Carbon tax or cap-and-trade: a computable general equilibrium analysis of Chinese economy

Yan Xu[1]

The James Hutton Institute, Cragiebuckler, Aberdeen AB15 8QH, UK

Abstract

This study analysed two hypothetical carbon dioxide (CO_2) controlling measures in China: carbon tax and cap-and-trade, using a recursive dynamic computable general equilibrium (CGE) model. The simulation period is from 2002 to 2020. The main conclusions are: there is slight increase of Gross Domestic Product (GDP) under CAP scenarios, but over 3% GDP decrease in 2020 compared with baseline under TAX; carbon tax cases bring about smaller reduction in carbon emissions in 2020, but greater accumulated reductions for the total simulation years; ancillary co-benefit of carbon reduction actions on local environmental pollution can be observed.

Key words: Environment, Carbon policy, GHG emissions, SO_2, dynamic CGE

1. Introduction

Alongside China's rapid economic growth, its greenhouse gas (GHG) emissions are increasing rapidly and gaining increasing attention from other countries. China is now the world's largest GHG emitter. A great deal of research has been published in recent years on the analysis of carbon taxes (Liang et al, 2007; Garbaccio et al, 1999; Zhang, 1998a; Zhang, 1998b) and emission caps (Zhang, 2000) in China, which are two of the main market-based mechanisms used to control carbon emissions. For example, Liang et al. (2007) established a computable general equilibrium (CGE) model simulating a carbon tax policy in China, and compared the macroeconomic effects of different carbon tax schemes as well as their impact on the energy- and trade-intensive sectors. The results show that the negative impact of carbon tax on the economy, and on the energy- and

---

[1] Corresponding author, The James Hutton Institute, Craigiebuckler, Aberdeen AB15 8QH, Tel: +44 1224 395314; Email: yan.xu@hutton.ac.uk

trade-intensive sectors, could be alleviated through properly relieving or subsidizing production sectors. Garbaccio et al. (1999) used a dynamic CGE model of the Chinese economy to examine the effects of using a carbon tax to reduce emissions of carbon dioxide (CO_2) in China on both total output and the output of individual sectors. They find potential for what is in some sense a "double dividend," a decrease in emissions of CO_2 and a long run increase in Gross Domestic Product (GDP) and consumption. Zhang (1998a, 1998b, 2000) analysed the macroeconomic effects of limiting China's CO_2 emissions through the levying of a carbon tax, using a 10-sector time-recursive dynamic CGE model of the Chinese economy. He concluded that China's Gross National Product (GNP) drops by 1.5% and 2.8% if China's carbon emissions in 2010 were cut by 20% and 30%, respectively, relative to the baseline.

However, few studies or papers dealing with both measures together can be found in the literature. Against this background, this study compared two different measures aimed at controlling CO2 emission from China: carbon tax and cap-and-trade using a recursive dynamic CGE model. The simulation period is from 2002 to 2020. Though the focus is on GHG emissions, the model also examines co-benefit of carbon mitigation policies on sulphur dioxide (SO2), one of the most important local air pollutants in China (Xu & Masui, 2009).

The paper is divided into five sections. Section 1 is the introduction. In Section 2, the theoretical and methodological framework of the model is presented. Data used in the model and scenario definitions are discussed in Section 3. In Section 4, the simulation results are analysed. Finally, key findings of the study are summarized in Section 5.

2. Model descriptions

The analytical model used by this study is a dynamic recursive CGE single-country model. Since recursive models are solved one period at a time, it is possible to separate the *within-period* specification from the *between-period* specification, where the former governs the static part of the model and the latter governs the dynamics of the model. Detailed basic descriptions of CGE modelling can be found in Shoven & Whalley (1992).

Here, only the description of specific characteristics of the model is presented, focusing on the assumptions that are needed to build the model.

2.1 Within-period specification

The within-period specification describes a one-period static CGE model. In this specification, the economic structure for a particular year is fully specified.

Production

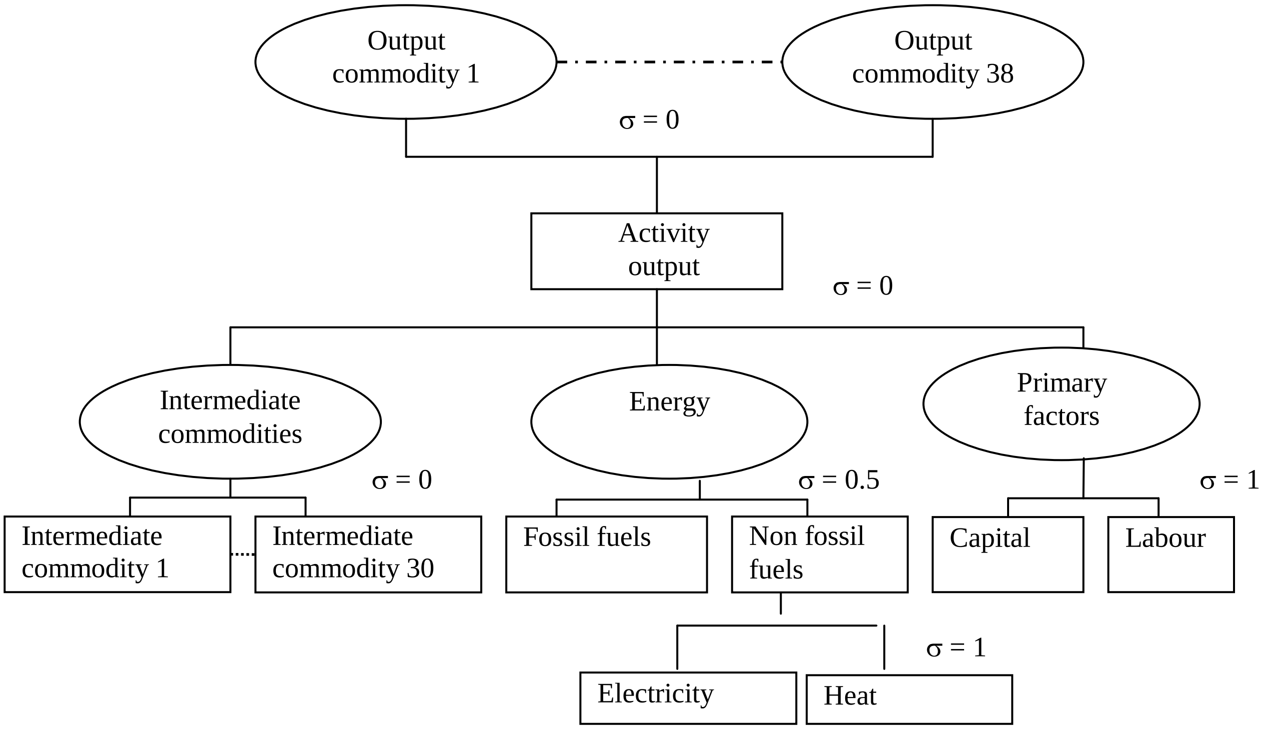


Fig. 1 Nesting of the production structure

In the production function, inputs are categorized into three types: intermediate commodities, energy commodities, and primary factors (capital and labour). The model encompasses 38 sectors (or activities)[2], including eight energy sectors, that combine primary factors with intermediate and energy commodities to determine the level of output. Substitution possibilities between production factors depend on the relative factor prices, following a nested constant elasticity of substitution (CES) production function as shown in Fig. 1. The values of σ in the figure represent the elasticity of substitution

---

[2] Detailed definitions of the sectors are listed in Table 1 in the next section.

between different inputs. Because there are very few econometric studies available to estimate the values of the elasticity of substitution in production and demand functions in China, this study mostly adopts the values used in the GTAP-EG model (Rutherford & Paltsev, 2000). Output is produced with fixed coefficient aggregation of the composites of intermediate inputs, energy inputs, and primary factors. The primary factors composite is a CES aggregation of labour and capital with a *Cobb-Douglas* form, while the composites of both the intermediate inputs and energy inputs are CES aggregations with a *Leontief* form.

