Heterogeneous Impact on the Industries of Each Province within the Yangtze River Delta Region of China under Regional Electricity Market Integration Background

Xiaozhe Yin[1,a], Huan Niu [2,b*], Zhong Wang[3,c]

[a]420045193@qq.com,[*] Corresponding author :[b]281454197@qq.com, [c]411639379@qq.com

[1]Department of Finance and Asset Management Changxing County Electricity Supply Company of SGCC Huzhou, China
[2]Department of Finance and Asset Management Anji County Electricity Supply Company of SGCC Huzhou, China
[3]Department of Finance and Asset Management Huzhou Municipal Electricity Supply Company of SGCC Huzhou, China

Abstract. The electricity price in each province is different in the Yangtze River Delta (YRD) region of China. Once the regional electricity was integrated in YRD Region, the electricity price would converge to the same level. That will in turn have different impact on the industries of each province in YRD region. This paper simulated what would happen to each industry in YRD region. By constructing the indicator of electricity output value elasticity, the results show Shanghai's industries has a lower impact than Zhejiang Province, Jiangsu Province, and Anhui Province, while Anhui Province has the highest impact in most of the industries, and Zhejiang Province and Jiangsu Province are in the middle of the range. It shows that the more developed the economy, the lower impact. So policymakers should be cautious on establish regional electricity market. Specific policy should be adopted to balance the interest of rich province and poor province.

Keywords: Electricity Market; Electricity Price; Yangtze River Delta

1 Introduction

China has push forward power market reform since 2015 and provincial power market has established. But that has setup an implicit barrier between provinces that generator and electricity customers can't trade electricity across provincial boundary. The electricity price in different province is different. Although the central government has proposed the national uniform electricity market target, its realization still depends on the provincial governments' altitude. The local government worried that industries would experience negative impact if the market price is rising.

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Electricity is an indispensable intermediate input for modern production, but the intensity of dependence on electricity varies markedly from industry to industry. Industries that depend more on electricity inputs in their production processes are more sensitive to electricity prices. Many industrial policymakers often use electricity prices as an important tool to achieve industrial policy objectives[1]. In China, local governments have the final say on electricity prices in their jurisdictions and often use differences in industry dependence on electricity to steer the course of structural change in industries in their regions.

China's Yangtze River Delta (YRD) region is one of the most important economic circles in China, including three provinces and a municipality directly under the central government. Since 2018, YRD has been promoted by the government and gradually formed a pattern of integrated development. Integration has broken down the barriers between administrative provinces and municipalities within the YRD region, which has led to a faster transfer of different enterprises and even industries within the region[2]. Enterprises in industries with a high intensity of dependence on electricity use are more likely to move from provinces (cities) with high electricity prices to those with low electricity prices. The differences in industry dependence on electricity within the YRD region reflect to some extent this change in industry structure, and they are also weathervanes for the evolution of economic development structure and industries.

2 Literature review

A large number of empirical studies have shown a robust relationship between electricity inputs and economic growth[3-7]. Electricity inputs can be guided through electricity price adjustments, which in turn affects economic output[8]. Electricity prices are often seen in China's industrial policy, and electricity prices as an important industrial policy tool that influences the development of China's economy. Numerous scholars[9-10] based on China's national conditions, have shown that electricity consumption can be better guided by designing a classified electricity pricing mechanism. The fundamental reason why electricity prices can be used as an important industrial policy tool is that different industries rely on electricity inputs to different degrees. Industries that are highly dependent on electricity inputs prefer to move to regions with abundant electricity and low electricity prices. Using Chinese data, Deng et al. concludes that an increase in the overall level of electricity prices is conducive to inhibiting the development of energy-intensive industries such as non-metallic minerals and metal smelting and calendaring, and to promoting a rational transformation of China's industrial structure[11]. The industry's dependence on electricity inputs can be measured by the amount of electricity consumed per output unit[12].

3 Models

In this paper, the electricity consumption per unit of output value is measured to reveal the differences in industry dependence on electricity within the Yangtze River Delta region of China. The following regression model is designed:

$$\ln Y(q) = c + e \ln X(q) + \varepsilon \tag{1}$$

Y and X denote the industry's electricity consumption and output, respectively, both of which are production q. And $\ln$ denotes taking logarithms. c and ε denote the constant term and residual term, respectively. The derivation of equation (1) can be obtained:

$$e = \frac{\partial \ln y(q)}{\partial \ln X(q)} = \frac{dY(q)}{Y(q)} \Big/ \frac{dX(q)}{X(q)} \tag{2}$$

In Eq.(2), e denotes the amount of electricity input required per unit change in output value, which is called the elasticity of electricity output value, referring to the elasticity of industrial output value to the demand for electricity. In other words, when the industrial output value changes by 1%, the required electricity input changes by e per cent.

