

## Analysis of Electricity Price Policy and Economic Growth

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This study presents the dynamic influences and changes of economic development on which the electricity price policy impact through theoretical model in China. The results show that from the static point of view, low electricity price level seems to be good for economic benefits. However, from a long-term and dynamic point of view, low electricity prices and economic development is not only having no obvious positive correlation, but instead a significant negative correlation. The emergence of this situation is mainly affected by short-term GDP and government officials in the pursuit of political achievements. In the short-term, low electricity price may promote the economic development. However, low electricity price will induce the development of high energy-consuming and low value-added industries in the long run, which is not good for the optimization and upgrading of industrial structure. Therefore, the low electricity price policy ultimately goes against economic development.

**Keywords:** Low Electricity Price; Energy Consumption; Industrial Structure; Economic Development.

### Introduction

Electric industry is not only the basic industry of a country, but also a capital and technology intensive modern industry. China implements low electricity price energy policy in the process of economic development for a long time. How is the effect of low electricity energy consumption policy in China? Does the low electricity price promote the national economy development or hind? This article will study these problems. At present, more and more scholars discuss the rationality of price level and theoretical basis of selecting electricity price energy policy from the view of relation between electricity price level and economic development. There are mainly two aspects as followings. The first one is the degree of influence that the changes of electricity price made to economic development. Lean H.H. and Smyth R. examined the causal relationship between electricity generation, economic growth, exports and prices in a multivariate model for Malaysia<sup>1</sup>. Mozumder P. and Marathe A. analyzed the relationship between per capita electricity consumption and per capita GDP for Bangladesh<sup>2</sup>. Yoo S.H. investigated the short and long run causality issues between electricity consumption

and economic growth in Korea<sup>3</sup>. Altinay G. and Karagol E. investigated the relationship between electricity consumption and real GDP, and found the supply of electricity was vitally important to meet the growing electricity consumption in Turkey<sup>4</sup>. Ghosh S. tried to examine the Granger causality between electricity consumption per capita and GDP per capita and found that there existed unidirectional Granger causality running from economic growth to electricity consumption without any feedback effect in India<sup>5</sup>. Jamil F. and Ahmad E. analyzed the relationship among electricity consumption, its price and real GDP at the aggregate and sectorial level in Pakistan<sup>6</sup>. Akkemik A.K. evaluated the potential impacts of changes in electricity prices from a social accounting matrix price modeling perspective<sup>7</sup>. According to the above-mentioned scholars, increasing electricity price would not cause obviously negative impact on economic growth. Han S.Y., Yoo S.H., Kwak S.J. studied the impact of the electricity rate rise on relevant products prices, and found that energy intensive industries were significantly influenced by the changes of electricity price<sup>8</sup>. Lin B.Q. thought that the increasing of electricity price would have a substantial impact on economic development, such as increasing of industrial products' prices<sup>9</sup>. So far, numerous studies have carried on the empirical

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research on the specific influences that the increasing of electricity price made on the national economy. They thought degree of influence that electricity price changes impacted on national economy could not be generally analyzed, but come to the conclusion from different industries<sup>10,11</sup>. In fact, the increasing of China's electricity price has significant influence on the energy and manufacturing industries. However, the impacts other industrial sectors and the price index are not obvious. The second perspective of the researchers' studies is the rationality of China's electricity price level and its policy choices. Li Y.<sup>12</sup> and Zhu C.Z.<sup>13</sup> made a comparative analysis among the electricity price of some countries. They thought that the electricity price of China is low. Jörgen H. *et al*<sup>14</sup>, Zhang X.C. and Zhang L.H.<sup>15</sup>, Zhu C.Z.<sup>16</sup>, Lu Y.<sup>17</sup> analyzed the reasons of the formation of lower electricity price and the policy factors of electricity price increasing from multiple perspectives. They pointed out that the main reasons of unreasonable electricity price level were the unscientific energy policy, distorted electricity price structure and other institutional factors. China Nonferrous Metals Industry Association<sup>18</sup> and other industries research institutions carried on empirical research on the China's price level influenced on specific industries. The influences that electricity price impacted on electrolytic aluminum industry and other energy intensive industries are especially analyzed. The conclusion showed that the increasing of electricity price would lead to the industrial product costs and sales prices rose sharply which will reduce the international market competitiveness of these enterprises. The electricity and other energy policies should maintain the sustainable development of these industries. He F. *et al* studied the energy consumption and technical efficiency of iron and steel enterprise, concluded that the iron and steel industry is very sensitive to the changes of coal and electricity price<sup>19</sup>.

