Center for Energy Economics
and Strategy Studies

Efficiency or Equity ?

SIMULATING THE CO_2 EMISSION TRADING SCHEMES IN CHINA WITH AN INTER-REGIONAL DYNAMIC CGE MODEL

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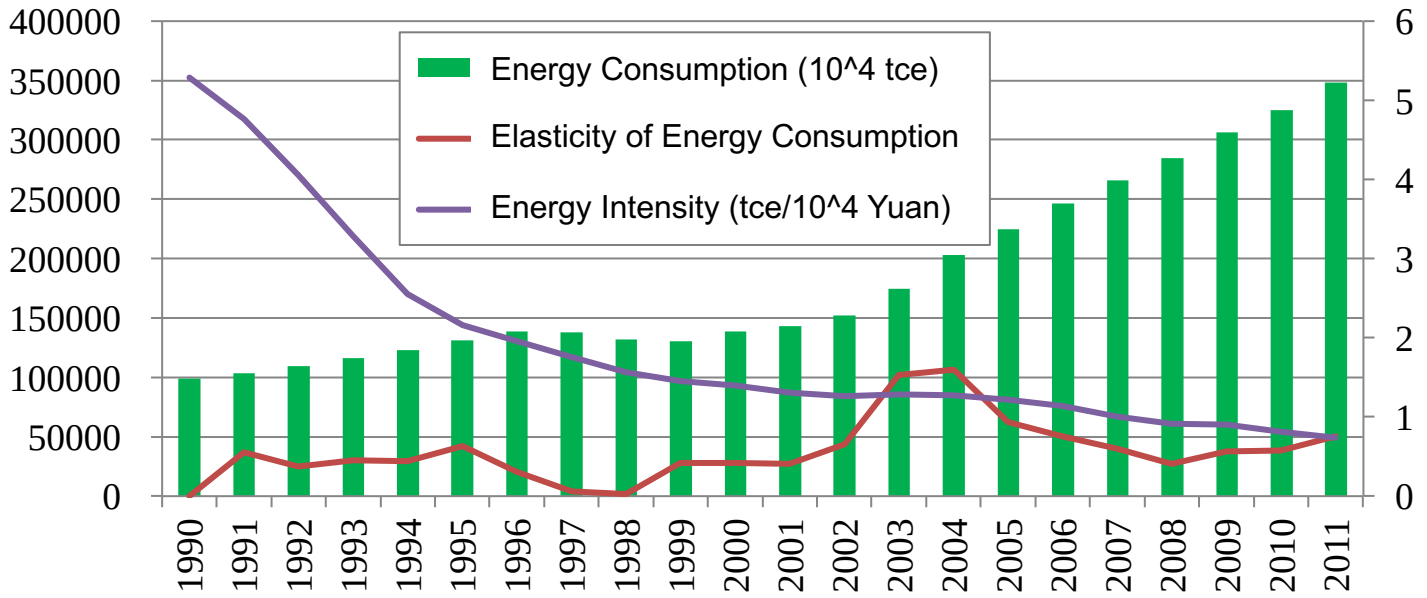
BACKGROUNDS

Exploding Energy Consumption Threatened Sustainability of Growth:

- Industrialization/Urbanization GEARED energy consumption with economic output;
- INDUSTRIAL STRUCTURE & GROWTH PATH are sensitive to energy/climate policies during economic transition;

⇒ *Rigidity & Arbitrariness in Climate Policy Caused DUAL LOSSES*

⇒ *Climate policies & Emission Reduction Activities must be designed & planned prudently so as not to retard economic growth and social stability.*

