

CGE Model Based Natural Gas Tax Exemption Analysis in Beijing Area with Emphasis on Social Welfare and Energy Usage

Abstract: Acting as a cleaning and great efficiency fuel, natural gas has gained more and more notice. Reflect on the low percentage of natural gas usage in China, how to motivate natural gas production and usage from macroeconomic view worth discussing. Although carbon tax can be efficiently used to promote carbon emission reduction, the implementation of levying carbon tax might negatively impact natural gas industry and other clean energy industry. Based on this, with the employment of CGE theory, this paper applies GAMS advanced modeling system to construct a CGE model which takes natural gas tax exemption as the target, and takes Beijing as an example to simulate and analyze the impact of gas tax exemption policy on carbon emissions, economic system and social welfare. The paper reveals that the exemption of natural gas might be a possible choice which can control the CO₂ emission in Beijing to a certain extent. At the same time, it has a positive impact on the macroeconomic variables and social welfare of the residents in Beijing. Therefore, I suggest that during the early periods of the design and implementation of carbon tax, the protection of natural gas industry can be considered.

Keywords: Carbon Tax; CGE; Carbon emission; Economic system; Social Welfare

1 Introduction

Nowadays, energy shortage and environmental pollution are seriously restricting the sustainable development of the world economy. As a developing country, the issues of energy and environment in China is particularly prominent. Therefore, we should agree on way to lower the road of carbon development, transform the traditional economic development pattern and vigorously promote the energy-saving emission reduction, which is not only in line with the national conditions of the development strategy, but also can resolve the problem of current international climate and ease the political pressure. However, with the acceleration of industrialization and urbanization, China's CO₂ emissions continue to grow rapidly. Therefore, it is an important and urgent task to take effective measures to achieve the "double dividend" of emission reduction and economic growth, and China needs to implement politically feasible, economically efficient environmental economic policy to develop a "low carbon" economy which is being characterized by reduced energy consumption and low pollution. And based on these measures, it can realize the optimization of source structure and industrial structure, improve energy efficiency, reduce greenhouse gas emissions, and ultimately realize the economy and society sustainable development.

Many of developed countries implement the path and mode of low carbon economy in the form of government macroeconomic regulation and control, and it is mainly through levying carbon tax or climate change tax to reduce domestic energy consumption and apply advanced technology. Therefore, carbon tax, as a long-term system to promote the reduction of carbon emissions, is not only an important tool for the government to actively control climate change, but also an effective measure to achieve emission reduction.

It is worth mentioning that as a policy scheme, the carbon tax involves the distribution of social wealth, and the difference in the level of its burden rate will inevitably lead to the change of social welfare. As a result,

many scholars have conducted researches from different perspectives on the social welfare effects of the carbon tax: Ma et al.^[1] established the optimization model of current energy tax system in China to maximize social welfare; Weitzed et al.^[2] “analyzed the carbon tax impact on emissions and social welfare in India by building a single national equilibrium model”; Springmann^[3] believed that the external effects of carbon tariffs have no significant impact on the social welfare of the country; Liao et al.^[4] “examined the impact of different carbon tax policies on the social welfare of the country by constructing a game model of two stage trade”, and the study shows that the carbon tax in the developing countries is conducive to enhancing the level of social welfare; Wang^[5] used the “Stackelberg game method to analyze the carbon emissions impact on the national social welfare, and the result shows that whether levying carbon tax has boosted social welfare depends on the social costs and other factors”; Almutairi et al.^[6] proposed a design theory of emission sector based carbon tax policy, and took the cement industry as an example to verify that this policy can effectively reduce the emissions of carbon dioxide, but the impact on social welfare is not significant; Chen et al.^[7] thought that levying carbon tax has a significant positive effect on improving the social welfare and controlling the emission of greenhouse gases through studying the existing carbon tax system in the United States; Grimand et al.^[8] pointed out that “CCS technology can change the negative impact of the carbon tax system on social benefits and consumption levels through constructing endogenous growth model of non renewable resources”.

According to comprehensive analysis of existing literature, scholars at home and abroad have not yet reached a unified opinion on the welfare effect caused by the carbon tax. Natural resources are classified as coal, oil and natural gas in this research process. But the consumption of each fossil energy and the carbon emission process caused by it are more complicated in reality. The carbon tax’s impact on various types of energy is also different. Especially it will bring some negative effects for the future usage of natural gas and other clean energy.

Further, as a country with coal dominating its energy structure, the energy consumption structure in China determines that there is a large difference on the carbon emissions per unit of output between the China and other countries. And natural gas as a clean and efficient fossil energy, if the gas tax exemption policy can be implemented, its utilization rate can be increased as well, and it is conducive to improving the energy utilization patterns of traditional manufacturing industry, balancing the social welfare and improving environmental quality. Therefore, the study of implementing the natural gas single tax exemption policy has an important practical significance on the production of the social sector, social welfare, regional economic and social development.