## Experimental Section

### Methodology

The analysis of electricity price policies is very complex from the perspective of enterprise, but relatively easy from the perspective of consumers. The authors of this article believe electricity price is the core of the electricity price policies. Comparing different levels of national electricity price policy choices and the electricity price policy selecting results of the same country in different periods, we

could find that there are mainly two basic types of electricity price level mode in the world. One is the low price model. And the other is the high price mode. The core difference between these two models is the price level. There are obviously differences on the specific factors, such as pricing method. At present, China adopts low price model. The average return on net assets of China's electric power enterprises is only 2.4% from 2008 to 2012, which is not only lower than bank lending rates, but much lower than the net assets returns ratio of the oil, coal and other energy production enterprises. Since the global financial crisis in 2008, China's five major electric power enterprise groups have suffered an overall loss. The average net assets returns ratio of these groups is only 8.7%. However, China implemented 'raising fund for electricity and capital & interest price policy' in the mid-eighth decade of twenty century. While the national investment electricity enterprises adopted low price, the foreign and local government investment electricity enterprises adopted high price level. There are two main ways of low price model. The first method is premised on the normal operation of the electric power enterprises. In order to improve the efficiency of electricity as much as possible, the government determines a lower price level reference to short-term marginal cost and realizes a maximization of social welfare. In the meantime, according to the financial situation of electric power enterprises and market supply and demand balance condition, the government will gave some fiscal subsidies and other policy support, such as ensuring the fixed cost compensation through the burial investment and satisfying the need of expanding reproduction. At present, China's low electricity price adopts this method on the whole. The second method is based on long-term marginal cost pricing. Although the benefits of economies of scale exist, there will be losses according to the marginal cost pricing. However, this method can provide parts of the compensation for the fixed cost recovery at least.

### Relationship of Electricity Price Level and Economic Development

From the perspective of China's regional differences, this article will carry out further empirical research on the relationship between the price level and economic development. The main data sources are as follows. Firstly, according to the seventh 'Five Year Plan' in 1987, this plan put forward China's economic zone division method for the first time and

used until today. This method divided China into eastern, central and western three major economic regions. The measurement of electricity price level chooses the sales price for terminal power users. The authors of this article obtain and process Chinese regional average price over 2000 to 2010 due to the national ‘Electricity Regulatory & Execution Report’ and ‘the Annual Report on Electricity Regulation’ which are reported by the State Electricity Regulatory Commission (Hereinafter referred to as the SERC). Secondly, this article selects the Gross Domestic Product (GDP) to measure the development level of China’s three big economic regions. The real GDP data of China’s each economic regions from 2000 to 2010 are calculated by the China Statistical Yearbook which is published by China’s State Statistics Bureau. As shown in Fig.1, the average electricity price level and economic development of China’s eastern, central and western three economic regions from 2000 to 2010 presents the following rules. The Fig.1 is derived from Appendix A. Firstly, the average electricity price level of each region shows a steady rising trend. The electricity price of central region is lower than eastern region’s while higher than western region. The rankings of electricity price remain the same over these ten years. The regional differences of China’s electricity price level are obvious. As time goes on, the differences between them remain relatively constant. Thirdly, the economic development level of each region was showing a rising trend. The economic development of China’s eastern region grew fastest. The central region grew slower than eastern region. And the economic development of western region grew slowest. Fourthly, different from the changes of average price level, the economic development gap between regions