4 Data

The Yangtze River Delta (YRD) region of China includes one municipality and three provinces, namely Shanghai, Zhejiang, Jiangsu, and Anhui. The data in this paper are obtained from the statistical yearbooks of the municipality and three provinces, which are the industrial output value and electricity consumption from 2013-2017. Primary, secondary, and tertiary industries are the first level of classification. Among them, there are two secondary classifications under the secondary industry, namely industry and construction. There are four more secondary classifications under the tertiary industry.

Table 1 The Descriptive Statistical Analysis

	Variables	Obs	Mean value	Standard deviation
Primary industry (PI)	Production value	20	2075.41	1389.41
	Electricity consumption	20	26.38	18.43
Secondary industry (SI)	Production value	20	18145.69	9949.57
	Electricity consumption	20	2199.12	1321.51
Industry (I)	Production value	20	20667.40	10307.61
	Electricity consumption	20	424.40	154.15
Construction industry (CI)	Production value	20	15879.46	8734.36
	Electricity consumption	20	2157.21	1313.18
Tertiary industry (TI)	Production value	20	2294.00	1229.03
	Electricity consumption	20	41.91	11.72
Transport, storage, and postal service (TSPs)	Production value	20	1582.69	773.94
	Electricity consumption	20	47.40	16.21
Commerce, accommodation and catering (CACs)	Production value	20	5228.63	2454.53
	Electricity	20	118.07	47.04

	consumption			
Finance, real estate, business, and residential service (FRBRs)	Production value	20	9371.32	4760.17
	Electricity consumption	20	141.89	59.21
Public Utility and Management Organizations (PMs)	Production value	20	4395.99	2477.85
	Electricity consumption	20	117.03	46.39

Note: Data from provincial and municipal statistical yearbooks. The unit of output value is billion yuan; the unit of electricity consumption is billion kilowatt-hours.

Table 1 shows that: in the primary, secondary, and tertiary industries of Shanghai, Zhejiang, Suzhou, and Anhui, the differences between the SI are much higher than that of the PI and TI, whether in terms of output value or electricity consumption, compared with the smallest differences of the TI. In the SI, the difference in the output value of the CI is lower than that of the I, but the difference in the electricity consumption is much higher than that of the I. In the TI, the differences in the output value and the electricity consumption of the FRBRs are higher than the others. The TSPs have the lowest differences in output value and electricity consumption.

5 Model results

A robust least square regression of Eq. (1) yields the elasticity of electricity production value , as shown in Table 1.

Table 2 Elasticities of Electricity Output Value by Industry in YRD

	Shanghai	Zhejiang	Jiangsu	Anhui
Primary industry (PI)	0.056	1.272	2.909	2.922
Secondary industry (SI)	0.098	0.742	0.425	0.851
Industry (I)	0.037	0.744	0.431	0.856
Construction industry (CI)	1.584	0.404	-0.364	0.700
Tertiary industry (TI)	0.485	0.919	0.718	0.832
Transport, storage, and postal service (TSPs)	0.604	1.700	2.166	3.280
Commerce, accommodation and catering (CACs)	0.325	0.896	1.125	0.934
Finance, real estate, business, and residential service (FRBRs)	0.598	1.097	0.704	0.850
Public Utility and Management Organizations (PMs)	0.322	0.639	0.475	0.705

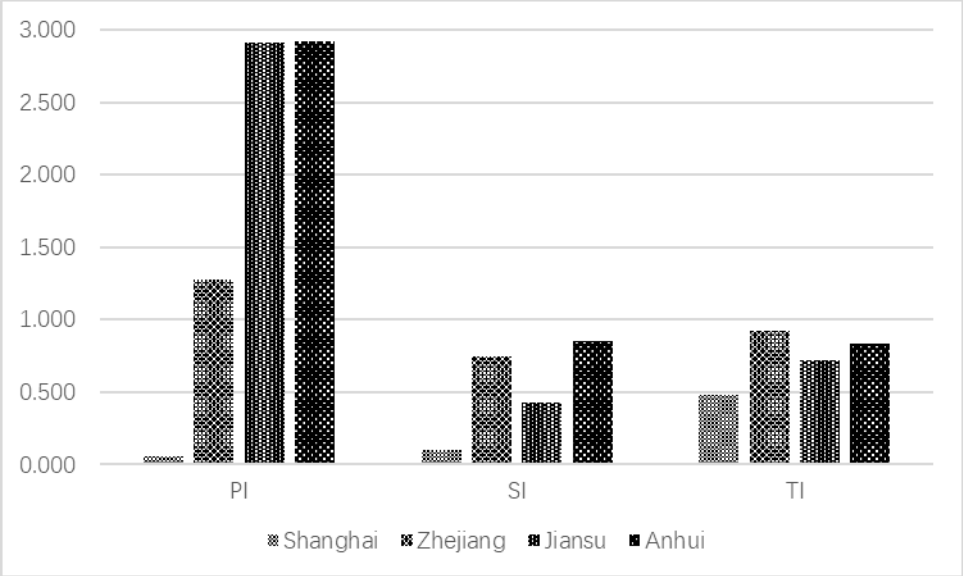

Fig. 1 Elasticities of Electricity Output for the First Classified Industries
Note: the number on the vertical axis is elasticity which is defined in Eq.(2). It is a ratio of two variables and has no units.

