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The effects of carbon reduction on sectoral competitiveness in China: A case of Shanghai

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HIGHLIGHTS

- A two region CGE model is developed.
- Carbon tax impact on sectoral competitiveness is evaluated by this CGE model.
- Price and scale effects are investigated for determining the impact of different carbon tax rates.
- Policy implications are presented for future mitigation policy making.

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ABSTRACT

The Chinese government has committed to reduce its carbon dioxide emissions per unit gross domestic product by 60–65% from 2005 levels by 2030. In order to achieve this commitment, various measures should be taken. Due to the complex relationship between carbon emission and economic development, it is critical to quantify the impacts of different measures. Under such a circumstance, this paper is to identify the effects of carbon tax on the sectoral competitiveness in Shanghai by 2030 under unequal imposition of carbon tax between Shanghai and the rest of China by using a two-region dynamic computable general equilibrium (CGE) model. Research results show that different carbon tax rates in different regions would affect GDP of Shanghai and the outcomes are different under different scenarios. In general, a lower carbon tax rate can lead to a higher output and these output changes could further influence the sectoral competitiveness. Under the tax44 scenario, sectors such as agriculture, textile, transport equipment, and electronics are the winners in Shanghai, with outputs increased by 2.02%, 1.47%, 1.08% and 3.05%, respectively; while food production, petrol oil, chemicals and non-metal are the losers, with outputs decreased by 2.02%, 0.87%, 0.03% and 2.39%, respectively. This study also reveals that price and scale effects are the key factors influencing the changes of sectoral outputs. Such findings provide useful insights to those policy makers to allocate appropriate carbon reduction targets to different regions.

1. Introduction

Climate change has received the global attention due to its increasing impacts on the natural ecosystem and economic development [1,2]. Various measures (such as stricter policies, technological measures and market-based instruments) have been proposed for reducing carbon emissions all over the world [3–8]. As the largest developing country and carbon emission emitter, China has actively responded climate change, with the implementation of carbon intensity reduction targets to different regions and market-based instruments (such as emission caps and trade) [9–12]. However, the carbon tax policy has not been implemented in China although it will significantly influence regional development [13–15].

As a representative Pigovian tax, carbon tax mainly focuses on the internalization of externalities induced by carbon emissions. It could efficiently reduce the use of fossil fuels and improve energy efficiency by means of a long-term market system. To date, many countries have implemented carbon tax, including Australia, Sweden, Norway, United Kingdom, British Columbia, Denmark, Switzerland, Mexico, Finland, Ireland, Japan, France,

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the Netherlands and Germany [16–20]. Studies on carbon tax emerged in the early 1990s. With the rapid economic development and the improvement of public environmental awareness, more relevant studies have been conducted, focusing on carbon tax at both macro and micro levels. These studies could be classified into three main categories, including the impacts of implementing carbon tax [7,21–23], optimal carbon pricing [19,24,25] and comparison of various mitigation options [26,27]. With regard to China, several studies have been published and could be classified into four levels. The first level is at the national level, in which the research objective is to quantify the impacts of different tax rates on the macro-economy so that the optimal carbon tax rate can be determined [28–30]. The second level is at the regional level, aiming to uncover the effects of one uniform carbon tax rate on the provincial economy. For instance, Zhang and Li [31] used the panel data of 29 provinces and applied a method of Generalized Least Squares estimation (GLS) to analyze the impact of carbon tax on economic growth in 29 Chinese provinces for the period of 1999–2008. Their results show that carbon tax could stimulate economic growth in most eastern regions, but hinder some provinces in the middle and western China. Yang and his colleagues [32] evaluated the changes of regional fuel demands induced by carbon tax and found that a total amount of more than 130 million tons of CO_2 emissions can be reduced in the east and southwest China, but with only marginal mitigation effects in the northwest China. The third level is at the sectoral level, in which short-term impacts of carbon tax on sectoral competitiveness were examined so that the best carbon tax rates can be identified [33,34]. Several studies also investigated how to apply complementary measures to reduce the negative effects of carbon tax on industrial sectors [35–37]. The fourth level is at the company or even industrial process level, aiming to identify the obstacles for the design of carbon tax policy. For example, Liu and his colleagues [38] investigated the relations between selected policy attributes and company policy preference and pointed out that carbon tax would determine one company's management preference. Kuo and his colleagues [39] further discussed the interactions between local governments and enterprises for implementing carbon taxes and found that appropriate carbon tax rates can encourage the enterprises to adjust their production processes to achieve carbon emission reduction.

