

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

Yan XU (Macaulay Land Use Institute)

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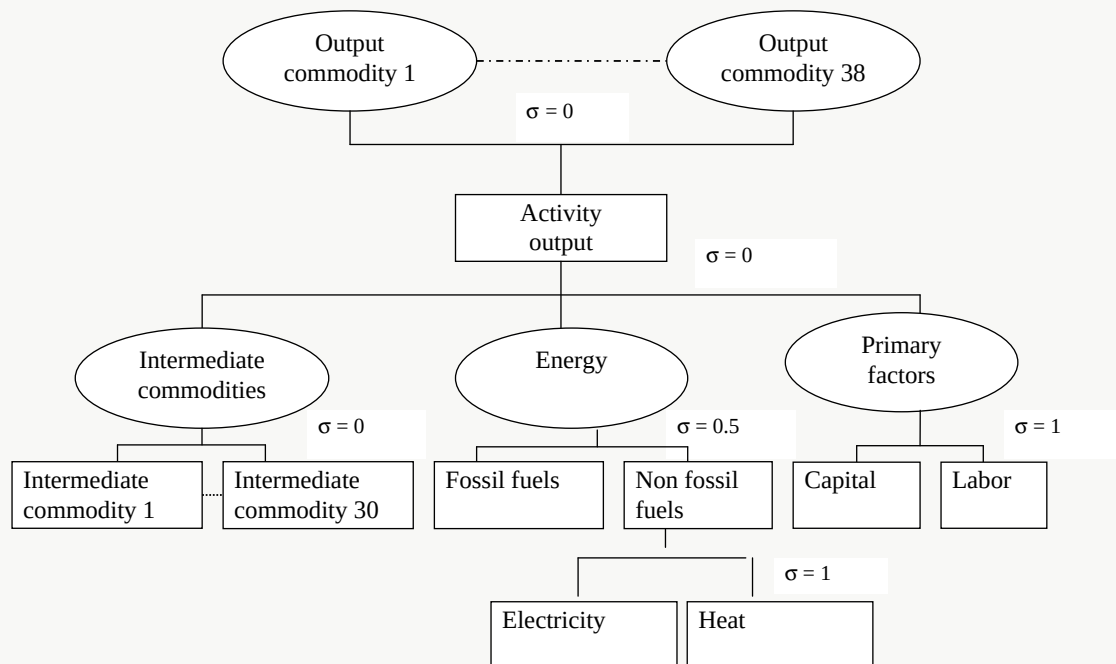
1. Introduction

- Accompanying China's rapid economic growth, GHG emissions from this country are increasing rapidly and gaining more and more external attention.
- A great deal of literatures has been published in recently years on the analysis of either carbon tax (Liang et al, 2007; Garbaccio et al, 1999; Zhang, 1998a; Zhang, 1998b) or emission cap (Zhang, 2000) in China
- However, few studies or papers dealing with both measures can be found in the literatures.
- Against this background, this study tries to analyze two different measures: carbon tax and cap-and-trade using a recursive dynamic CGE single country model.

2. Model descriptions

- Production & Consumption: Nested CES function
- International Trade:
 - Small open economy assumption
- Environment: CO₂ & SO₂
- 2002 Input-Output (IO) table
- 38 sectors, including 8 energy goods
- Software: GAMS/MPSGE

Nesting of the production structure



Sector definitions in the model

Agriculture	Manufacture of rubber
Coal mining and processing	Manufacture of Cement
Crude petroleum extraction	Manufacture of Glass
Natural gas extraction	Non-metal mineral products
Mining and Processing of Ferrous Metal Ores	Ferrous metal smelting
Mining and Processing of Non-Ferrous Metal Ores	Non-ferrous metal smelting
Mining and Processing of Nonmetal Ores	Non-metal mineral products
Food manufacture	Manufacture of General and Special Purpose Machinery
Tobacco processing	Manufacture of Transport Equipment
Textile industry	Manufacture of Electrical Machinery and Equipment
Manufacture of Leather and Related Products	Manufacture of Machinery for Cultural Activity and Office Work
Manufacture of Sawmills and furniture	Other industry
Manufacture of Paper	Electricity production
Printing, Reproduction of Recording Media	Heat production
Petroleum processing	Gas production and supply
Coking	Water production and supply
Manufacture of Chemicals	Construction
Manufacture of Medicine	Transportation
Manufacture of Fiber	Other services

Recursive Dynamic

- Simulation is iterated year by year.
The main driving forces of the economic growth are the labor force, capital accumulation, and technology change.

