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Economic evaluation of Chinese electricity price marketization based on dynamic computational general equilibrium model

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ABSTRACT

The Chinese government has accelerated the pace of electricity market reform in recent years. The primary objective is to create a market-oriented electricity price which can accurately reflect the relationship between market supply and demand, resource scarcity, and the cost of environmental damages. This study adopted a dynamic computational general equilibrium model of China (CDECGE) to conduct quantitative assessment of the economic impact of Chinese electricity market reform. As abatement policies may affect electricity price significantly, the carbon intensity reduction targets for China in 2020 and 2030 were also accounted for during simulation. The results show that reform is indeed beneficial in terms of energy savings and reduction of carbon emissions. Compared to results under regular electricity price, the total primary energy consumed from 2016 to 2030 under market-oriented electricity price will decrease by 5.01%, while the accumulated carbon emission will decrease by 4.70%. The marketization of electricity price also benefits reduced abatement costs in China, where the accumulated GDP from 2016 to 2030 would be about 1012.80 trillion RMB (an increase of nearly 0.25%) compared to that under regulated electricity price. We also found that the economic cost of electricity market intervention is very high for China, as it would force the government to pay expensive subsidies to keep the price of electricity at a relatively low level. Marketization reform may also exacerbate inflation, although it not to any substantial degree. The findings altogether demonstrate that electricity price marketization may result in multiple economic benefits; the results presented here also may provide a useful reference for Chinese market reform policies in future.

1. Background

The electricity industry is one of the fundamental components of any national economy, as it concerns energy safety, economic development, and social stability. For a lengthy portion of its history, China regarded electric power resources as a "quasi-public good", under which concept the price of electricity was regulated by the state. However, price distortions in the electricity industry have become increasingly severe precisely because of the "quasi-public good", as the price of electricity cannot effectively reflect the generating cost, causing power generation enterprises to suffer losses accordingly. Since 2002, especially, China has been faced with widespread power shortages (Ye, Yuan, Li, & Li, 2014). In effort to stabilize the electricity industry and relieve the shortage of resources, China has attempted to limit electricity usage and/or increase prices, but these methods have generated adverse effects on economic and social development. Reforming the electricity market, regulating resource allocation, setting prices appropriately to reflect consumption costs, the relationship between market supply and demand, the degree of resource scarcity, and potential threats posed by the industry to the environment are all major – and urgent – concerns of officials and decision-makers tasked with enabling the electricity industry to better serve economic and social development in China.

In March 2015, the State Council of China published *Several Opinions on Further Deepening Electricity System Reform*, a document that proposed several changes to the electricity industry by insisting that market-oriented reform, including an electricity pricing mechanism which can adapt to market requirements, is the best way to move forward in China's current economic context (The State Council of China, 2015). Electricity price reform concerns energy safety in general and relates to a fundamental quality-of-life issue, as well as the overall economic and social development of Chinese society as a whole. Accurate assessment of the economic

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effects of electricity price marketization reform, especially in regard to price fluctuations on the transmission mechanism in China's macro-economy and relevant, feasible policy suggestions, is of crucial practical significance in the current and future electricity market.

Electricity market reform began in China in the 1980s, and can be roughly divided into five stages. The first stage, prior to 1985, took place during a period of economic planning: the electricity industry implemented an operation mode integrating generation, transmission, distribution, and sales, and the state implemented mandatory electricity price, thus, the degree of electricity marketization degree was quite low (Wang & Chen, 2012). The second stage took place during the reform period (1985–1997), when the RCI (repayment of principal and interest) pricing method was implemented. At that time, the country implemented coexisting policies for electricity price and mandatory electricity price, then gradually introduced the RCI feed-in tariff (Zhao, Lyon, & Song, 2012). The third stage was characterized by operation period price reform (1998–2002). To encourage enterprises to reduce their costs, the government also revised the RCI pricing policy and introduced the operation period price policy (Zhao et al., 2012). The fourth stage took place after the separation of plants and the grid in 2003, the year that the *Electricity System Report Scheme* proposed a reform policy of "separation of plant and grid, separation of primary and secondary subject, separation of transmission and distribution, and competitive communication". The policy explicitly divided the price of electricity into four individual price points: generation, transmission, distribution, and sales (Wang & Chen, 2012). The fifth and current stage has been underway since 2015, the year that *Several Opinions on Further Deepening Electricity System Reform* was published by the State Council, proposing that China should orderly enact electricity price reform, rationalize the electricity price formation mechanism, encourage competitive electricity prices, separate transmission-distribution price from generation-selling price as far as formation mechanisms, bolster the electricity transaction system, and improve the market-oriented transaction mechanism. In summary, China has conducted multiple highly effective reforms to its electricity industry. Although electricity price marketization has not yet been fully realized, the reform orientation and determination of the Chinese government in regard to marketization and general improvement have been steadfast.

