The Impact of China’s Carbon Trading Scheme

Though President Donald Trump announced to withdraw the U.S. from the Paris Accord on climate change, China’s government committed to fulfill the Paris Accord to the fight against climate change. The report of the "19th National Congress of the CPC" pointed out “Building an ecological civilization is vital to sustain the Chinese nation’s development.”

To achieve the goal of controlling greenhouse gas emissions, the Chinese government has released the National Emission Trading Scheme (Power Sector) at the end of 2017. The Scheme pointed out that China’s will start the nationwide carbon emission trading system in the power generation industry (including combined heat and power) firstly and then cover more and more sectors in the carbon market.

However, the current carbon emissions trading system only involves the power industry, and power is still priced by government. It’s not clear whether the carbon emissions trading system can achieve the expected target. This paper attempts to construct a multi-regional (31 provinces) computable general equilibrium model to evaluate the impact of the current carbon trading scheme. In order to model the impacts of carbon trading scheme it is essential to include different power generation technologies in the model. There are five main power technologies operating in model: coal, natural gas, hydro, new renewables, and nuclear.

1.China's Carbon Trading Scheme

Different from the previous use of administrative measures, in recent years China is actively seeking market measures such as carbon emissions trading to control greenhouse gas emissions. In 2011, the National Development and Reform Commission approved trials of carbon emissions trading in seven provinces and cities including Beijing, Tianjin, Shanghai, Chongqing, Guangdong, Hubei and Shenzhen, and accumulated experience to lay the foundation for the construction and implementation of a nationwide carbon emissions trading system. Based on the pilot, the Chinese government announced on December 19 the construction of an ETS scheme. The program has gained years of pilot experience in several provinces and cities in China, and has also learned from other local experiences. It will begin implementation in the power industry and incorporate other major emission industries by 2020.

(1) The main body of the transaction. The main trading entity is the key emission units in the power generation industry. The annual discharge of electricity generation industry has reached 26,000 tons of carbon dioxide equivalent (comprehensive energy consumption is about 10,000 tons of standard coal) or above, or other economic organizations are key emission units. The annual captive power plants in other industries that have an annual discharge of 26,000 tons of CO2 equivalent or more are treated as key emission units in the power generation industry. On this basis, we will

gradually expand the scope of key emission units to other high energy-consuming, high-pollution and resource-based industries.

(2) Trading Products. The initial trading products are spot quotas, and when the conditions are ripe, increase the national certified voluntary emission reductions and other trading products that meet the trading rules.

(3) Quota management. The development and reform department of the State Council is responsible for formulating quota allocation standards and methods. The competent departments of climate change response at the provincial level and separately designated cities shall allocate quotas to the key emission units within the jurisdiction according to the standards and measures. The quota for the power generation industry is allocated according to the distribution standards and methods formulated by the development and reform department of the State Council in conjunction with the energy sector. The key emitters in the power generation industry need to submit annual quotas equal to the actual carbon emissions of the provincial level and single-planned municipalities where they are located to meet the climate change authorities in order to fulfill their emission reduction obligations. Its surplus allowances can be sold to the market, and the shortages need to be purchased through the market.

In addition, we will promote the transition of the regional carbon trading pilot to the national market. Since 2011, regional pilots of regional carbon trading have gradually incorporated eligible emission units into the national carbon market and implemented unified management. The regional carbon trading pilot regions continue to play their existing roles, and gradually transition to the national carbon market after the conditions are ripe.

2. China's Multi-regional Computable General Equilibrium Model

The model in this paper belongs to a family of DRC-CGE-models used extensively over the past two decades to analyze environmental policy and other policy reforms, and maintained at the Development Research Center of the State Council in China. In China the model is used in regional development planning and macroeconomic planning for the State Council, including the Five Year plans.

The model has 30 region and 23 sectors (including 1 agricultural sectors, 3 mining sectors, 7 manufacturing sectors, 8 utility sector, and 4 services sectors). There are 4 production factors: land, resource, labor, and capital. Labor is disaggregated into 3 types by occupation. There are 2 representative households by area.

