal, Rubber and Plastic Products	0.043	2	0.043	1
36	Non-Metallic Mineral Products, except Products of Petroleum and Coal	0.032	6	0.012	9
37	Basic Metal Industries	0.038	3	0.041	2
38	Fabricated Metal Products, Machinery and Equipment	0.032	6	0.032	3
39	Other Manufacturing Industries	0.028	8	0.015	7

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

Figure 5 shows the share of various manufacturing subsectors in the Philippines and Indonesia. The data indicates that composition of Philippine manufacturing changed in favor of machinery and other labor-intensive subsectors while shares of food, chemicals and other power-intensive sectors declined.[6]

[6] Data availability limits further validation information on electricity intensities in services.

Figure 5. Share of manufacturing sub-sector to total, 1984-2001.



Subsectors are ranked such that the bottom subsector has the highest electricity intensity. The data indicate that the composition of Philippine manufacturing changed in favor of labor-intensive subsectors between 1984 and 2001. In contrast, shares of Indonesia's more power intensive sectors were continuously growing.

Sources of basic data: 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)

Notes: Authors' calculations. Food – Manufacture of Food, Beverage, and Tobacco; Textile - Textile, Wearing Apparel, and Leather Industries; Wood - Manufacture of Wood and Wood Products, Including Furniture; Paper - Manufacture of Paper and Paper Products, Printing and Publishing; Chemicals - Manufacture of Chemicals and Chemical, Petroleum, Coal, Rubber, and Plastic Products; Minerals - Manufacture of Non-Metallic Mineral Products, except Products of Petroleum and Coal; Metals - Basic Metal Industries; Machinery - Manufacture of Fabricated Metal Products, Machinery and Equipment; Others – Other Manufacturing Industries.

The fastest growing subsector in the Philippines was machinery, whose growth in turn came from the labor-intensive assembly operations in the production of semiconductors and electronics. In contrast, textiles, metals, and chemicals, which are more power-intensive, grew at

0.40%, 0.69%, and 2.37%, respectively. The data provides an indication that manufacturing growth in the Philippines was largely composed of the growth of less power-intensive subsectors. In contrast, growth in Indonesian manufacturing has been driven by power-intensive manufacturing subsectors, including metals which grew at 15.32% in 1984-2001. The machinery subsector also grew at 19.43%. Compared to its ASEAN neighbors, Indonesia's power prices were both lower and flatter during the period. Moreover, the shares of Indonesia's more power intensive sectors were continuously growing during the same period. Total manufacturing gross value added during the period grew at 2.76% in the Philippines and 14.56% in Indonesia.

This descriptive relationship between the growth rates of manufacturing subsector, their shares, and their power intensity in the Philippines and Indonesia gives an indication of how power prices may be influencing the growth of the manufacturing and industry. This in turn, suggests that the level of power prices affects development. We examine this issue more formally in the next section.

3. METHODOLOGY

We build on Rodrik (2016)'s econometric model and show the potential influence of power prices on the share of industry in the economy across countries and downscale the model to the Philippine regions.

3.1 Empirical model

The empirical strategy for determining how an economy's industrial growth paths are associated with power rates makes use of the cross-sectional and temporal variations in power prices among countries and within the regions of the Philippines. To examine the relationship among power price, the share of industry output, and per capita output, we estimate the following reduced-form model adapted from Rodrik (2016):

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

where S_{ct} denotes the share of industry in total output of country *c* in year *t*, $P_{c,t}$ is the unit price of power (measured in USD/kWh), and $GDP_{c,t}$ is the country-specific GDP per capita and its quadratic form are interacted with power price to account for the possibility that the relationship between industry share and GDP per capita is partially determined by power prices.

The variable α_c is a country fixed effect to account for unobserved time-invariant heterogeneity across countries (e.g., initial resource endowments, history), and ε_{ct} is the usual error term. X' is a $k \times 1$ vector of period dummies (i.e. 1980s, 1990s and 2000s) and population. The population variable is both in levels and quadratic form following Rodrik (2016). All variables, excluding indicator variables and share of industry in total output, are all expressed in logarithms.

We estimate equation (1) for regions of the Philippines and use the share of services as an outcome variable to validate the robustness of our results.

A major issue in said estimation is the potential endogeneity of power prices. For example, the estimated effect of power prices on industry shares will be biased if an omitted variable correlated with power 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 cross-country and pre-1990 for regional analysis). The period dummies used in the regression analysis help to control for the endogeneity of power prices.[7] We also used one-period lagged values for price and GDP per capita in order to represent the sluggish behavior of macroeconomic variables to energy price shocks.