Consumption

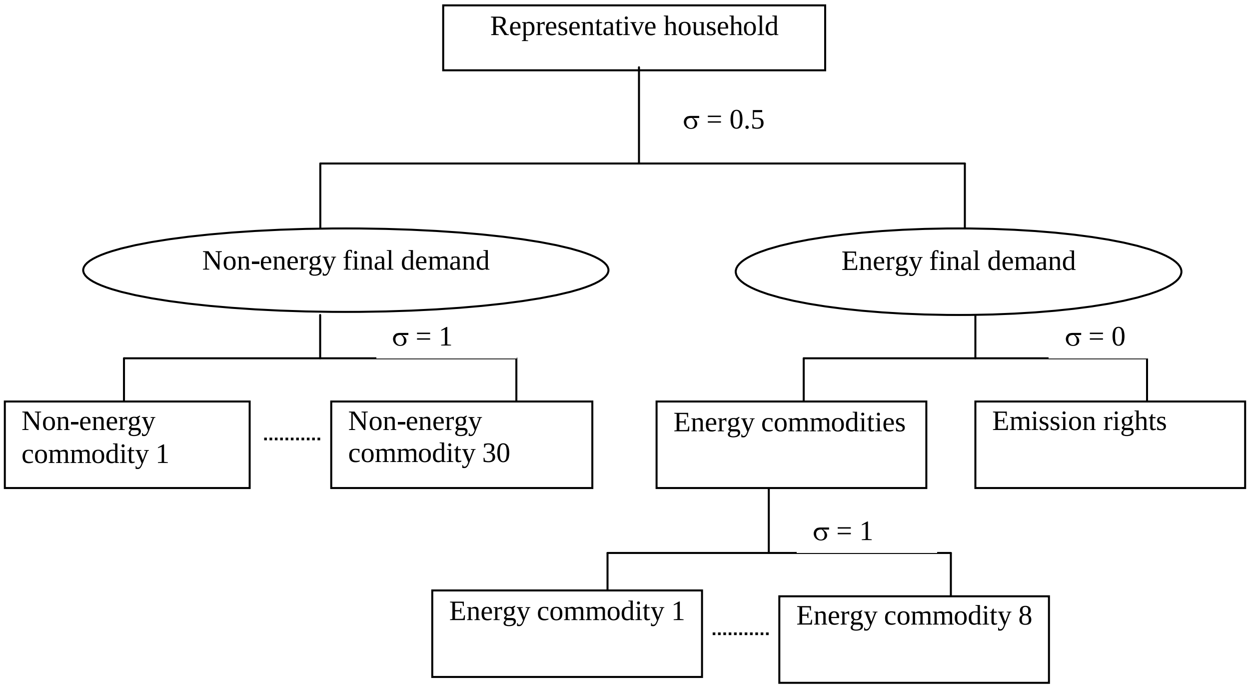


Fig. 2 Nesting of the consumption structure

On the consumption side, the model distinguishes two types of consumers: the government and households. Consumers are symbolized by one representative household. The representative household receives all income generated by providing primary factors to the production process. Factor markets are perfectly competitive and full employment of all factors is assumed. The supply of capital is fixed within a given time period and cannot move across activities. On the other hand, labour is assumed to be a homogenous good and can move across activities within the country but is internationally immobile. A fixed share of income is saved in each time period and invested in the production sectors. The disposable income (net of savings and taxes) is then used for maximizing utility by purchasing commodities. The nested consumption structure is shown in Fig.2.

Government

The government sector is also a final demand sector, similar to the household sector. However, the roles of the government sector are significantly different from those of the household sector: its main activities are taxation, government expenditure, transfer to households, and emission rights allocation. Only indirect tax is considered in this model due to data limitations. In addition, the government levies a tax on air pollutant emissions, such as SO_2 emissions. The government obtains revenue by collecting indirect tax and emissions tax, then spends it on final government consumption and transfers to households while providing public investment.

Investment (fixed capital formation)

In this within-period specification, investment (fixed capital formation) is treated as one final demand similar to final consumption. Investment is disaggregated into production investment and public investment in this model. The household sector plays the role of investor by using its savings to purchase productive investment goods, and the government utilizes the tax revenue to provide public investment.

International trade

The model follows the small open economy assumption, meaning that the international trade market is not affected by the country's activities. Based on this assumption, international prices are fixed and given exogenously.

The produced goods are distributed into domestic and exported goods through a constant elasticity of transformation (CET) function. The model adopts the Armington assumption, which treats domestic and imported goods as imperfect substitutes. In this study, the values for elasticity of transformation and domestic-import elasticity of substitution (see Fig. 3) are the same as those used in the GTAP-EG model reported by Rutherford & Paltsev (2000).

