Monitoring and Analysis on the Overall Economic Operation to Formulate Feasible Carbon Tax Policies by Utilization of CGE Model

Long Zhou and Fang Liu*

Business School, Cardiff University, Cardiff, CF10 3EU, UK

*Corresponding Author Email: ansoceanjob@gmail.com

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Abstract: Carbon tax policy serves as a very significant economic means of policy in environment and resource, which is conducive to the realization of energy conservation and emission reduction and sustainable development goals in China. By building the CGE analysis model of carbon tax policy, this paper monitors and analyzes the overall economic operation. On this basis, the reasonable tax design of carbon tax collection and the corresponding carbon tax policy reference suggestions are put forward.

Global warming has become a common difficulty confronted by all countries in the world. In order to reduce consumption of fossil energy and effectively reduce carbon dioxide emissions, it is imperative to utilize carbon tax to achieve the purpose of environmental governance. Carbon tax policies can be used to increase the government's fiscal revenue, but the most fundamental goal of policy formulation and implementation is to effectively reduce carbon dioxide emissions, improve energy efficiency, optimize energy consumption structure, and promote industrial structure upgrading.

1. Analysis of the Status of China's Carbon Emission and Research Significance of Carbon Tax Policy

1.1 Analysis of Overall Measurement of Carbon Emission in China

In 2020, China's carbon emissions stood at 10 billion tons, accounting for about 29 percent of the global total. We can conclude from the analysis and comparison of China's per capita GDP, M2/GDP, labor productivity and total factor productivity data that: China's population was about 430% of the United States, and GDP accounted 70% of that of the United States.Besides,broad money supply was about 175% of the United States, carbon emissions accounted for about 200%, while energy consumption stood at about 150% of the United States. Through the comparison of several groups of data, it can be concluded that improving energy efficiency and capital efficiency in China is an problem demanding prompt solution.

Currently, the large amount of carbon emissions in China lies in the following two reasons [1]: First, China enjoys a large population base. Although the per capita carbon emissions are less than that of the United States, the amount of carbon dioxide produced by living and production in China has already reached the threshold that the environment can bear due to the large population of more than one billion people with the deteriorating ecological environment. Second, the unreasonable industrial structure in China. China's rapid economic development is achieved mainly based on fossil energy consumption with the consumption of natural resources in a constant manner. This extensive economic growth mode will surely cause serious impact on sustainable development.

1.2 Spatial Pattern of Carbon Emission in China

Per capita GDP and per capita carbon emissions of the spatial characteristics can be manifested as: Most of the municipality directly under the central government and inland provinces belong to

the "low - low pattern", the per capita GDP and per capita carbon emissions are below the national average, such as Yunnan, Sichuan, Guizhou, Anhui, Henan, Hunan, Hubei, Jiangxi and Guangxi and other places, these provinces should be given attention in economic development to improve the level of per capita income. Some coastal provinces and municipalities belong to the "low-high pattern" with high per capita income and low carbon emissions, such as Guangdong, Zhejiang and Fujian, where the current development pattern should be maintained. Some provinces and municipalities present a "high-high pattern", with high per capita GDP and high carbon emissions. For example, Liaoning, Jiangsu, Tianjin and Shanghai, carbon emissions should be reduced with a more effective low-carbon development model. There are also a small number of provinces belonging to the "high-low pattern" with low per capita GDP and high carbon emissions, mainly including Hebei, Shanxi and Ningxia, which should seek for a new economic development model to achieve economic transformation and development [2].