3.2 Data

We used data from the WDI and International Energy Agency (IEA) Energy Price and Statistics for 1980-2014 to include the dramatic industrial growth period in Asia between 1984 and 1996. Our cross-country analysis of the relationship between industry and power prices relies on respective GVA (as a percent of GDP) data from the WDI. Power price data come from various sources. Non-Asian country data was obtained from IEA-OECD Library with data (USD/kWh in PPP terms) available from 1980 to 2014. Data from Southeast Asian countries--Philippines, Malaysia, Thailand, Indonesia, and Singapore-- are from power distribution utility companies: Meralco, Malaysia Energy Information Hub (MEIH) Statistics, Singapore Statistics, Singapore Public Utilities Board (PUB). These are supplemented by data from Enerdata and individual country statistics offices. We also rely on Aldaba (2003) for older power prices from 1980 to 1991 in select Southeast Asian countries. Table 2 presents summary statistics for the cross-country data.

[7] We thank an anonymous referee for this point.

Table 2. Summary Statistics, Cross-country data, 1980-2014

	Obs	Mean	SD	Min	Max
Power Price (USD/kWh)	944	0.16	0.12	0.05	1.26
Industry GVA (% GDP)	947	28.38	8.00	10.72	49.20
Manufacturing GVA (% GDP)	947	15.66	4.95	4.49	31.07
GDP per Capita (in '000 constant 2005 $)	1082	26.86	6.57	8.03	54.22
Population (in millions)	1155	42.46	59.91	0.36	318.56
Observations	1155				
No. of years (1980 -2014)	35				
No. of countries	33				

Sources of basic data: Aldaba (2003), Enerdata (various years), Meralco (various years), MEIH Statistics (various years), Singapore National Library Board (various years), Singapore Statistics (various years), WDI-WB (various years), IEA-OECD (various years)

Notes: Unless expressed as percentage shares, all variables are expressed in real terms. For other countries, we drop Turkey, Mexico, and Greece from the analysis due to their extremely unusual CPI trend.

For the Philippine regional analysis, we use regional gross domestic product (RGDP) data from the regional income accounts publications of Philippine Statistics Authority or PSA (Table 3). We focus on the years 1990 to 2014–the longest period for which there is comparable regional groupings (16 regions in total)–and a common base year (1985). Average annual power prices (PhP/kWh measured in 2008 prices) for each region are derived from the Department of Energy's (DOE) historical prices on distribution utilities or DUs (derived from revenues divided by sales). For each year, prices of DU outputs are averaged using each DU's relative share of regional sales from 1998 to 2012. For Meralco, the biggest DU which operates in Metro Manila and surrounding provinces, the relative shares of average regional consumption (2002-2013) compared to total consumption are the weights used for each of three regions it covers. As a check on the accuracy of this DOE-generated data, we compute the simple correlation coefficient with official power price indices of 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 NCR).

Table 3. Summary Statistics (Philippine data), 1990-2014.

	Obs	Mean	SD	Min	Max
Average electricity price, in PhP/kWh, constant 2000 prices)	386	4.66	0.94	2.88	6.78
Average electricity price, in PhP/kWh, weighted by sales, constant 2000 prices)	386	4.27	0.89	0.97	6.37
Industry share, (% of RGDP)	386	0.25	0.08	0.04	0.46
Manufacturing share, (% of RGDP)	386	0.14	0.08	0.01	0.29
RGDP per capita, (constant 2000 prices)	386	586.70	1162.28	105.00	7982.96
Population (in millions)	400	5.03	3.07	1.15	16.22
No. of years (1990-2014)	25				
No. of regions	16				

4. RESULTS AND DISCUSSION

4.1 Cross-country analysis

Results from estimating equation (1) using our cross-country data are presented in Table 4, without period dummies, and Table 5, with period dummies. Columns (1), (2), and (3) of Table 4 and 5 show the results for industry's share in total GDP in real terms, nominal terms, and for industry's share in total employment, respectively.

In the specification without period dummy (Table 4), we find that holding other things constant, power price (in real terms) is negatively associated with the shares of industry in both real output and employment, but not in nominal output. These relationships are statistically significant.

