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Economic analysis of coal price–electricity price adjustment in China based on the CGE model

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ABSTRACT

In recent years, coal price has risen rapidly, which has also brought a sharp increase in the expenditures of thermal power plants in China. Meantime, the power production price and power retail price have not been adjusted accordingly and a large number of thermal power plants have incurred losses. The power industry is a key industry in the national economy. As such, a thorough analysis and evaluation of the economic influence of the electricity price should be conducted before electricity price adjustment is carried out. This paper analyses the influence of coal price adjustment on the electric power industry, and the influence of electricity price adjustment on the macroeconomy in China based on computable general equilibrium models. The conclusions are as follows: (1) a coal price increase causes a rise in the cost of the electric power industry, but the influence gradually descends with increase in coal price; and (2) an electricity price increase has an adverse influence on the total output, Gross Domestic Product (GDP), and the Consumer Price Index (CPI). Electricity price increases have a contractionary effect on economic development and, consequently, electricity price policy making must consequently consider all factors to minimize their adverse influence.

1. Introduction

The power industry is one of the basic industries in the national economy, and electricity is one of the public's basic goods. Hence, electricity prices in China have long been fixed and strictly controlled by the Chinese government to maintain smooth economic development and a stable overall price level. In recent years, coal pricing has become more and more market-oriented, and coal price, which was artificially lowered during the price regulation period, increased rapidly due to its resource costs, production costs, and environmental costs, as well as the market's supply and demand conditions. Coal price, as the largest expense, greatly increases the cost of thermal power plants when it increases. In China, as the coal–electricity price linkage mechanism was not fully implemented, a large number of power enterprises incurred substantial losses and since then have urged the government to raise the on-grid power price to improve their business condition. In this work, the analysis and evaluation of the influence of the coal price increase on the electric power industry, especially on the electric power industry's cost and the influence of electricity price adjustment on the economy, were reported. These measures are of great importance for the review of the policies regarding electricity price and the intensification of the reform of the electric power industry.

The impact of the energy price increase around the world has drawn great attention. Oil is a vital input in the production process of an economy, and most of earlier studies have focused on oil price shocks or volatility. Rafiq et al. (2009), Zhang (2008), and Huang et al. (2005) adopted different methods to investigate the relationship between oil price shock and economic growth, and found that oil price shocks exert an adverse impact on economic growth. Rodríguez (2008) assessed the dynamic effect of oil price shocks on the output of the main manufacturing industries in six OECD countries and found that the pattern of responses to oil price shocks by industrial output was diverse across the four European Monetary Union (EUM) countries. Doroodian and Boyd (2003) used a dynamic computable general equilibrium (CGE) model to examine whether oil price shocks are inflationary in the United States. Their findings indicated that the aggregate price changes were largely dissipated over time at the aggregate level. Faria et al. (in press) developed an ARDL model to examine the impact of oil price shocks on China's export. They found that there was a positive correlation between China's exports and oil price due to the large labor force surplus. Huang and Guo (2007) constructed a four-dimensional structural VAR model to investigate the impact of oil price shock on China's real exchange rate. The results suggest that real oil price shocks would lead to a minor appreciation of the long-term real exchange rate due to China's lesser dependence on imported oil than its trading partners. In China, coal accounts for

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about 70% of total energy consumption while oil accounts for about 20%; thus China's economy is coal-based rather than oil-based. Lin and Mou (2008) used a CGE model to examine the impact of coal and oil price increases on China's economy and concluded that the impact of energy price increases has contractionary effects, and the levels of contraction are different across industries. For most industries in China, the contraction effects of coal are two to three times that of oil for the same price increase. So, it is necessary to consider the different influences of coal, oil and other kinds of energy resources when making energy policies.