In the study of policy analysis tool, Computable General Equilibrium (CGE) has been largely used in the world, especially in the field of macroeconomics. CGE model can use the economic operation of the real data for solving equations and measuring variables, and it can effectively predict the impact of changes in government policy on the economic behavior of the various sectors of society. Therefore, the CGE model has been used to study the effectiveness level of carbon tax policy implementation in different countries: Ferran^[9] used CGE model to study whether the energy tax can achieve the double dividend effect in making government revenue unchanged and improving the quality of the environment; Xiao et al.^[10] discussed the impact of environmental tax on social and economic effects in China by “using a dynamic recursive multi-sectoral CGE model”; Xu et al.^[11] “explored the impact of coal resource tax reform” on GDP and regional economy in China by using a dynamic CGE model; Virginie^[12] studied the replacement efficiency of bio diesel and fossil fuels by using a dynamic CGE mode; On the basis of CGE model, Guo^[13] studied the

effects of carbon tax on fossil fuel consumption carbon emissions and social economy in China; Hirte et al.^[14] “used a dynamic CGE model to analyze the impact of the income tax on the automobile travel and commuting distance in Germany”; Wissema and Dellink^[15] used CGE model to explore the impact of changes in the energy tax policy on the carbon dioxide emissions and the use of renewable energy sources in Ireland; Jia and Li^[16] “explored the relationship between carbon emissions quota ratio and carbon trading price through using a dynamic recursive CGE model”; Waschik et al.^[17] “used CGE model to analyze the influence of Australia's new carbon tax on domestic coal industry”; Li et al.^[18] used CGE model to “study the impact of China's existing carbon dioxide emission reduction measures on future society”.

Through the analysis of existing literature, it can be known that the CGE model not only can closely combined the various components of the national economy, but also can guide the activities of various economic entities under the market mechanism. In view of the good use effect of CGE model in economic or tax policy evaluation, this research plans to use CGE model to study the impact of carbon tax, with emphasis on social welfare and energy consumption.

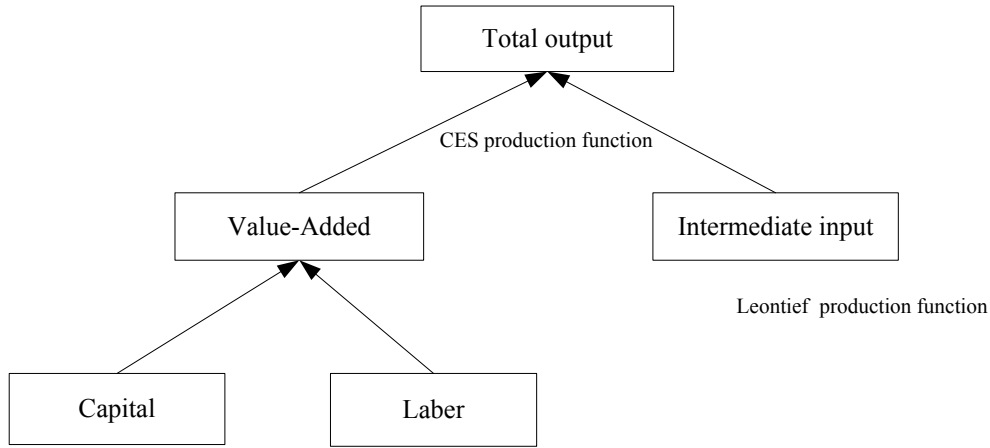
Based on the above reasons, this study constructs a CGE model which takes natural gas tax exemption as the target, quantify and analyze comprehensively the dual influence of natural gas tax policy on social welfare and carbon emissions, and takes Beijing as an example to simulate and analyze the impact of gas tax exemption policy and examine the policy effect of different carbon tax policy design. The results are expected to provide a reference for optimizing the industrial structure and energy consuassmption structure of Beijing region, exploring a win-win strategy of low carbon development and regional economic coordination and formulating regional carbon tax system.

2 The construction of CGE model

The CGE model constructed in this paper mainly consists of six parts: Production module, Revenue module, Consumption module, Balance and closing module, Social welfare module and Carbon emission module.

2.1 Production module

The production module is being constructed by a two-layer, nested Constant Elasticity Substitution function as shown in Fig. 1. Total output is composed of two parts, the intermediate input and value-added. Leontief production function (Fixed input proportion production function) is used in the middle part of the second layer. This paper takes two factors into consideration, labor and capital. Therefore, the production function of value-added part is composed of labor and capital elements. The concrete layer is shown in Figure1.



Figure

2-1 Nesting relation of production function

$$ND_i = a_i^{nd} (PX_i / PND_i)^{\sigma_i^p} XP_i \quad (1)$$

$$VA_i = a_i^{va} (PX_i / PVA_i)^{\sigma_i^p} XP_i \quad (2)$$

$$PP_i = (1 + \tau_i^x + \tau_i^c) PX_i \quad (3)$$

$$L_i^d = \alpha_i^l (PVA_i / W)^{\sigma_i^y} VA_i \quad (4)$$

$$K_i^d = \alpha_i^k (PVA_i / R)^{\sigma_i^y} VA_i \quad (5)$$

$$XAp_{ij} = a_{ij} ND_j \quad (6)$$

$$PND_j = \sum_i a_{ij} PA_i \quad (7)$$

Where, Formula (1) and (2) are the first layer CES production function; Formula(3) indicates that the output price (PP_i) is equal to the cost of the production unit multiplied by the indirect tax rate and Carbon tax rate; Formula (4) and (5) indicates the intermediate input beam demand for labor and capital; Formula (6) and (7) are the intermediate input function, which are make up of Leontief direct consumption coefficient. In which, the symbols and the parameters are being explained in Table 2-1.