An analysis of the elasticities of electricity output for the first classified industries (Table 2 and Fig. 1) reveals the following findings:

(1) Between 2013 and 2017, the intensity of dependence on electricity consumption in the primary industry was in Anhui, Jiangsu, Zhejiang, and Shanghai in descending order. Anhui and Jiangsu were closer, with a 1% increase in primary industry output requiring an additional 3% of electricity input, while Zhejiang required an additional input of less than 1.3%, which was less than half that of Anhui and Jiangsu, and even lower in Shanghai, less than half that of Zhejiang.

(2) Between 2013 and 2017, the intensity of dependence on electricity consumption in the secondary industry was Anhui, Zhejiang, Jiangsu, and Shanghai in descending order. A 1 percent increase in the output value of the secondary industry in Anhui required an additional 0.85 percent of electricity input, Zhejiang was about 0.11 percentage points lower than Anhui, while Jiangsu was only half the size of Anhui, and Shanghai was much lower than Anhui, Zhejiang, and Jiangsu, at less than 0.1 percent.

(3) Between 2013 and 2017, the intensity of dependence on electricity consumption in the tertiary industry was, in descending order, Zhejiang, Anhui, Jiangsu, and Shanghai. Among them, Zhejiang and Anhui are closer to each other, and a 1% growth in the output value of the tertiary industry in Zhejiang requires an additional 0.92% of electricity input, which is higher than that of Anhui by about 0.09 percentage points, while that of Anhui is higher than that of Jiangsu by about 0.11 percentage points, compared with that of Shanghai which is much lower than that of Zhejiang, Anhui and Jiangsu, which is lower than that of Zhejiang, Anhui, and Jiangsu by 0.43, 0.34, and 0.23 percentage points, respectively.

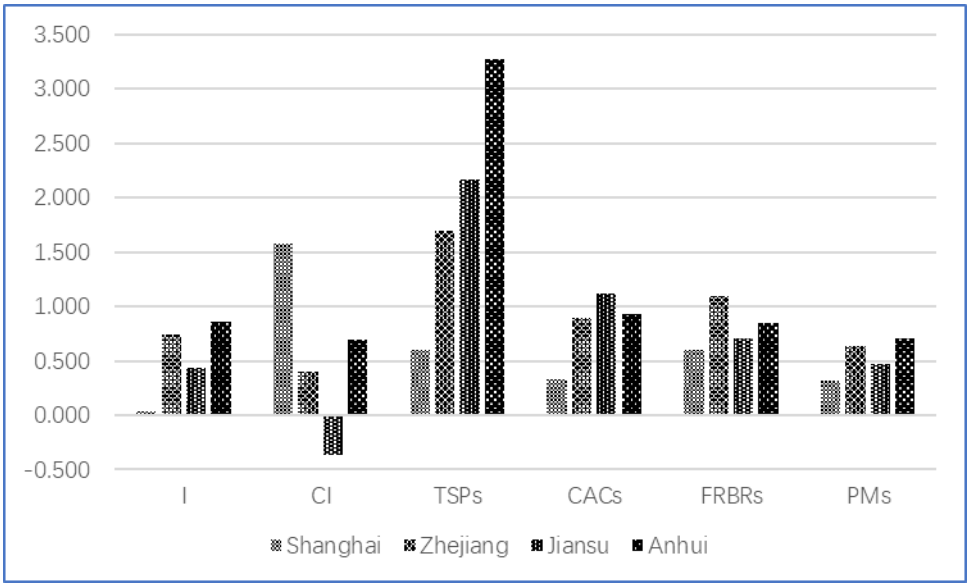

Fig. 2 Elasticity of Electricity Output for the Secondary Classified Industries
Note: the number on the vertical axis is elasticity which is defined in Eq.(2). It is a ratio of two variables and has no units.

An analysis of the elasticity of electricity output for the secondary classified industries (Table 2 and Fig. 2) reveals the following findings:

(1) The intensity of dependence on electricity consumption in industry is in the order of Anhui, Zhejiang, Jiangsu, and Shanghai from high to low, which is consistent with the secondary industry. However, the intensity of dependence on electricity consumption in the construction industry is quite different from that of the secondary industry, which is in the order of Shanghai, Anhui, Zhejiang, and Jiangsu from high to low. In contrast, Shanghai's construction output growth on electricity dependence is much higher than that of Anhui, Zhejiang, and Jiangsu, more than twice as much as that of Anhu, while Jiangsu's construction electricity dependence is negative, and during 2013-2017, Jiangsu's construction output value has maintained growth, while electricity consumption is declining overall.