Table 4. Regression results: dependent variable is share of sector to total

	Industrial Share		
	(1)	(2)	(3)
Variables	% GDP, real	% GDP, nominal	Employment
$Price_t$	-90.863***	-50.816	-72.731**
	(24.033)	(31.481)	(27.895)
$(GDP/capita)_t$	86.126***	78.694***	120.986***
	(14.767)	(18.215)	(15.422)
$(GDP/capita_t)^2$	-4.323***	-4.102***	-6.695***
	(0.784)	(0.997)	(0.838)
$Price_t$ x $(GDP/capita)_t$	20.109***	10.439	16.530***
	(5.535)	(6.719)	(5.991)
$Price_t$ x $(GDP/capita)_t^2$	-1.097***	-0.538	-0.925***
	(0.310)	(0.356)	(0.320)
$Population_t$	59.796**	63.304*	19.082
	(26.938)	(32.200)	(26.096)
$(Population)_t^2$	-2.316***	-2.227**	-0.785
	(0.821)	(0.961)	(0.753)
Constant	-745.820***	-776.870**	-606.384**
	(249.059)	(320.881)	(270.416)
Country-fixed effects	Yes	Yes	Yes
Period dummies	No	No	No
Observations	815	798	918
R-sq. (adjusted)	0.483	0.385	0.635
R-sq. (within)	0.487	0.391	0.638

Note: Industry sector is the sum of the shares of manufacturing, mining and quarrying, construction, electricity gas and water supply. The table above presents the results from estimating equation 1 using the share of each sector's output to total output (in current USD and constant 2005 USD) and employment. All variables are expressed in logarithms, except indicator variables and share of industry in total output. Robust standard errors clustered at the country level are in parentheses. *p<.10; **p<.05; ***p<.01.

Table 5. Regression results: dependent variable is share of sector to total.

	Industrial Share		
	(1)	(2)	(3)
	% GDP, real	% GDP, nominal	Employment
$Price_t$	-83.399***	-42.332	-40.677
	(25.362)	(33.278)	(30.163)
$GDP/capita_t$	78.721***	66.989***	88.319***
	(15.055)	(16.309)	(15.194)
$(GDP/capita_t)^2$	-3.852***	-3.318***	-4.636***
	(0.800)	(0.879)	(0.873)
$Price_t$ x $(GDP/capita)_t$	18.366***	8.349	9.000
	(5.853)	(7.176)	(6.610)
$Price_t$ x $(GDP/capita)_t^2$	-0.992***	-0.405	-0.482
	(0.329)	(0.384)	(0.355)
$Population_t$	43.777	34.907	-37.894*
	(26.718)	(28.662)	(21.014)
$(Population)_t^2$	-1.793**	-1.286	1.094*
	(0.832)	(0.853)	(0.603)
1980s	1.689**	3.793***	6.969***
	(0.762)	(1.034)	(1.344)
1990s	1.589***	2.642***	5.300***
	(0.496)	(0.550)	(0.791)
2000s	1.137***	2.153***	3.406***
	(0.299)	(0.369)	(0.544)
constant	-598.587**	-529.068*	-65.743
	(243.301)	(279.440)	(224.369)
Country-fixed effects	Yes	Yes	Yes
Observations	815	798	918
R-sq. (adjusted)	0.511	0.452	0.713
R-sq. (within)	0.517	0.459	0.716

Note: Industrial share is the sum of the shares of manufacturing, mining and quarrying, construction, electricity gas and water supply. The table above presents the results from estimating equation 1 using the share of each sector's output to total output (in current USD and constant 2005 USD) and employment. All variables are expressed in logarithms, except indicator variables and share of industry in total output. Robust standard errors clustered at the country level are in parentheses. **p*<.10; ***p*<.05; ****p*<.01.

Table 5 shows robust negative associations between power prices and output shares of industry. These relationships are statistically significant. With interaction of price and GDP per capita, a 1 unit increase in power price together with a 1 unit increase in GDP per capita, the negative effect on industry share is reduced by -65.033 (= -83.399 + 18.366).   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 estimated coefficients on these period dummies yielded positive and significant results and a declining trend in all specifications. This implies that the average country in our sample had a level of industry that is lower in 2000s than in the 1970s.

Table 6 presents the results using one-period lagged values for price and GDP per capita. The lagged values seek to capture the sluggish behavior of macroeconomic variables to energy price shocks. The sign of the coefficients of the key variables, price and time trends, in column (1) are consistent with the results in Tables 4 and 5.