1.3 Background and Significance of Carbon Tax Policy Research

With the acceleration of China's urbanization and industrialization process, the continuous growth of carbon dioxide emissions has caused many environmental problems, which has restricted the sustainable development of China's economy and society. To cope with this severe challenge, the Chinese government made a commitment at the World Climate Change Conference in Copenhagen and announced the target of carbon dioxide emission reduction: By 2020, carbon dioxide emissions per unit of GROSS domestic product should be reduced by 40 to 45 percent from 2005 levels. The 13th Five-Year Plan further proposes to reduce carbon intensity by 60 to 65 percent from 2005 levels by 2030 through market means. As a long-term mechanism to promote carbon emission reduction, carbon tax is not only an effective means for the government to achieve emission reduction, but also an important tool to regulate climate change. The Third Plenary Session of the 18th CPC Central Committee has formally integrated the legislative issues of carbon tax and environmental tax into the scope of discussion, which has very important strategic significance for the policy impact assessment of carbon tax [3].

2. Construction of Carbon Tax CGE Model and Scenario Setting

CGE model describes the equilibrium relationship between supply and demand among various sectors in the process of social economic activities through a set of equations system. CGE model was used to simulate the impact of policy changes on economic activities, that is, to compare and analyze the changes of equilibrium state caused by policy changes.

2.1 Construction of CGE Model of Carbon Tax

In the simulation of carbon tax, carbon emissions are taken as the basis for tax calculation, and carbon tax policy CGE model is constructed accordingly.Compared with the total demand for fossil energy, the final use of fossil energy accounts for a relatively small proportion. To simplify the problem, it is assumed that carbon tax is not levied on the final utilization, rather it was only on the fossil energy during intermediate utilization [4].The equation for introducing carbon tax into CGE model is as follows:

$$CTAX_i = t_c \cdot \sum_j E_{ji} \cdot \theta_j$$

(1)

$$j = coal、 oil、 gas$$

$$CTAX_j = t_c \cdot \sum_i E_{ji} \cdot \theta_j$$

(2)

$$j = coal、 oil、 gas$$

$$TCTAX = \sum_j CTAX_j$$

(3)

$$t_{cj} = CTAX_j / (PQ_j.QQ_j) \tag{4}$$

In which, $CTAX_i$ refers to the carbon tax levied by the government on the production sector i. $CTAX_j$ denotes the the amount of tax to be paid for fossil energy j, including coal, oil and gas. t_c represents the tax rate of specific tax, that is, the carbon tax levied per unit of carbon dioxide emissions. $TCTAX$ represents the total amount of carbon tax. t_{cj} demonstrates the AD valorem tax rate for conversion of fossil energy j, that is, the ratio of carbon tax levied on a fossil energy to the value of domestic demand for the energy.

Due to the imposition of carbon tax, the demand price of fossil energy will rise to the level $(1+t_{cj}).PQ_j$, which will impose direct effect on the demand cost of fossil energy in the corresponding production function. Meanwhile, the tax will increase the revenue of government departments. Therefore, the total revenue function of government is changed as:

$$YGT = \sum_i GINDTAX_i + \sum_i GTRIFM_i + GHTAX + GETAX + GWY + TCTAX \tag{5}$$

2.2 Scenario Setting for Carbon Tax

Due to the large differences in emission reduction targets and energy consumption structure among countries, there are also large differences in the setting of carbon tax rates.In 2010, the Ministry of Finance and members of the Chinese People's Political Consultative Conference (CPPCC) concluded that it was feasible to implement carbon dioxide emission reduction policies in China, but the tax rate should be gradually raised. Before that, the tax rate should not exceed 10 yuan per ton.For environmental protection departments, the tax rate can be raised from 20 yuan per ton to 50 yuan by 2020.In 2019, authorities have fixed the level of the tax at between 10 yuan and 100 yuan per ton.Therefore, tax rates are set as 10 yuan/ton, 20 yuan/ton, 40 yuan/ton, 60 yuan/ton and 100 yuan/ton in this paper, and different carbon tax levels are respectively substituted into CGE model as economic policy impact variables to simulate and analyze the policy impact results.