was not always equal. However, as time goes on, the economic development gap became wider and wider. It showed the trumpet-shaped extension on Fig.1. As we can see, the electricity price level and economic development level have obvious regional difference. And the trend of change had similar characteristics. Therefore, there is reason to suspect that there is a certain relationship between the electricity price and economic development level. Then, the authors carry out a regional differences empirical research through the econometric analysis of electricity price level and the level of economic development. Considering the resources differences of different regional, this article introduces the per capita GDP to measure the relative levels of economic development and studies the relationship among electricity price level, the absolute level of economic development (total GDP) and relative levels of economic development (GDP per capita).

**Experimental Design and Data Inspection**

Firstly, in the electricity price level and the absolute level of economic development view, the electricity price of China’s three major economic regions and China’s total GDP are significantly correlated at the 0.01 level from 2000 to 2010. The eastern region is 0.997. The central region is 0.961. The western region is 0.950. Then, in the electricity price level and the relative levels of economic development view, the electricity price level and GDP per capita of China’s three major economic regions are also significantly correlated at the 0.01 level. The eastern region is 0.987. The central region is 0.962. The western region is 0.948. On the whole, in the traditional electricity policy selection, the price level and economic development level are usually

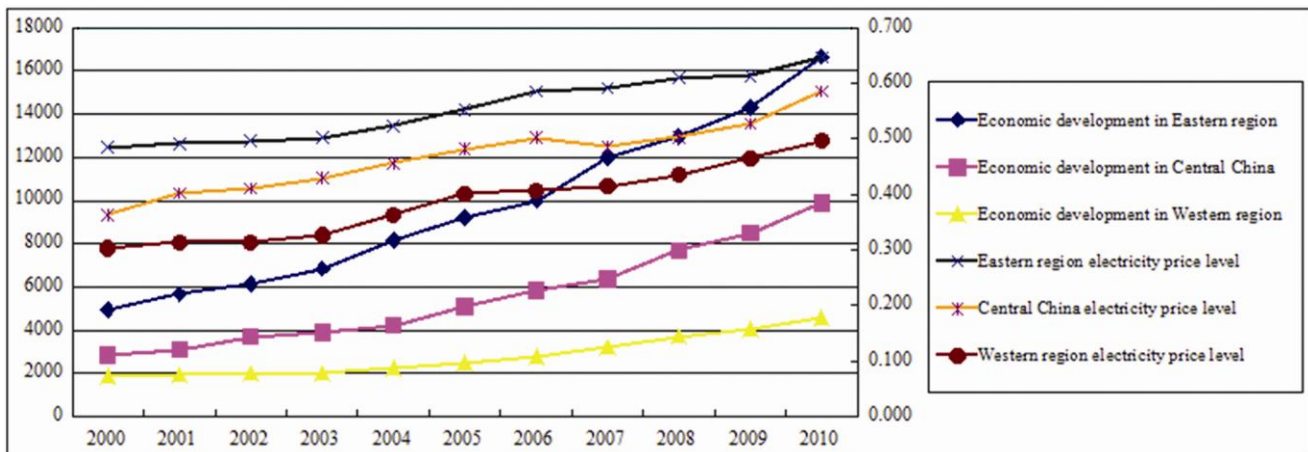


Fig. 1: Eastern, central and western electricity price level and economic development trends (Refer to Appendix A)

