Economic Impact Assessment of the Dual-track Electricity Price System in China

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Abstract. With the continuing advance of electricity market reforms, China is currently in the transition stage from a dual-track electricity price system to a market-based single-track system. The new electricity price system, which is based on market transaction electricity prices and transmission and distribution prices; and the original electricity price system, which is based on the feed-in tariffs price and catalog electricity prices, are dual-track operation. Based on the evolution path of China’s macro development, this paper clarifies the connotation and settlement mechanism of China’s dual-track electricity price system and discusses the differences and connections between the dual-track system settlement, planned settlement, and market-based settlement. Then, by adopting an adjusted Computable General Equilibrium (CGE) model, this paper quantitatively evaluates the economic and social benefits of the dual-track electricity price system. Based on these results, this paper further analyses the subsequent challenges and countermeasures of the transition from the dual-track electricity price system to the market-oriented price system.

1. Introduction
In the current stage, a new round of China’s electric power market reform is continuously advancing. The core idea of this reform is to “control the transmission and distribution network part but deregulate the generation part and the power seller part”.

In terms of the formation mechanism of electricity price, the original “bundled” catalog price was released, suggesting that the electricity price is determined by the market, while the transmission and distribution price is determined by the government with strict supervision. At present, part of the electricity price has been liberalized. Power generation enterprises and electricity consumers (or power sales companies) can wholesale trade part of the electricity at the market transaction price through the listing, bilateral negotiation, and centralized bidding. Under this background, the Dual-Track Electricity Price (DTEP) system has been developed. Clarifying the connotation and settlement mechanism and evaluating the economic impact of the DTEP system, investigating the subsequent challenges and countermeasures of the transition from DTEP system to market-oriented electricity price system is beneficial to realize the market-oriented allocation of electricity resources and establish a mature and perfect electricity market price system.
2. The connotation and settlement mechanism of DTEP system

2.1. The definition of the DTEP
The DTEP refers to the phenomenon in which the planned electricity price and the market-oriented electricity price all exist in the economy [1]. In order to clarify the connotation of the DTEP system, it is necessary to analyse the reasons for the formulation of the DTEP system. China’s economic development is a very remarkable process with Chinese socialist characteristics, but it also exposes the unbalanced development of the factor market, such as the electricity industry. As the main body of the market, electricity enterprises need to gradually learn market rules, and consumers need to adjust to the price changes caused by market-oriented reform, thus the electric power market reform cannot be completed overnight [2]. The readjustment and allocation of production and industrial structure corresponding to the existing electricity price system need a slow process. Therefore, the “shock therapy” is not suitable for the electric power market reform [3].

The core of the DTEP system is to liberalize the price regulation progressively, and gradually expand the share of market price regulation, so as to change from a planned price system to a market-oriented price system on the premise of maintaining basic economic growth [4]. At present, China is in the initial stage of a new round of electricity market-oriented reform. The new electricity price system based on the market transaction price and transmission and distribution price is being implemented, but the original electricity price system based on the feed-in tariffs price and catalog price is still the mainstream. The dual-track operation of these two systems forms China’s current extremely distinctive electricity price system.

2.2. The settlement mechanism of the DTEP system
The current electricity price system in China is a dual-track operation. About 70% of electricity is planned electricity, and its price is composed of three parts, including feed-in tariffs price, transmission and distribution price (including line loss), and government funds and surcharges. Where, the feed-in tariffs price is equivalent to the electricity price sold by power plants to power grid companies; the transmission and distribution price is used to compensate power transmission cost of power grid enterprises; the cross-subsidy embodied in the difference between the purchase price and sale price of power grid enterprises, i.e., sales price minus feed-in tariffs price and government funds and surcharges. For the market-oriented electricity that accounts for about 30% of total electricity, its price consists of three parts, including market purchase price, transmission and distribution price (including line loss), and government funds and surcharges. Where the cross-subsidy is reflected in the transmission and distribution price.

2.3. Comparative analysis of different electricity price settlement methods
To identify the differences and relations between the dual-track settlement mechanism, planned settlement mechanism, and market-oriented settlement mechanism, it is necessary to clarify the current electricity price system and its logical relationship.

