能源与环境政策研究中心

Center for Energy & Environmental Policy Research

Prepared for the 21th AIM International Workshop, NIES, Tsukuba, JAPAN, 2015

Abatement Performance Evaluation of Climate Policies in China- A Study based on Integrated Assessment Model

Lei Zhu, Pan Peng, Ying Fan

Center for Energy and Environmental Policy Research
Institute of Policy and Management
Chinese Academy of Sciences

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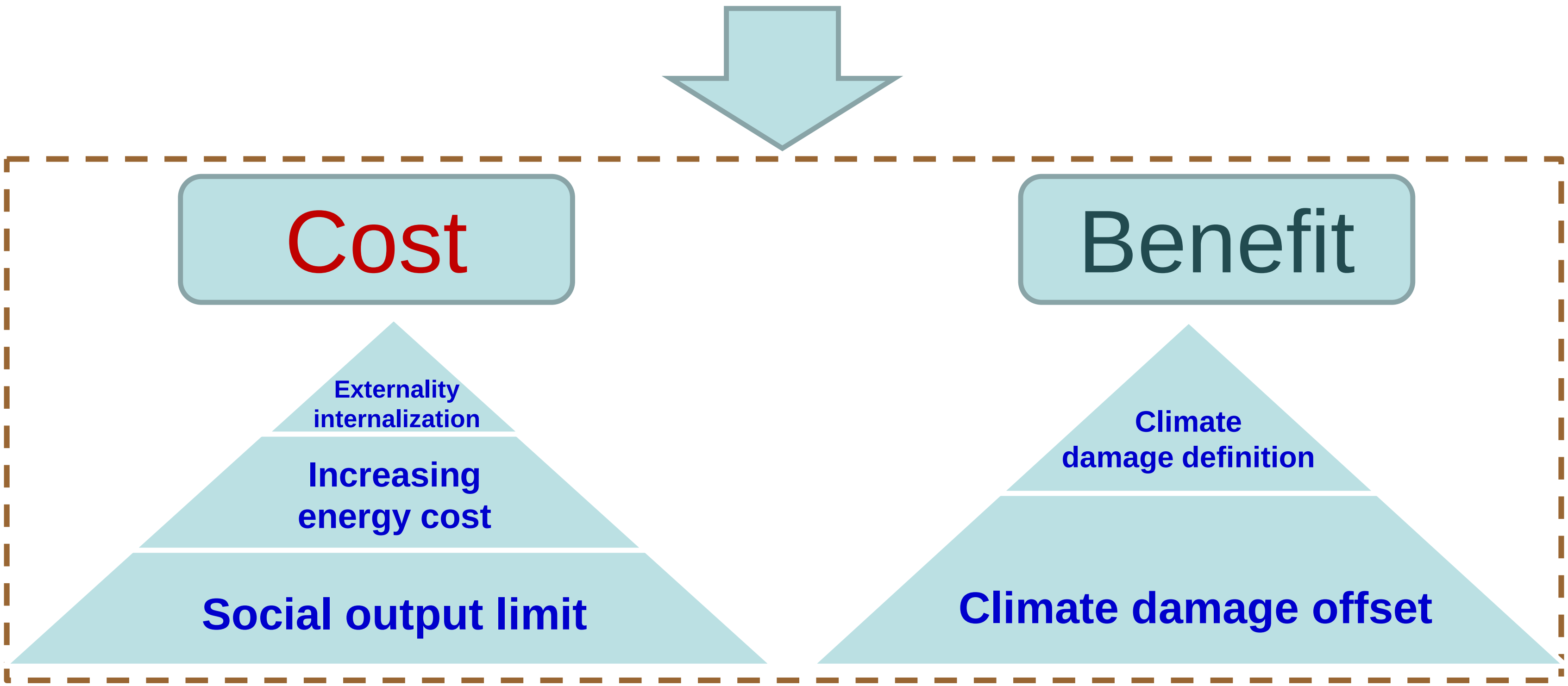
Introduction

- Countries need to adopt measures/policies to control domestic greenhouse gas (GHG) emission in response to global climate change
- The implementation of climate policies has two sides



Introduction

- In general, climate policies evaluation has two aspects:

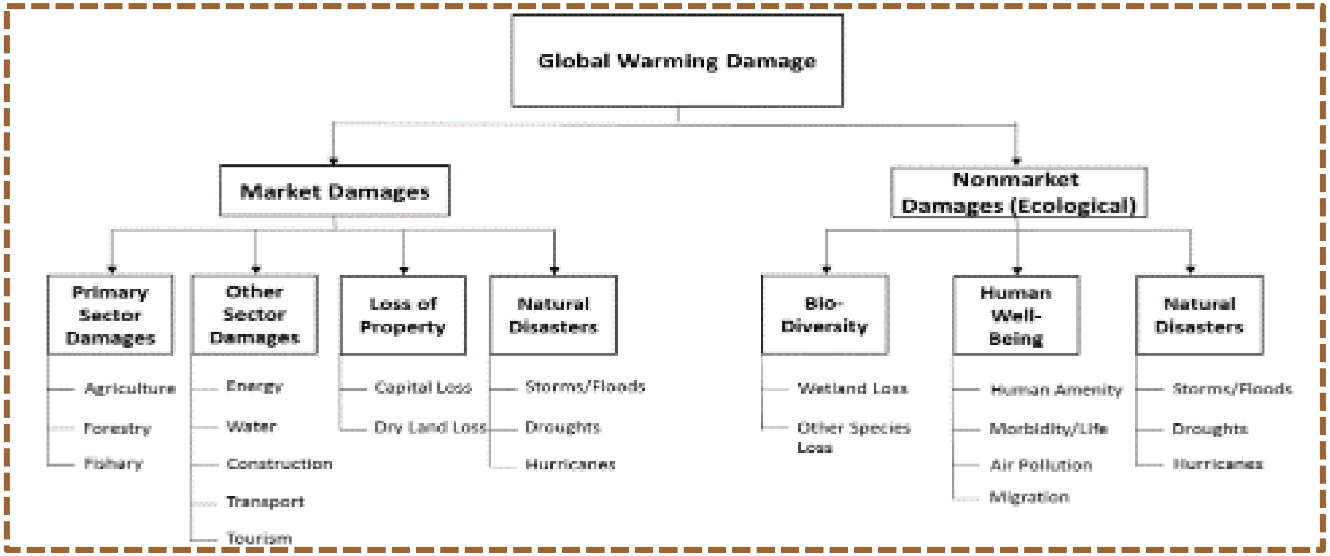
Cost-Effectiveness Analysis (CEA)

- ✓ GDP loss
- ✓ Consumption loss
- ✓ Energy cost increase
- ✓ Energy investment increase

Cost-Benefit Analysis (CBA)

- ✓ Cost
- ✓ Benefit：damage avoided

- ➢ The relative cost advantage between different energy technologies may be adjusted
- ➢ Increasing energy cost in the short term
- ➢ Social output will be limited because of the shortage of energy supply
- ➢ Substantial energy investment for promoting non-fossil energy technologies
- ➢ Consumption of final goods limits （van der Zwaan et al., 2002; Gerlagh et al., 2004, 2006; Duan et al., 2014;Zhu et al., 2014）



(Source：Manne et al., 1995)