Table 2-1 The meaning of symbols and parameters in production function

Symbol	Implication	Symbol	Implication
ND_i	Intermediate input demand of department i	PX_i	Output producer prices of department i
PND_i	Intermediate input price of department i	XP_i	Total input of department i
VA_i	Department i demand for added-value bundle	PVA_i	Department i Synthetic price of inputs of added-value bundle

PP_i	Department i tax inclusive price of input	L_i^d	Department i demand for labor
R	Average wage of labor	K_i^d	Department i demand for capital
W	Average profit rate of capital	XA_i	The demand for the i species of Amin's goods
a_i^{nd}	CES share parameter of intermediate input beam	a_i^{va}	CES share parameter of added-value
a_i^l	CES share parameter of labor	a_i^k	CES share parameter of capital
a_{ij}	Intermediate input coefficient	σ_i^p	Elasticity of substitution between ND and VA
τ_i^x	Indirect tax rate	τ_i^c	Carbon tax rate
σ_i^v	Labor and capital: elasticity of substitution		

2.2 Income module

Income module includes residents, enterprises, government. Resident income is being consists of household labor income, enterprise profit and government payments, which showed in formula (8) ; Enterprises income is from capital revenues, government contribution, which showed in formula (9) ; The government receives income from corporate income taxes , government indirect taxes, residents income taxes and carbon taxes, and the calculation method was found (11), (12), (13), (14) .

$$RI = \sum_i WL_i^d + \beta EI + TR_h^g \quad (8)$$

$$EI = \sum_i RK_i^d + TR_e^g$$

(9)

$$PR = TAX_1 + TAX_2 + TAX_3 + TAX_4 \quad (10)$$

$$TAX_1 = etEI \quad (11)$$

$$TAX_2 = rtRI \quad (12)$$

$$TAX_3 = \sum_i XP_i PX_i t_i^x \quad (13)$$

$$TAX_4 = \sum_i XP_i PX_i t_i^c \quad (14)$$

Table 2-2 The meaning of symbols and parameters in income module

Symbol	Implication	Symbol	Implication
RI	Resident income	TR_h^g	Government transfer payments to residents
EI	Enterprise income	TR_e^g	Government transfer payments to enterprise
PR	Government revenue	TAX_1	Corporate income tax
TAX_2	Personal income tax	TAX_3	Government indirect tax
TAX_4	Carbon tax	β	Enterprises to residents of the profit distribution of the proportion of enterprise income
et	Direct corporate tax rate	rt	Personal income tax rate
t_i^x	Indirect tax rate	t_i^c	Carbon tax rate

2.3 Consumption module

Consumption module includes productive consumption, consumption of residents, government consumption and investment demand. Consumption in the production process is mainly in the form of intermediate inputs as the production factors, It is described by Leontief function on the number of factors of production demand; Residents' consumption is based on the consideration of savings and income levels, and the principle of maximizing the effectiveness of the utility to determine the amount of consumption of the product; Government consumption and investment demand is based on the total level of fixed ratio to determine. In which, the symbols and the parameters are being explained in Table2-3.

$$XAp_{ij} = a_{ij}ND_j \quad (15)$$

$$PND_j = \sum_i a_{ij}PA_i \quad (16)$$

$$XAc_i = a_i^c \frac{YD(1 - mpsh)}{PA_i} \quad (17)$$

$$S^h = YDmpsh \quad (18)$$

$$XAg_i = a_i^g \frac{P\overline{XG}}{PA_i} \quad (19)$$

$$S^g = YG - P\overline{XG} - \overline{PTR}_h^g - \overline{PTR}_e^g \quad (20)$$

$$S^e = YE(1 - \beta) - TAX_1 - TAX_4 \quad (21)$$

$$XAi_i = a_i^i \frac{XI}{PA_i} \quad (22)$$

$$XA_i = \sum_i XAP_{ij} + XAC_i + XAg_i + XAi_i \quad (23)$$

Table 2-3 The meaning of symbols and parameters in consumption module

Symbol	Implication	Symbol	Implication
XAP_{ij}	Intermediate input demand for j of department i	a_{ij}	Intermediate input coefficient
ND_j	Intermediate input demand of department j	PND_j	Intermediate input price of department j
PA_i	Composite price of i Amin goods	XAC_i	The residents' demand for i Amin goods
a_i^c	The proportion of the residents' consumption of i commodity	YD	Disposable income of residents
$mpsh$	Residents' savings rate	S^h	Savings of residents
XAg_i	The government's demand for i Amin goods	a_i^g	The proportion of the government's consumption of i commodity
P	GDP price deflator	\overline{XG}	Total government expenditure
S^g	Government savings	YG	Total government revenue
TR_h^g	Government transfer payments to residents	TR_e^g	Government transfer payments to enterprises
S^e	Enterprise savings	YE	Enterprise income
TAX_1	Business tax	TAX_4	Carbon tax
XAi_i	Investment demand for i Amin goods	a_i^i	The proportion of the investment's consumption of i commodity
XI	gross investment	XA_i	the demand for i Amin goods

2.4 Equilibrium and macro closure module

Equilibrium and macro closure module is mainly described in a variety of equilibrium relationships, that is, the total investment is equal to the total savings, supply and demand balance of commodity market and factor, balance of payments. In which, the symbols and the meaning of the parameters are shown in table2-4.

