Energy Policy 113 (2018) 9–19

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Exploring the impacts of regional unbalanced carbon tax on CO_2 emissions and industrial competitiveness in Liaoning province of China

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ARTICLE INFO

Keywords:
Carbon tax
Nationally determined contributions (NDCs)
Computable general equilibrium model
Liaoning in China

ABSTRACT

Carbon tax is regarded as a useful policy instrument to achieve the environmental target efficiently. However, the effect of regional unbalanced carbon tax is still unknown. In this study, an improved two-region computable general equilibrium (CGE) model is developed to fill this research gap with Liaoning Province and the rest of China (ROC) as the study area. Business as usual (BaU) and nine carbon tax scenarios are designed. Results show that in 2030, the highest carbon tax of 221 USD/ton-CO_2 in taxC4P8 scenario in Liaoning province will lead to carbon reduction of 44.92% with the cost of 5.54% Gross Domestic Product (GDP) loss. Price effect and scale effect are the two mechanisms that affect the changes in GDP, industrial output and CO_2 emissions. Industrial structure, energy consumption and carbon intensity of Liaoning are overwhelmingly affected by the price effect. Most less energy-intensive industries belong to the winner industries due to the higher influence of domestic market. By contrast, loser industries, including most of the energy-intensive industries, are mainly affected by the changes of provincial and international markets. ROC region is mainly affected by the price effect. Suggestions about preferential developmental industries are offered to balance the environmental and economic concerns.

1. Introduction

As an important factor of climate change and global warming, the concentration of carbon dioxide (CO_2) in the atmosphere have experienced an accelerated growth from 280 parts per million (ppm) CO_2 equivalent (CO_2e) at the beginning of Industrial Revolution to over 430 ppm recently with the development of industrialization (Harris and Roach, 2016; IPCC, 2007; Mohajan, 2011; Shakun et al., 2012). Stabilization at 450 ppm CO_2e, recognized as the carbon cap to avoid the increase of temperature within 2 °C comparing to the pre-industrial levels (IPCC, 2014), is hard to achieve without zero-carbon emissions or even "carbon negative" options. Therefore, lots of countries announced their carbon reduction plans. As the biggest carbon emitter, China promised to reduce its carbon intensity by 60–65% in 2030 comparing to the level in 2005 and carbon emissions will peak before 2030. However, it remains a challenge to achieve these targets without affecting the economic development.

Carbon tax is recognized as one of the most cost effective economic instruments to control carbon emissions with mild economic impact and is highly recommended by some economists and organizations. Some countries, like Denmark, Finland, Sweden, Netherlands, Norway, etc, have built a comparatively complete carbon tax system. Evaluation of practical application of carbon tax in Denmark showed that the green tax package (including carbon tax) makes a great contribution to environment conservation (Hansen, 2001). Swedish Environmental Protection Agency also confirmed the carbon reduction effect of carbon tax, and different impacts occurred in each industrial sector because of the various carbon tax rate (Bohlin, 1998; Lin and Li, 2011). However, only 2% carbon emissions intensity reduction was contributed by carbon tax in Norway during 1990–2000 because of the tax exemption in energy-intensive industries (Bruvoll and Larsen, 2004). These experiences indicate that the effect of carbon tax will be affected by different implementation measures.

Plenty of simulation studies on carbon tax in China suggested the

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http://dx.doi.org/10.1016/j.enpol.2017.10.048
Received 11 July 2017; Received in revised form 16 October 2017; Accepted 26 October 2017

positive effects on carbon emissions reduction and climate change mitigation with limited economic losses (Chen et al., 2015; Guo et al., 2014; Zhang et al., 2017). Gross Domestic Product (GDP) and consumption in carbon tax scenarios even exceed baseline levels due to the investment mechanism in the research of Garbaccio et al. (1998). Yao and Liu (2010) concluded that carbon tax is beneficial to carbon emission reduction, energy efficiency improvement and industrial structure adjustment. Effect of Fossil fuel conservation and renewable energy promotion is another advantage of carbon tax (Lu et al., 2010). However, in the research of Glomsrød and Wei (2005), carbon tax on fossil fuel combustion has a limited effect on total emissions because of the coal leakage to tax exempted processing industries. To improve the effect of carbon tax, Zhang et al. (2016) found that moderate carbon tax rate and carbon tax recycling policy could cushion the negative impacts of carbon tax. By combining capital tax with subsidy policy, carbon tax can play a better role in improving both cost-effectiveness and emission performance (Zhang et al., 2017). The environmental and economic effects of carbon tax on specific industry and industry chain were also estimated (Liu and Lin, 2017; Wang et al., 2017; Zhang et al., 2017). For example, Dong et al. (2017) analyzed the effect of carbon tax on the industries in 30 provinces in China and evaluated the carbon tax effect in each region. In addition, Liu et al. (2015) searched the preferred carbon tax policy from the company perspective, and suggested that carbon tax system should allow tax relief to energy-intensive sectors. Distributional effect of a carbon tax on households in various income groups and the food consumption patterns was analyzed by Jiang and Shao (2014) and García-Muros et al. (2017).