Introduction

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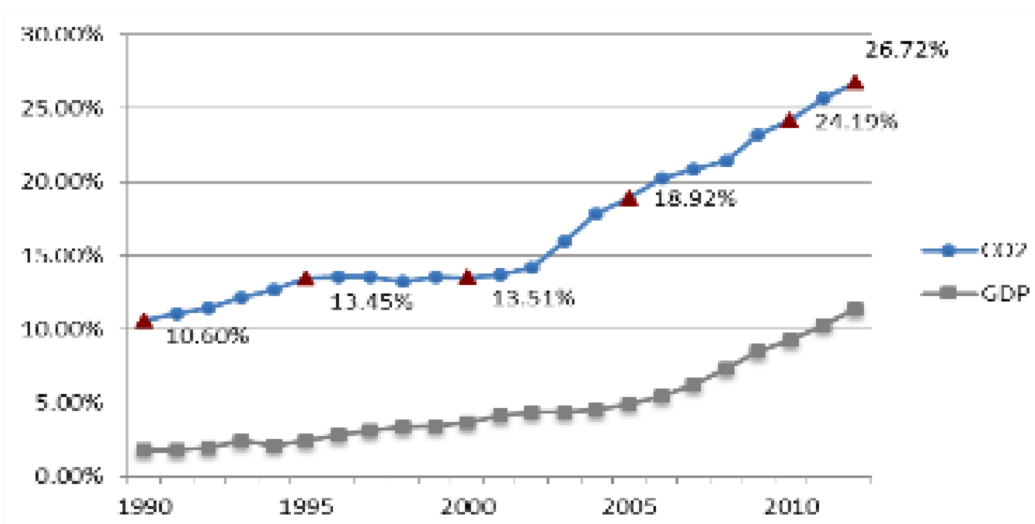
- The global response to climate change has been influenced to a great extent by particular regions with large CO_2 emissions (e.g. the USA, the EU and China)
- China, the world's largest developing country, is the nation with the greatest CO_2 emission; approximately 92 million tons in 2012, which is around 26.72% of total global emission (BP, 2013).



Source：BP，wind

Therefore, the implementation of China's climate policies can not only impact on domestic sustainable development, but can also have a direct effect on the performance of global actions on climate change

Introduction

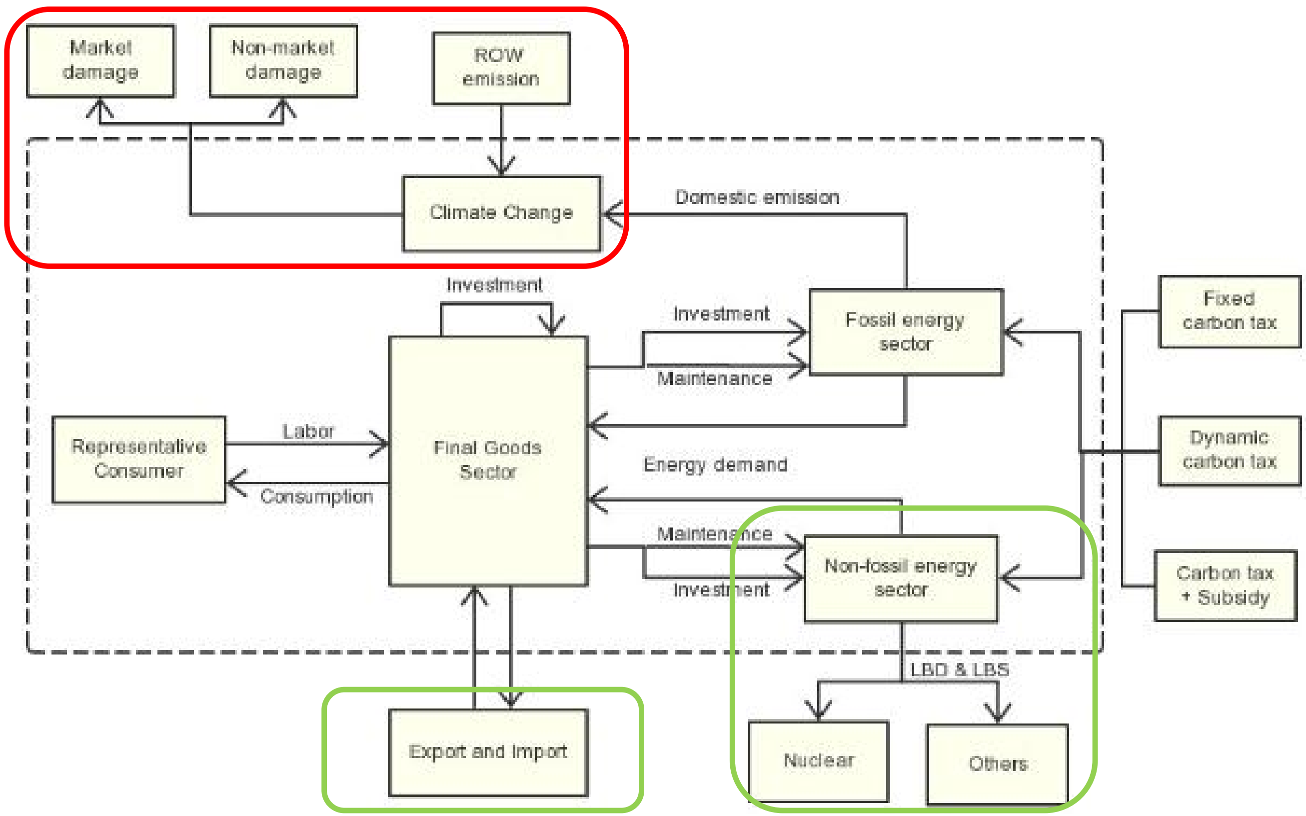
- Several difficulties exist in policy evaluation based on integrated general equilibrium models in single region:
  - Difficult to clearly consider and describe the characteristics of specific regional economic development, as well as energy use
  - In addition to the global temperature target, countries can adopt different types of domestic emission reduction measures, or policy mix
  - Due to the global greenhouse effect, climate damage in a specific region is directly influenced by the global CO_2 emission, not by the region itself (Nordhaus and Boyer, 2000)

Our Work

- To better analyze and evaluate abatement performance of a specific region in the medium- and long-term, we establish a modified single-region version of DEMETER model (DEMETER-R), to evaluate China's climate policies

Model

- **Model:** DEMETER-R
- **Subject:** social welfare maximization
- **Agent:** consumer、fossil energy sector and non-fossil energy sector
- **Technological change:** AEEI、LBD、LBS curve
- **Climate module:** multi-stratum carbon recycle system (Nordhaus and Boyer, 2000)
- **Term:** 2010-2150
- **Policies:** fixed carbon tax, dynamic carbon tax, and mixed policy



Model

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- Definition of Regional Climate Loss
  - ✓ Regional and Global Emission Ratio Setting
  - ✓ Multi-stratum carbon recycle system (Nordhaus and Boyer, 2000)
  - ✓ Market and Non-Market Climate Loss (Manne et al., 1995)

'Burden'

The abatement ratio of China compared to the world will increase when its CO2 emission share decreases compared to the world

Free-riding'

Conversely, the abatement ratio of China will decrease compared to the world when its CO2 emission share increases compared to the world