$$XI = S^h + S^g + S^e + \overline{ERS}^f \quad (24)$$

$$XD_i^d = XD_i^S \quad (25)$$

$$\bar{L} = \sum_i L_i^d \quad (26)$$

$$\bar{K} = \sum_i K_i^d \quad (27)$$

$$GDPFC = \sum_i WL_i^d + RK_i^d \quad (28)$$

$$RGDP = \sum_i W_0 L_i^d + R_0 K_i^d \quad (29)$$

$$P = GDPFC / RGDP \quad (30)$$

Table 2-4 The meaning of symbols and parameters in equilibrium and macro closure module

Symbol	Implication	Symbol	Implication
XI	Gross investment	S^h	Savings of residents
S^g	Government savings	S^e	Enterprise savings
ER	exchange rate	\overline{S}^f	The residents' demand for i Amin goods
XD_i^d	The domestic market's demand for i domestic goods	XD_i^S	The output of sector i for the domestic market
\bar{L}	Total labor supply	L_i^d	The demand for labor of sector i
\bar{K}	Total capital supply	K_i^d	The demand for capital of sector i
$GDPFC$	Nominal GDP	W	Average profit rate of capital
$RGDP$	Actual GDP	R	Average wage of labor

2.5 Social welfare part

The determination of social welfare indicator could be calculated by numerous different functions. In this research, I chose the Hichsian equivalent variation function to analyze the influence degree of the social welfare when set the different carbon tax to natural gas. The symbols in the calculation equation and their implementation are shown in table2-5. The calculation equationis:

$$EV = E(U^s, PQ^b) - E(U^b, PQ^b) = \sum_i PQ_i^b \cdot HD_i^s - \sum_i PQ_i^b \cdot HD_i^b \quad (31)$$

Table 2-5 The meaning of symbols and parameters inHichsian equivalent variation function

Symbol	Implementation	symbol	implementation
EV	Equivalent variation	$E(U^s, PQ^b)$	Effectiveness level after policy implementation
$E(U^b, PQ^b)$	Effectiveness level before policy implementation	PQ_i^b	The ith commodity price before policy implementation
HD_i^b	The ith commodity consumption quantity before policy implementation	HD_i^s	The ith commodity consumption quantity after policy implementation

EV represents Hichsian equivalent variation of residents' welfare, and the economic meaning of EV is that consumers are willing to pay at most the EV's price in return for the disappearance of the government tax. IF the EV based on the calculation result is minus, it indicates the policy implementation is advantageous to residents' welfare; If it is positive number, it means the policy implementation is disadvantageous to residents' welfare.

2.6 Carbon emission part

This paper assumes base on fact that the main energy being consumed in China are coal, oil and natural gas. The fossil energy consumption multiplied by the coefficient of each carbon emission, which converted to the carbon dioxide emissions. It is the tax basis when the government impose a carbon tax in in the production process. Formula(32),(33) represent the carbon dioxide emissions.

$$CE_j = \sum_j Q_j \cdot \varepsilon_j \quad (32)$$

$$TCE = \sum_j CE_j \quad (33)$$

Table 2-6 The meaning of symbols and parameters in carbon dioxide emissions function

Symbol	Implementation	Symbol	Implementation
CE_j	Total carbon dioxide emissions of the jth fossil fuels	TCE	Total carbon dioxide emissions
ε_j	Each carbon emissionco efficient	CO_{2i}	Carbon dioxide emissions of department i
CO_{2j}	Carbon dioxide emissions of finally using part	TCO_2	The total carbon dioxide emissions
$COEI_i$	Carbon dioxide emissions intensity of department i	$TCOEI$	The to talcarbon dioxide emissions intensity
θ_{coal}	Carbon dioxide emissions coefficient of Unit coal	θ_{oil}	Carbon dioxide emissions coefficient of Unit oil
θ_{gas}	Carbon dioxide emissions coefficient of Unit natural gas		

3 Social sector division and social accounting matrix

3.1 Division of social production sector

This paper mainly studies the effects of different natural gas carbon tax levels on the economic system, social welfare and carbon emission in Beijing. Based on the input-output table of Beijing city in 2012, the 42 production sectors are divided into 16 sectors as shown in table 3-1 according to the characteristics of energy consumption, energy intensive industries and other industries.

Table 3-1 CGE Model sector allocation table

No.	Code	Sector classification
01	Agriculture, forestry, animal husbandry and fishery products and services	Agriculture, forestry, animal husbandry and fishery
02	Coal mining products	Mining and Washing of Coal
03	Oil and natural gas products	Natural gas and gas industry
04	Gas production and supply	
05	Dressing and other non-metallic mineral products	Manufacture of Non-metallic Mineral Products
06	Non-metallic mineral products	
07	Food and tobacco	Manufacture of Foods and Tobacco
08	Textile	Manufacture of Textile and Related Product
09	Textile, leather and feather products	
10	Processed wood and furniture	Processing Manufacture of Timber, Paper, Printing
11	Paper printing and educational and sports goods	
12	Petroleum, coking and nuclear fuel processed products	Petroleum and Coke
13	Chemical products	Chemical industry
14	Metal smelting and rolling processed	Manufacture of Metals and Related Product
15	Metal product	
16	Metal mining products	Manufacture of Machinery and Equipment
17	General equipment	
18	Professional setting	
19	Electrical machinery and equipment	
20	Instruments	Manufacture of Transport and Storage
21	Other manufactured products	
22	Transportation equipment	
23	Transportation, storage and postal services	Manufacture of Communication Equipment, Information Instruments and Other Manufacturing
24	Communications equipment, computers and other electronic devices	
25	Information transmission, software and information technology services	
26	Electricity, heat production and supply	Production and Supply of Water and