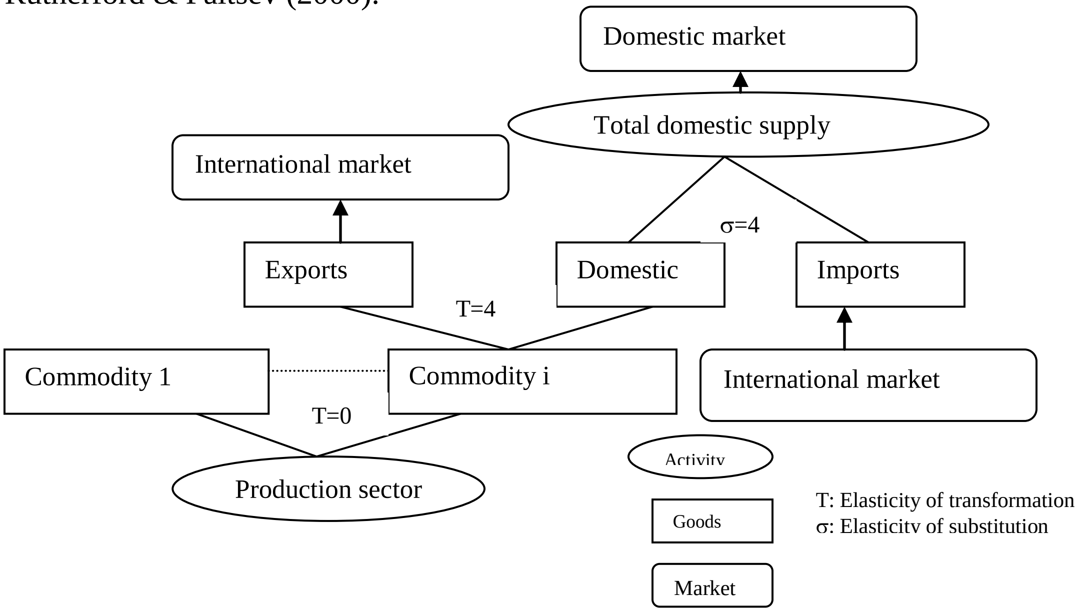


Fig.3 Relationship between domestic market and international market

Environment

In a coal fuelled economy such as China's, reducing CO_2 emissions implies reducing coal consumption, thus reducing local air pollutant. In order to observe such co-benefit of GHG mitigation policies, the model deals with not only CO_2 but also SO_2 emissions. In the model, SO_2 emissions are introduced in the same way as CO_2; that is, when fuels are combusted, CO_2 emissions are emitted. The conversion of fuel (e.g., from crude oil to gasoline) does not emit CO_2. The model only considers atmospheric CO_2 emissions related to energy consumption. More precisely, CO_2 emissions are computed in a linear relationship (using exogenous emission factors) to the use of fossil fuels.

2.2 Between-period specification

A recursive system is applied in this model, meaning that the simulation is iterated year by year. The main driving forces of economic growth are the labour force, capital accumulation, and technology change.

In order to expand from a static model to a dynamic model, the following relationships between investment, capital stock, and technology improvement are assumed:

(1) Total investment in each year is calculated based on an investment function of the acceleration principle type. Total investment is calculated from the expected GDP growth rate in the next period, present capital stock, and technology change as shown in Equation 1[3][4].

$$I_{TOT,t} = CAP_t * \left[\delta + \left\{ \frac{(1+g_{t+1})}{(1+l_t)^{\alpha_L}} \right\}^{\frac{1}{\alpha_K}} - 1 \right] \tag{1}$$

Where,

$I_{TOT,t}$: Total investment in Year t;

CAP_t: Total capital stock in Year t;

δ: Depreciation rate;

g_{t+1}: Expected GDP growth rate in Year t+1;

l_t: Labour growth rate (taking into account labour productivity change)

α_K, α_L: Share of capital, labour

(2) After total investment is determined, the investment is distributed between sectors. The following mechanism is adopted in this model. First, the sectors which are subject to planning by the government, comprising the energy sectors in this model, follow the future plan. Secondly, the remaining sectors share the investment in proportion to capital income using a logic function as presented in Equation 2.

---

[3] Economic growth can be achieved from not only capital growth but also labor growth. In this model, capital and labor are aggregated through a Cobb-Douglas function.

[4] Total saving equals total investment, which will determine saving rate from the household.

$$I_{j,t} = I_{TOT,t} * \frac{(\frac{PK_{j,t}}{PK_{j,t=1}})^{\gamma} * I_{j,t=1}}{\sum_{j}\left\{(\frac{PK_{j,t}}{PK_{j,t=1}})^{\gamma} * I_{j,t=1}\right\}} \tag{2}$$

Where, I_j: investment to sector j, PKj: price of capital (rental price of capital) in sector j and γ is investment propensity among sectors.

(3) It is assumed that the relationship between investment and capital stock in each sector follows the optimal path as shown in Equation 3. New investment in each sector is added to existing stock, depleted atδ.

$$CAP_{j,t+1} = CAP_{j,t} * (1-\delta) + I_{j,t} \tag{3}$$

(4) On the technology side, this model distinguishes between technologies embodied in new investment from technology embodied in capital stock. When new capital with more efficient technology is accumulated, the average efficiency will be improved. In addition, both energy efficiency change and labour efficiency change are taken into account in this model. Both types of efficiency change are set exogenously.

(5) As in the static model, international prices are given exogenously following those reported by AIM Japan Team (2005).

3. Data and scenarios

A recursive system is applied in this model, meaning that the simulation is iterated year by year. The main driving forces of economic growth are the labour force, capital accumulation, and technology change. Base year data are founded mainly on the 2002 Input-Output Table of China published by the China Statistical Publishing House in 2007, the most recent version available at time of writing. Thirty-eight sectors and commodities were incorporated into this model, comprising eight energy commodities and thirty non-energy commodities, as shown in Annex 1.

The scenario dataset required for dynamic model simulation in this study includes the following: economic growth rate, labour supply, productivity of new investment in the initial year, productivity change of labour and energy in new investment, and future international prices.

In this model, the labour growth rate is set equal to the population growth rate. Fig. 4 shows the projected population of China from 2001 to 2020, based on forecasting by the National Population and Family Planning Commission of China. The growth rates of exports, imports, and social investment are assumed to be the same as the GDP growth rate. The depreciation rate for capital stock is assumed to be 10% for all sectors. It is further assumed that international commodity prices are exogenous and that the prices of all commodities except energy goods remain the same during the simulation period. For energy commodities, the assumption is that their prices will increase annually during the simulation period. The annual productivity change of labour in new investment is assumed to be 1%. The annual improvement of energy efficiency is taken from the AIM/Enduse China study carried out by the Energy Research Institute of China (Xu & Jiang, 2009).

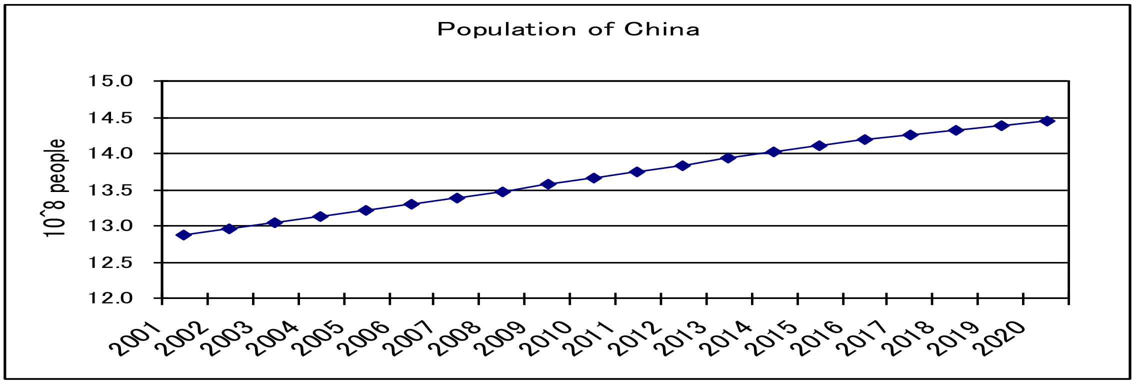


Fig. 4 Population of China from 2001 to 2020

Source: National Population and Family Planning Commission of China, 2003

In this study, there are two sets of reference scenarios based on the economic growth rate: Low and High. Economic growth is represented by the growth in Gross Domestic Product (GDP): and for both scenarios the GDP growth rate from 1997 to 2006 is based on the actual growth rate (NBS, 2007). In the Low Scenario, average GDP growth rates from 2006-2010 and from 2010-2020 are set at 9% and 6.5%, respectively. In the High

Scenario, the average GDP growth rate during 2006 to 2010 is set at 9.5%, not so different from Low Scenario, as this is based on the actual growth rate observed to date. However, the GDP growth rate during 2010 to 2020 is set much higher than that in Low Scenario. The details of the GDP growth rates are contained in table 1.