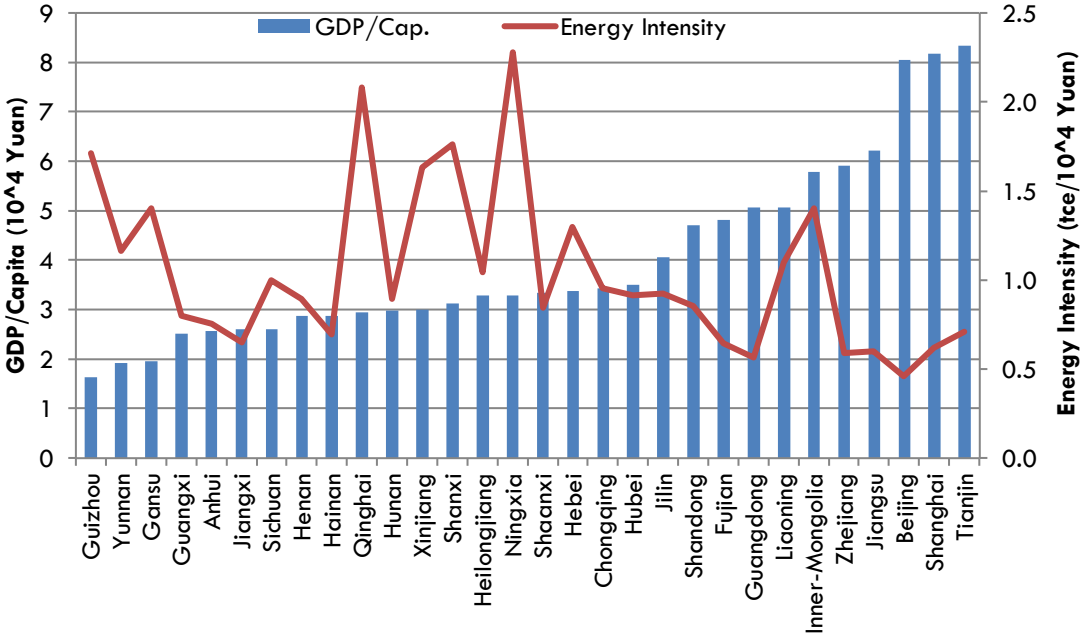


BACKGROUNDS

Conflict between Efficiency & Equity is One Reason for the:

- REGIONAL DISPARITY differentiate emission reduction potential, and intensify inter-regional economic interaction and correlation;
- STRUCTURAL TRANSITION leads to rapid change in economic structure & different growth path across regions.

⇒ *It's essentially related to proper ASSIGNMENTS of abatement targets & FLEXIBILITY in policy schemes;*



MODEL STRUCTURE AND FEATURES

Model Structure & Data base:

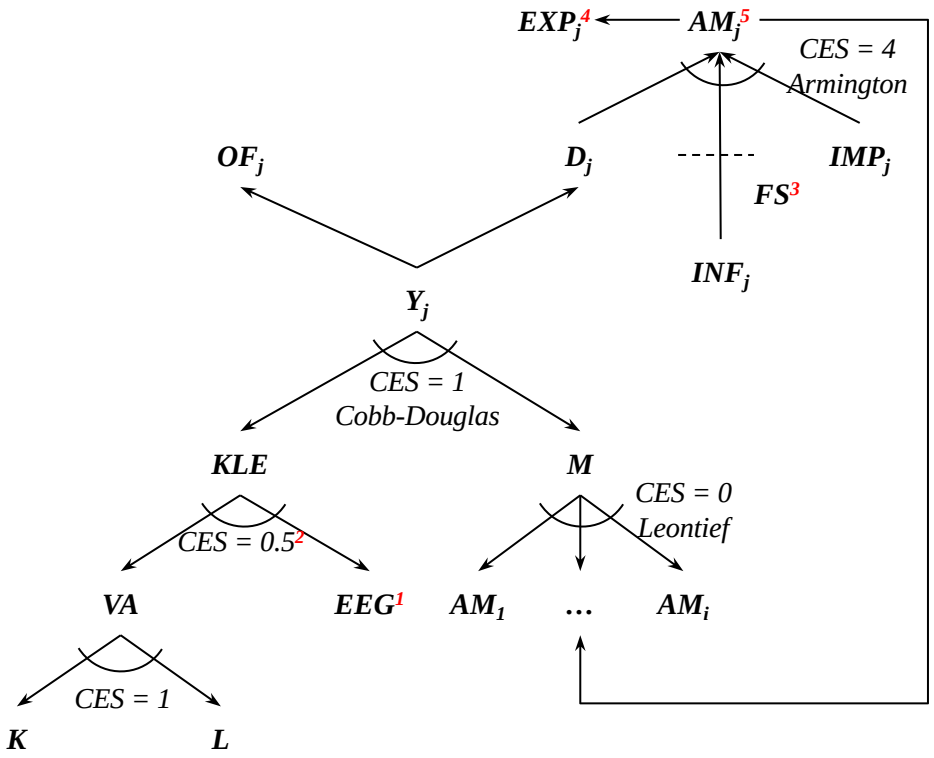
- 30 Regions, 42 industries;
- 3 factors -- Capital [1], Labor & Emission Permits;
- 2 Agencies – Households & Regional Governments;
- “Small Economy” in international trade; “Large Economy” in domestic trade;
- Data base -- 2007 Regional Input-Output Data.