Table 6. Regression results: dependent variable is share of sector to total

	Industrial Share		
	(1)	(2)	(3)
	% GDP, real	% GDP, nominal	Employment
$Price_{t-1}$	-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)
$Price_{t-1}$ x $GDP/capita_{t-1}$	19.438***	8.466	10.750
	(5.692)	(6.758)	(6.632)
$Price_{t-1}$ x $(GDP/capita)_{t-1}^2$	-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-sq. (adjusted)	0.495	0.440	0.709
R-sq. (within)	0.501	0.447	0.712

Industrial share is the sum of the shares of manufacturing, mining and quarrying, construction, electricity gas and water supply. The table above presents the results from estimating equation 1 using the share of each sector's output to total output (in current USD and constant 2005 USD) and employment. All variables are expressed in logarithms, except indicator variables and share of industry in total output. Robust standard errors clustered at the country level are in parentheses. *p<.10; **p<.05; ***p<.01.

We use the resulting estimates from equation (1) using the specification with period dummies to simulate the trend of industry's share with respect to each GDP per capita level, holding power price constant at different percentiles. The percentiles are based on the distribution of prices across 33 countries over 35 years in our sample (see Appendix Figure A.1). Table 7 shows power prices for each percentile, from the relatively low 20th percentile price of 0.10 US$/kWh to the 80th percentile price of 0.19 US$/kWh. Table 7 also shows the GDPs per capita (log transformed) where the shares of industry and employment peaked.

Table 7. Power rates by select percentile, and simulated GDP per capita turning points of industry share.

Power Rates		Log (GDP per capita, US$) turning points		
Percentile	**US$/kWh**	**% employment**	**% GDP (real)**	**% GDP (nominal)**
80	0.19	9.57	10.94	10.03
60	0.15	9.57	11.12	10.03
40	0.13	9.57	11.31	10.02
20	0.10	9.59	11.63	10.01

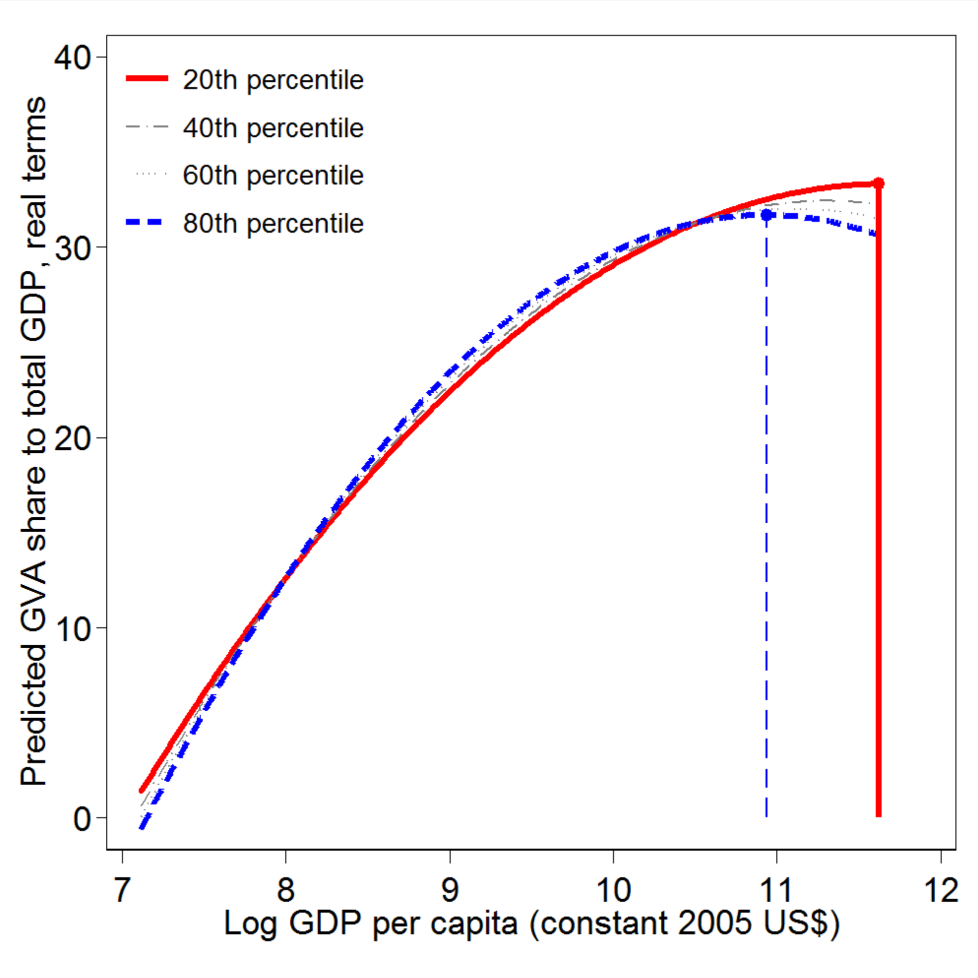
Note: The table presents the calculated GDP per capita where the share of industry to total GVA peaks using estimates generated from equation (1).