Table 1: GDP growth rate under the two reference scenarios used by this study

	Low	High
2002	9.1%	9.1%
2003	10.0%	10.0%
2004	10.1%	10.1%
2005	10.2%	10.2%
2006-2010	9.0%	9.5%
2010-2020	6.5%	8.0%

Besides the two reference scenarios (Low and High), there are four policy scenarios (reflecting changes in two policy measures) based on research questions discussed in the first section. Therefore, there are a total of six scenarios included in this study, as shown in Table 2. There is a reference scenario, cap and trade scenario, and carbon tax scenario, each under both low economic growth and high economic growth assumptions.

Under the CAP scenario, there is not an absolute cap on CO_2 emissions, but slower emission growth rate than for the reference case. The tax rates under the TAX scenario are set so as to obtain the same income from carbon taxation as income from emission permits under CAP. Therefore, based on the carbon price and carbon emissions amounts under the CAP scenario, the average unit carbon price during the predicted period is estimated. This estimate is used as the unit carbon price for carbon tax scenarios, levied from 2008[5] (the start date for all four policy scenarios). The carbon prices are shown in Figure 5. Carbon prices under the CAP scenario, which were obtained endogenously depending on the carbon emissions constraint, increased rapidly with time. Carbon prices

---

[5] This study was started in 2008, hence the starting year of carbon constraints in the simulation.

under TAX scenario were set exogenously, as discussed above, and were constant from 2008 to 2020.

Table 2: definition of scenarios.

	REF	CAP	TAX
LG	Low economic growth; no carbon constraint	Low growth, No more than 3% growth of carbon emissions from 2008	Low growth, Carbon tax of 988RMB (Chinese Yuan) (119$)/tC is levied from 2008
HG	High economic growth; no carbon constraint	High growth, No more than 3% growth of carbon emissions from 2008	High growth, Carbon tax of 1260RMB (152$)/tC is levied from 2008

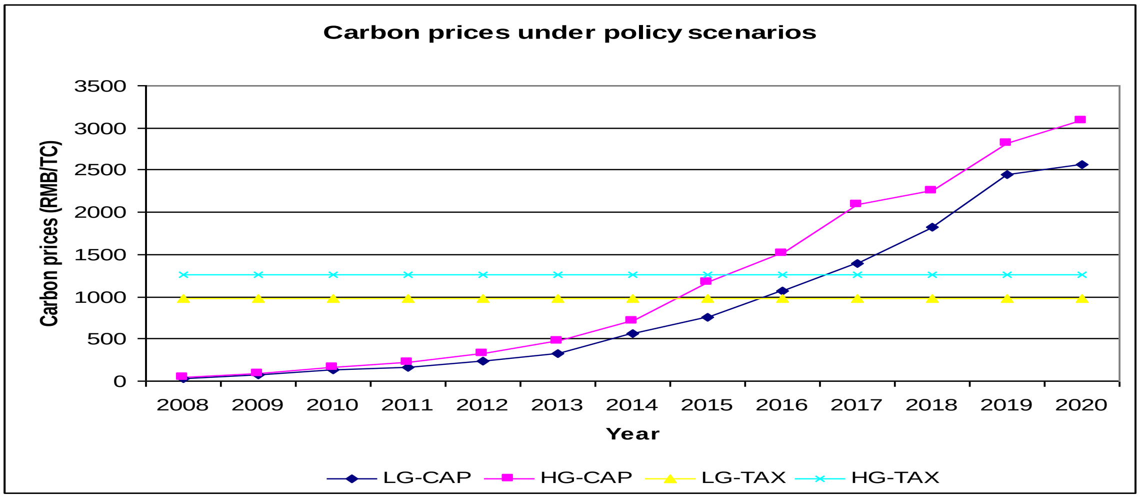


Fig. 5 Carbon prices under four policy scenarios

4. Results

By applying the recursive dynamic CGE country model for China, the effects of carbon tax and cap-and-trade under both low and high economic growth scenarios on GDP, economic structure change, energy consumption, CO_2 emissions, and SO_2 emissions were assessed and compared.

4.1 Macroeconomic effects

Table 3 shows main macroeconomic effects for China in the year of 2020 under two types of policies. It can be seen that there is slight increase of GDP and private consumption under CAP scenarios. But there will be 3.57% and 3.88% GDP decrease in 2020 compared with reference cases under LG-TAX and HG-TAX, respectively. On the other hand, CAP will cause more reduction in energy consumption, CO_2 and SO_2 emissions than TAX. The reason for this might be that endogenous tax rates under CAP are quite small (and much lower than those under TAX) and increase very slowly for the first several yeas then increase rapidly (see Fig. 5), which causes less reduction at earlier years but greater reduction at later years (see Fig.10) thus allows more time for Chinese economy to adapt and transition to lower carbon economy.

Table 3: Main macroeconomic effects for China in 2020 (percentage deviations relative to the baseline)

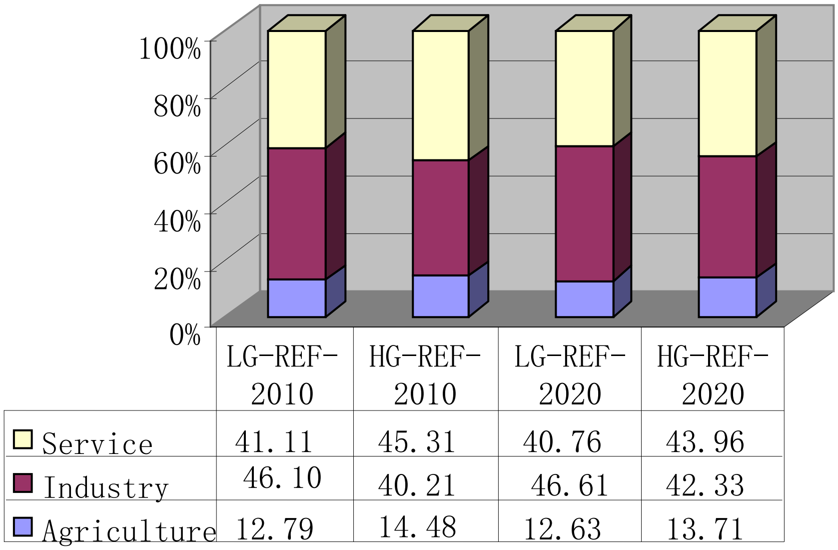
	LG-CAP	LG-TAX	HG-CAP	HG-TAX
GDP	+0.02	-3.57	+0.07	-3.88
Private consumption	+1.28	-5.69	+3.12	-6.85
Energy consumption	-21.79	-12.33	-25.76	-13.65
CO_2	-27.02	-16.72	-31.60	-17.33
SO_2	-39.62	-24.87	-45.69	-25.91

Source: own calculation based on simulation results. A positive sign indicates an increase; a negative sign indicates a decline.