In DRC-CGE model, five types of energy are included, namely coal, crude oil and natural gas, petroleum products, gas and electricity. The electricity activity is divided into different sub-sector by source (Thermal-, hydro-, nuclear and renewable power generation). Emissions in DRC-

CGE-model have three drivers. Most are generated through intermediate consumption of fossil fuels. Some are driven by final demand on fossil fuels. And the remainder is generated by aggregate output—for example emissions from cement production. The amount of a given polluting emission takes the following form:

$$E = \sum_i \sum_j \alpha_{i,j} XAp_{i,j} + \sum_i \beta_i XP_i \quad + \sum_j \gamma_j XAf_j$$

Where, *E* is the emission level of a given polluting emission, $\alpha_{i,j}$ is the emission volume associated with one unit consumption of commodity *i* used by sector j, and XAp refers to intermediate input; β_j the emission volume associated with one unit production of sector *j*, and XP refers to sectoral output; γ_j the emission volume associated with one unit consumption of product *j* in final consumption, and XAf refers to finial demand. Thus, the first two elements of the right-hand side expression represent supply-related emissions, the third one final-demand-related emission.

DRC-CGE model has a flexible system of carbon mitigation policies. The simplest is a provincial specific carbon tax—that also allows for exemptions for designated sectors or households. An alternative is to provide a cap on emissions at either provincial or national level. The model will then produce the shadow price of carbon, i.e. the carbon tax, as a model outcome. If a national cap is imposed, a single uniform tax will be calculated. This type of regime assumes no trading. A final option is to have a provincial or national cap with trading and assigned quotas. Similar to the previous regime, a uniform carbon tax will be calculated (and would be nearly identical to the no-trade carbon tax), but emissions trading would occur depending on the initial quotas and the shape of the individual marginal abatement curves for each member of the trading regime.

The model is calibrated to DRC multi-regional Social Accounting Matrix with a 2002 base year1. For a detailed description see Appendix 2.

3. Scenario design for carbon trading system

With multi-regional CGE model, this study will apply the method of scenario analysis to study the effects of China’s carbon trading system (CTS). The study will design a baseline scenario is prospect China’s economic development without carbon trading system. Based on baseline scenario, three contrasting scenarios are designed to capture the effects of CTS. First one is trading with fixed power price. In this scenario, China’s will implement carbon trading system and the emissions trading scheme will cover only the power sector. However the power is priced not by market, but government. Second is trading with free power price. In contrast with first one, this scenario will eliminate pricing restriction. Third is trading with all sectors. In this scenario, China’s will implement carbon trading scheme covering all sectors. Comparing the contrasting scenarios

[1] The latest published regional Input-Output tables are 2002 tables.

with baseline scenario, this study will analyze the effect China's carbon trading scheme.

4. Simulation Result for Baseline and Carbon Reduction Scenarios

4.1 Baseline

In baseline, GDP growth rate for each region is set exogenously, based on historical trend (See Appendix 2). Average growth rate for all regions be set to 8.3% per year in 2010-2020 and 5.6% in 2020-2030. Population, labor supply and urbanization rate are all from the forecast in IIASA (IIASA, 2010). Meanwhile, autonomous energy efficiency improvement (AEEI) – the rate at which the required energy input per unit output falls – is fixed at 2% and 1% annually for 2010-2020 and 2020-2030 respectively. Based on all these assumption, the study runs DRC CGE model in 2002-2030 and the simulation result shows energy demand and carbon emission for each region in next 20 years (See Appendix 3 and 4). CO2 emissions rise to 15.4Gt CO2 in 2020 and 24.3Gt CO2 in 2030 respectively. The overall carbon intensity of GDP in the Baseline falls 30% and 37% from 2005 levels in 2020 and 2030 respectively.