27	Water production and supply	Electricity
28	Building	Construction
29	Wholesale and Retail	
30	Metal products, machinery and equipment repair services	
31	Accommodation and catering	
32	Financial	
33	Real estate	
34	Leasing and business services	
35	Scientific and technical services	
36	Water conservancy, environment and public facilities management	Service
37	Resident services, repairs and other services	
38	Education	
39	Health and social work	
40	Scrap waste	
41	Culture, sports and recreation	
42	Public administration, social security and social organizations	

3.2 Preparation of social accounting matrix

The Social Accounting Matrix (SAM) formed in this paper is based on the input-output table, is the most important primary data sources of CGE model. This paper uses input-output table of Beijing in 2012 and the Beijing Statistical Yearbook 2011 in conjunction with article studies need. The SAM is divided into eight categories of accounts: activities, products, account factors (labor and capital), residents, businesses, government, investment savings. The activity accounts reflect the input and output of the manufacturer's production activities in Beijing City, it obtains income through the total output while paying the middle input, factor costs and indirect taxes. The commodity accounts reflect the supply and demand of all commodities, mainly for intermediate inputs, consumer spending, government consumption, investment demand, and its expenditure is the purchase of the activities account. The factor accounts mainly reflect the input of the factors and the distribution of the income. The resident accounts reflect the main source of income of the residents and its main expenditure items are consumption, personal income tax and savings. The corporate accounts reflect the main source of revenue, including capital income, the government transfer payment to the enterprise, and its item of expenditure is on the residents of the profit distribution, corporate taxes and savings.

4 Model forecast analysis

4.1 Carbon tax design of natural gas

From the practice of carbon tax policy abroad and the theoretical study of carbon tax policy in China, it can be known that carbon tax levy for different fossil energy will have different degrees of influence on social economic system, social welfare as well as carbon emissions. The carbon emissions of natural gas is less relative to other fossil energy due to its own default carbon content is far less than the coal, oil energy. Therefore, in order to protect the development and utilization of natural gas, the international carbon tax rate on natural gas is low, and the natural gas carbon tax reduction and exemption may become the trend of tax reform.

Natural gas carbon tax is being leveraged on the production sectors of natural gas, which is based on the carbon content of natural gas to levy tax on products of natural gas mining industry. Combined with the experience of developed countries and the current situation of our country, we sets natural gas carbon tax rates at 100 yuan/tons of carbon, 50 yuan/tons of carbon, 0 yuan/tons of carbon on the assuming the condition that coal, oil and other fossil energy carbon tax keeping invariant, and uses GAMS(the optimal computer numerical analysis of commercial software) which is commonly used to solve CGE model to simulate implementation of natural gas carbon tax policy. The aim is to study the effect of natural gas carbon tax reduction and exemption, especially the effect of carbon tax exemption policy on Beijing's economic system, social welfare and carbon emissions.

4.2 Different carbon tax rates effects on the output of the production sector

The introduction of carbon tax policy on natural gas and other energy sources will lead to rising energy prices, thereby increasing the cost of energy exploitation and utilization, resulting in a decline in energy product of the production sector. As a clean and efficient fossil energy, natural gas is in the upper reaches of the industrial chain, and is widely used in chemical, smelting, manufacturing, building materials and other energy consuming industries. Gas price fluctuations caused by different carbon tax levels will also lead to changes in the cost and price of the downstream industry sectors as well as the alternative energy industry sectors, thereby affecting the sectors' output. As can be seen from table 4-1, the growth of natural gas prices caused by the tax has a negative impact on the output of most related industries, but the negative effect gradually decreases with the reduction of the carbon tax level. Among them, to Beijing's main supply of energy like coal, oil etc, the reduction of natural gas carbon tax rates promotes the exploitation and utilization of natural gas and restrains the demand of high energy consuming, high polluting energy, which makes sector output declined sharply. For the chemical industry, transportation, gas and other strong correlation of energy intensive industries, natural gas carbon tax levy usually bring great impact to these industries, and with the implementation of the gas tax reduction and exemption policy, the outputs of various industries will be restored. For example, when the carbon tax rate reduces from 100 yuan/ton to 50 yuan/ton, the chemical industry output increases by 0.0791%, transportation increased by 0.0768%; Tax is 0 yuan (tax exemption), the sector output increased significantly. Metal smelting, power production and other industries due to their own large correlation degree with coal and

other traditional fossil energy, their output indirectly affected by the carbon tax of natural gas, presenting a gradual decrease trend; Agriculture, forestry, animal husbandry and fisheries, textiles, food and other industries due to the need to invest less fossil energy, the impact of natural gas carbon tax on them is small.

