Impact of quota decline scheme of emission trading in China: A dynamic recursive CGE model

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ARTICLE INFO

Article history:
Received 31 May 2017
Received in revised form 30 January 2018
Accepted 9 February 2018
Available online 12 February 2018

Keywords:
Emission trading scheme (ETS)
Quota decline scheme
Carbon rights
Computable general equilibrium (CGE)
Carbon dioxide (CO2) emission

ABSTRACT

Emission Trading Scheme (ETS) may be the effective way for CO2 reduction to mitigate global warming. However, less research has been conducted on ETS quota decline scheme. This paper establishes 6 countermeasure scenarios with different carbon right allocation decline schemes to explore the impact of these schemes on energy, economy and the environment. The results show that the emission-based ETS quota decline scheme will motivate the society to pay more attention to emission reduction. However, the scheme based on CI will make the society to focus more on resources allocation, which means that it will result to more emission and less Gross Domestic Product (GDP), but higher social welfare compared to the emission-based scenarios. The higher annual decline factor will increase the industry's pressure to cut emissions. This will cause less social welfare, GDP, sectorial output and fluctuation in commodity price. Moreover, we find that as the government fines are higher than ETS price, industries are reluctant to raise prices when they trade for cost minimization, especially those industries that incur government fine.

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1. Introduction

The problems of energy scarcity, global warming and environmental degradation are current urgent global issues. With the increasing degree of industrialization in the world, excessive energy consumption and carbon dioxide (CO2) emission may be the main cause. To solve these problems, many methods have been studied and implemented. At the policy level, carbon tax [1,2], Emission Trading Scheme (ETS) [3–5], Clean Development Mechanism (CDM) [6,7], and forest carbon sinks [8,9] are the common methods for emission reduction. At the technical level, grid energy storage [10,11], electric vehicle [12,13], Carbon Capture and Storage (CCS) [14–16], and power generation by energy solar, wind and nuclear are reliable means of emission reduction.

Carbon tax was first implemented in Finland in 1990 and was widely used in U.S. Norway, Iceland, Australia, Japan and Canada etc. [17]. Thus, Carbon tax and ETS may be the effective means of CO2 reduction [18]. Carbon tax is a market-based instrument and should be one of the most effective ways to reduce CO2 emissions. However, ETS may be less effective since the transaction costs are quite high, information is not perfectly transparent, and allocation of initial burden sharing may affect the overall macroeconomic cost of carbon reduction. Thus, studying the carbon emission trading mechanism is very significant.

Previous studies on the subject are listed in Table 1. Most research focuses on the impact of ETS, the evaluation of ETS and design of ETS.

There are many literature that assess ETS in China's ETS pilot cities and provinces or national ETS in China. Zhang et al. (2013) [34] developed a computable general equilibrium (CGE) model with regional detail to assess current CO2 intensity targets and assess the impact of provincial CO2 emissions intensity targets under the Twelfth Five-Year Plan in China. Cui et al. (2014) [35] focused on the cost-saving effects of carbon emissions trading in China for the 2020 target and found that the carbon emissions trading could yield different impacts on different provinces, and the cost-saving effects of the eastern and western provinces are more pronounced than the central provinces. Cheng et al. (2015) [36] aimed to assess the impacts of ETS policy on air pollutant emission reduction in Guangdong province, especially with respect to the embedded air pollutant emission flow caused by carbon ETS. Dai

https://doi.org/10.1016/j.energy.2018.02.039
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et al. (2018) [37] accessed the economic impact of ETS policy among sectors in China and found that emissions trading price and market scale are related to the specific design of the ETS policy. Wu et al. (2017) [38] utilized a multi-regional CGE model to analyze the economic impacts of ETS policy when combined with RES policies in China. Zhang et al. (2017) [39] implemented different scenario analysis and simulated a conceivable multi-region integrated emissions trading scheme using a CGE model. Wang et al. (2015) [40] analyzed the economic impacts of ETS among four energy intensive sectors in Guangdong province with a two-region dynamic CGE model. Xia & Tang (2017) [41] proposed an interregional input-output model to derive cost curves for regional marginal abatement and estimate interregional embodied emissions and presented an emission trading model. Nevertheless, the impacts of some details of the ETS market are ignored, such as the impact and the choice of quota allocation scheme of carbon emission, and quota decline scheme. Thus, this paper fills the knowledge gap of the impact of ETS quota decline scheme and explores the impact of ETS’s quota decline scheme on the economy, energy and environment.

Many methods, such as econometric model [42,43], input-output method [44], Logarithmic Mean Divisia Index method [45,46], and Computable General Equilibrium (CGE) model [47–49], are employed in the study of energy policy. The econometric method is mainly used to explore the relationship between policy and economy. The prediction power of input-output method is relatively weak. However, using CGE model could analyze the energy, environmental, and economic impacts of energy policy and can accomplish a certain forecast [50].

This paper establishes a dynamic recursive CGE model and constructs a Business as Usual (BaU) scenario and six Countermeasure (CM) scenarios to simulate and analyze the impact of different ETS quota decline scheme, which is commonly used in China, to determine the sensitive factors. The main innovation of this paper is:

1) Few literature have studied the quota allocation and the ETS decline scheme. This paper will fill the research gap on the impact of ETS quota decline scheme.

2) A dynamic recursive CGE model is established in this paper to simulate the different quota decline scheme in China’s national ETS during 2017–2030.

The remaining part of the study is as follows: section 2 introduces the CGE model, social accounting matrix and model dynamics in this paper. In section 3, scenario design is described and the CM scenarios are introduced. Section 4 shows the simulation results and discussion. A sensitive analysis is introduced in section 5. The final conclusions are presented in section 6. In order to make this paper better understood, the main abbreviations in this paper are shown in Appendix B.

2. Methodology

2.1. CGE model

CGE model is widely used in policy analysis [51–53]. Constructions of all CGE models are based on traditional Walras paradigm, which means that the model can be described as a system of simultaneous equations deduced by all actors’ maximizing behavior. CGE model simulates the activity of social subject like residents/households, enterprises, government, and foreigners [54,55]. Five (5) blocks make up the CGE model in this paper to analyze the impact of ETS: production block, income-expenditure block, trade block, ETS block, and macroscopic-closure & market-clearing block. The general framework of the CGE model is according to CCI-ETS model in Lin & Jia (2017) [56], and is illustrated in Fig. 1.

2.1.1. Production block

The CGE model in this paper assumes that one sector only produces one kind of product by the utilization of factors, as not all
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