This study focused on internal motivations for economic development to conduct a comprehensive and systematic assessment of the economic influence of Chinese electricity market reform via the China Dynamic Energy Computable General Equilibrium (CDECGE) model. More specifically, we studied the influence of different electricity price formulation mechanisms on economic growth, energy demand, and carbon emissions in China in the future. In fact, because emission reduction is a factor significantly influencing electricity consumption, to lend our analysis the most practical significance possible, we set our primary objective as the potential influence of electricity price marketization on carbon intensity reduction mandates in China in 2020 and 2030.The remainder of this paper is organized as follows: Section 2 is the literature review, Section 3 introduces the features of the CDECGE model, Section 4 provides details regarding the specific context of this study and our analysis process, Section 5 presents our results, and Section 6 contains relevant policy suggestions and a brief conclusion.

2. Literature review

The key component of electricity market reform is electricity price reform. The influence of price fluctuations on the macro-economy has proven problematic and uncertain in academic circles in China and abroad. According to our review of the existing literature, we find that related studies can be roughly divided into two categories. The first category includes works by scholars who insist that increasing electricity prices drive inflation, i.e., increasing price levels. For example, Lin (2006) conducted a questionnaire survey with 900 Chinese industrial enterprises, then analyzed the influence of rising electricity prices on outputs of different industries and social levels by establishing a transcendental logarithmic model to find that industrial enterprises are more sensitive to electricity price, and that increased electricity price would improve inflation level. Nguyen (2008) conducted a similar analysis in Vietnam and found that if the electricity price was increased and set as the cost of long-term marginal production, most commodity prices would notably increase but the total price level passed on to society would remain fairly stable. Akkemik (2011) analyzed the potential influence of rising electricity prices on Turkey's national economy via social accounting matrix price model and found that electricity price fluctuation has caused producer and consumer prices to rise, impacting the country's economic development and consumption. Song (2011) measured and calculated the relation between Chinese electricity price and total price level with an input–output table and found that small increases in electricity price would not overly exacerbate the level of inflation.

The second category includes works by scholars who assert that the influence of rising electricity prices on economic output is the most important factor of electricity market reform. Some believe that increasing electricity price would reduce outputs and increase unemployment – for example, Patrick, Blandford, and Peters (2015) estimated the elasticity of American electricity price through a fixed-assets model and found that if the nominal electricity price was increased by 10%, America would lose one million jobs and see a drop in GDP by 142 billion USD. Cox, Peichl, Pestelet, and Siegloch (2014) estimated the cross-price elasticity between manufacturing sector electricity consumption and the heterogeneous labor in Germany, and found that the Renewable Energy Act of 2014 decreased the country's labor demand in the manufacturing sector by 1.4%. Kwon, Cho, Robertset, Kim, and Yu (2015) studied the relationships among power demand, economic output, and electricity price in Korea via generalized two-stage least square model and found that if the electricity price was increased by 2% each year, the output of the manufacturing industry of Korea would drop 4.5% between 2013 and 2022.

Conversely, other scholars insist that rising electricity prices would promote economic development in the long run. For example, Faisal and Ahmad (2010) analyzed the influence of electricity price reform in Pakistan and found that electricity price increase would not damage the real economy but would improve the operation conditions of power enterprises. He et al. (2015) studied the dynamic influence of electricity price fluctuation on the Chinese economy and found that relatively low electricity prices in the country seem beneficial to economic development, but will damage the positive correlation with economic development in the long run. Ye, Yuan, and Li (2013) performed a regression analysis on average electricity price and economic development data of east-central-west regions of China from 2000 to 2010, and found that China may fall into a "trap" formed by low electricity prices characterized by only short-term social benefits resulting from low prices. In short, in the long run, the electricity price level of China is in positive correlation with economic development level. Low electricity price policies benefit economic development in the short term, but may be harmful in terms of industrial structure adjustment and economic growth pattern transitions, thus actually harming the long-term development of China's economy (Ye et al., 2014).

The researchers mentioned above all adopted classical econometric models to conduct their respective studies. To study elec-