- Total investment is decided from expected GDP growth rate in the next period, present capital stock, and technology change

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

- The total investment is distributed into each sector based on logit function taken into account profit from capital.

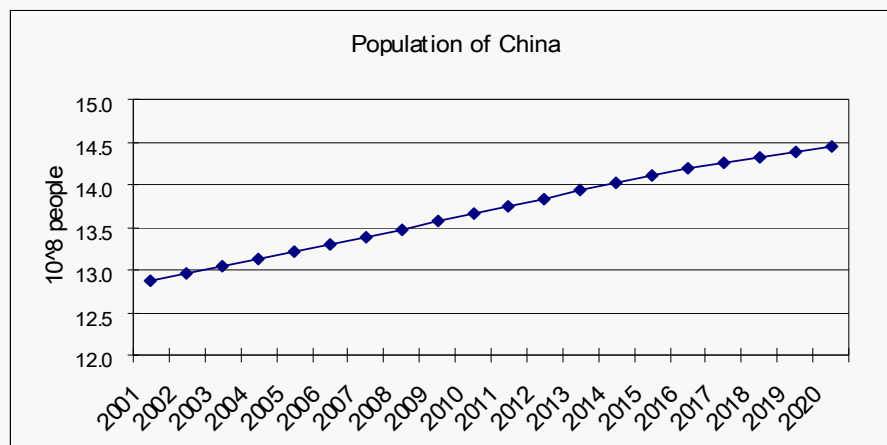
$$I_{j,t+1} = I_{TOT,t+1} * \frac{\left(\frac{PK_{j,t}}{PK_{j,t=1}} \right)^{\gamma} * I_{j,t=1}}{\sum_j \left\{ \left(\frac{PK_{j,t}}{PK_{j,t=1}} \right)^{\gamma} * I_{j,t=1} \right\}} \quad (2)$$

- The capital stock in each sector is estimated from the investment.

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

3. Data and scenarios

- Base year data: 2002 Input-output table
- Simulation period: 2002-2020
- 6 scenarios