Definition	Equation
Emission ratio	$\tilde{E}m_t^{ROW} = \Theta_t \tilde{E}m_t^{domestic}$
Market damage factor	$D_t = d_1 \cdot TEMP_t^{d_2}$
Non-market damage factor	$WTP_t = d_3 \cdot TEMP_t^{d_4} / (1+100 \cdot \exp(-0.23 \cdot GDP_t / L_t))$
Regional climate damage	$Damage_t = (MD_t + WTP_t) \cdot GDP_t$
Output distribution	$Y_t^C = GDP_t + Damage_t + \sum_k M_t^k$

Model

- Abatement Performance Measure

✓ Cost-Effectiveness Performance

- ➢ Consumption Loss (CL)
- ➢ GDP Loss (GL)
- ➢ Energy Cost Increase (EC)
- ➢ Energy Investment Increase (EI)

✓ Cost-Benefit Performance

- ➢ Consumption loss Cost Benefit Ratio (CBR)
- ➢ GDP Loss CBR
- ➢ Energy Cost Increase CBR
- ➢ Energy Investment Increase CBR

Performance	Indicators	Equation
Cost-Effectiveness Performance	Consumption Loss (GL)	$CL_i = \sum_t^T [(1+\rho)^{-t}(C_{BAU,t} - C_{i,t})]$
	GDP Loss	$GL_i = \sum_t^T [(1+\rho)^{-t}(GDP_{BAU,t} - GDP_{i,t})]$
	Energy Cost Increase	$ECI_i = \sum_t^T \sum_j [(1+\rho)^{-t}(p_{i,t}^j Y_{i,t}^j - p_{BAU,t}^j Y_{BAU,t}^j)]$
	Energy Investment Increase	$EII_i = \sum_t^T \sum_j [(1+\rho)^{-t}(I_{i,t}^j + ARD_{i,t}^j - I_{BAU,t}^j - ARD_{BAU,t}^j)]$
Cost-Benefit Performance	Consumption loss Cost Benefit Ratio	$CCBR_i = \frac{\sum_t^T [(1+\rho)^{-t}(C_{BAU,t} - C_{i,t})]}{\sum_t^T [(1+\rho)^{-t} Benefit_{i,t}]}$
	GDP loss Cost Benefit Ratio	$GCBR_i = \frac{\sum_t^T [(1+\rho)^{-t}(GDP_{BAU,t} - GDP_{i,t})]}{\sum_t^T [(1+\rho)^{-t} Benefit_{i,t}]}$
	Energy cost increase Cost Benefit Ratio	$ECBR_i = \frac{\sum_t^T \sum_j [(1+\rho)^{-t}(p_{i,t}^j Y_{i,t}^j - p_{i,t}^j Y_{i,t}^j)]}{\sum_t^T [(1+\rho)^{-t} Benefit_{i,t}]}$
	Energy Investment increase Cost Benefit Ratio	$ICBR_i = \frac{\sum_t^T \sum_j [(1+\rho)^{-t}(I_{i,t}^j + ARD_{i,t}^j - I_{i,t}^j - ARD_{i,t}^j)]}{\sum_t^T [(1+\rho)^{-t} Benefit_{i,t}]}$
Technology Abatement Contribution Performance	Consumption-decreasing Abatement contribution Share	$CAS_{i,t} = (Y_{BAU,t}^F - Y_{BAU,t}^F \frac{\sum_j Y_{i,t}^j}{\sum_j Y_{i,t}^j}) / (Y_{BAU,t}^F - Y_{i,t}^F)$
	Technology-switching Abatement contribution Share	$TAS_{i,t}^j = [(Y_{i,t}^j - Y_{i,t}^j) + (Y_{i,t}^j - Y_{i,t}^j \frac{\sum_j Y_{i,t}^j}{\sum_j Y_{i,t}^j})] / (Y_{BAU,t}^F - Y_{i,t}^F)$
	Annual Technology-switching Change Ratio	$ATCR_{i,t}^j = \sqrt{\frac{TAS_{i,t}^j}{TAS_{i,t-1}^j}}$
	Technology Relative Price	$TRP_{i,t}^j = \frac{P_{i,t}^j}{P_{i,t}^F}$

Empirical Study

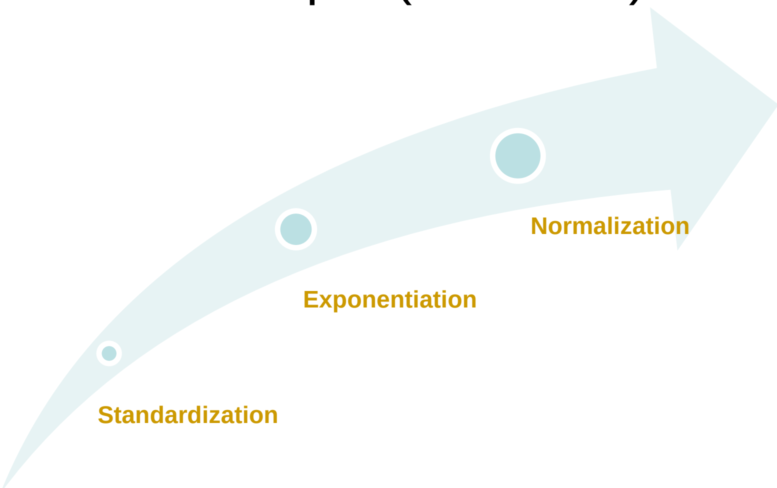
- Scenario Setting

		Atmosphere	Carbon Tax	Emission Share	Subsidy
BAU		No	No	BAU	No
Group 1	**Case 1**	550 ppmv	Fixed	BAU	No
	Case 2	500 ppmv	Fixed	BAU	No
	Case 3	450 ppmv	Fixed	BAU	No
	Case 4	550 ppmv	Dynamic	BAU	No
	Case 5	500 ppmv	Dynamic	BAU	No
	Case 6	450 ppmv	Dynamic	BAU	No
Group 2	**Case 7**	450 ppmv	Fixed	Up	No
	Case 8	450 ppmv	Dynamic	Down	No
	Case 9	450 ppmv	Fixed	Up	No
	Case 10	450 ppmv	Dynamic	Down	No