4.2 Economic structure

Fig. 6 presents the economic structure under two reference cases. The share of industry will increase slightly by 0.50% under LG-REF scenario and 2.12% under HG-REF from year 2010 to year 2020. This means the industrial sector will still be the main driving force for economic growth in China over the next one to two decades.

However, if comparing the LG-REF with the HG-REF scenario, it can be found that the service industry and primary industry will grow more in the latter scenario. For example, in 2010, the share of the service industry in the HG-REF scenario is 45.3%, compared with 41.1% in the LG-REF scenario. In 2020, though the difference between these two scenarios becomes smaller, the share of service industry under HG-REF scenario is still 3.2% higher than that under LG-REF. As a result, it could be expected that when a higher economic growth is achieved, the economy’s structure will be optimised to some degree.



	LG-REF-2010	HG-REF-2010	LG-REF-2020	HG-REF-2020
🟨 Service	41.11	45.31	40.76	43.96
🟥 Industry	46.10	40.21	46.61	42.33
🟦 Agriculture	12.79	14.48	12.63	13.71

Fig. 6 Comparison of economy structure between REF scenarios with low and high GDP growth

The carbon constraint policies will have some effect on the structure of the economy, but to varying degrees. The carbon cap measure will have very little effect on the structure of the economy. In the LG-CAP and HG-CAP scenarios, the economic structure is almost same as that in the reference scenario. However, the levy of a carbon tax will result in a more remarkable change, especially in the early stage of the prediction period. In the LG-TAX scenario, the share of the service sector was higher than that in the LG-REF scenario by 1.36% in 2010 and 0.56% in 2020, and in HG-TAX scenario, the difference in the share of the service industry when compared with the HG-REF scenario is 1.43% in 2010 and 0.61% in 2020 (see Fig. 7 and Fig. 8). The reason for this might be that the revenue from a carbon tax will be distributed to the service sector, which will encourage the growth of service sector. It also could be that the service sector is less energy intensive, hence less negatively impacted by payment of tax, no matter what happens to the tax.

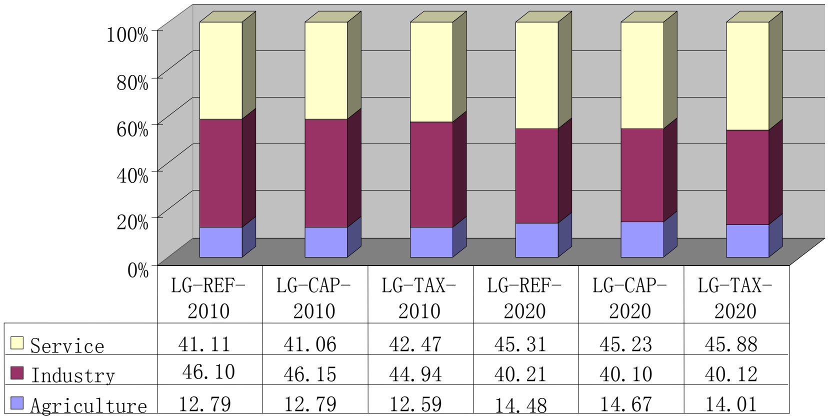


Fig.7 Economic structure under different low-economy-growth scenarios in 2010 and 2020

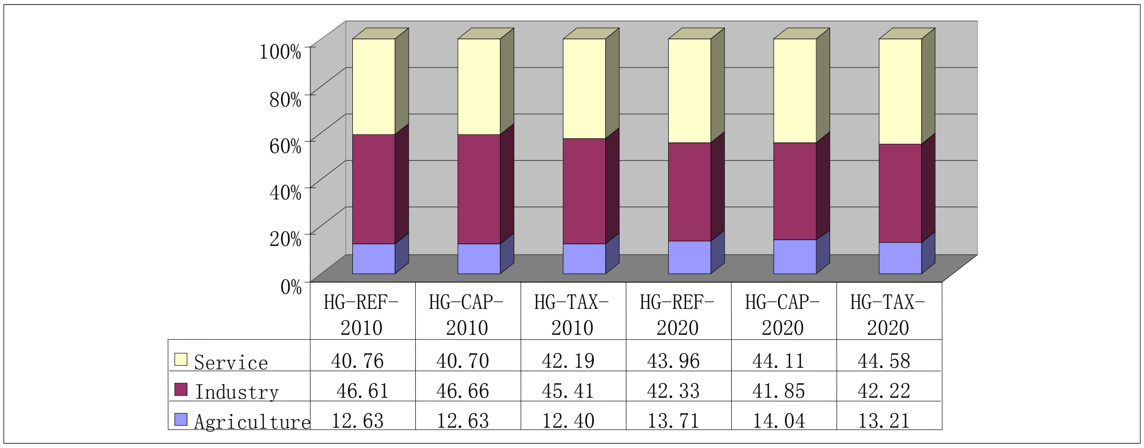


Fig.8 Economic structure under different high-economy-growth scenarios in 2010 and 2020

4.3 Energy consumption

Simulation results on energy consumption under different scenarios are shown in Fig.9. There is an apparent decline under both CAP and TAX scenarios. Compared with the CAP scenario, from 2008 to 2020, there is an increasing reduction of energy consumption under the CAP scenario but a diminishing reduction under the TAX scenario. Furthermore, at first there is a greater reduction under TAX than CAP, but as time goes on, there is a greater decrease under the CAP scenario. Taking the low-economic-growth scenarios as an example, CAP will result in 4%, 11%, and 22% decrease in energy consumption compared with REF in 2010, 2015, and 2020, respectively. However, TAX will reduce energy consumption by 17%, 13%, and 12% compares with REF in 2010, 2015, and 2020, respectively.

