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Economic and environmental influences of coal resource tax in China: A dynamic computable general equilibrium approach

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ABSTRACT

Coal resource tax reform from quantity-based collection to ad valorem collection has been implemented by the Chinese government in December 2014, to develop a low-carbon economy. This paper builds a multi-sectoral dynamic computable general equilibrium (CGE) model with a coal resource tax module, to study the general impacts of such reform policy on the Chinese economy and environment. Based on the proposed model, different policy designs with different ad valorem tax rates are simulated and further compared with the current quantity-based policy, and some interesting results can be obtained. As for the economic influence, the gross domestic product (GDP) of China would be somewhat negatively affected by the reform in terms of output shrinkage in most sectors, and the effect will be larger with a higher tax rate but decrease as time goes. From the environmental perspective, the energy structure would be improved by the reform policy, with a sharp decrease in coal consumption but increases in the consumptions of cleaner energy forms. Accordingly, the total carbon emissions and other main air pollutants (SO_2 and NO_x) would be significantly mitigated, which can effectively improve the environment and guarantee the achievement of China's promise in carbon emissions reduction.

1. Introduction

In recent decades, coupled with rapid economic development, the increasing energy demand and hence environmental pollution have become the dominant contributor to the greenhouse effect and global climate change (Tang et al., 2015). Since 1979, a group of international organizations (e.g., IPCC, UNFCC, and APPCDC) have been created to work on energy conservation and emission mitigation. As one of the largest developing countries facing the double challenges of energy shortage and environmental pollution, the Chinese government has proposed a series of energy policies to develop a low-carbon economy, e.g., resource tax policy and carbon emission trading system (Wu et al., 2014). Amongst them, resource tax reform from quantity-based collection (which calculates the tax based on the total quantity of the target commodity) to ad valorem collection (based on the market value), has recently aroused a wild interest as one of the most effective measures. A pilot project of resource tax reform on oil and natural gas was carried out in Xinjiang in the year 2010, from quantity-based collection (8–30 RMB yuan/ton on oil and 2–15 RMB yuan/m^3 on natural gas) to ad valorem collection with a tax rate of 5%[1]; and such reform policy was further extended to a nationwide scale in 2011.

Compared with oil and natural gas, an appropriate reform on coal resource tax would certainly benefit China, in terms of improving energy structure and mitigating carbon emissions (Xu et al., 2015). Specifically, the traditional volume-based resource tax encourages resource companies to develop and utilize high-quality mineral resources and quite low-grade resources, which results in a waste of state-owned mineral resources (Zhang et al., 2013). According to the current coal resource tax policy in China, the tax rate on coal is still at a low level (around 0.3–5 RMB yuan/ton), which neglects or at least underestimates its environmental cost, i.e., that the tax rate is far lower than the real value of coal resource, leading to overexploitation and depletion (Guo et al., 2011; Xu et al., 2015). Accordingly, coal resource tax reform from quantity-based collection to ad valorem collection has been implemented by the Chinese central government in December 2014, and different

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[1] http://www.chinanews.com/ny/news/2010/06-02/2318467.shtml.

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Table 1
Tax rate of coal resource taxation policy in China.

	Previous policy (before December 2014) Method: Quantity-based collection (RMB yuan/ton)	Current policy (since December 2014) Method: Ad valorem collection (%)
General range	0.3–5	2–10
Inner Mongolia Autonomous Region	3	9
Hebei Province	2–4	4
Henan Province	4	4
Hunan Province	2.5	2.5
Shanxi Province	3.2	8

taxation policies have been designed in different provinces,[2] as listed in Table 1. Under such backgrounds, this study focuses on the economic and environmental effects of coal resource tax reform in China, aiming at providing helpful insights into policy design finely balancing the economic growth and environmental protection.

There are an abundance of studies focusing on the resource taxation from different perspectives. As for the effect in protecting exhaustible resources, Hotelling (1991) put forward the concept of "time-tilting" and suggested that the government could control the exploitation of some exhaustible resources by using resource taxation. As for the impact on fiscal revenue, Gupta and Mahler (1995) surveyed different policy designs with different petroleum tax rates in 120 countries and argued that the domestic taxation on petroleum products could be an important source of fiscal revenue in most countries. As for the impact on general economy, Groth and Schou (2007) suggested that resource tax instruments might affect the economic growth in the long run. Hung and Quyen (2009) implemented the dynamic Hotelling model for exhaustible resource taxation simulation and suggested the ad valorem taxation is welfare-superior to the specific one.