The peak of the share of industry to total GDP is more vividly illustrated in Figure 6.[8] Using the estimates from equation (1), each curve in the figure represents predicted share of industry for power-prices at the four percentiles. The vertical solid line indicates the log of GDP per capita level when the share of industrial GVA is at its maximum, holding power price equivalent to 20th percentile (relatively low power prices). The vertical dashed line shows the

[8] The level of GDP where the share of industry's GVA to total output is indicative and should not be interpreted as the exact level at which the structural transformation might have occurred.

GDP per capita level where the share of industrial GVA is at its maximum, this time holding power price at the 80th percentile level.

Figure 6. Estimated trends of industrial real gross value added or GVA (% of GDP) under different levels of power price, 1980-2014.



Each curve represents the simulated trend of industry's share using equation (1). The predicted values are calibrated to show the average share of industry in our sample countries in 1980-2014. As shown, higher energy prices decrease the slope of the curve, implying an earlier turning point and a more rapid manufacturing decline. The vertical solid line points to the log GDP per capita level when the share of industry GVA is at its maximum, holding power price equivalent to 20th percentile (relatively low power prices). The vertical dashed line points to the GDP per capita level when the share of industry GVA is at its maximum, this time holding power price equivalent to 80th percentile (relatively high power prices).

It is apparent that for relatively high prices, say at the 80th percentile, the turning point comes at a much lower per-capita GDP, about US$16,000, which is lower compared to a regime where power rates are at the 20th percentile mark, about US$19,000. Moreover, the slope of the industrial share becomes substantially steeper as power prices increase. That is, there is a tendency for countries to deindustrialize sooner and more rapidly as power prices increase.

Moreover, in all regression results, we find an inverted U-shape path for industry share vs. per capita income. The inverted U-shape path is consistent with Rodrik's finding that industry share as a function of per capital GDP has shifted downwards and to the left. In other words, deindustrialization occurs sooner (in terms of GDP per capita) and at lower industry shares. Our result of a negative and significant effect of power price on industry share suggests that power prices may augment premature deindustrialization.

4.2 Subnational analysis: Philippine case

Given the above interesting results at the cross-country level, we examine the influence of power prices on industry by exploiting cross-sectional and temporal variations in power prices across Philippine regions. First, we estimated equation (1) using longitudinal data of regions in the Philippines and using the share of industry and services in national GVA (in real terms). We use the estimates to predict the average trend of each outcome variable, holding power price constant.

Table 8 illustrate the results of our estimation for the industry and services shares of real GVA. Annual dummies are included to capture time trends. Dummy coefficients for industry shares (column 1), are significantly negative and exhibit a declining trend. This also implies that the average region the Philippines had a share of industrial sector that is lower in 2014 than in 1991.

Table 8. Regression results: (dependent variable: Share of sector, % of total GVA)

	Industry	**Services**
	(1)	(2)
Price	-2.183*	1.687
	(1.082)	(1.038)
GDP/capita	0.820	-0.259
	(0.580)	(0.469)
$(GDP/capita)^2$	0.058	-0.015
	(0.043)	(0.035)
Price* Log GDP/capita	-0.676*	0.520
	(0.325)	(0.322)
Price* Log $(GDP/capita)^2$	-0.051*	0.039
	(0.024)	(0.024)
Population	2.751*	-2.408*
	(1.465)	(1.191)
$Population^2$	-0.076*	0.056
	(0.040)	(0.032)
1991	-0.009	0.018**
	(0.008)	(0.008)
1992	-0.015	0.019
	(0.017)	(0.018)
1993	-0.032	0.054**
	(0.021)	(0.022)
1994	-0.048*	0.077**
	(0.027)	(0.028)
1995	-0.060*	0.101**
	(0.032)	(0.034)
1996	-0.071*	0.129***
	(0.039)	(0.039)
1997	-0.082*	0.164***
	(0.046)	(0.045)
1998	-0.080	0.190***
	(0.053)	(0.052)
1999	-0.104*	0.218***
	(0.058)	(0.056)
2000	-0.103	0.240***
	(0.065)	(0.060)
2001	-0.110	0.259***
	(0.070)	(0.066)