hypothesized negative correlation. However, the relationship between electricity price level and economic development of China's three major economic regions has a significant positive correlation, and the correlation coefficient is bigger. Table 1 lists the test results of the correlation between electricity price and economic development level in eastern region. The goodness of fit is 0.953 ( $R^2=0.953$ ). The adjusted goodness-of-fit is 0.948. In  $R^2$  (the goodness of fit) view, the scatter which formed by the independent variable (the electricity price level of eastern region) and dependent variable (the GDP of eastern region) is closed to regression curve. The value of F is 207.086. The value of P is 0.000. Both of these two values indicate that the regression equation can commendably interpret the data. The regression model of the relationship between the electricity price level and economic development level of eastern region is statistically significant. The authors of this article do further regression analysis using the data of eastern, central and western region. The authors take the electricity price and absolute level of economic development of eastern region as an example, using SPSS10 software processing the data. As shown in Table 2, regression equation of electricity price level and absolute economic development level in eastern region. The authors make further analysis as follows. Assuming that  $GDP_i$  and  $GDP_i^*$  respectively denote the absolute

regional economic development and the relative level of regional economic development. The subscripts are on the behalf of the eastern, central and western regions, respectively ( $i= E, C, W$ ). Using the same calculation method in table 2, this article gets the regression equations of the relationship between the electricity price level and the absolute and relative economic development level in the eastern, central and western regions.

$$GDP_E = -41398.617 + 101.913 \times EP_E$$

$$GDP_E^* = -81758.216 + 210.481 \times EP_E$$

$$GDP_C = -21008.982 + 62.915 \times EP_C$$

$$GDP_C^* = -39930.071 + 120.582 \times EP_C$$

$$GDP_W = -10752.904 + 38.782 \times EP_W$$

$$GDP_W^* = -34828.861 + 126.278 \times EP_W$$

**Results and Discussion**

This article assumes that the subscripts of A and R denote the absolute level and relative level of economic development respectively. And the regression co-efficient  $S_{EA}$ ,  $S_{CA}$  and  $S_{WA}$  represent the influence degree that the electricity price level makes to the absolute economic development of eastern, central and western regions respectively. The regression co-efficient  $S_{ER}$ ,  $S_{CR}$  and  $S_{WR}$  respectively denote the influence degree that the electricity price level makes to the relative economic development of eastern, central and western regions. The authors of

Table 1: Test result of the correlation between electricity price and economic development level in eastern region

Note: 'a' is the dependent variable. GDP refers to the eastern region. 'b' is the independent variable which refers to the electricity price levels of eastern region

Model description <sup>b</sup>						
Model	R	Goodness of fit ( $R^2$ )	Adjusted Goodness-of-Fit	Standard error	Test statistics	
1	0.976a	0.953	0.948	1513.736	1.842	
Analysis of variance						
Model 1		Quadratic sum	Degree of freedom	The average of squared	F	Sig.
	Regression	4.75E+08	1			
	Residual	2.29E+07	10	4.75E+08	207.086	0.000a
	Summation	4.97E+08	11	2291398.672		

Table 2: Regression equation of electricity price level and absolute economic development level in eastern region

Note: 'a' is the dependent variable. GDP refers to the eastern region. 'b' is the independent variable which refers to the electricity price levels of eastern region.

Co-efficiency						
Model 1	Unstandardized coefficients			Standardized coefficients		
Constant value	Regression coefficient	Standard error	Regression coefficient	T	Sig	
Electricity price level of eastern region	-41398.618	3774.908	0.976	-10.966	0.000	
	101.913	7.081		14.390	0.000	

Table3: The real GDP data of China's each economic regions from 2000 to 2010 Billion Yuan

Data Source: The real GDP data of China's each economic regions from 2000 to 2010 are calculated by the China Statistical Yearbook which is published by China's State Statistics Bureau<sup>20</sup>.

Year	Economic development in Eastern region	Economic development in Central China	Economic development in Western region
2000	4957.71	2838.87	1865.72
2001	5679.32	3102.4	1914.63
2002	6142.15	3702.39	1980.24
2003	6849.39	3886.53	1996.57
2004	8176.83	4225.56	2247.06
2005	9215.03	5105.57	2479.76
2006	9989.97	5845.75	2765.59
2007	11998.79	6375.88	3193.75
2008	12958.87	7697.47	3693.06
2009	14303.84	8487.06	4047.4
2010	16671.48	9879.73	4576.66