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

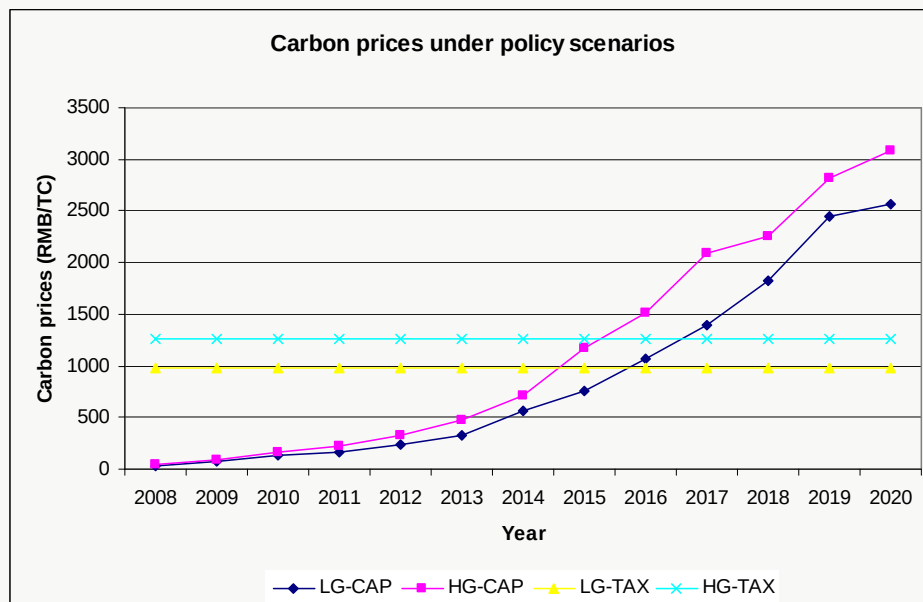
GDP growth rate

	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%	9.5%
2010-2020	6.5%	8%

Scenarios descriptions

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

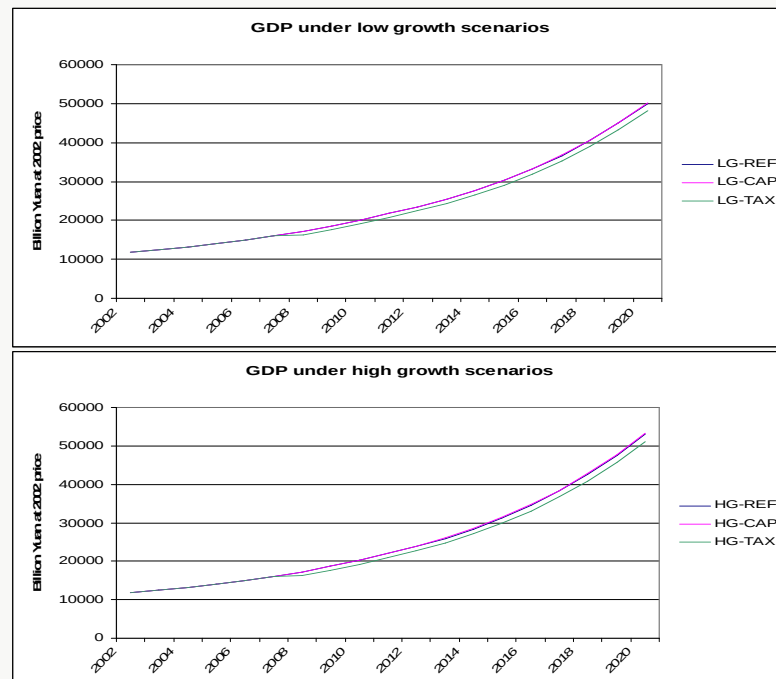
Carbon prices



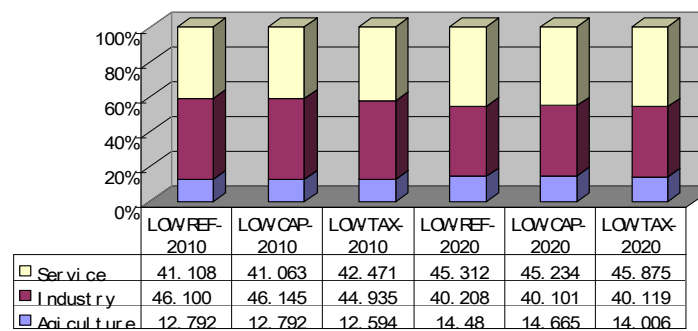
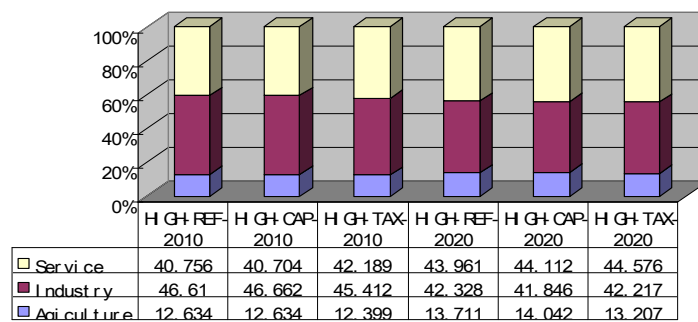
4. Primary results

Results-GDP

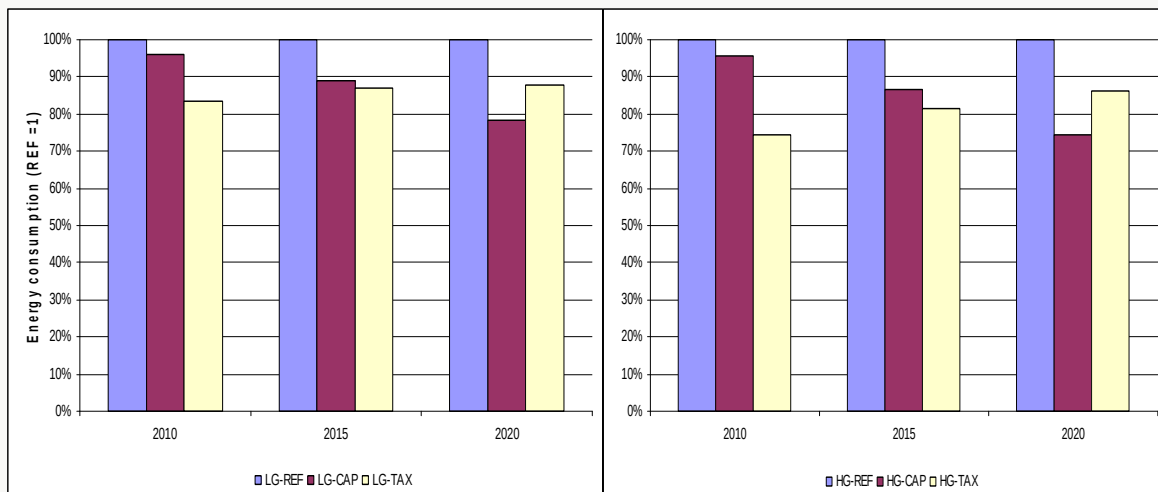
	Annual Inc. rate of GDP
LG-REF	8.30%
LG_CAP	8.30%
LG_TAX	8.10%
HG-REF	8.70%
HG_CAP	8.70%
HG_TAX	8.40%