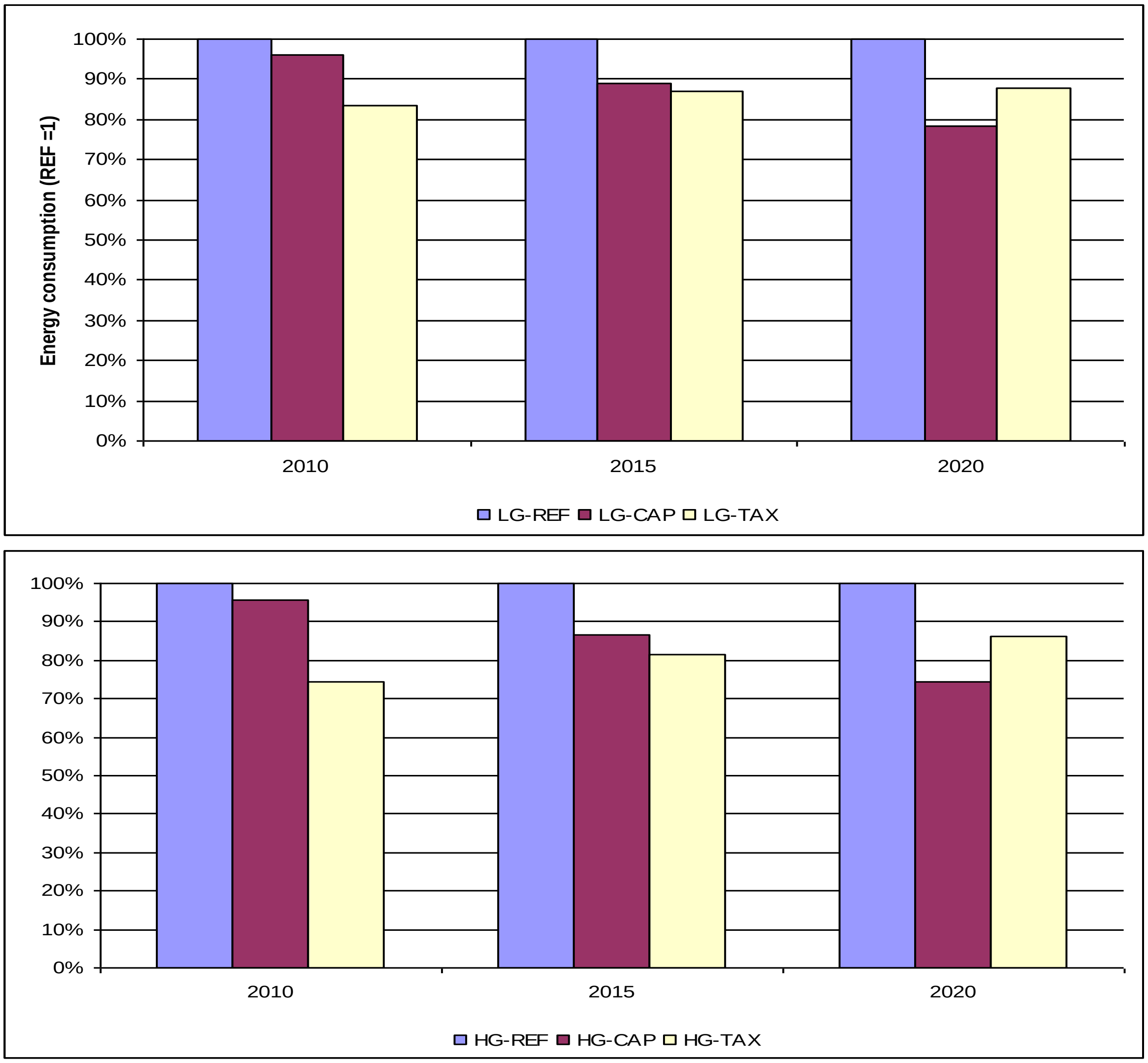


Fig.9 Energy consumption reduction under low and high economic growth scenarios

4.4 CO_2 emissions

Fig.10 presents total CO_2 emissions under the different scenarios. During the whole simulation period, total carbon emissions increase under all scenarios, but the introduction of a carbon cap or a carbon tax somewhat mitigates this trend. However, the degree to which the carbon emissions are mitigated varies according to the scenario. The carbon cap is introduced in a gradual way in this study, so the carbon emissions are reduced gradually. By 2020, total carbon emissions under the carbon cap scenario are still similar to that in year 2015 under the reference scenario. The carbon tax is levied from 2008, so it will result in a great reduction in that year. However, since the tax rate is constant during the whole simulation period, the percentage of carbon reduction will remain unchanged and in 2020, the total carbon emission will be roughly similar to that in 2017 under the reference scenario.

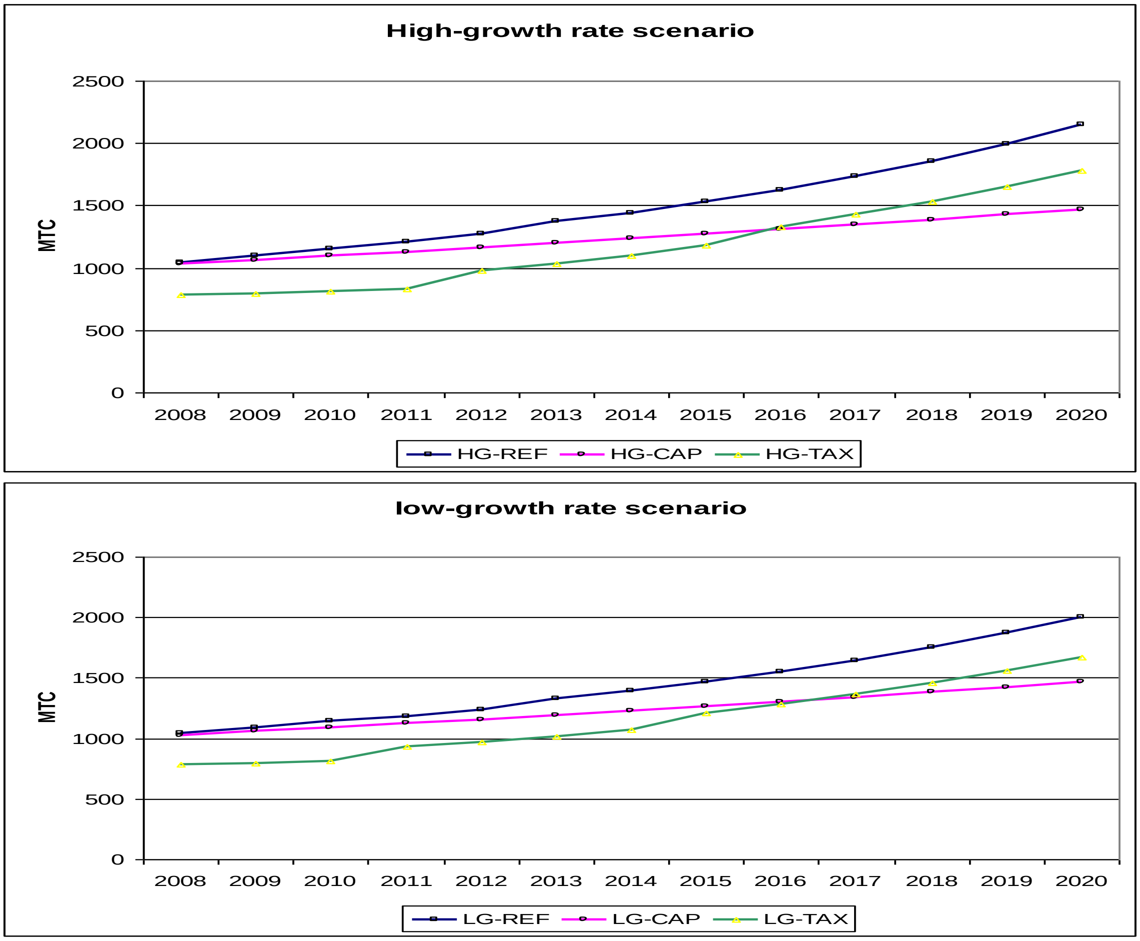


Fig.10 CO_2 emissions under low and high economic growth scenarios

If we look at total accumulated CO_2 emissions shown in Fig.11, it is much clearer which policy measure results in the greatest reduction in carbon emissions. During the whole simulation period, CAP will obtain 11% and 13.5% reductions compared with REF under Low and High economic growth scenarios, respectively. TAX will result in 15.7% and 17% reductions compared with REF under Low and High, respectively, about 4% more of reductions than through CAP.