Regarding analysis techniques, the most popular models for quantitatively estimating the impacts of resource tax policy can be generally referred to econometric models (e.g., Lv et al., 2009), input-output models (e.g., Llop and Pié, 2008), and computable general equilibrium (CGE) models (e.g., Semboja, 1994; Wissema and Dellink, 2007; Guo et al., 2011; Zhang et al., 2013). Compared with other methods, the CGE model possesses its unique merit in energy policy simulations by providing a comprehensive analysis under the general equilibrium framework. Since this paper explores the economic and environmental impacts of coal resource tax reform in China, the CGE model could not only well depict the whole Chinese economy with the supply and demand equilibrium in each detailed sector, but also integrate the consistent real-world databases with sound theoretical basis (Shoven and Whalley, 1972). Therefore, based on the CGE model, the income effects and substitution effects caused by the reform policy could be effectively estimated and compared, which would help to explore how and why the reform policy would affect the Chinese economy and environment.

Actually, the CGE model has widely been applied to various energy taxation and environmental policies. For example, some well-known works can be referred to: the effect of carbon tax on the US economy (Goulder, 1995; Mathur and Morris, 2014), impact of greenhouse gas (GHG) tax on EU economy (Gottinger, 1998; Hermeling et al., 2013), and influence of carbon tax on China (Garbaccio et al., 1999; Liang et al., 2007; Guo et al., 2014; Liu and Lu, 2015). Especially, there are also some studies focusing on the coal resource tax in China based on the CGE model. For example, Guo et al. (2011) and Zhang et al. (2013) studied the impacts of resource tax reform on the Xinjiang province; Xu et al. (2015) explored the effects of coal resource tax reform on the different regions in China. However, to the best of our knowledge, there are few studies concerning the general impacts of coal resource tax reform on China's whole economy, based on a dynamic CGE model.

Generally speaking, the main aim of this paper is to study the general economic and environmental impacts of the coal resource tax reform in China by using a multi-sectoral dynamic CGE model, and provide some valuable insights into policy design. The rest of the paper is organized as follows. The multi-sectoral dynamic CGE model of China, together with model calibration and parameters specification, are detailed formulated in Section 2. The simulation results are reported and discussed in Section 3. Further discussions about the policy implications and model extensions are presented in Section 4. Section 5 concludes the paper and outlines the future research.

2. Model formulation

A multi-sectoral dynamic computable general equilibrium (CGE) model is developed in this section to study the impacts of coal resource tax reform on China's economy and environment. According to existing studies, various types of CGE model have been developed and applied to energy and environmental policies, such as WARM (Carraro and Galeotti, 1997), GTAP-E (Burniaux and Truong, 2002), and SCREEN (Frei et al., 2003), and different models have different features. In particular, WARM decomposes the capital stock into environmental-friendly and polluting parts, GTAP-E includes a specific treatment of carbon emissions trading, and SCREEN integrates a process-oriented energy-environment linear activity analysis framework into the CGE settings (Kumbaroğlu, 2003). Compared with these well-known CGE models, the proposed model in this paper is a fairly standard CGE approach which tries to picture the economic system of China (Liang et al., 2007; Bao et al., 2013).

The model assembles or disaggregates all sectors in China into 30 non-energy sectors and 10 energy sectors (including 6 fossil energy sectors and 4 electricity sectors), as listed in Table 2. Notably, the waste and recycling sector, which largely helps improve environment (Simões and Marques, 2012; Ferreira et al., 2014), is included in Sector other services (ORS). To capture the interactions amongst different sectors and other economic agents, three main modules are involved in the proposed model, i.e., the supply module, demand module, and closure and equilibrium module, as the model framework shown in Fig. 1. In particular, to clearly depict the coal resource tax reform policy, a novel module (i.e., coal resource tax module) is especially introduced. Sections 2.1–2.4 give detailed descriptions into these four modules, respectively, and Section 2.5 provides the data, model calibration and scenarios settings.

2.1. Supply module

Supply module represents the total supply of the market, derived from domestic products and foreign imports. The Armington assumption (Armington, 1969) is adopted here that the commodities from domestic products and foreign imports are incomplete substitutions.

For domestic products, two main assumptions are used. First, the producers gain no extra profit in a complete competitive market under the equilibrium framework (Wright, 1987). Second, the producers make optimal production decisions by minimizing the production costs. To describe the production process, a five-level nested production structure is constructed (Bao et al., 2013), as shown in Fig. 1. At the first level, for sector i at time t, 6 fossil

[2] http://www.gov.cn/xinwen/2014-12/03/content_2785819.htm.

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