4.2 Cap and Trading its regional impact

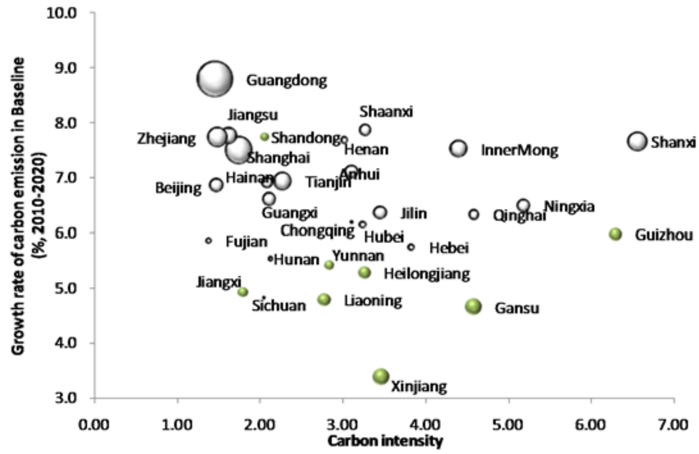
Allowance allocation is a contended issue in virtually every cap-and-trade programme as it critically determines the policy's distribution impact (Steffen Brunner, 2008). From regional point of view, the key question is which province can receive scarcity rent created by capping emissions.

The impact of emission trading on regional welfare is analyzed as follow.

CNT1 and CAT1 Scenario (Graderfather principle)

The following will begin with analysis of CNT1 scenarios. From the national point of view, In CNT1 scenario, in which emission cap for each region is set according to its emission level in 2010, the national GDP decrease by 0.7% and 1.9% in 2020 and 2030 respectively compared with the Baseline, which are 0.5 and 0.9 percentage point higher than that in the uniform tax scenario. This also shows that setting cap without trading scheme will increase the overall costs of emission reduction.

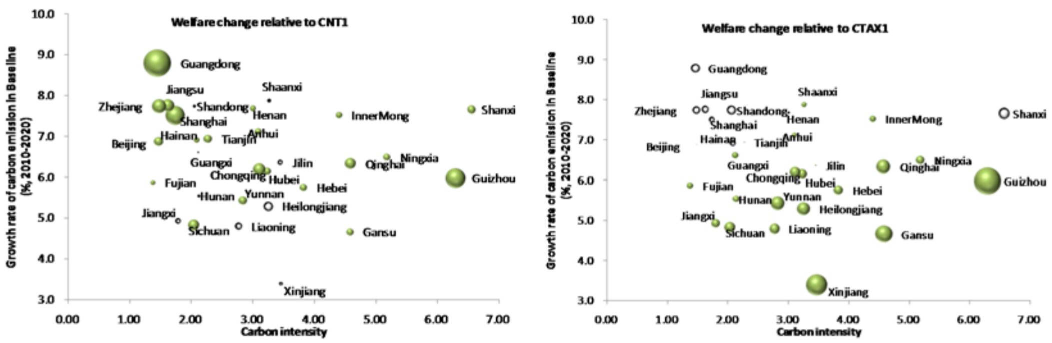
Figure 7 shows the simulation results in CNT1 scenario. The vertical axis represents the average annual growth rate of carbon emissions from 2010 to 2020 in the baseline scenario, while the horizontal axis indicates the carbon intensity. Based on the figure, we can find regions which have the fast growth in the amount of carbon emissions in Baseline will suffer greater GDP losses in the CNT1 scenarios than regions with slow growth of carbon emission. The region with high carbon intensity will suffer lower GDP loss than that with low intensity, because the lower marginal cost, the higher carbon intensity. Meanwhile, according to the simulation result, we can find that the way in which cap is set in CNT1 will limits the development of undeveloped areas to some extent.



Note: Green bubble refers benefit and empty bubble means loss; the size of bubble denotes level of benefit/loss

Fig 7 change of GDP in Cap without trading (CNT1, relative to Baseline)

Figure 8 presents the change of welfare in CAT1, relative to CNT1 scenario and CTAX1 scenario. According to left part of the Figure, most of regions will benefit from emission trading, relative to CNT1 scenario. The regions with high growth rate of carbon emission in baseline will bear greater loss of welfare in CAT1 than that with low growth of carbon emission.