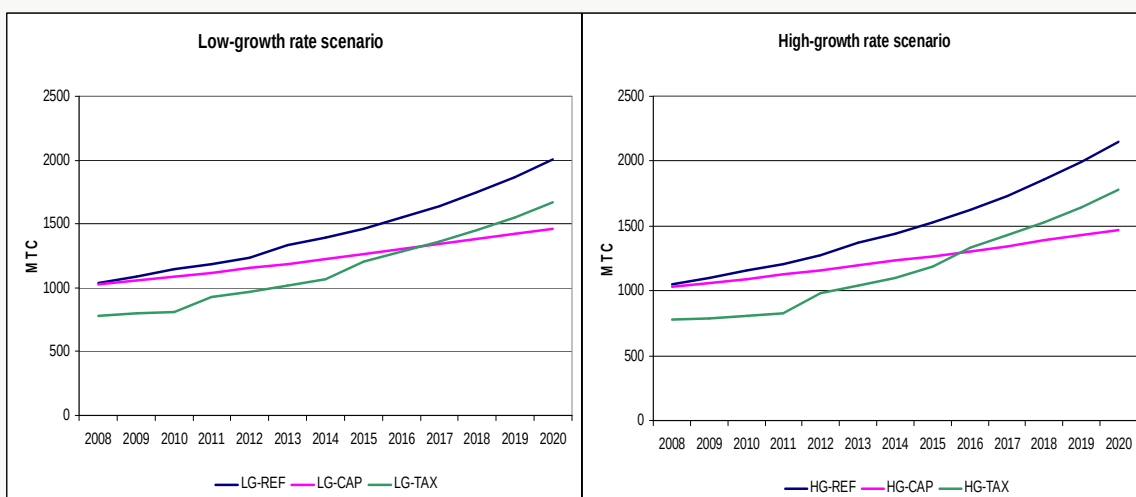
Results-economic structure



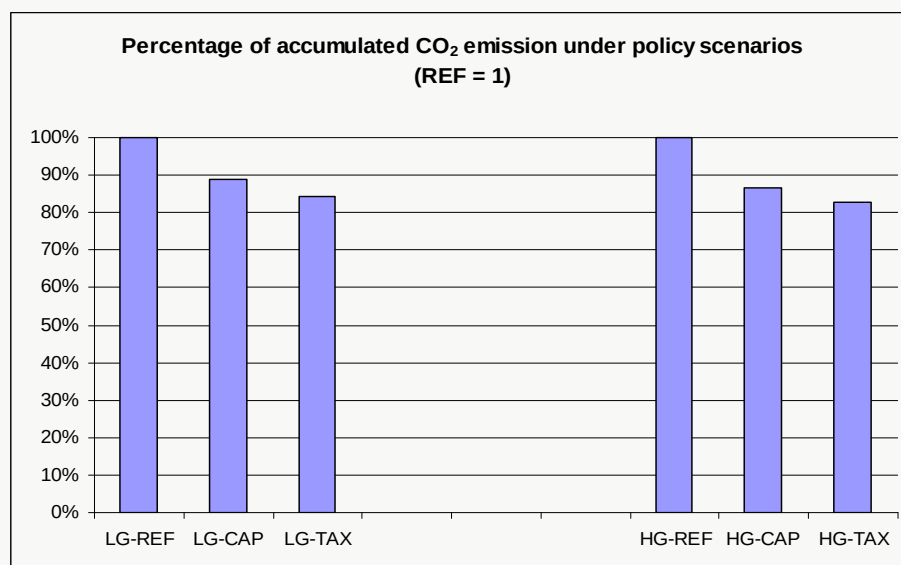
Results-Energy consumption



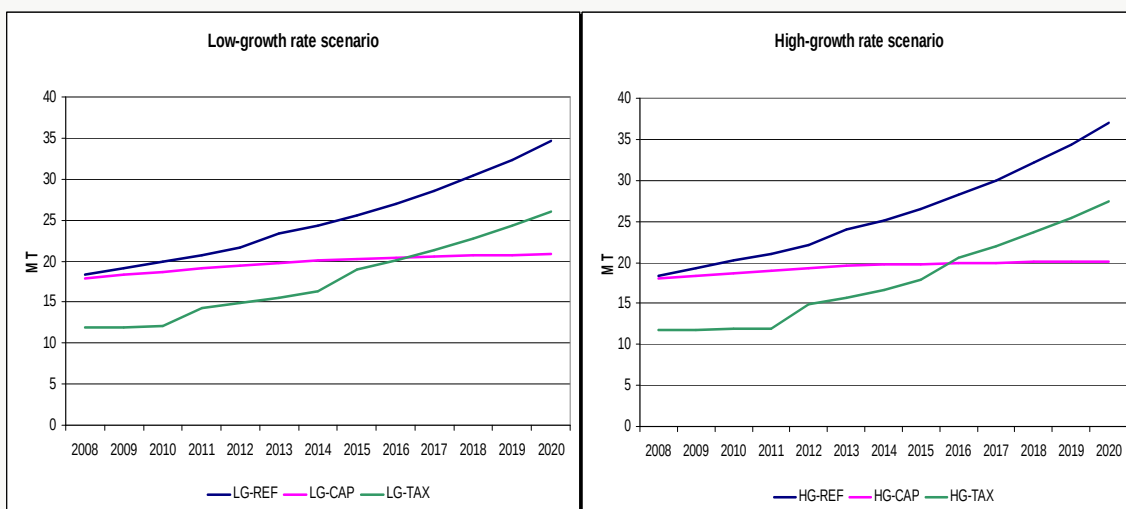
Results- CO₂ emissions



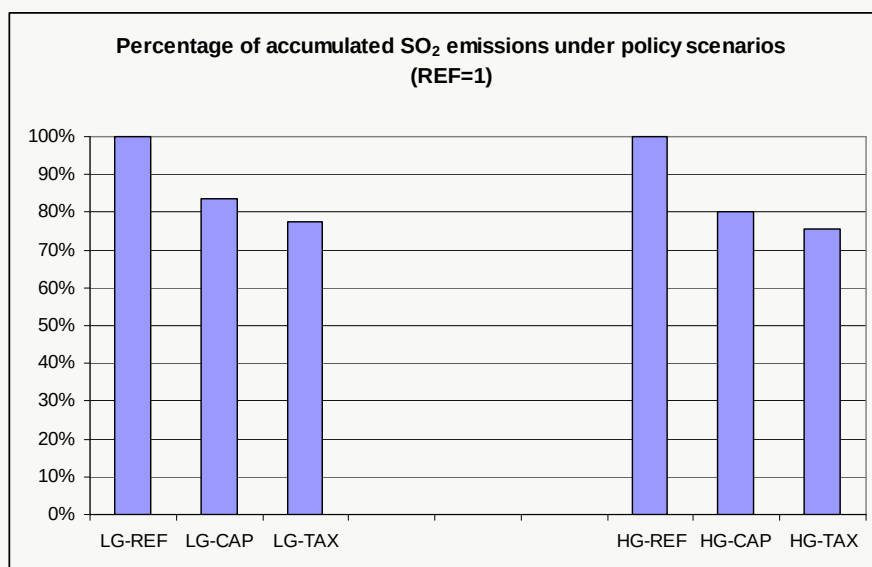
Results- accumulated CO₂ emissions



Results- SO₂ emissions



Results- accumulated SO₂ emissions



5. Discussion

Primary findings

- Though slight decrease can be found under TAX scenarios, GDP is not affected much, under both policy scenarios (CAP, TAX)
- The reason why GDP is not influenced may include:
 - The transaction and other management costs are not considered in model;
 - As model does not separate government from household, the revenue of tax is redistributed to the consumption side and will in some sense promote the consumption;
- TAX leads to more reductions of accumulated CO₂ emissions but with greater GDP loss.
- Co-benefit of carbon reduction actions on other air pollutant can be observed, as SO₂ example shows

Further work

- Dynamic mechanism is important and should be improved;
- Sector should be expanded, e.g.
 - power sector should be separated by renewable, nuclear, fossil fuel, etc;
 - government should be separated from households;
- Improving the linking with energy model to get more reasonable assumption on energy efficiency improvement
- A mechanism of gradually increasing the tax rate should be considered in the future
- Tax refund mechanism should be analyzed

Yan XU

Social-economic group,
Macaulay Land Use Institute,
<http://www.macaulay.ac.uk/>
y.xu@macaulay.ac.uk
(+44)1224-395314