this article draw the following conclusions through comparative analysis the above-mentioned regression model. There are significant positive correlation between the electricity price level and the absolute economic development level. With the increasing of the electricity price level, the positive correlation represents acceleration effect. The correlation coefficient that are between the electricity price level and the absolute level of economic development of eastern, central and western regions respectively are  $S_{EA}=101.913$ ,  $S_{CA}=62.915$  and  $S_{WA}=38.783$ . These three coefficients are greater than zero and much greater than 1 which illustrates that the electricity price level and the absolute economic development level not only has an obvious positive correlation, and a certain proportion changes of electricity price corresponding to a greater proportion changes of the absolute economic development level. The average electricity price ratio of each year in eastern, central and western regions is 1.42:1.21:1.00 which corresponds to the correlation coefficient ratio of the absolute economic development level in eastern, central and western (2.63:1.62:1.00). There are strict orders between these two groups' ratio. And the correlation coefficient is greater than the electricity price level. These results illustrate two characteristics: 1) the differences of the electricity price level and absolute economic development level of China's three regions are bigger than the differences in the levels of electricity price; 2) as to different economic regions or electricity price levels, electricity price changes are

Table 4 Chinese regional average price over 2000 to 2010 Yuan/KWH

Data Source: this article obtain and process Chinese regional average price over 2000 to 2010 due to the national 'ElectriRegulatory & Execution Report ' and 'the Annual Report on Electricity Regulation ' which are reported by the State Electricity Regulatory Commission (Hereinafter referred to as the SERC)<sup>21-22</sup>.

Year	Eastern region electricity price level	Central China electricity price level	Western region electricity price level
2000	0.485	0.363	0.303
2001	0.492	0.402	0.314
2002	0.496	0.411	0.314
2003	0.502	0.429	0.326
2004	0.524	0.457	0.363
2005	0.553	0.482	0.401
2006	0.586	0.502	0.407
2007	0.592	0.486	0.415
2008	0.61	0.503	0.435
2009	0.614	0.527	0.465
2010	0.647	0.586	0.496

different from the changes of absolute economic development. The electricity price increase part corresponding to the improving part of absolute level of economic development in central region is 1.62 times to the western region. While the eastern region's improving part of absolute level of economic development is 2.63 times that of the western region. The above-mentioned characteristics show that the higher the electricity price level, the greater the absolute level of economic development. The level of electricity price has an accelerating effect on the absolute development of economic. Duo to the intercept and correlation coefficient of the three regression curve have opposite order on ranking, there is only one node between them. The regression curve of electricity price level and absolute economic development level between eastern region and central region is 0.553 yuan/KWh. The regression curve of electricity price level and absolute economic development level between central region and western region is 0.429 yuan/KWh. The regression curve of electricity price level and absolute economic development level between eastern region and western region is 0.485 yuan/KWh. These results illustrate that the region of lower electricity price level will experience one of the electricity price level and absolute economic development combinations of higher electricity price level region in the process of improving electricity price level and absolute

economic development level. Electricity price level and relative level of economic development have a significant positive correlation. However, the correlation degree and the acceleration effect of absolute economic development is less than the relative level of economic development. The eastern, central and western regions' correlation coefficients of electricity price level and relative level of economic development are  $S_{ER}=210.481$ ,  $S_{CR}=120.582$ ,  $S_{WR}=126.278$ , respectively. These three coefficients are greater than 0, which illustrates that there are positive correlation between the electricity price level and relative level of economic development. and they are much over 1 and the correlation coefficients that use the absolute development of economy to calculate, which indicating their positive correlation is much more obvious, and a certain percentage change of the electricity price will affect the relative development of economy more than the absolute development of economy as above shows. Corresponding to the ratio '1.42:1.21:1.00' of average year electricity price in eastern, central and western regions, the ratio of the correlation coefficients between the electricity prices in the three regions and the relative development of economy is '1.67: 0.95:1.00'. There is no strict relationship between the two ratios. The later ratio is less than the ratio of correlation coefficient between electricity price and the absolute development of economy, and they are not strictly corresponding. With different economic regions or electricity prices, changes in electricity price are not the same with the corresponding changes in relative development of economy. The raise of electricity price lead to the corresponding raise of the development of economy in the central region is 0.95 times of that in the western region, while the eastern region is 1.67 times of that. In addition, only the eastern and the central regions, the east and the west regions' regression curves of the electricity price and the relative development of economy have their intersections in the three regression curves, which corresponding to the electricity price are 0.465 Yuan/KWh and 0.557 Yuan/KWh. When the central and the western regions' regression curves intersect, the corresponding electricity price is minus 0.896 Yuan/KWh, however, electricity price cannot be negative, so it indicates that the two regions' regression curves have no intersection. Therefore, the relationship between electricity price and the