	Industry	**Services**
	(1)	(2)
2002	-0.119	0.279***
	(0.075)	(0.071)
2003	-0.131	0.295***
	(0.080)	(0.076)
2004	-0.150	0.319***
	(0.085)	(0.080)
2005	-0.154	0.330***
	(0.090)	(0.084)
2006	-0.161	0.347***
	(0.095)	(0.089)
2007	-0.165	0.360***
	(0.102)	(0.092)
2008	-0.178	0.371***
	(0.105)	(0.098)
2009	-0.186	0.395***
	(0.111)	(0.106)
2010	-0.198	0.425***
	(0.119)	(0.125)
2011	-0.214	0.443***
	(0.124)	(0.130)
2012	-0.218	0.465***
	(0.128)	(0.133)
2013	-0.226	0.484***
	(0.131)	(0.135)
2014	-0.232	0.496***
	(0.136)	(0.139)
Constant	-21.304	23.030**
	(13.352)	(10.362)
Observations	2363925	2363925
R-sq. (adjusted)	0.380	0.685
R-sq. (within)	0.380	0.685

Note: The table above presents the results from estimating equation 1 using the share of each sector's GVA to total GVA (in constant 2000 prices) in the Philippines during the period 1990-2014. All variables are expressed in logarithms, except indicator variables and share of industry and services in total output. Robust standard errors clustered at the regional level are in parentheses. $^{*}p<.10$; $^{**}p<.05$; $^{***}p<.01$.

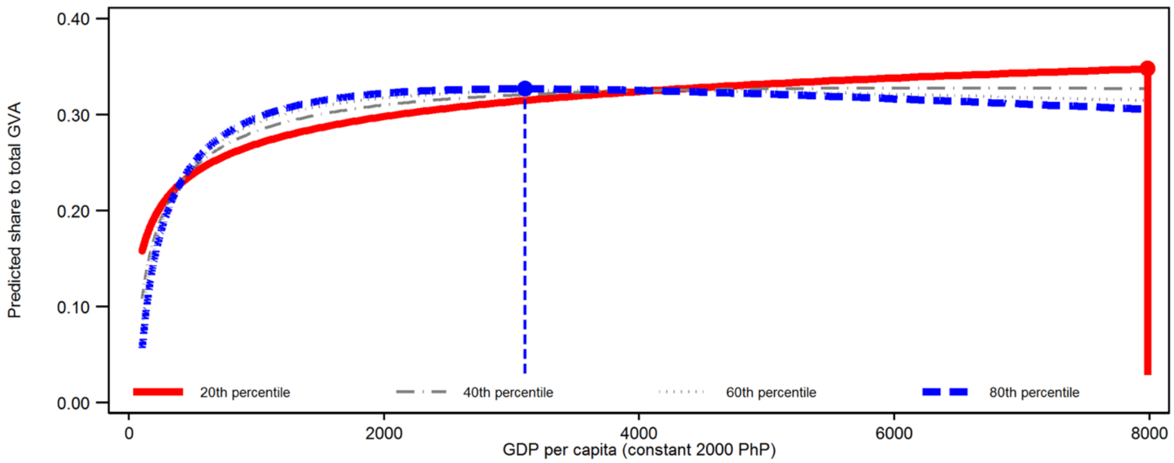
Table 9 shows the power price at each percentile for the Philippines, from 3.62 PhP/kWh at the 20th percentile level and at 5.46 PhP/kWh for the 80th percentile. It also shows the corresponding regional gross domestic product (RGDPs) per capita where the shares of industry and services to total RGDP peaked.

Table 9. Power rates by select percentile, and simulated RGDP per capita turning points of industry share.

Power Rates		RGDP per capita, PhP turning points	
Percentile	**PhP/kWh**	**Industry**	**Services**
80	5.46	3,104.76	2,241.82
60	4.97	3,774.71	2,341.30
40	4.48	6,425.12	2,553.71
20	3.62	7,982.99	3,071.24

Results show that regions experiencing high power rates (e.g., those at the 80th percentile) exhibit an inverted U-shape curve relating industry share to GVA of the economy (Figure 7). In contrast, parts of the country with low power rates, such as those at the 20th percentile, do not exhibit a declining stage of industry. These results are consistent with the cross-country analysis reported above. We regard this as a further indication that power prices play a role in structural transformation in the Philippines.