The exploitation and use of fossil energy is the main source of carbon dioxide, the carbon tax not only affects the output of the social sector, but also is an effective means to promote the intensive energy industry, high energy-consumption industry to reduce emission. Through the calculation and simulation of CGE model, the table 4-1 lists the impact of the reduction of natural gas carbon tax level on carbon emissions of related energy industry as well as alternative energy industry. In general, levying the carbon tax restrains the carbon emissions of the energy consumption sector, the implementation of natural gas single carbon tax reduction and exemption policy will weaken this effect and make carbon emissions increase. However, due to the low carbon content and less pollution of natural gas itself, the increase in carbon emissions of various sectors is not large, as shown in table 4-1. In the chemical industry, for example, when the level of carbon tax decreases from 50 yuan to 0 yuan (tax exemption), natural gas price decreases and output increases, the development and use of it has been released, carbon emissions increases by only 0.4722%; While the output of transportation and manufacturing sector increase, carbon emissions increase by only 0.4759%, which suggests the negative impact of natural gas carbon tax reduction on carbon emissions is small. For coal, oil, etc. Beijing's main source of fuel, under the conditions that coal and oil and other energy carbon tax remain unchanged, the implementation of natural gas carbon tax reduction and exemption policy will greatly promote the use of natural gas and restraint use of coal, oil and other high pollution traditional energy. From the results of carbon emissions, when the natural gas carbon tax decreases from 50 yuan to 0 yuan, the natural gas industry carbon emissions increase by only 0.0334%, while coal, oil and other energy carbon emissions reduce by 0.0474%, 0.0908%, the effect of carbon emission reduction is significant. This shows that the reduction of natural gas carbon tax will make the relevant industrial sector carbon emissions increase, but smaller. It has a inhibitory effect on development and utilization of other energy sources such as coal, oil and other fossil energy, which can control the carbon dioxide emissions amount in Beijing partially and contribute to the realization of fundamental objectives of carbon emission reduction and environmental protection.

Table 4-1 Effect of natural gas carbon tax on the output of social production sectors(%)

Item	Output			Carbon emission		
	100 yuan/ton	50 yuan/ton	0 yuan/ton	100 yuan/ton	50 yuan/ton	0 yuan/ton
Mining and Washing of Coal	0.1721	0.0899	0.0237	0.1915	0.0997	0.0523
Petroleum and Coke	0.4327	0.2254	0.1325	0.4317	0.2235	0.1327
Natural gas and gas industry	-15.703	-8.805	1.23F28	-4.8951	-3.8544	-3.8210
Chemical industry	-0.1672	-0.0881	0.7695	-1.3174	-0.6915	-0.2193
Production and supply of water and electricity	0.0777	0.0408	0.0125	0.5789	0.3041	0.2712
Construction	-0.1576	-0.0823	0.2437	-0.9137	-0.4781	-0.1787
Manufacture of Metals and Related Product	-0.1003	-0.0531	0.2185	-0.9959	-0.5246	-0.0500

Manufacture of Non-metallic Mineral Products	-0.1389	-0.0728	0.2391	-1.0679	-0.5594	-0.0736
Manufacture of Communication Equipment, Information	-0.0274	-0.0142	0.0937	-0.6290	-0.2791	-0.2536
Manufacture of Transport and Storage	-0.1618	-0.0850	0.6932	-1.5951	-0.8360	-0.3601
Manufacture of Transport and Storage	-0.0889	-0.0469	0.4573	-0.7855	-0.4126	-0.0795
Agriculture, forestry, animal husbandry and fishery	-0.0139	-0.0075	0.0547	-0.5224	-0.2737	-0.1565
Manufacture of Textile and Related Product	-0.1596	-0.0829	0.4372	-0.3626	-0.3581	-0.1877
Manufacture of Foods and Tobacco Processing	-0.0404	-0.0213	0.0436	-0.1929	-0.1012	-0.0774
Manufacture of Timber, Paper, Printing	-0.0371	-0.0196	0.0253	-0.3127	-0.3123	-0.0789
Services	-0.0458	-0.0242	0.0318	-0.4648	-0.2437	-0.1545

4.3 The influence of natural gas tax exemption policy on social economic variables

The reduction and exemption for natural gas carbon tax relief will reduce the production department cost and increase the production output, thus causing the rise of demand for capital goods and inputs, and ultimately affect real GDP, nominal GDP, resident income, resident consumption, business income, government revenue, government consumption and other macro social economic system variables, as shown in table 4-2.

For the resident subject of social economic system, residents' income mainly includes labor income, capital income and government's transfer payment to the residents. In the social economic system of Beijing involved in this paper, labor price is as a benchmark price and the labor market is full employment, thus the labor income of the residents is invariant. With the reduction of natural gas carbon tax level, social production sector's output is generally increased, causing the demand for capital and the capital price rise accordingly, thus the capital income of the residents shows the increasing trend. Consumption and savings is increasing accordingly.

For the enterprise subject, capital income is the main source of income of the enterprise. In this paper, the reduction of natural gas carbon tax causes the rise of capital price, which leads to the increasing of the income of the enterprise, and the savings of the enterprise also increases.

For the government subject, natural gas carbon tax level's decreasing and carbon tax relief reduce the

government income for enterprise income tax the and the reduction range of enterprise income tax is far greater than the increasing range of indirect taxes, personal income tax of residents and other tax, so government revenue decreases gradually with the reduction of natural gas carbon tax. In addition, from the point of view of data, government consumption gradually rise, which makes the government savings decreases with the decreasing of natural gas of carbon tax level.