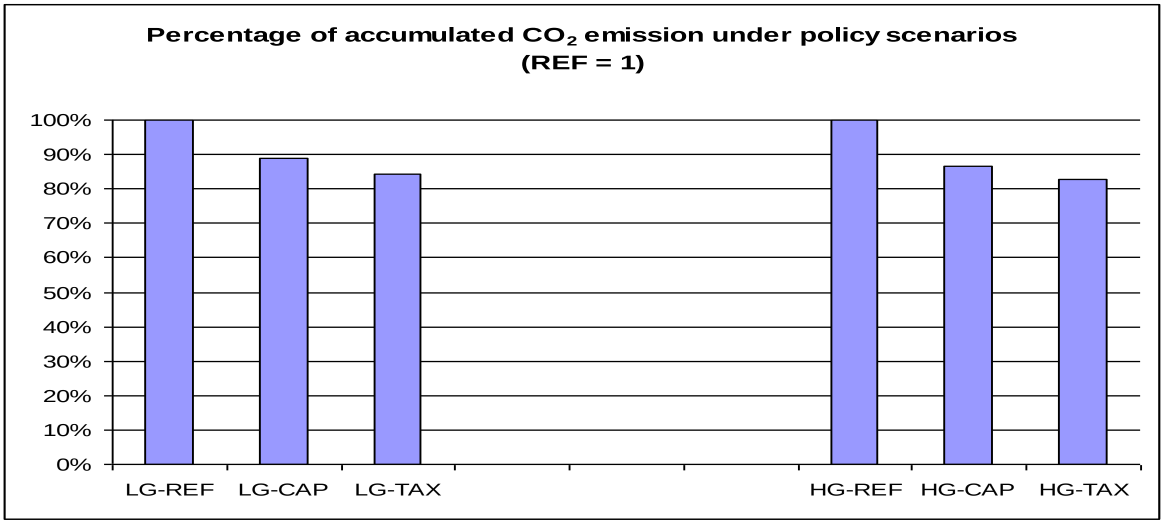


Fig.11 Reduction of accumulated CO_2 emissions under policy scenarios

4.5 SO_2 emissions

Fig.12 shows the SO_2 emissions trajectory and Fig.13 presents the reduction of accumulated SO_2 emissions under the different policy scenarios. SO_2 emissions have similar trajectory as CO_2 emissions. The reason for this is that carbon emission mitigation under the policy scenarios arises from the reduction of fossil fuel use, especially coal, which is the most important energy source in China. Therefore, these carbon control policies will also have benefits for SO_2 emissions mitigation. The reduction of accumulated SO_2 emissions during the simulation period compared with REF is appropximately 20% to 25% under the different policy scenarios.