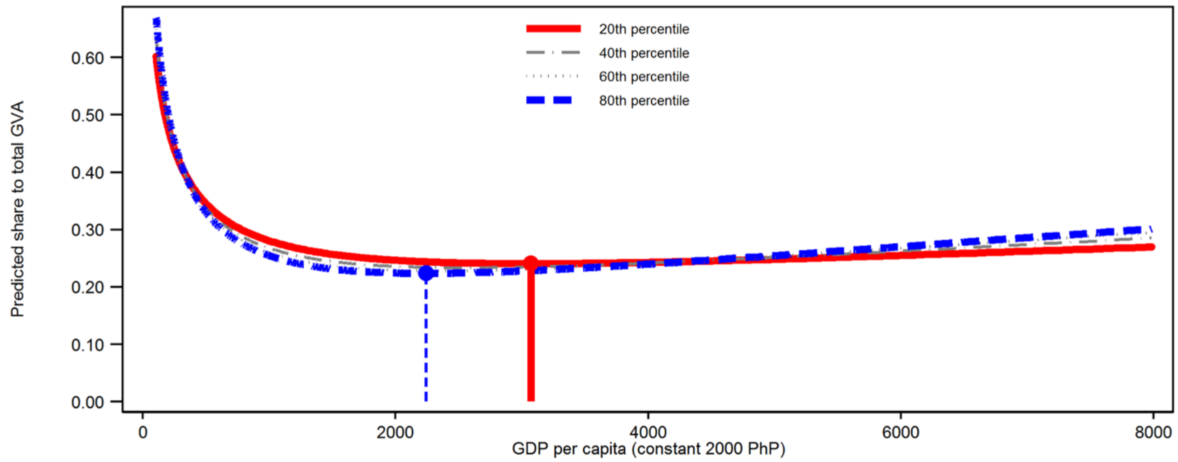
Figure 7. Estimated trend of industry GVA (% of real GDP) under different levels of power price, Philippine Regions, 1990-2014.



Note: Each curve represents predicted trend of industry value-added share to regional GDP, given a certain level power price (i.e., whether price is equivalent to 20th or 80th percentile), using equation (1), with maximum GVA within the period 1990-2014 as weights.

One way to further illustrate the potential influence of power price on the growth path of industrial across different levels of per capita income is to find the opposite trend in the services sector, which is consistent with the findings and predictions of Rodrik (2016). We estimate equation (1) using the share of services to total GVA in the Philippine regions as outcome variables. Results are summarized in Table 8, column (2) and illustrated in Figure 8.

Figure 8. Estimated trend of services GVA (% of GDP) under different levels of power price, Philippine regions, 1990-2014.



Note: Each curve represents predicted trend of services value-added share to regional GDP, given a certain level power price (i.e., whether price is equivalent to 20th or 80th percentile), using equation (1), with maximum GVA within the period 1990-2014 as weights.

We find strong evidence to support the hypothesis that the GVA share of services is responsive to power prices. In particular, the share of services is positively related to power prices and the relationship satisfies statistical tests at conventional significant levels. We also find that the share of services with respect to RGDP per capita follows a U-shaped curve, with its turning point right after the median level RGDP per capita (about PhP2,241). More interestingly, high-power-rate regions tend to exhibit the share of services increasing at relatively low levels of per capita GDP. This is consistent the patterns that resources are increasingly allocated towards services and away from industry and manufacturing.

5. CONCLUSIONS AND POLICY IMPLICATIONS

We explore the dynamic effects of energy policy by studying the role of high power prices in the process of structural transformation across countries and regions of the Philippines.

Power prices can augment other factors that induce premature deindustrialization. We adapt Rodrik’s (2016) specification to investigate how industry share moves with economic development and estimate the relationship between power prices, the share of manufacturing output, and per capita output using 33 countries. This allows us to illustrate the potential effect of high power prices on both the level and growth rates of industry. We also apply this methodology across regions of the Philippines.

For the sampled countries studied, we find that higher power prices are associated with industry shares turning downward at lower industry shares and at lower levels of GDP per capita. Moreover, the downtrend tends to be steeper, the higher power prices are. We find the same trend at the regional level for the Philippines. Data limitations constrain definitive conclusions about causality, but it appears that structural transformation is not independent of power prices, as shown in more detail for the Philippines.

The Philippine manufacturing sector still accounts for a 20 percent 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. However, realizing this potential may be difficult without lowering prices and improving the quality of power.