For variable GDP, the social real GDP and nominal GDP presents a rising trend with the reduction of natural gas carbon tax, and there are some differences in the range. In the process of social and macroeconomic estimates, due to the lowering of the level of carbon tax, the income of the total social capital is increasing, labor income remains unchange, indirect tax increases with the increase of output, therefore the nominal GDP is rising steadily. Real GDP is the sum of consumption, investment and net exports, although the consumption of residents rises, the government consumption falls, the proportion of government consumption is relatively small, so the overall consumption rises in consumption; in addition, the investment equals savings, the total savings increases, investment will also increase with it; carbon tax level reduction causes a relative decline in the prices of domestic products, foreign products prices remains unchange, net exports also rise to a certain degree, eventually leads to a rise in real GDP. As shown in table 4-2, with the natural gas carbon tax level reducing from 100 yuan / ton to 50 yuan / ton, nominal GDP rises from -0.2212% up to -0.1101%, when cancels the tax revenue, nominal GDP rises by a large margin, resulting in 0.1214% positive fluctuations; with the natural gas carbon tax level reducing from 100yuan/ton to 50yuan/ on, real GDP from -0.1812% up to -0.0508%, when cancels the tax revenue, actual GDP produces 0.1020% positive fluctuations. From this we can know that the reduction or even relief of natural gas carbon tax level will have a positive impact on the social macroeconomic variables.

Table 4-2 Effects of natural gas carbon tax on social macro economic variables in Beijing (%)

Item	Natural gas tax rate level		
	100yuan/ton	50yuan/ton	0yuan/ton
Total investment	-0.1478	-0.0929	0.0817
Real GDP	-0.1812	-0.0508	0.1020
Nominal GDP	-0.2212	-0.1101	0.1214
Resident income	-0.0481	-0.0218	0.0572
Resident consumption	-0.0479	-0.0218	0.0572
Business income	-0.3540	-0.1749	0.0260
Business savings	-0.3540	-0.1749	0.0260
Government revenue	0.3161	0.1490	0.0754
Government consumption	0.1352	0.2892	0.3728
Government savings	-0.1446	-0.2166	-0.4697

4.4 Influence on social welfare of Beijing City

The relative changes in the product output price will lead to changes in consumer decision-making in different consumer groups, and then the welfare benefits will eventually be affected by varying degrees. Table 4-3 lists the changes in the level of natural gas carbon tax caused by changes in social welfare indicators. From the table, we can learn that when natural gas carbon tax is collected, the social welfare of the residents is reduced, and when the carbon tax level reduces from 100 yuan / tons to 0 yuan / ton, which means tax level decreases and gradually abolishes tax revenue, the welfare level of the residents will be improved ,which indicates that the residents' income increasing due to the reduction of the carbon tax leads to an increase in the level of welfare benefits brought by their own consumption and the increasing range will gradually increases.

Table 4-3 effect of carbon tax on social welfare in Beijing City

Item	100yuan/ton	50yuan/ton	0yuan/ton
Hicks variable EV	-11.36	-3.47	2.85

5 Conclusion

The implementation of different energy carbon tax rates will lead to fluctuations in the output of the social production departments and ultimately affect the social welfare of the residents. However, the existing research rarely on the carbon tax policy under the background, the quantitative estimation of the level of different natural gas carbon tax impacts on energy saving. Based on the theoretical framework of CGE model, the paper simulated the implementation situation of different natural gas carbon tax rates, and then analyzed the effects with different extents of Beijing's social economic system, social welfare and carbon emission. According to the simulation results, this paper obtains the following policy implications:

(1) The implementation of natural gas carbon tax reduction and exemption policy has a certain effect of energy-saving emission reduction. With the decreasing of natural gas carbon tax, natural gas can gradually replace the traditional high carbon emissions energy in some sectors, thereby gradually reducing the carbon

emissions from coal, oil and other traditional energy sources. Therefore, Beijing can restrict the use of coal and oil by means of encouraging natural gas and other clean energy, and reduce carbon emissions so as to achieve the emission reduction effect.

(2) The decreasing of natural gas carbon tax rate gradually leads to a rise of output, as well as the rising of demand for capital and the price of capital. Accordingly, the overall capital income of residents is rising. Carbon tax reduction and exemption reduces the government's income, but the total income of the residents has been improved with the reason that reduced income is less than the rise of capital income. With the gradual reduction of carbon tax, increasing of factor income enhance the level of welfare brought by the consumption of residents, and so does the social welfare level. The carbon tax policy has produced some positive effects on most macroeconomic variables. From the view of relative amount, such effects are not obvious because natural gas accounts for a smaller proportion in the energy consumption structure. However, due to the larger economy, so the absolute cost of emission reduction is relatively high, so in the design of carbon tax rates, should avoid a higher carbon tax rates.