Function Module:

- Production & Demand Module;
- Recursive Dynamic Module;
- Inter-regional economic interaction and correlation module;
- Energy & Emission Module.

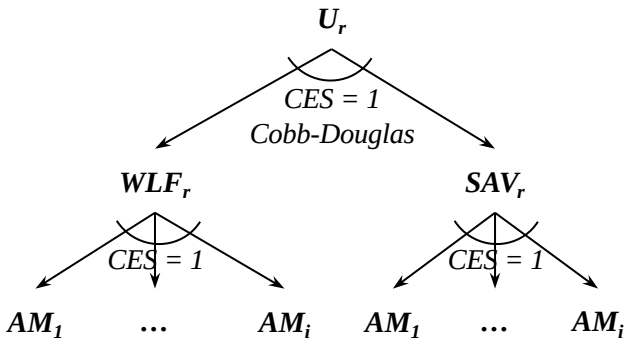
PRODUCTION & DEMAND MODULE

Nested CES Production Function (KLEM Nesting Structure):



PRODUCTION & DEMAND MODULE

Nested CET Utility Function:

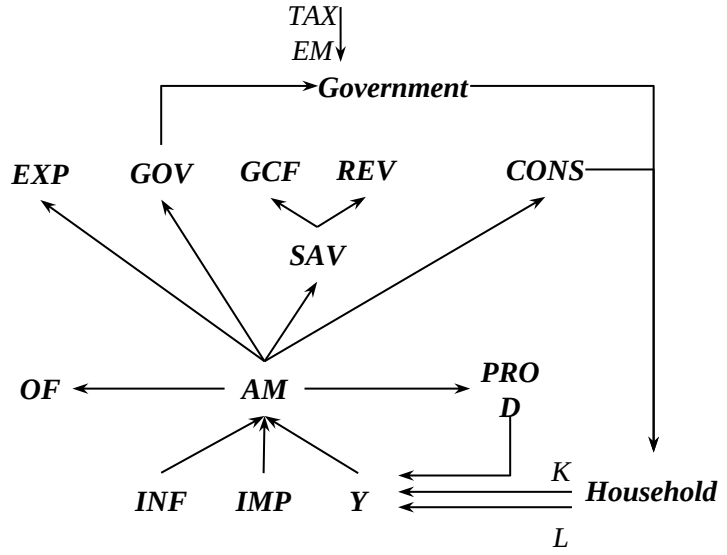


$$\max_{\{WLF,DINV\}} U_r = D_r + \eta \cdot \ln WLF_r + (1-\eta) \cdot \ln SAV_r$$

$$WLF_r = \sum_i \varepsilon_{r,i} \cdot \ln cam_{r,i} + \sum_e \varepsilon_{r,e} \cdot \ln cae_{r,e}$$