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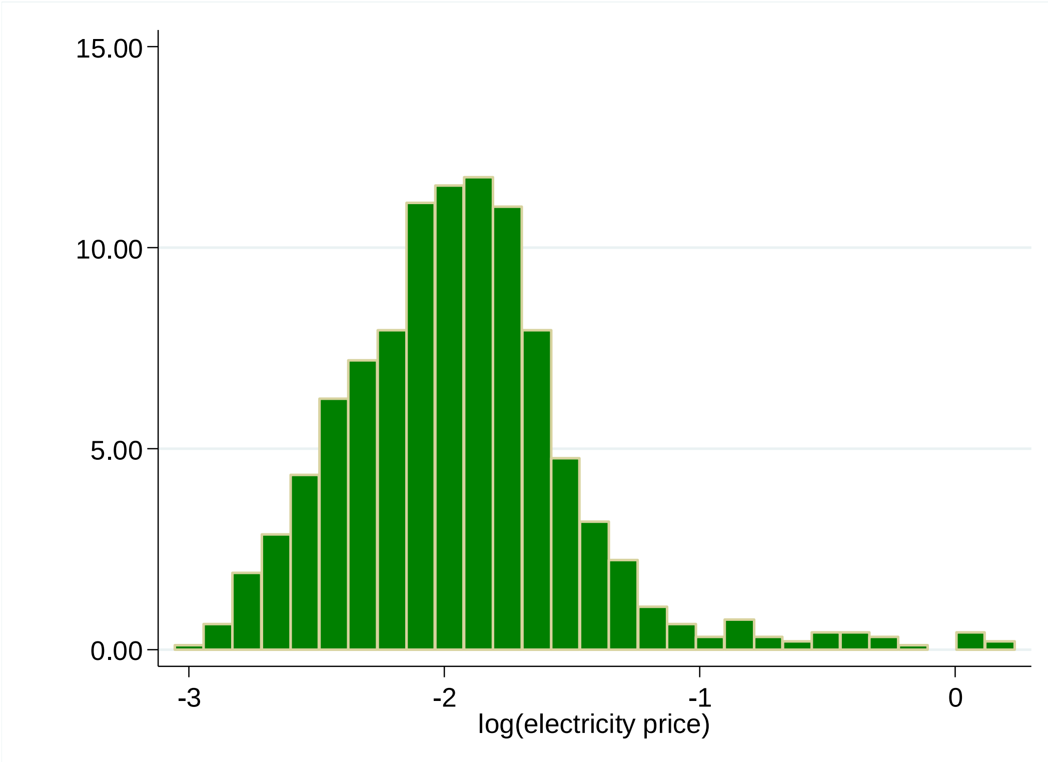
APPENDIX

Table A.1. Manufacturing and industry indicators, 1970-2014

	1970	1980	1990	2000	2010	2014
	(a) Share of manufacturing to total employment (%)					
China			13.5	11.2		
Indonesia		9.0	10.1	13.0	12.3	13.2
South Korea	13.2	21.6	27.2	21.3	16.9	16.9
Malaysia		16.1	19.9	22.8	16.7	16.7
Philippines		10.8	9.7	10.0	8.4	8.3
Singapore	22.0	29.2	28.4	20.7	17.7	15.0
Thailand		7.9	10.2	14.5	14.1	16.9
Viet Nam				9.2		
	(b) Share of manufacturing to GDP (%)					
	1970	1980	1990	2000	2010	2014
China	33.7	40.2	32.5	31.9	31.9	
Indonesia	10.3	13.0	20.7	27.7	22.6	21.6
South Korea	16.7	22.8	25.0	29.0	30.7	30.3
Malaysia	12.4	21.6	24.2	30.9	24.5	24.0
Philippines	24.9	25.7	24.8	24.5	21.4	20.5
Singapore		27.5	25.6	27.7	21.4	
Thailand	15.9	21.5	27.2	33.6	35.6	32.6
Viet Nam			12.3	17.1	18.0	17.5
	(c) Share of industry to GDP (%)					
	1970	1980	1990	2000	2010	2014
China	40.5	47.9	40.9	45.4	46.2	42.6
Indonesia	18.7	41.7	39.1	45.9	43.9	42.9
South Korea	24.5	34.2	38.2	38.1	38.3	38.2
Malaysia	27.4	41.0	42.2	48.3	41.2	40.5
Philippines	31.9	38.8	34.5	34.5	32.6	31.2
Singapore		36.2	32.3	34.8	27.6	
Thailand	25.3	28.7	37.2	42.0	44.7	42.0
Viet Nam			22.7	34.2	38.2	38.5

Sources of basic data: WDI-WB (various years), ILO (various years)

Figure A.1.Percentile distribution of price.



Note: The percentile distribution of price is taken from across 33 countries over 35 years.
r(r1) = -2.323350191116333 | r(r2) = -2.055578708648682
r(r3) = -1.866601467132568 | r(r4) = -1.652250289916992