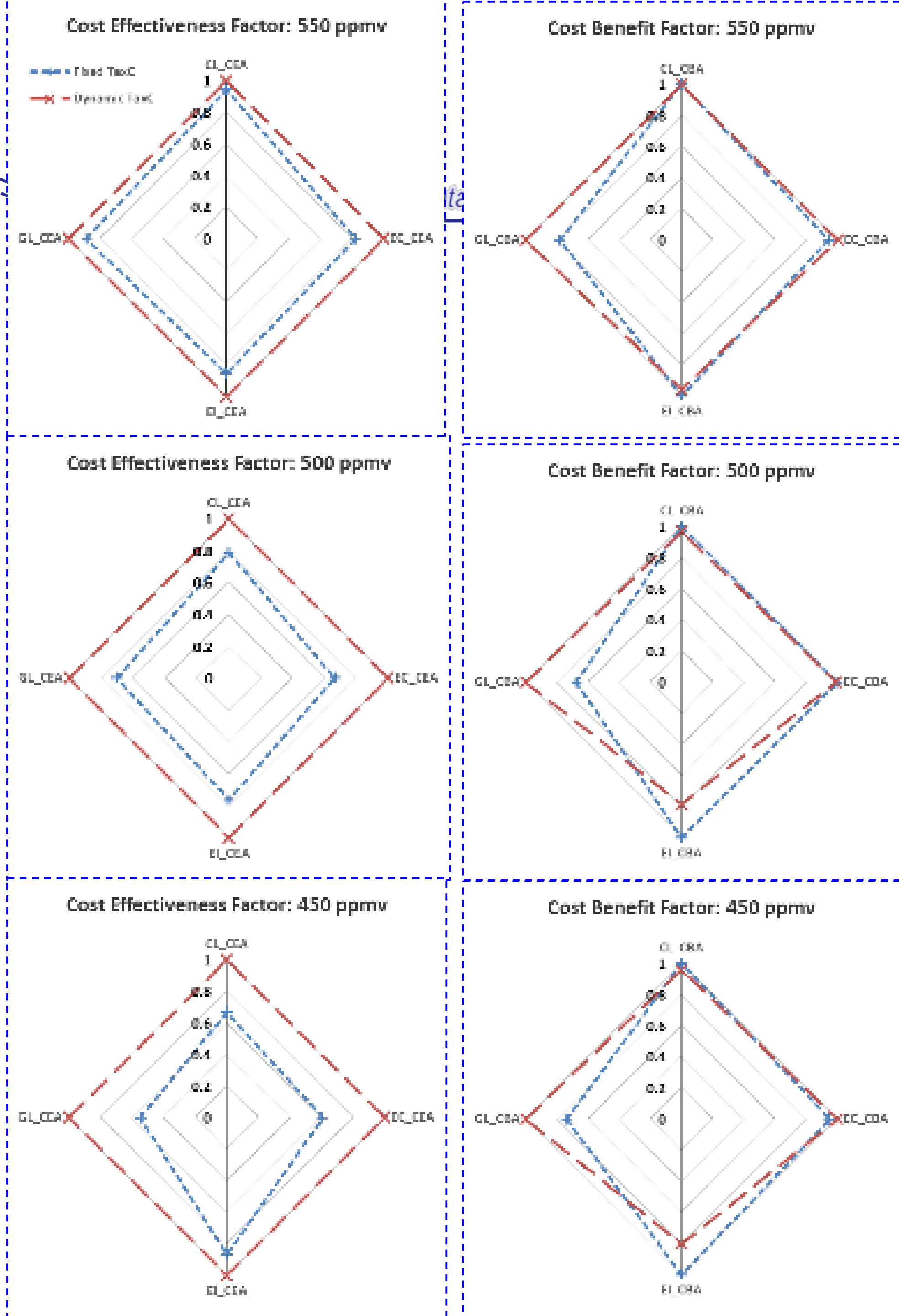
In the BAU scenario, the emission share between the world and China was calculated by the estimate of CO_2 emission of global DEMETER and DEMETER-R under the BAU scenario

Result and analysis

- Group 1 (Case 1-6)



- The results show that the performance of dynamic carbon tax from the perspective of cost-effectiveness is clearly better than that of fixed carbon tax
- But the implementation of fixed carbon tax will lead to a lower GL and EC cost-benefit ratio, which are interpreted as better cost-benefit efficiency of fixed carbon tax



Result and analysis

- Group 2 (Case 7-10)

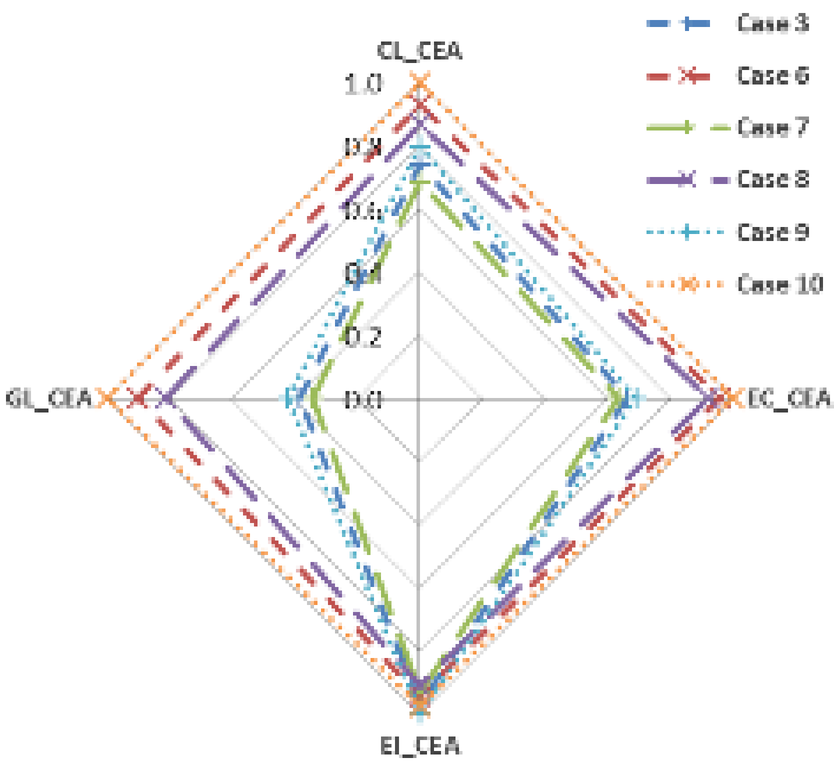


Figure 3. Four types of cost effectiveness factor under 450 ppmv

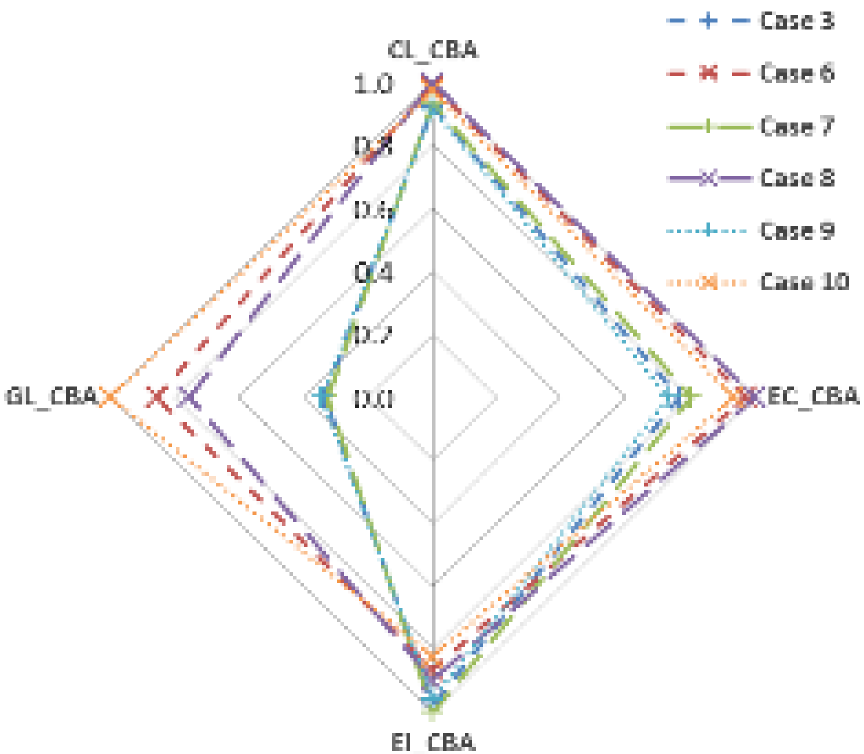


Figure 4. Four types of cost benefit efficiency factor under 450 ppmv

- For these two policies, the four cost effectiveness factors declined with ‘burden’ and increased with ‘free-riding’
- However, the EC and EI cost-benefit efficiency factors increased with ‘burden’ and decreased with ‘free-riding’