The impact of the electricity price increase has also drawn great attention recently, and many research studies are being conducted both in China and abroad. In Vietnam, Nguyen (2008) examined the impacts of increase in the electricity tariff in the long run on the marginal cost on prices of other products using a static input–output approach. He concluded that such an increase would drive up the prices of all other products. Although the aggregate price impact from such an increase is not large, it would be socially difficult to implement this increase at one time given that Vietnam is facing a high inflation rate. Silva et al. (2009) analyzed the environmental and social impacts of an increase in residential electricity tariffs, which range from 40% to over 100% in Montenegro. He reported that such a significant price rise would impose such a heavy burden on poor households that it might adversely affect the environment, and that the government of Montenegro should combine the tariff reforms with a carefully evaluated set of policy measures to mitigate the effect of the electricity price increase on the poor. Lin (2006) analyzed the impact of electricity tariff increases on various industries and provinces in China and quantified the impact of lower power quality on the industry using survey data. In this research, Lin adopted a C-D demand function to analyze the impact of electricity price increases on the price of end-use industrial products. He concluded that all industrial sectors are sensitive to increase in electricity prices, and that such an increase will lead to a corresponding rise in the prices of industrial products. Furthermore, he found that the direct impact of power shortages on industries was substantially larger than the cost of electricity supply and the magnitude of impact depended on the industrial mix, level of dependency on electricity, and the available alternatives. Zhang (2006) used a CGE model to explore the relationship between electricity price and industrial structure in China. The results showed that the cross-elasticity of each industry's output to electricity price is very low and that the industries with more electricity consumption are more sensitive to changes in electricity price. He et al. (2009) quantified the impact of the recent electricity price adjustment on related sectors and residents living in China based on the input–output method. She quantified the impact of electricity price increases on sectoral price, the change in CPI and end-use product price index based on the input–output table of 2002 of China under different scenarios. The CPI increases from 0.3% to 0.9% while the end-use product price increases from 0.32% to 0.97% when the electricity price increases from 5% to 15%. The conclusion is that such an adjustment would not have much adverse impact on the economy and residents' lifestyles; therefore, the impact of electricity price adjustments on each sector is different, and it is necessary to consider each sector's capacity for acceptance when a new price policy is made. Price volatility analysis has been reported in the literature for most competitive electricity markets around the world. However, only a few studies have been carried out that quantify price volatility in China's electricity market, which is the focus of the present paper. Furthermore, none of the above research examined the impact of coal price increases on the electric power industry and the impact of electricity price increase on China's economy from the angle of the industrial chain. For that reason, this paper reports the research conducted regarding this matter.

CGE models have been used to analyze the effects of a wide range of policy issues in both developed and developing countries. It can simulate the workings of an economy in which prices and quantities adjust to clear markets for products and factors. Equilibrium is achieved as a result of the independent optimising decisions of the producers and consumers of goods and services. CGE models are usually based on a comprehensive economy-wide database and can serve as a laboratory for policy. The CGE framework captures interrelationships among economic sectors and accounts for the repercussion effects of policy. For these reasons, this paper chose the CGE model to investigate the impact of the coal price and electricity price adjustment. However, a static CGE model, which we adopted in this paper, is incapable of modeling the long-term trend of the economy and a dynamic CGE model is needed to capture the characteristics of long-term trends in the economy, which will be the main challenge of our research in the future.

This paper is organized as follows: Section 2 discusses the CGE model, data, and parameters. Section 3 analyses the impact of coal price increases on the electric power industry. Section 4 analyses the impact of electricity price increases on China's economy, and Section 5 presents the conclusion.

2. Analytical framework

In the early 1960s, Johansen established a multi-sectoral growth model used to study the economic growth in Norway —considered to be the first practical CGE model. After nearly half a century, the CGE model was developed quickly in terms of the depth of theory, structure of the model, modeling technique, and application field. Particularly under the advocacy of international organisations such as the World Bank, almost all the developed countries and most of the developing countries have established their own CGE model, which is widely used in the field, such as for: the impact of taxation and tax reform, global trade, trade liberalization, economic integration, policy reform, price reform of agricultural markets, imperfect competition, income distribution, energy, natural resources, and environmental protection in developing countries (Zhou and Wang, 2006).

2.1. CGE model structure

CGE depicts the basic problems of total supply, total demand, and their balance. In the microeconomic analysis, firms and households are described as economic agents that take certain actions to maximize their evaluation functions under certain constraint conditions. That is, households select a different combination of consumer goods to maximize their utility under budget constraints, while firms choose the appropriate combination of intermediate inputs and factor inputs to maximize their profits, which are subject to certain technological constraints. Producers and consumers jointly decide the supply and demand function of the entire economic system, and the price and quantity where the equilibrium would meet. The CGE model is a set of equations describing the balance between the supply and demand of the economic system. The structure of the CGE model is shown in Fig. 1. Generally, the CGE model is composed of price equations, quantity equations, income equations, expenditure equations, market clearing conditions, and macroeconomic closure (Robinson, 1999), which are explained as follows:

(1) *Price equations*: on the import and export side, the model incorporates the "small country" assumption that world prices are exogenous. The composite commodities QQ consist of the constant elasticity of substitution (CES) aggregation of sectoral imports QM and domestic goods supplied to the domestic market (QD). Sectoral output QX is a constant