3. Analysis of Simulation Results of Carbon Tax Policy

3.1 The Impact on China's GDP

The implementation of carbon dioxide emission reduction policy will inevitably cause a certain degree of impact on the production costs of various industries. From the perspective of China's macro economy, the negative impact of carbon dioxide emission reduction policy is reflected that the higher the tax rate of carbon tax, the greater the decline of GDP [5].The reasons are as follows: first, due to the implementation of the tax policy, the production sector will raise the prices of products, and the rise in prices will inevitably lead to the decline of residents' desire for consumption and the overall consumption level.Second, the carbon tax policy leads to the decline of output. The savings of enterprises will decrease with the decrease of their capital income. The total savings of the government, residents and enterprises will decrease, and the corresponding investment will also decrease.Third, when the price of domestic products rises while the price of foreign products stays the same, people's willingness to buy foreign products will increase [6].

3.2 The Influence on Economic Entities in China

The implementation of emission reduction policies will have a certain impact on macroeconomic entities.The impact of five carbon tax rates on residents, government, enterprises, social welfare and total investment [7] is analyzed, as shown in Table 1.

In terms of residents' consumption and income and the carbon tax paid by relevant enterprises, product prices will rise, and consumer demand will decline, and residents' savings and income will increase.As far as residents' social welfare is concerned, according to the utility function, the

decrease degree of residents' consumption level will increase according to the increase of tax rate, so residents' social welfare shows a downward trend.The collection of carbon tax increases the government revenue, and at the same time improves the government's purchasing power and consumption level [8].In light of total income of enterprises, capital income accounts for a large proportion. Even if the government transfer payment income is partly increased, overall enterprise income shows a downward trend.

Table 1. Impacts of different carbon tax policies on economic entities

Economicentity	Items	10Yuan/ton	20Yuan/ton	40Yuan/ton	60Yuan/ton	100Yuan/ton
Residents	Resident income	0.023%	0.046%	0.267%	0.287%	0.327%
	Consumer prices	-0.149%	-0.315%	-0.495%	-0.694%	-1.164%
	Socialwelfare	-150.12	-310.11	-485.11	-684.12	-1021.88
Government	Governmentrevenue	1.081%	2.189%	3.333%	4.518%	7.042%
	Government consumption	0.991%	1.998%	3.028%	2.094%	4.326%
Enterprises	Enterprise income	-0.119%	-0.249%	-0.388%	-0.544%	-0.922%
	Enterprise consumption	-0.119%	-0.249%	-0.388%	-0.544%	-0.922%
	Total investment	-0.051%	-0.091%	-0.152%	-0.221%	-0.452%

3.3 Impact on China's Energy Consumption

With the increase of the national carbon tax rate, the energy consumption of various sectors is significantly impacted, as shown in Table 2.

Table 2. Impacts of different carbon tax policies on total energy consumption

Category	10Yuan/ton	20Yuan/ton	40 Yuan/ton	60 Yuan/ton	100Yuan/ton
Coal	-6.103%	-12.455%	-18.024%	-25.101%	-37.545%
Petroleum	-0.413%	-0.823%	-1.345%	-2.013%	-3.645%
Natural gas	-0.612%	-1.213%	-1.985%	-2.789%	-5.106%

Energy with intensive consumption is the main body for carbon tax and the main source of CO_2 emissions. As the carbon tax rate rises, the prices of these energy sources will increase significantly, such as coal, oil and natural gas, as shown in Table 2, and in order to save expenses and pay less taxes, enterprises will try efforts to reduce the consumption of high-energy energy sources, so the consumption of energy will gradually decrease[9].In addition, the coal contribute the largest proportion of CO_2 emissions in China. With the increase of tax rate, the consumption of coal among the three energy sources is also affected the most, which leads to its proportion in the energy structure becoming smaller and smaller, while the proportion of oil and natural gas is relatively larger. Therefore, the implementation of carbon tax policy can improve China's energy consumption structure to a certain extent.

3.4 Impacts on Emissions of Carbon Dioxide of Various Sectors in China

After the carbon tax is levied, the CO_2 emissions of each sector will decrease with the increase of the carbon tax rate, so as to effectively reduce the greenhouse effect and achieve the purpose of environmental protection.