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Integrating carbon pricing and technology investment for low carbon development

Speaker: Prof. Michael Grubb, from Institute for Sustainable Resources, UCL

Time: 16:00, Nov.13, 2015

Room: Room A622, New Main Building, Beihang University

The Center for Energy and Environmental Policy Research (CEEP) is a joint research center of Institute of Policy and Management, CAS and Research Institute of Economics and Technology, CNPC. Addressing on the solutions to national energy and environmental issues, CEEP conducts scientific research on the area of energy and environment, promotes the development and application of energy economics, policy and management science. CEEP aims to provide energy scenario forecasting, energy system analysis and policy implications for government and enterprises. And CEEP also serves the decision-support of both domestic and abroad development strategy for China's oil companies.

Latest News

Lecture:Integrating carbon pricing and technology investment for low carbon deve 2015-11-10

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Lecture：Trends in the Sustainability Innovation Discussion in Germany 2015-10-09

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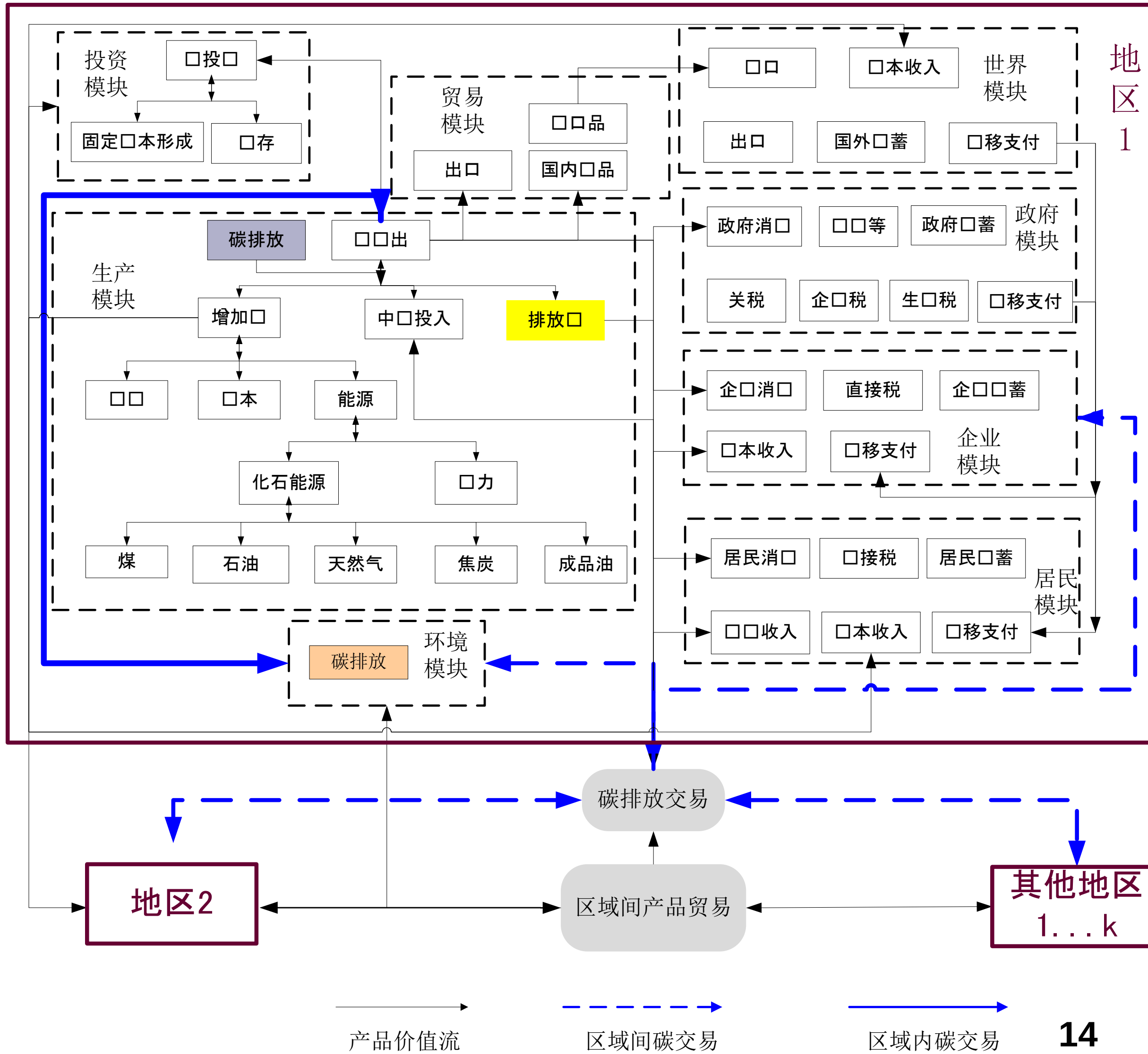
Models in CEEP-CAS

1. MRCGE Model

- China multi-regional resource-environment dynamic computational general equilibrium model (MRCGE)
- 30 Provinces, 42 Sectors
- Energy Market, Commodity Market, Emission Trading Market