However, these former studies only considered the effects of carbon tax under unified standard at the national or regional scale. Regional development level in China is highly diverse, which brings unbalanced carbon emissions. The same carbon tax level will bring different influences for different region. In affluent areas, slightly extra cost induced by carbon tax will ultimately be transferred to the final customers and has limited effect on industrial upgrading. While, same tax level in backward areas may bring certain economic pressures for the enterprises and affect their upgrading ability (Lin and Li, 2011). Thus, regional unbalance tax plan is necessary. Moreover, the existing regional economic synergistic development will be disrupted because of the different increasing production cost brought by regional unbalance carbon tax. Therefore, industrial competitiveness under regional unbalance carbon tax also should be figure out to ensure the normal development of regional economy (Lu et al., 2010).

Given these concerns, in this study, Liaoning Provice and the rest of China (ROC) are chosen as the two research regions. Relative levels of carbon tax between both regions from 2012 to 2030 are different, which we call the regional unbalanced carbon tax. Three research aspects are focused: 1. To investigate the economic and environmental impacts of regional unbalanced carbon tax and provide empirical evidences of the interaction between two research regions; 2. To explore the competitiveness of different industries in Liaoning province under unbalanced regional carbon tax. 3. To provide policy suggestions based on the impact results of regional unbalanced carbon tax. CGE Model is applied as the research method. The paper is organized as follows: the situation of Liaoning province is introduced in the second part. The third part explains the detailed information about model structure and scenario setting. Section 4 presents the research results and discussion. The policy suggestions and conclusions are put forward in Section 5 based on the research results.

2. Research area

Liaoning is located in the northeast part of China (Fig. 1) with a total area of 148,000 km^2. In 2014, the GDP in Liaoning province was 2862.66 billion, ranking 7th among 31 provinces in China. Half of the GDP was contributed by the secondary industry. Tertiary industry accounted for 41.77% of the total GDP. The share of agriculture was only less than 10%. The population was 43.91 million in Liaoning Province, of which 29.44 million are urban residents (NBS, 2014a).

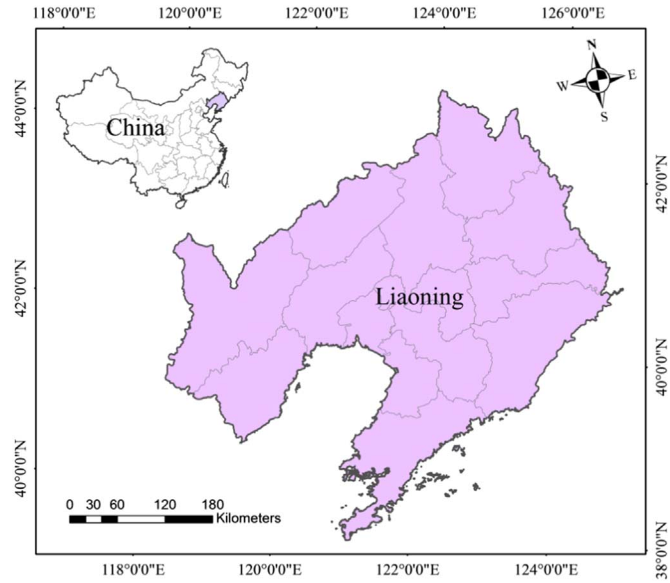

Fig. 1. Location of Liaoning Province.

As the first typical heavy industrial base, Liaoning has played a key role on promoting China's industrialization due to its rich natural resources and solid industrial foundation. However, along with the development of the reforms and opening-up of China, the economic center transferred to the coastal regions in southeast area whereas the development of Northeast region slowed down. In 2003, Northeast Area Revitalization Plan was promulgated by the State Council and brought a new development peak for Liaoning Province.

Crude oil production and processing, steel production and automobile production in Liaoning province still provide strong support for the national industrialization and the region's development. Hence, energy-intensive industries are the main economic pillars. Together with the outdated equipment and technology, environmental problems in Liaoning Province are severe. In 2015, Liaoning province emitted 680.08 Mt CO_2, accounting for 6.39% of the national total. In global level, its emission is between Germany (777.91 Mt, ranking 7th in the world) and Islamic Republic of Iran (633.75 Mt, ranking 8th in the world). (EDGARv4.3.2, 2016; Guan et al., 2016; Statistics, 2016).

3. Methodology

3.1. The IMED/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 global (Böhringer and Löschel, 2005; Fujimori et al., 2014, 2015) and national levels (Wang et al., 2009; Zhang, 1998).

The IMED/CGE (**I**ntegrated **M**odel of **E**nergy, Environment and Economy for Sustainable **D**evelopment/**C**omputable **G**eneral **E**quilibrium) model applied in this study can be classified as a multi-sector, 2-region, recursive dynamic CGE model continuously developed by the Institute of Environment and Economy (IoEE) at Peking University. It includes Liaoning province and ROC using the latest dataset of Liaoning and China in 2012. Industries are classified into 31 sectors, including basic and energy transformation sectors (Tab. A1). This CGE model is solved by Mathematical Programming System for General Equilibrium under General Algebraic Modeling System (GAMS/MPSGE) (Rutherford, 1999) at a one-year time step. Major model