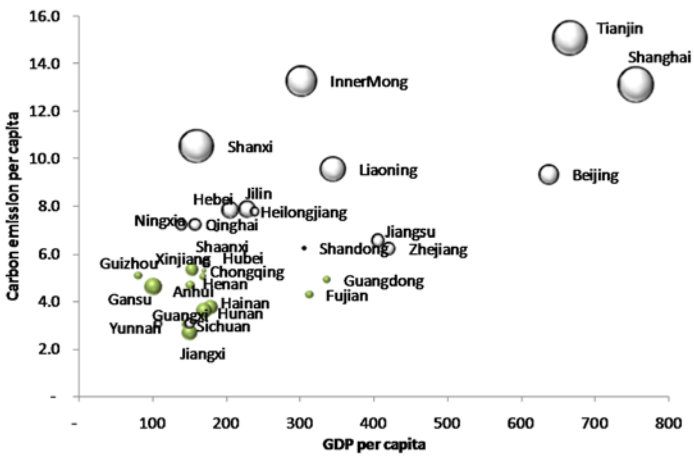
Note: Green bubble refers benefit and empty bubble means loss; the size of bubble denotes level of benefit/loss

Fig 8 change of welfare in Cap and trading (relative to CTAX1)

CNT2 and CAP2 Scenario (per capita principle)

In CNT2 scenario, the aggregated GDP will be reduced by 1.7% and 3.1% in 2020 and 2030, compared with Baseline. However, the loss of aggregated GDP will increase by 1.5 and 2.1 percentage point, compared with CTAX1 scenario. The reason for this is that there is big disparity between regions in terms of per capita carbon emission.

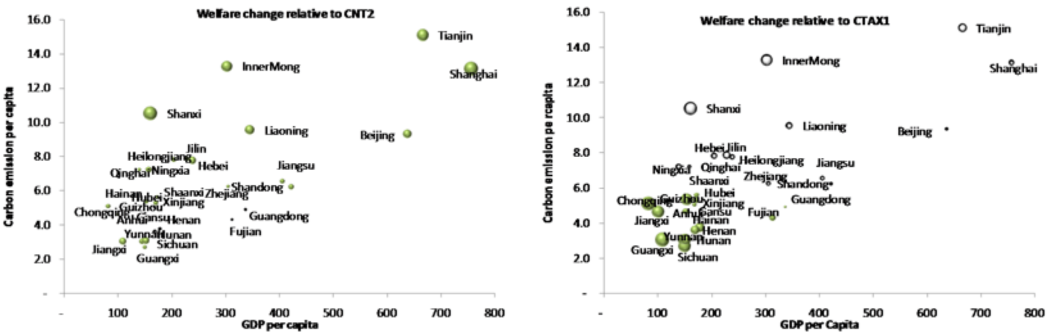
Figure 9 shows the simulation results in CNT2 scenario. The vertical axis represents the carbon emission per capita, while the horizontal axis indicates GDP per capita. Based on the figure, we can find regions which have the high carbon emission per capita will suffer greater GDP losses in the CNT2 scenarios than regions with low per capita carbon emission. Meanwhile, the more developed the region, the higher its carbon emission per capita. Therefore most of rich regions will get loss of GDP in CNT2 scenario.



Note: Green bubble refers benefit and empty bubble means loss; the size of bubble denotes level of benefit/loss

Fig 9 change of GDP in Cap without trading (CNT2, relative to Baseline)

Figure 10 presents the change of welfare in CAT2, relative to CNT2 scenario and CTAX1 scenario. According to left part of the Figure, most of regions will benefit from emission trading, relative to CNT2 scenario. The regions with high carbon emission per capita will bear greater loss of welfare in CAT2 than that with low per capita carbon emission, compared with CTAX1 scenario. Therefore CAT2 scenario is good for poor provinces in terms of welfare.



Note: Green bubble refers benefit and empty bubble means loss; the size of bubble denotes level of benefit/loss

Fig 10 change of welfare (2020，CAP2)

5. Conclusion

This paper built a multi-regional computable general equilibrium model including 30 provinces of China to simulate the regional effect of reducing 20% of carbon emissions. The paper mainly focuses on change of the regional welfare level and some conclusions are followed:

1. Energy resources in china are mainly located in western and central regions with relatively poor economy, but their carbon emission of unit GDP are relatively high.
2. Imposing a uniform carbon tax on all regions to achieve the reduction of carbon emissions, the welfare losses of energy- and resource-rich provinces in central and western regions is much bigger than that of developed coastal provinces. If without other support measures, the carbon policy will expand the regional gap.