Models in CEEP-CAS

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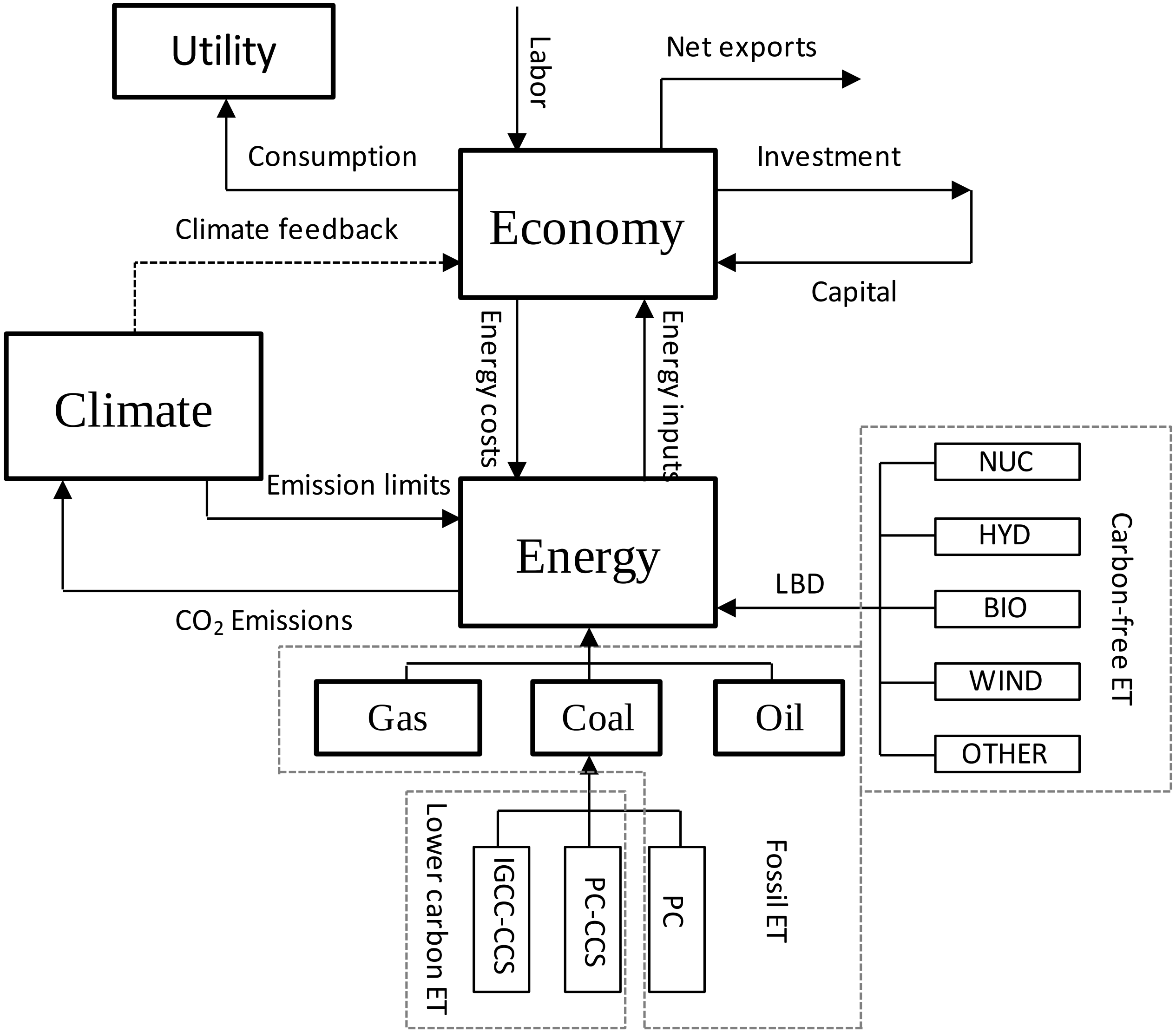
2. CE3METL Model

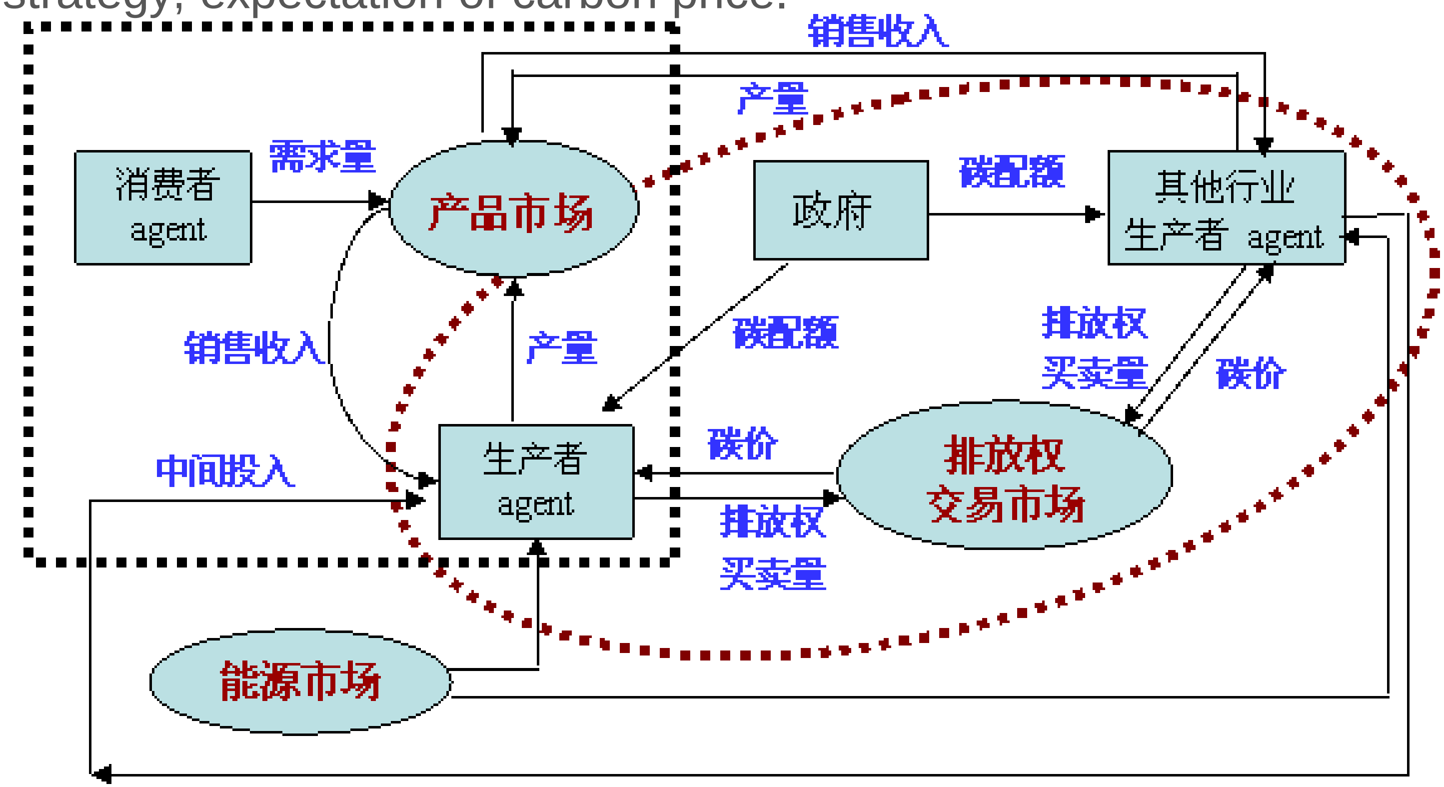
- Long-term dynamic optimal economic development model,
- including economic, energy, and environment/climate modules
- A policy logistic sub-module has been introduced to energy module to describe the learning and diffusion among non-fossil and fossil energy technologies



Models in CEEP-CAS

3. ETS-Agent Model

- A system for emission trading simulation.
- Agents are set as the firms covered by ETS. The diversities among firms are reflected at the output, initial emission intensity, and emission abatement technology set.
- Rules of agents: emission abatement strategy, allowance trading strategy, expectation of carbon price.