development of economy is not like the assumption made by the traditional tariff policy that showing a negative correlation, which means the lower is the electricity price, the more development is the economy. Instead, they are showing a positive correlation significantly as a whole, which means the higher the electricity price, the better the economic develop. Lower electricity price seems conducive to the development of economy, but actually, the result is just the opposite. In this article we call it "Low Electricity Price Trap". Low electricity price induces the development of high energy-consuming industries.

#### Causes of the "Low Electricity Price Trap"

For the low electricity price trap causes and its adverse consequences, some scholars have done some researches on that. They suggest that inadequate electricity price formation mechanism and lower the price on purpose are the main reasons for the low electricity price in China. From the response of different demand, with two cases of short-term and long-term, this article makes some different interpretations for the results of influence that low electricity pricing policy to the economic develop in theory. The basic opinion is that the low electricity pricing policy is beneficial to the maximization of social welfare in favor of short-term, however, it will affect industrial structure etc., and change of social welfare is at least uncertainty. The following will indicate the relation between China's electricity price and industrial structure through analysis of the correlation between electricity price and heavy industrial structure of different economic regions' typical provinces.

#### Low Electricity Price and Industrial Structure

We select Shandong, Hunan and Gansu these three provinces, each of which is from the eastern, central and western regions, as the research objects and use the output value of heavy industry accounted for the proportion of the output value of total industry to explain the characteristics of industrial structure. Then we will analyze and compare the mutual relation between the low electricity price and the industrial structure. From 2000 to 2010, the average electricity price of Shandong Province is 0.473 Yuan/KWh, Hunan Province is 0.456 Yuan/KWh and Gansu Province is 0.335 Yuan/KWh. The ratio of electricity price of Shandong, Hunan and Gansu is 1.41:1.36:1.00; In the same period of time, Shandong, Hunan and Gansu these three provinces' average

ratios of heavy industry were 59.84%, 64.57% and 80.30% respectively. The proportion of heavy industry ratio is 0.75:0.80:1.00. The ratio of electricity price that three provinces in different economic regions and the proportion of heavy industry is opposite in rank. The higher is the electricity price, the smaller is the proportion of heavy industry; the lower is the price, the greater is the proportion of heavy industry. That means the low electricity price can promote the relative development of heavy industry, while high price will inhibited it. Compare the ratio of the electricity price and the proportion of heavy industry's relative size, find that the electricity price level is substantially uniform for promote or inhibited the relative development of the heavy industry. On the basis of the overall horizontal comparison, analyze the relation between changes of different electricity prices and changes of the proportion of heavy industry, and do individual longitudinal comparison, the obvious rule can also be found. Although the electricity price of Gansu Province was increase during 2000-2010, the gap with Shandong and Hunan hasn't changed, and it has been in a relatively low price constantly. And corresponds to this, the proportion of heavy industry in Gansu province continued to show an upward trend, which increased from 70.12 percent in 2000 to 88.50% in 2010, increased by 18.38%. In the same period of time, although the proportion of heavy industry in Shandong and Hunan which have a relatively high electricity prices was increased, it was a relatively small increase range. In 2000, the proportion of heavy industry in Shandong Province and Hunan Province were 52.32% and 64.2% respectively. In 2010, they were 67.61% and 68.90% respectively. That increased by 15.29% and 4.7%. It's worth noting that in 2000-2010, the ratio of the increasing electricity price of Shandong, Hunan and Gansu provinces were 31.49%, 41.93% and 41.77% respectively, and a relative ratio of 0.75:1.00:1.00; But in the same period, the relative ratio of the increasing range of the proportion of heavy industry in that three provinces is 0.83:0.26:1.00. There is no strict relative changing rule for the comparison of the relation between the two ratios. And it indicates that the absolute level of electricity price has a greater impact on the proportion of heavy industry. However, Hunan has the largest relative ratio of the increase range of electricity price and the smallest relative increase range of the proportion of heavy industry, which also provides