As shown in Figure 1, we note that China’s electricity price operates in a dual-track system. The related government department should not only identify the transmission and distribution electricity price but also define the sales price simultaneously. The parts connected by the dotted line in Figure 1 are the sections of the original electricity system and will be phased out in the future.

On the power generation side, the current “planned electricity” still occupies a dominant position, which is purchased by grid companies, and dispatched according to user needs with the implementation of benchmark feed-in tariffs price; while “market-oriented electricity” is sold to large industrial users or power sales companies with the implementation of market-oriented transaction prices. On the power consumption side, some users such as the agriculture, residents, important public utilities, and public service users that need to be guaranteed at priority, they have not yet participated in market-oriented transactions, thus the sale price is implemented. For some large industries and general industrial and commercial users, they can obtain electricity through market-oriented
transaction, and their electricity price is determined by the market transaction price, terminal transmission and distribution price, and government funds and surcharges. For users are not within the scope of the preferential purchase, nor can they participate in the electricity market transactions, their electricity consumption is still uniformly sold by the grid enterprises with the implementation of the sale price.

Figure 1. Current power system in China

The originally planned settlement system needs to give priority to some guaranteed users, such as residents, agriculture, thus the electricity supply price for such users is significantly lower than its electricity supply cost, and the corresponding funding gap is made up by the cross-subsidy of industrial and commercial user prices. However, this cross-subsidy has negative economic externality and cause unnecessary losses, which is harmful to the reasonable allocation of power resources and the improvement of social welfare. Besides, the planned settlement method cannot fully reflect the relationship between electricity supply and demand, so the power generation entities lack incentives to actively reduce the electricity price, which is bad to the realization of the China’s macro-economic goal of “reducing the electricity price of general industrial and commercial users by 10%”. On the contrary, the market-oriented settlement mechanism can reveal the true information of electricity supply cost, which reflects the principle of fairness and justice and helps to maintain the high-quality and stable operation of the power market. Meanwhile, the electricity price formed by the market-oriented settlement is often lower than that of planned settlement (catalog price) which is helpful to the decline of the overall electricity price by introducing market-oriented competition. As the transition path from planned settlement to market-oriented settlement, the dual-track system gradually liberalizes the power price regulation, which can achieve the goal of reducing the burden of enterprises more effectively than the administrative reduction of electricity price at the current stage.
3. Economic Impact Assessment of China’s DTEP System

3.1. The construction of Computable General Equilibrium (CGE) model

The CGE model can establish the dynamic relationship between the power system and economic system, quantitatively analyse the relationship between the electricity price mechanism and various economic sectors, and explore the correlation effect of input and output.

Combined with the scenario analysis method (different marketization rates), the CGE model can be used to quantitatively estimate the impact of the DTEP system on macro-economy and residents’ welfare. To accurately evaluate the economic impact of the DTEP system, we need to adjust the CGE model. Under the planned settlement model, because of the existence of excess installed capacity of power generation, the capital of the power sector is not fully utilized and the return on investment cannot be reflected in the electricity price. When part of the electricity in the DTEP system participates in the market-oriented transaction, it can improve the utilization rate of effective capital and the overall output level, eventually the feedback is that the consumers can enjoy a lower price level.

3.1.1. The calculation of capacity utilization rate

The capacity utilization rate of power supply can be calculated according following equation.

\[ \mu = \frac{\sum G_i}{\sum G_i / \mu_i} \] (1)

Where \( \mu \) denotes the capacity utilization rate; \( G \) represents the power generation of different sources; \( \mu_e \) represents the overall capacity utilization of the power generation industry; \( i \) represents different power sources.

China has implemented the security purchase system for renewable energy, such as wind power, photovoltaic power, and hydropower, the system includes the priority of power generation on the grid and following planning. Besides, the marginal cost of nuclear power is very low, thus, it also adopts the mode of full access to the power grid. Therefore, it can be considered that the production capacity of these types of power sources has been fully utilized. Thus, under the existing power system, thermal power bears the fluctuation of market demand [5]. In 2004, the operating hours of thermal power were 5991, but this value was only 4219 in 2017. Divided by the highest operating hours in history, the capacity utilization rate of thermal power is calculated as only 70.42%. By considering the generation data of different power sources in 2017, we can get the overall capacity utilization rate of 78.76%.