Most of the aforementioned studies are from an aggregated perspective. As a country with a large territory and significant regional disparities, it is important for the Chinese government to allocate the appropriate carbon reduction targets to all the provinces. Practically, the Chinese central government allocates carbon intensity reduction targets for all the provinces in its Five-Year-Plans. For instance, in the latest 13th Five-Year-Plan (2016–2020), each Chinese province has to achieve the reduction target of carbon dioxide intensity by 2020 stated in the Copenhagen Commitment. Eastern provinces such as Beijing and Shanghai need to decrease by 20.5%, provinces in the middle China such as Hunan and Anhui need to decrease by 18%, while western provinces such as Qinghai and Xinjiang just need to decrease by 12%. The allocation essence of such reduction targets is that more developed regions need to bear higher burden of carbon reduction while those western provinces have much lower targets. Such allocations are based upon the economic development levels, rather than considering many other relevant factors, such as resource endowments, industrial structure, energy structure, historical contributions, and cultural difference. Consequently, the local stakeholders may feel unfair and reluctant to implement such targets seriously, which eventually leads to the failure of national reduction target. Under such a circumstance, it is rational to initiate carbon tax as one effective policy to further encourage all the stakeholders to reduce their carbon emissions although the potential impacts of such a policy on the regional economy should be evaluated. Academically, no relevant studies have been conducted, resulting in that the effects of carbon tax on different markets (local, national and international markets) are still unknown. In order to fill in such gaps, the main objectives of this study are to answer the following questions:

- What are the effects of different carbon tax rates on the regional development?
- How do the local industries respond to different carbon tax rates between the target region and other competing regions?
- How could market mechanism influence the sectoral outputs in the target region?

Shanghai is chosen as the target region since it is the largest Chinese city and has an advanced economy [40]. The rest of China is regarded as one competing region so that the potential effect of carbon tax can be examined under different scenarios. One two-region dynamic CGE model is developed to quantify the effects of carbon tax on sectoral outputs in the target region. The CGE model has been widely applied for carbon tax issues due to its features on capturing the full range interaction and feedback effects between different agents in the economic system. It can help clarify the interconnected economic effect among different regions and sectors [36,40–43]. Several studies have been conducted by linking the CGE model with carbon tax [39,41,44,45], making it an effective method on such a topic. It is expected that the research outcomes from this study will help the Chinese government to examine the potential impact of levying a carbon tax and help the local policy makers to prepare more appropriate policies to transit their economy toward low carbon development. The whole paper is organized as below. After this introduction section, Section 2 details the two-region dynamic CGE model and lists data sources, as well as explaining how to set different scenarios. Section 3 presents the research results. Section 4 discusses the policy implications. Finally, Section 5 draws research conclusions.

2. Methods and data sources

2.1. Two-region dynamic CGE model

The CGE model could capture the full range of interaction and feedback effects between different agents in the economic system. It has been widely used to assess the economic and environmental impacts of different climate policies at the global [46,47] and national [48] levels. In this study a two-region dynamic CGE model that includes shanghai and the rest of China (ROC) is developed based on the provincial CGE model developed by Dai [49].

Such a CGE model can be classified as a multi-sectoral, multi-regional, and recursive dynamic CGE model that covers 37 economic commodities and corresponding sectors. The features of this model are similar to the one-region model [49], including a production block, a market block with domestic and international transactions, as well as government and household income and expenditure blocks. Activity output for each sector follows a nested constant elasticity of substitution (CES) production function. Inputs are categorized into material commodities, energy commodities, labor, capital and resources. Technical descriptions are provided in supporting material of this paper. This CGE model is solved by Mathematical Programming System for General Equilibrium under General Algebraic Modeling System (GAMS/MPSGE) [50] at a one-year time step. It has been intensively used for assessing China's climate mitigation at the national [49,51,52] and provincial [40,53] levels.