(2) The intensity of dependence on electricity for the TSPs is Anhui, Jiangsu, Zhejiang, and Shanghai in descending order. Anhui’s TSPs rely on electricity to a much higher intensity than Jiangsu, Zhejiang, and Shanghai. The output value of 1 percent growth needs to be more than 3.28 percent of the power input, respectively, than Jiangsu, Zhejiang, and Shanghai, about 1.11, 1.58, and 2.68 percentage points higher. Jiangsu is about 0.47 percentage points higher than Zhejiang. These two provinces are closer. Shanghai is much lower than Anhui, Jiangsu, and Zhejiang.

(3) During the period 2013-2017, the intensity of dependence on electricity consumption in the CACs was Jiangsu, Anhui, Zhejiang, and Shanghai in descending order. Among them, Jiangsu's CACs rely on electricity to a much higher intensity than Anhui, Zhejiang, and Shanghai. The output value of 1% growth needs to be put into 1.13% more electricity input, respectively, than the Anhui, Zhejiang, and Shanghai, about 0.2, 0.23, and 0.8 percentage points. Anhui was about

0.03 percentage points higher than Zhejiang. These two provinces are closer. Shanghai is much lower than the three provinces of Jiangsu, Anhui, and Zhejiang.

(4) Between 2013 and 2017, the intensity of dependence on electricity consumption in the FRBRs was in the order of Zhejiang, Anhui, Jiangsu, and Shanghai. Among them, the intensity of reliance on electricity for FRBRs in Zhejiang is much higher than that of Anhui, Jiangsu, and Shanghai, and about a 1% growth in output value requires an additional 1.10% of electricity input, which is about 0.25, 0.4 and 0.5 percentage points higher than that of Anhui, Jiangsu, and Shanghai, respectively. Anhui is 0.15 percentage points higher than that of Jiangsu, and Jiangsu is 0.1 percentage points higher than that of Shanghai. Jiangsu and Shanghai are closer.

(5) During the period 2013-2017, the intensity of reliance on electricity consumption by PMs was Anhu, Zhejiang, Jiangsu, and Shanghai in descending order. Anhui and Zhejiang were closer, with a 1 percent increase in industrial output requiring an additional 0.71 percent and 0.64 percent of electricity input, respectively. Shanghai was much lower than Anhui, Zhejiang, and Jiangsu, with 0.39, 0.32, and 0.16 percent less than Anhui, Zhejiang, and Jiangsu, respectively.

(6) Comparison of the dependence on electricity for the secondary classified industries within the same region. Shanghai's construction industry relies on electricity to a much higher intensity than industry, while Zhejiang, Jiangsu, and Anhui Shanghai are more dependent on electricity for industry than construction. Compared with the secondary classified industries in the tertiary industry, the intensity of dependence on electricity consumption in the industries of Shanghai and Zhejiang Province is similar, both of which are shown as follows: TSPs > FRBRs > CACs > PMs. Jiangsu and Anhui are more similar, both show TSPs > CACs >FRBRs > PMs.

6 Conclusions

The intensity of industry dependence on electricity input shows a clear pattern with the regional economy. Shanghai has the highest level of economic development in the Yangtze River Delta region, Anhui the lowest, and Zhejiang and Jiangsu about the same and in the middle. Except for the construction industry, Shanghai's primary, secondary, and tertiary industries and their subsectors are less dependent on electricity than those of Zhejiang, Jiangsu, and Anhui, while Anhui's dependence on electricity input is higher than that of the other cities and provinces in the Yangtze River Delta. The higher the degree of economic development, the lower the intensity of industry dependence on electricity.

From the point of view of the intensity of dependence on electricity for secondary classified industries, the same pattern is also present. Anhui Province has the highest intensity of dependence on electricity in most of the secondary classified industries. Zhejiang Province and Jiangsu Province in different industries rely on electricity intensity of mutual high and low. Only from the point of view of industry classification, these two provinces are neck and neck. Shanghai, on the other hand, still has the lowest intensity of dependence on electricity in most of the secondary classified industries.

This pattern is also consistent with the tendency of industries with a higher intensity of electricity dependence to move to regions with lower electricity prices, with Anhui Province

having the lowest electricity prices and Shanghai having the highest electricity prices in the YRD region. As the integration of the YRD advances, inter-regional barriers will be lowered and the movement of enterprises within the industry will become easier, which will accelerate the transfer of highly electricity-dependent industries to regions with low electricity prices. Industrial policymakers can take advantage of this law to better use the tariff tool to adjust the industrial structure in the region.

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