3.1.2. The setting of the DTEP model

Under the planned electricity price mechanism, the feed-on grids price is regulated by the government. As the selling price is higher than the market-clearing price, the electricity consumption is lower than the market-clearing electricity. However, because the feed-on grids price is higher than the marginal cost, the excess capacity of the power industry can be compensated by the premium of the feed-on grids price, this is one of the reasons for overcapacity. To describe the overcapacity in the CGE model, it is assumed that only \( \mu_e \) capital investment can be utilized in the power industry. After the electricity market is partially liberalized, the generator unit participating in the market-oriented transaction will be able to gain profits by increasing the generation capacity when the market price is higher than the marginal cost. When the proportion of the market-oriented trading capacity is \( \alpha \), the capacity utilization rate of the power industry \( \mu_e \) can be calculated according to following equation.

\[ \mu_e = \alpha + (1-\alpha)\mu_e \] (2)

3.2. Economic and social benefit evaluation of the DTEP system

The macroeconomic indicators show great differences under different transaction proportions of market-oriented electricity. As shown in Table 1, It can be noted that the GDP will increase
significantly with the increase of the marketization rate of electricity trading. When the electricity market is completely marketized (marketization rate=100%), GDP will increase by 0.51%, and meanwhile, the electricity price will be significantly decreased. That is to say, with the increase of the proportion of electricity participating in the market-oriented transaction, the generation capital will be more fully utilized, and the economic development with higher quality can be supported with a lower electricity price.

It should be noted that in the fully competitive electricity market, the electricity price in the equilibrium state is 9.51% lower than the planned price, which is close to the target of “the general industrial and commercial electricity price is reduced by 10%”. This suggests that market-oriented transaction is more effective than administrative regulation in reducing electricity price. Considering the current downward pressure of economic growth, it is necessary to deeply explore the regulatory role of the “invisible hand” of the market on electricity prices.

Table 1 The change ratio of macroeconomic indicators under different marketization level

| The degree of marketization level | 20%  | 40%  | 60%  | 80%  | 100% |
|----------------------------------|------|------|------|------|------|
| Changes in GDP (%)              | 0.11 | 0.22 | 0.32 | 0.42 | 0.51 |
| Changes in electricity consumption (%) | 3.43 | 6.82 | 10.08 | 13.17 | 16.27 |
| Changes in electricity price (%) | -2.22 | -4.28 | -6.16 | -7.88 | -9.51 |
| Changes in inflation (%)        | 0.02 | 0.05 | 0.07 | 0.09 | 0.11 |
| Changes in wage (%)             | 0.11 | 0.22 | 0.32 | 0.41 | 0.50 |
| Changes in interest rate (%)    | 0.17 | 0.33 | 0.48 | 0.62 | 0.76 |
| Changes in net exports (%)      | 0.61 | 1.18 | 1.72 | 2.23 | 2.72 |

Sources: Result of data analysis

Benefited from the low electricity price brought by market-oriented transactions, the electricity demand will be increased by 1.77%-16.27% under different degrees of marketization level, this will improve the level of terminal electrification. With the gradual expansion of the trade share of market-oriented electricity, the wage, interest rate, and net exports will also be improved to some extent. For example, the overall wage level will be increased by 0.06%-0.50%, which indicates that residents could have higher incomes while enjoying lower electricity prices and the overall social welfare could make “Pareto improvement”.

Table 2. Electricity consumption changes of different industries under different marketization level