strong evidences for showing the relative changes of the electricity prices have significant impacts on the proportion of heavy industry. Therefore, the lower the electricity price and the smaller increase range of price changes, the more it can induce the rapid development of heavy industry, and cause much heavy industry and deformity in industrial structure.

## Conclusions and Policy Recommendations

### Conclusions

1) Two theories of electricity price level model. Various countries in the world set the price policy by the perspective of electricity price level, including high price model and low price. Low price model follows the marginal cost in order to pursue the maximization of social welfare, but the loss of economies scale of the power companies takes a variety of subsidies from the government. High price model is based on the average cost pricing to preferentially ensure electricity supply surplus electricity losses and obligations. Electricity supply and demand different levels of response mechanism and the result is an important prerequisite to influence and determine the effectiveness of the two tariff rafter. Nowadays, theories and policies at home and abroad for the supply response of different price patterns are becoming more, but less on the demand response.

2) Presence of "low price trap". The theoretical logic of low price model is it can increase greatly the power users to get more social welfare surplus. So in the price policy, the government would rather directly or indirectly give power companies subsidies than raise the price. However, the empirical results of economic development in different regions of China showed that the relationship : the relationship between the price level and the level of economic development is not only inconformity to the above logic, and on the contrary, shows overall positive correlation between a direct relationship. The low- price policy in the long term did not increase but reduce the social welfare. Therefore, the Chinese electricity price policy is actually a "low price trap".

3) The low price policy induces high energy-consuming industries developing, which is not conducive to the optimization and upgrading of industrial structure. This is the main cause of the "low-price trap". The low electricity prices relatively induces the development of high heavy energy industries, and the industrial structure adapt to the

extensive economic growth pattern, which will reduce the quality of economic growth and cause the ecological degradation and environmental pollution. In the long term it will inevitably slow the development speed and level and cause accelerated effect.

#### Policy Recommendations

With adapting to the current economic growth mode transformation and construction of ecological civilization, Chinese policy should come out from the "low trap" unswervingly, adapt gradually to the "high price model", and fully internalize the social costs, so that it will be the policy based on the real cost of production and operation. Specific tasks are: to cancel power construction fund, directly incorporate into the catalog price; ask for the power enterprises turn in the capital gain according to the social yield. Regardless of the electrovalence level mode and the level of price, it is necessary to develop and adjust related approaches on the electrovalence formation mechanism. Therefore, if the high electrovalence pattern wants to play a role, the reform of mechanism is necessary. We recommend that on the basis of Electricity Law, Electrovalence Reform Program, Electrovalence Reform Implementation Measures and other regulations, introducing electrovalence setting and adjustment implementations of which the core is cost and revenue or rate of return on investment pricing method. Now the low electrovalence trap has already been shown in different ways in China's electrovalence policy. When the government is adopting high electrovalence mode, it needs to coordinate each electrovalence policy to avoid local-meaning low electrovalence trap. The main methods are merging discriminatory electrovalence into catalog electrovalence, limiting enterprises building owned power plants, increasing system reserve capacity charge standard of owned power plants and requiring them to undertake some social cost.

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