(3) Natural gas carbon tax reduction has different effects on social production sector. For energy intensive industries, for example the chemical industry, transportation industry, natural gas can become the alternative energy of coal, oil and other traditional energy sources to develop and utilize. With the decrease of natural gas carbon tax, such classed of industries can achieve the increasing of output under the condition of low cost and low pollution, thereby enhance the comprehensive benefit of the enterprise. For the non-energy sector, natural gas carbon tax reduction and exemption policy is relatively weak. For other energy extraction industries, such as coal, oil and other high-polluting fossil energy industries, they will be influenced greatly by natural gas carbon tax reduction and exemption policy. On the opposite, other green clean energy with low pollution can become complement with natural gas so as to promote the realization of the goal of environmental protection. Overall, the impact of natural gas carbon tax reduction and exemption on the various sectors is different. How to achieve the increase of output by the implementation of carbon tax policy is worth further research. For example, the government should consider tax return of manufacturers and environmental technology support, in order to mobilize the enthusiasm of production and emission reduction, and thus to achieve industrial upgrading and product structural adjustment.

The research resulted from this paper on Beijing can provide some theoretical support for the formulation of Chinese carbon tax policy of natural gas and other clean energy. The energy saving and emission reduction only relying on administrative means is usually difficult to mobilize the enthusiasm of the economic subject. Furthermore the radical emission reduction targets and actions may inhibit economic growth potential and reduce social welfare. Therefore, in addition to rely on administrative methods to promote emission reduction, the government should make the economic main body to undertake certain obligations for emission reduction. It's necessary for China to give full play to the market mechanism regulation to improve the cost hard constraints of carbon emissions of enterprise, such as carbon tax policy with the characteristics of price control and carbon emissions trading mechanism with the characteristics of number control. To achieve the emission reduction goals by 2020 and the continued growth of our country economy, we should mobilize the enthusiasm of social production and emission reduction from government and market dimensions to achieve "win-win" of economic growth and improving the quality of the environment.

Reference

- [1] Ma J, Song Y, Ji L H. Benefits Analysis of Energy Tax Reform[J]. *Advanced Materials Research*, 2014, 986-987:251-254.
- [2] Weitzel M, J Ghosh. Effects of international climate policy for India: evidence from a national and global CGE model[J]. *Environment & Development Economics*, 2015, 20(4):1-23.
- [3] Springmann M. A look inwards: Carbon tariffs versus internal improvements in emissions-trading systems[J]. *Energy Economics*, 2012, 34(2):S228-S239.
- [4] Liao Y Q, Chen X. Social welfare, climate change and strategy selections for developing countries[J]. *Computers Modelling and New Technologies*, 2014, 18(11):718-723.
- [5] Wang M, Liu K, Choi T M, et al. Effects of Carbon Emission Taxes on Transportation Mode Selections and Social Welfare[J]. *IEEE Transactions on Systems Man & Cybernetics Systems*, 2015, 45(11):1-1.
- [6] Almutairi H, Elhedhli S, Almutairi H, et al. Modeling, analysis, and evaluation of a carbon tax policy based on the emission factor[J]. *Computers & Industrial Engineering*, 2014, 77(C):88-102.
- [7] Chen X, Huang H, Khanna M, et al. Alternative transportation fuel standards: Welfare effects and climate benefits [J]. *Ssrn Electronic Journal*, 2011, 67(3):241-257.
- [8] Grimaud A, Rouge L. Carbon sequestration, economic policies and growth[J]. *Resource & Energy Economics*, 2014, 36(2):307-331.
- [9] Sancho F. Double dividend effectiveness of energy tax policies and the elasticity of substitution: A CGE appraisal[J]. *Energy Policy*, 2010, 38(6):2927-2933.
- [10] Xiao B, Niu D, Guo X, et al. The Impacts of Environmental Tax in China: A Dynamic Recursive Multi-Sector CGE Model[J]. *Energies*, 2015, 8(8):7777-7804.
- [11] Xu X, Xu X, Chen Q, et al. The impact on regional “resource curse” by coal resource tax reform in China—A dynamic CGE appraisal[J]. *Resources Policy*, 2015, 45:277-289.
- [12] Doumax V, Philip J M, Sarasa C. Biofuels, tax policies and oil prices in France: Insights from a dynamic CGE model[J]. *Energy Policy*, 2014, 66(3):603-614.
- [13] Guo Z, Zhang X, Zheng Y, et al. Exploring the impacts of a carbon tax on the Chinese economy using a CGE model with a detailed disaggregation of energy sectors[J]. *Energy Economics*, 2014, 45:455-462.
- [14] Hirte G, Tscharaktschiew S. Income tax deduction of commuting expenses in an urban CGE study: The case of German cities[J]. *Transport Policy*, 2013, 28(28):11-27.
- [15] Wissema W, Dellink R. A CGE analysis of the impact of a carbon energy tax on the Irish economy[J]. *Ecological Economics*, 2014, 61(61):671-683.
- [16] Li W, Jia Z. The impact of emission trading scheme and the ratio of free quota: A dynamic recursive CGE model in China[J]. *Applied Energy*, 2016, 174:1-14.
- [17] Waschik R, Tol R S J, Weyant J P. Differentiated products, increasing returns to scale and heterogeneous firms in a CGE model of the Australian coal sector[J]. *Energy Economics*, 2015, 51:521-529.
- [18] Li W, Li H, Sun S. China's Low-Carbon Scenario Analysis of CO₂ Mitigation Measures towards 2050 Using a Hybrid AIM/CGE Model[J]. *Energies*, 2015, 8(5):3529-3555.