As can be discovered in Table 3, the emissions of CO_2 all decrease with the increase of carbon tax level by simulation analysis of the six sectors .In addition, for sectors with high energy consumption such as coal, the effect of emission reduction is more significant.

Table 3. Impacts of different carbon tax policies on emissions of carbon dioxide

	10 Yuan/ton	20Yuan/ton	40Yuan/ton	60Yuan/ton	100Yuan/ton
Primary industry	-3.224%	-6.123%	-9.154%	-11.541%	-19.261%
Secondary industry	-2.256%	-5.598%	-12.365%	-18.254%	-20.365%
Tertiary industry	-3.625%	-7.325%	-10.568%	-12.545%	-19.245%
Coal	-8.254%	-21.265%	-29.562%	-42.652%	-57.629%
Petroleum	-0.926%	-2.561%	-3.854%	-4.126%	-9.972%
Natural gas	-4.654%	-8.845%	-12.456%	-15.84%	-26.662%

4. Suggestions on Improving the Carbon Tax Policy System

In the process of China's development of low-carbon economy, it is necessary to make gradual trial and implement a complete and feasible carbon tax policy system in line with China's national conditions: First, it is urgent to establish and improve laws and regulations for promoting energy conservation and emission reduction, as well as financial input mechanisms and economic incentive policies, so as to provide a strong legal and policy guarantee for promoting the realization of carbon emission reduction targets.Second, to actively promote the development of clean energy while studying and implementing the carbon tax policy.Besides, to further strengthen the optimal allocation of energy production and consumption structure and adjust the development structure of energy with coal as the dominate alternative so as to actively promote the clean utilization of fossil energy[10].Third, to further optimize the industrial structure of China's economy, strictly control the rapid growth of industries with high pollution and high energy consumption, and vigorously promote the rapid development of strategic emerging industries and modern service industries.Fourth, to actively encourage and promote the innovation in energy science and technology. Through technological progress, we will promote the technical emission reduction of energy-intensive industries and the clean utilization of fossil energy, and constantly build and improve the innovation system of green energy technology.

References

[1]Tang Ling, Zhang Liang, Yu Le'an, Research on the impact of carbon tax policy based on CGE model[J].Journal of China University of Petroleum(Edition of Social Sciences),2020(1):11-17.

[2]Yang Lili, Shao Shuai, Cao Jianhua, Review on the economic effects of carbon tax policy[J].Study & Practice,2012(05):38-49.

[3]National Bureau of Statistics, energy consumption report of China industrial research institute [Z].2019,09.

[4]Lou Feng, Simulation study on the impact of carbon tax on China's macro economy and carbon emission reduction[J].The Journal of Quantitative & Technical Economics,2014,31(10):84-96.

[5]Li baoyu, Liu Yang. The balance test of data on national economic accounting [J]. Statistical Research,2015,32(06):11-19.

[6]Liu Heng, Research on the impact of carbon tax on China's Civil aviation Industry based on CGE model [D].Doctoral Dissertation of China University of Geosciences, 2014,74-75.

[7]Dong Mei, Comparison of carbon reduction effect between carbon tax and energy efficiency improvement: Analysis based on CGE model.Journal of Financial and Economic Theory, 2020(1):47-55.

[8]Sun Licheng. Research on carbon emission decision of enterprises considering the substitution effect of carbon tax and carbon trading[J].China Population,Resources and Environment,2019,29(11).

[9]Wang Jun, Cheng Xianxue, Jiang Yushan, et al.Research on behavior selection of supply chain members based on carbon emission under carbon tax policy[J].Chinese Journal of Management Science, 209:1-12.

[10]Ma Wencong, Ye Yangping, Chen Xiude.Innovation based portfolio policy: A review and future prospects [J].Science & Technology Progress and Policy, 2020, 37(15):152-160.