Models in CEEP-CAS

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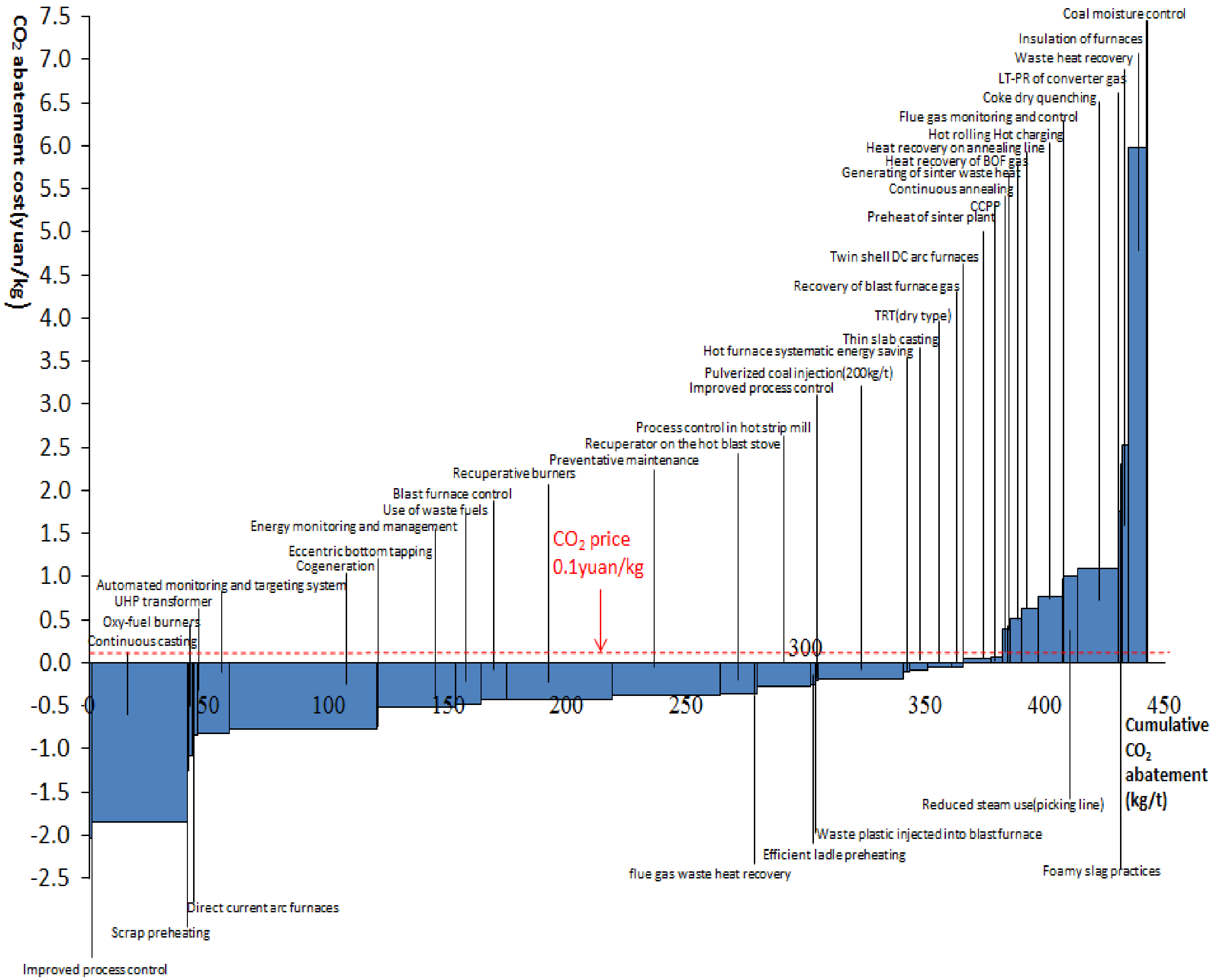
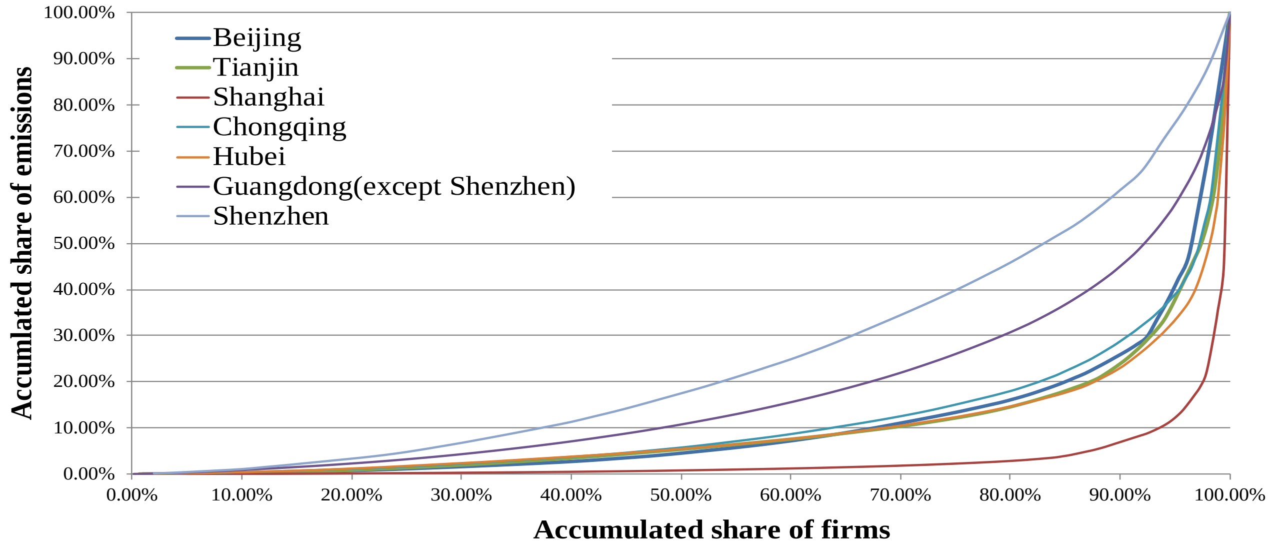
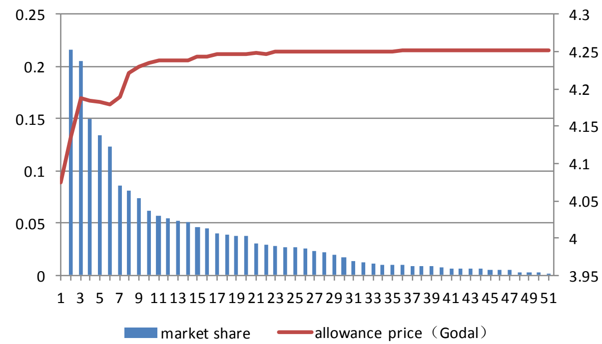
4. Bottom-up-based MACCs
   - Analyze the production process in energy-intensive sectors, complete a list of all technology options for emission reduction.
   - Normalize each technology under ‘Cost of Supply Curves (CSC)’ and rank them according to their cost for per unit energy saving/emission abatement.