| Industry                                      | Marketization level |
|-----------------------------------------------|---------------------|
|                                               | 20%     | 40%     | 60%     | 80%     | 100%    |
| Agriculture, Forestry, Animal Husbandry and Fishery | 3.12%   | 6.16%   | 9.08%   | 11.86%  | 14.62%  |
| Mining industry                               | 3.08%   | 6.08%   | 8.97%   | 11.71%  | 14.43%  |
| Manufacturing industry                        | 3.17%   | 6.27%   | 9.25%   | 12.10%  | 14.91%  |
| Production and supply of electricity, gas and water | 4.01%   | 8.03%   | 11.92%  | 15.55%  | 19.29%  |
| Construction industry                         | 3.23%   | 6.38%   | 9.42%   | 12.31%  | 15.17%  |
| Transportation, warehousing and postal industry | 3.65%   | 7.23%   | 10.69%  | 14.00%  | 17.30%  |
| Commercial, accommodation and catering industry | 2.91%   | 5.75%   | 8.48%   | 11.07%  | 13.63%  |
| Information transmission, computer and software | 2.77%   | 5.46%   | 8.05%   | 10.50%  | 12.93%  |
| Finance, real estate, business and residential services | 3.27%   | 6.46%   | 9.54%   | 12.47%  | 15.39%  |
| Public utilities and management organizations  | 3.15%   | 6.23%   | 9.19%   | 12.00%  | 14.79%  |
Table 3. Output changes of different industries under different marketization level

| Industry                                      | Marketization level |
|-----------------------------------------------|---------------------|
|                                               | 20%     | 40%     | 60%     | 80%     | 100%    |
| Agriculture, Forestry, Animal Husbandry and Fishery | 0.07%   | 0.13%   | 0.19%   | 0.25%   | 0.31%   |
| Mining industry                               | -0.09%  | -0.17%  | -0.24%  | -0.32%  | -0.38%  |
| Manufacturing industry                        | 0.10%   | 0.20%   | 0.29%   | 0.37%   | 0.45%   |
| Production and supply of electricity, gas and water | 2.91%   | 5.79%   | 8.56%   | 11.18%  | 13.81%  |
| Construction industry                         | 0.13%   | 0.26%   | 0.37%   | 0.49%   | 0.60%   |
| Transportation, warehousing and postal industry | 0.07%   | 0.13%   | 0.20%   | 0.25%   | 0.31%   |
| Commercial, accommodation and catering industry | 0.07%   | 0.14%   | 0.20%   | 0.26%   | 0.32%   |
| Information transmission, computer and software | 0.07%   | 0.13%   | 0.19%   | 0.24%   | 0.30%   |
| Finance, real estate, business and residential services | 0.08%   | 0.15%   | 0.22%   | 0.29%   | 0.35%   |
| Public utilities and management organizations | 0.07%   | 0.13%   | 0.19%   | 0.25%   | 0.30%   |

From the sub-sector perspective, the market-oriented transaction in the DTEP system has significantly improved the electricity consumption and output of various sectors of the national economy. The results are presented in Table 2 and Table 3. The production and supply of electricity, gas and water industry are most affected. Under the full marketization level, the electricity consumption of the sector will increase by 19.29%, and the output will also increase by 13.81%. The intuitive economic reality is that this sector is closely related to the electricity price, the decline of the overall price caused by the market-oriented transaction creates considerable profit space. An interesting finding reflected in Table 3 is that the output of Mining industries has decreased with the implementation of the DTEP system. A reasonable reason is that the decrease in electricity price accelerates the substitution of electricity for fossil energy products such as coal, oil, and natural gas, and then such impacts are transmitted to the corresponding sectors through the industrial chain.

4. The subsequent challenges and countermeasures during the transition process

4.1. The subsequent challenges

Even though these two electricity systems are independent of each other in most cases, there is still room for rent-seeking in the DTEP system. As a transition path from planned settlement to market-oriented settlement, the DTEP system still faces three main challenges [6].

Local governments and power users have high expectations for the reduction of market price. At present, the formation of market-oriented electricity price is dominated by unilateral price reduction of power generation enterprises. The market-oriented electricity price is lower than the catalog price for a long time, and the price formation mechanism is not perfect. Some local governments and power users have a biased understanding of the power market function. The main reason why consumers participate in the market transaction is to enjoy the price dividend brought by reform, and they have insufficient expectation on the market price fluctuation. In the future, with the deepening of power market reform, consumers may lack the ability to deal with the risk of price fluctuations.