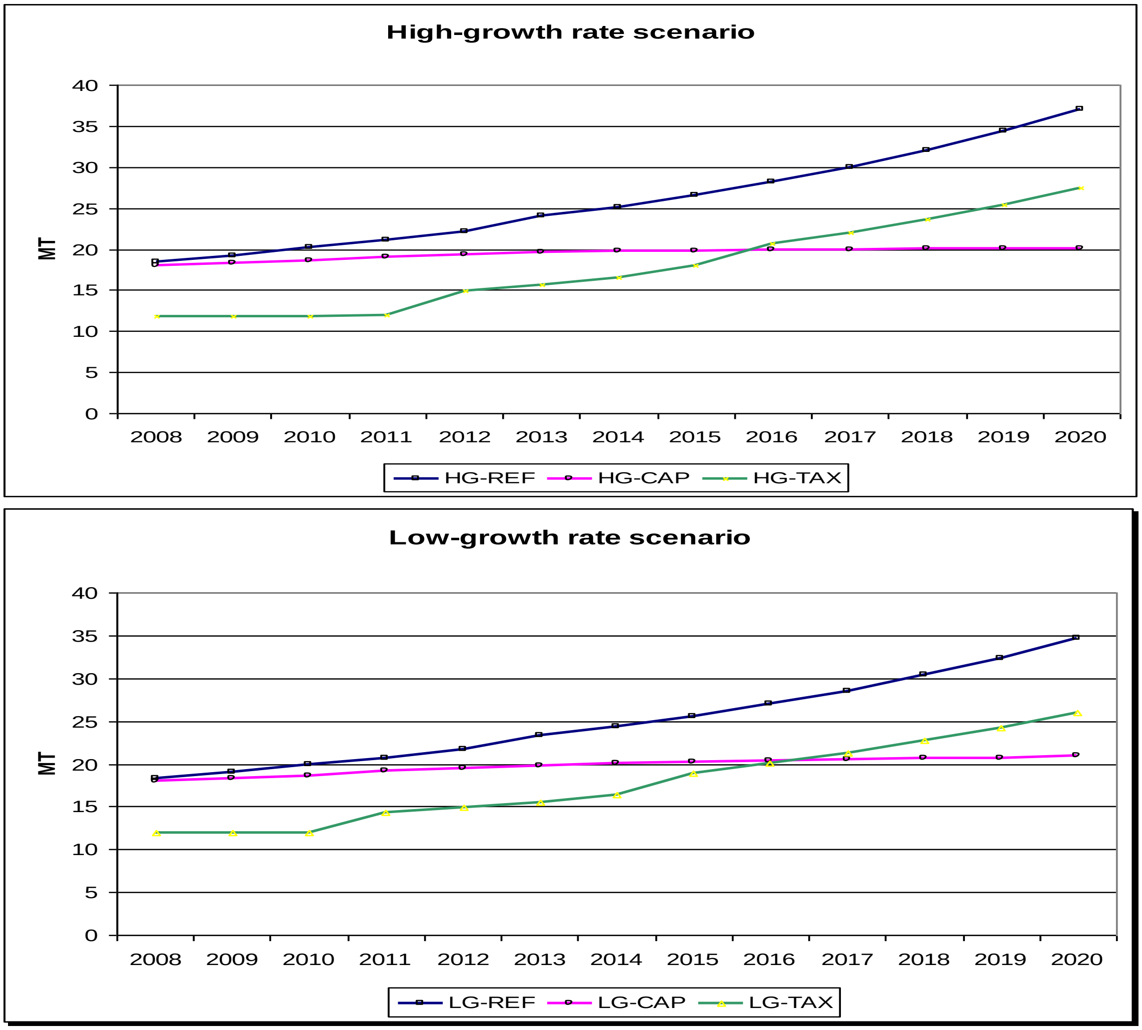


Fig.12 SO_2 emissions under low and high economic growth scenarios

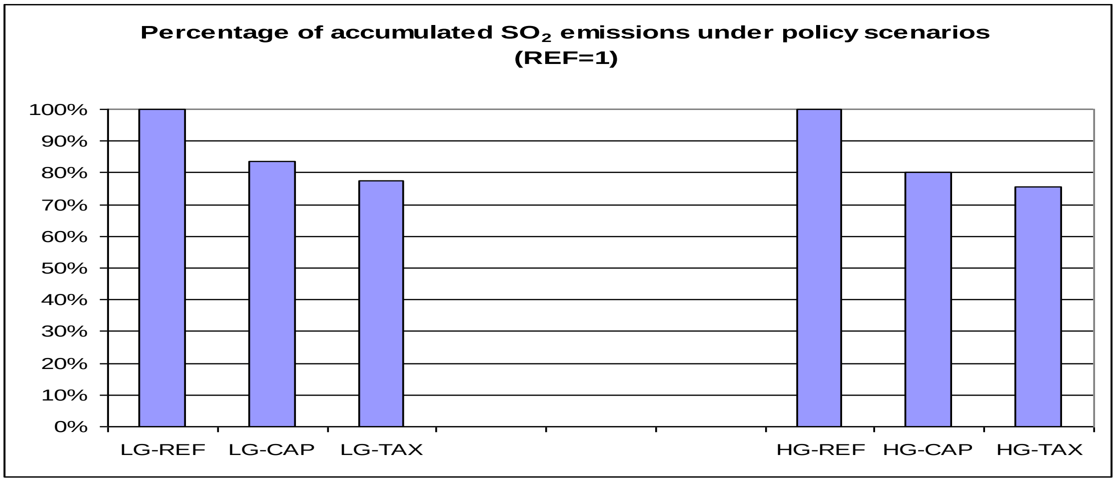


Fig.13 Reduction of accumulated SO_2 emissions under policy scenarios

5. Conclusions

China is now the world's largest GHG emitter. Although a great deal of literature has been published in recent years on the analysis of either carbon taxes or emission caps in China, few studies or papers dealing with both measures can be found in the literature. Against this background, this study tries to analyse two different methods of controlling CO_2 emissions from China: a carbon tax and cap-and-trade using a recursive dynamic CGE model of the economy of China. The simulation period is from 2002 to 2020. In addition to CO_2, the model also examines co-benefit of these policies on SO_2, one of the major local air pollutants in China.

Based on the simulation results, primary findings include:

First, there is slight increase of GDP under CAP scenarios. But there will be 3.57% and 3.88% GDP decrease in 2020 compared with reference cases under LG-TAX and HG-TAX, respectively. The reason is that CAP scenario causes less reduction at earlier years but greater reduction at later years, which allows more time for Chinese economy to adapt and transition to lower carbon economy.

Second, though the absolute levels of GHG emissions rise rather substantially in all scenarios, both policies produce a great deal of reduction in energy consumption and CO_2 emissions compared with reference case. For example, CAP will result in a 22% reduction of energy consumption compared with REF in 2020 under the Low economic growth scenario and TAX will reduce energy consumption by 12% in 2020. During the whole simulation period, CAP will obtain 11% and 13.5% reductions in carbon emissions compared with REF under the Low and High economic growth scenarios, respectively. TAX will result in 15.7% and 17% reduction of carbon emissions compared with REF under Low and High economic growth scenarios.

Third, when comparing the effectiveness of CAP and TAX, the results are interesting. TAX cases induce smaller reduction in 2020 but greater accumulated reduction in carbon emissions for the total simulation period, and it also leads to higher costs. For example, in the Low scenarios, the TAX case reduces CO_2 by 25.43% more than CAP case, and costs 24.87% more than the CAP case.

Finally, there is an additional benefit of actions to reduce carbon emissions, in that SO2 emissions are also predicted to decline, supporting the results of other studies (Xu & Masui, 2009).

References:

AIM Japan Team (2005) AIM/CGE [Country]: Data and Program Manual (Version 3).National Institute for Environmental Studies, Tsukuba, and Kyoto University, Kyoto, Japan

Garbaccio RF, Ho MS, and Jorgenson DW (1999) Controlling carbon emissions in China. Environment and Development Economics **4:** 493-518

Liang QM, Fan Y, and Wei YM (2007) Carbon taxation policy in China: how to protect energy- and trade-intensive sectors? Journal of Policy Modelling 29: 311-333

National Bureau Statistics of China (NBS) (2007) China statistical yearbook 2007. China Statistics Press, Beijing

National Population and Family Planning Commission of China (2003) http://www.cpirc.org.cn/tjsj/tjsj_cy_detail.asp?id=1422

Rutherford TF and Paltsev SV (2000) GTAPinGAMS and GTAP-EG: global datasets for economic research and illustrative models. http://www.mpsge.org/papers/gtaptext.pdf

Shoven JB and Whalley J (1992) Applying general equilibrium, Cambridge University Press, New York

Xu Y and Jiang KJ (2009) Hybrid modelling of China 11th-five energy intensity reduction target. Submitted to Energy Policy

Xu Y and Masui T (2009) Local air pollutant emission reduction and ancillary carbon benefits of SO2 control policies: Application of AIM/CGE model to China. European Journal of Operational Research 198: 315–325

Zhang ZX (1998a) Macroeconomic effects of CO_2 emission limits: A computable general equilibrium analysis for China. Journal of Policy Modelling 2:213-250.

Zhang ZX (1998b) The economics of energy policy in China: Implications for global climate change. Edward Elgar, Cheltenham, UK.

Zhang ZX (2000) Can China afford to commit itself an emissions cap? An economic and political analysis. Energy Economics 22: 587- 614

Annex 1: sector definitions in the study

1	Agriculture	20	Manufacture of rubber
2	Coal mining and processing	21	Manufacture of Cement
3	Crude petroleum extraction	22	Manufacture of Glass
4	Natural gas extraction	23	Non-metal mineral products
5	Mining and Processing of Ferrous Metal Ores	24	Ferrous metal smelting
6	Mining and Processing of Non-Ferrous Metal Ores	25	Non-ferrous metal smelting
7	Mining and Processing of Nonmetal Ores	26	Non-metal mineral products
8	Food manufacture	27	Manufacture of General and Special Purpose Machinery
9	Tobacco processing	28	Manufacture of Transport Equipment
10	Textile industry	29	Manufacture of Electrical Machinery and Equipment
11	Manufacture of Leather, Fur, Feather and Related Products	30	Manufacture of Measuring Instruments and Machinery for Cultural Activity and Office Work
12	Manufacture of Sawmills and furniture	31	Other industry
13	Manufacture of Paper	32	Electricity production
14	Printing, Reproduction of Recording Media	33	Heat production
15	Petroleum processing	34	Gas production and supply
16	Coking	35	Water production and supply
17	Manufacture of Chemicals	36	Construction
18	Manufacture of Medicine	37	Transportation
19	Manufacture of Fiber	38	Other services