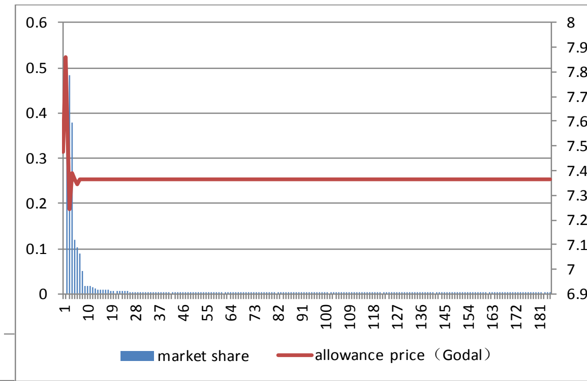


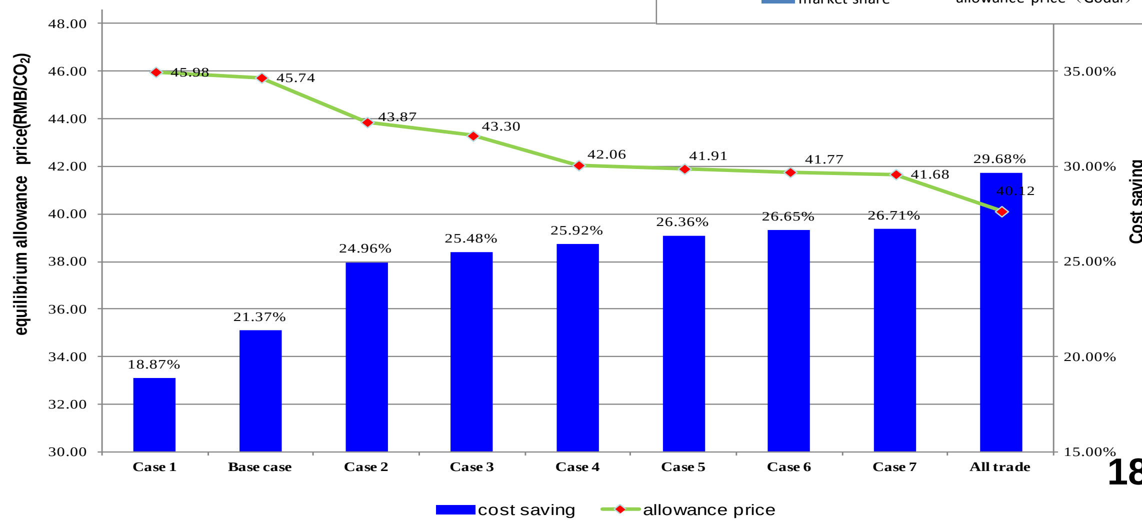
Models in CEEP-CAS

5. Partial Equilibrium Analysis
   - Based on the analysis framework of environmental economics
   - Modeling the emission control behaviors of specific firms/sectors covered by ETS
   - Transparency and flexibility





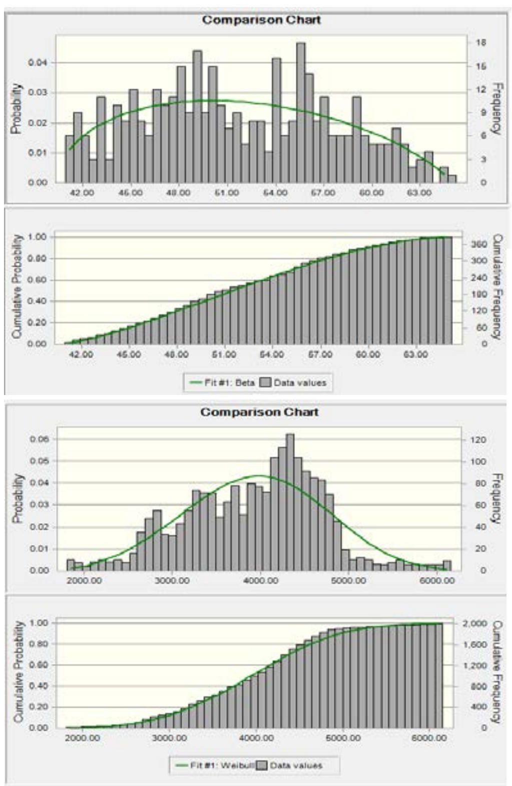


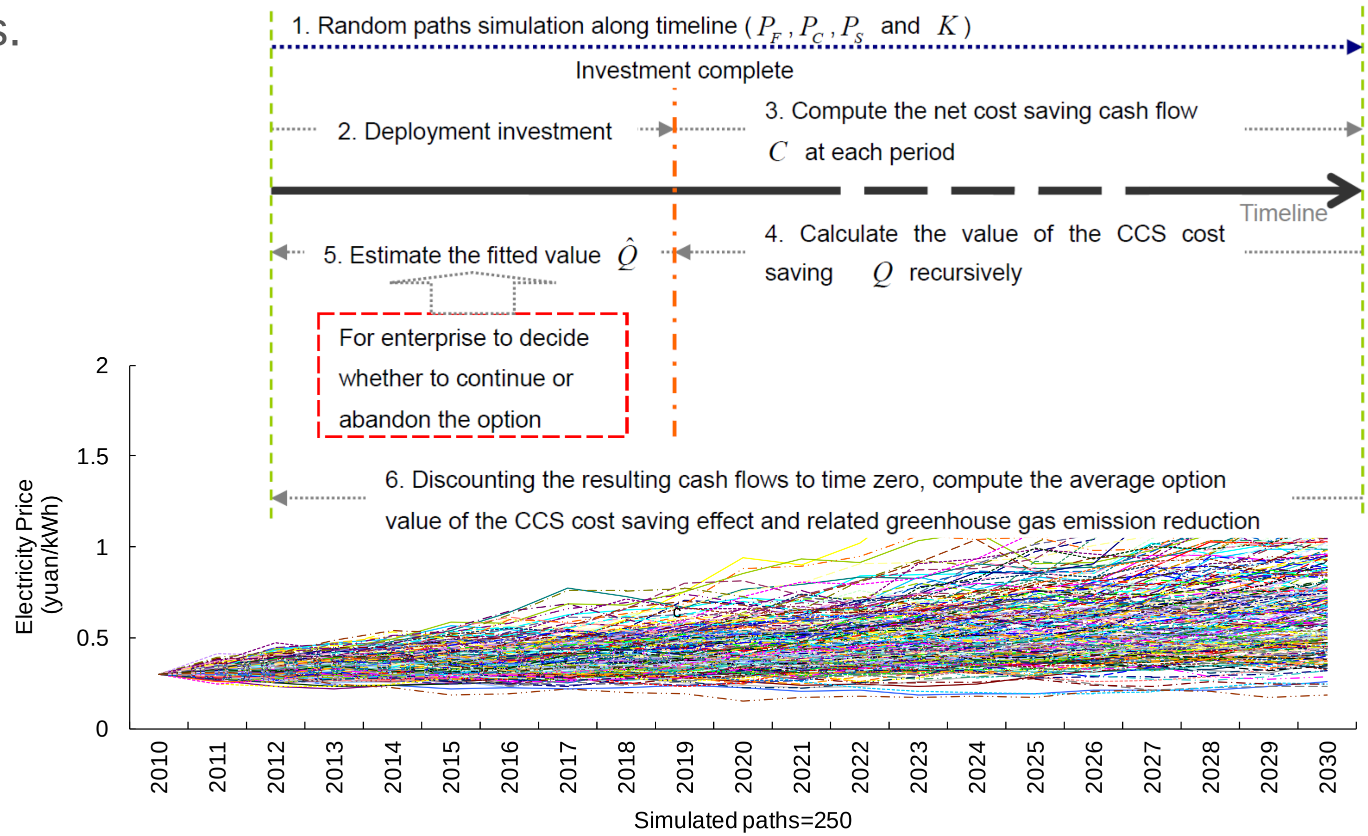


Models in CEEP-CAS

6. Evaluation Model for Low-Carbon Technologies

- Based on the Real options approach, taking consideration of several uncertainty factors and the investment flexibility.
- Model is numerically solved by the Least-Squares Monte-Carlo approach, to investigate the possibility of the technology investment under different policy scenarios.





Thanks a lot!

Lei ZHU

lions85509050@gmail.com