There are some problems in the connection between catalog price and market price. There is an inverted phenomenon between catalog price and market price, as well as general industrial and commercial electricity price and large industrial price. In the market-oriented electricity, cross-subsidy mainly exists in the transmission and distribution price, which leads to the catalog price of the general industrial and commercial users in Anhui, Hubei and other provinces is lower than the electricity purchase price. With the continuous decline of general industrial and commercial electricity prices in the future, the price difference may further expand, which will affect the willingness to participate in market-oriented transactions. Moreover, at present, the general industrial and commercial electricity price in some provinces is lower than that of large-scale industry, which is not conducive to simplifying the list price and promoting the cancellation of catalog price.
Low price power supply entering the market brings new challenges. Different power sources have different power generation costs. Compared with other power sources, the cost of hydropower generation is relatively low. Under the planned electricity price mechanism, power grid enterprises can support the cross-subsidy by purchasing low-cost power sources (such as hydropower). However, with the more competitive low-cost power supply entering into the market-oriented transaction, the low-cost electricity that can be purchased by the power grid enterprises is gradually decreased. Under the comprehensive influence of the general industrial and commercial electricity price reduction and the increase of the proportion of residential electricity consumption, the power grid enterprises are faced with severe adjustment of the increase of the electricity demand by the guaranteed users and the reduction of the cross-subsidy sources.

4.2. The countermeasures during the transition process
At present, China’s electric power industry is in the process of transforming the DTEP system to the single-track market-oriented system. Therefore, identifying the countermeasures during the transition stage is of great significance for the stable development of China’s social economy.

Releasing the catalog price in a stable and orderly way and establishing a transition mechanism. Firstly, it should be clear that the scope of cancelling the catalog price only involves industrial and commercial users. For non-operating industries such as resident and agricultural production, the power grid enterprises should guarantee the minimum power supply and implement the catalog price for a long time. Secondly, the compulsory implementation mechanism should be established. For the power users who enter the market, they must participate in the transaction with their all electricity demand, and in principle, they cannot withdraw from the market. Besides, the punitive electricity price should be set to promote the implementation of market-oriented electricity price.

Speed up the establishment of a sound market-oriented price formation mechanism. Accelerate the formation of a market-oriented price formation mechanism of “benchmark price plus floating mechanism”, avoid unilateral price reduction of power generation enterprises, and make the market-oriented transaction price truly reflect the power supply cost, and the situation of power grid operation and power supply and demand.

Properly handle the cross-subsidy of transmission and distribution price. Firstly, the government should improve the residential tiered electricity pricing system, reduce the demand for the cross-subsidy; which makes the first-tier tariff users can enjoy a certain cross-subsidy, the second-tier tariff users just cover the power supply cost, and the third-tier tariff users provide cross-subsidy funds for residents and agriculture. Secondly, the policy of load rate electricity price should be introduced for industrial and commercial users, thereby promote the same price for large industry and general industry and commerce. Finally, the government should clarify the cross-subsidy responsibilities of market-oriented trading users, steadily promote the entry of low-cost power into the market, and improve the preferential power purchase system.

5. Conclusions
This paper identifies the connotation and settlement mechanism of the DTEP system and discusses the differences and connections between the dual-track settlement, planning system settlement, and market-oriented settlement. Then, based on an adjusted CGE model, this paper quantitatively evaluates the economic and social benefits of the DTEP system.

The results show that the improvement of the marketization level of electricity transactions makes the generation capital more fully utilized, which helps to support higher quality economic development with a lower price. In the fully competitive electricity market, the electricity price in the equilibrium state is 9.51% lower than the planned price, which is close to the target of “the general industrial and commercial electricity price is reduced by 10%”. This suggests that market-oriented transaction is more effective than administrative regulation in reducing electricity price. Meanwhile, the result also indicates that residents can have higher incomes while enjoying lower electricity prices and the overall social welfare can make “Pareto improvement”. The estimation results of sub-sectors
show that with the degree of marketization level changed from 10% to 100%, the electricity consumption of economic sectors increased by 1.60%-14.32%, and the output increased by 0.09%-0.79%. Finally, the paper identifies the subsequent challenges and countermeasures of the transition from the DTEP system to the market-oriented electricity price system. In order to deal with the contradictions and problems in the transition process, this paper suggests that some measures should be taken, such as steadily and orderly liberalizing the catalog price, speeding up the establishment of market-oriented price formation mechanism, and properly solving the cross-subsidy problem existed in transmission and distribution electricity prices, thereby promoting the high-quality and stable development of society and economy.

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