$$SAV_r = \min\left(\phi_{j \neq e} \cdot dam_{j \neq e,invd}\right)$$

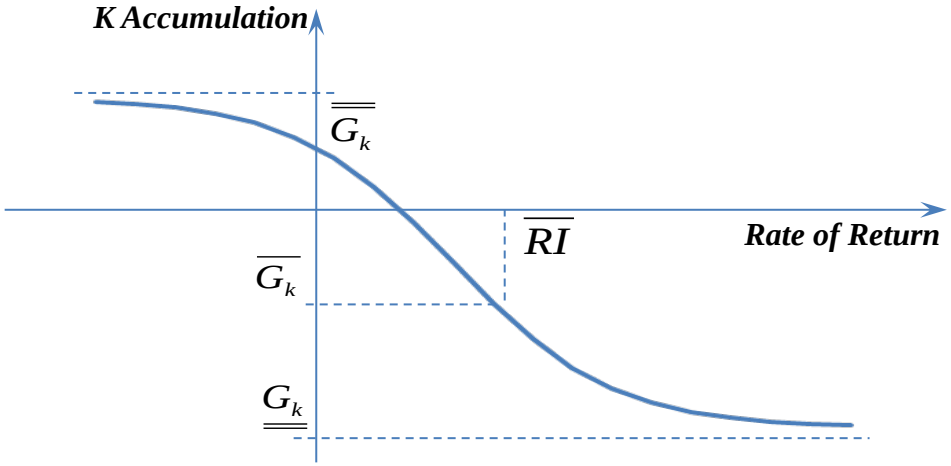
$$rk_r \cdot K + w_r \cdot L + TRANS_r =$$
$$\sum_i pam_i \cdot cam_{r,i} + \sum_e pae_e \cdot cae_{r,e} + SAV_r + BOP_r$$



RECURSIVE DYNAMIC MODULE

Economic Growth & Structural Change are Modeled Recursively:

- Quasi-Putty-Clay Mechanism;
- Neo-Classical Macro-Closure for Capital Accumulation;
- Allocation of Total Investments Determined by Capital Rate of Return

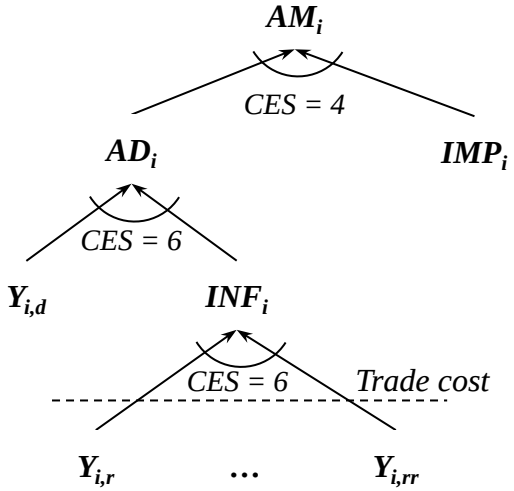


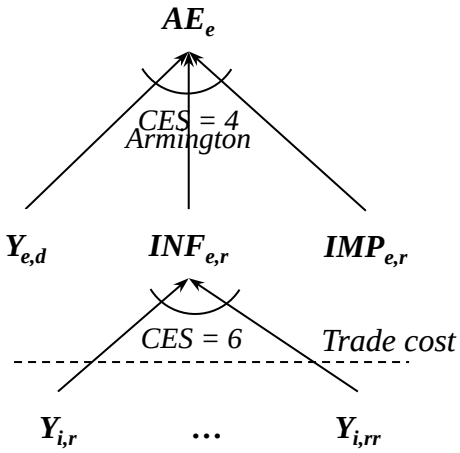
$$\begin{cases} RISE_i^t = \dfrac{1}{1+\rho}\cdot\dfrac{RK_i^t}{PINV^t} + \dfrac{1-\delta}{1+\rho} - 1 \\ RI_i^t = \dfrac{1}{1+\rho}\cdot\dfrac{RK_i^{t+1}}{PINV^t} + \dfrac{1-\delta}{1+\rho}\cdot\dfrac{PINV^{t+1}}{PINV^t} - 1 \\ \Rightarrow \quad RIE_i^t = \xi\cdot RI_i^{t-1} + (1-\xi)\cdot RIE_i^t \end{cases}$$

INTER-REGIONAL MODULE

Inter-regional Trade Flows Modeled Directly:

- Destination of outflow indifference to producers;
- Source of inflow perceivable by consumers; indigenous preference;
- No indigenous preference for energy (highly standardized);
- Inflow cost determined by producing cost and TRADE COST [1]

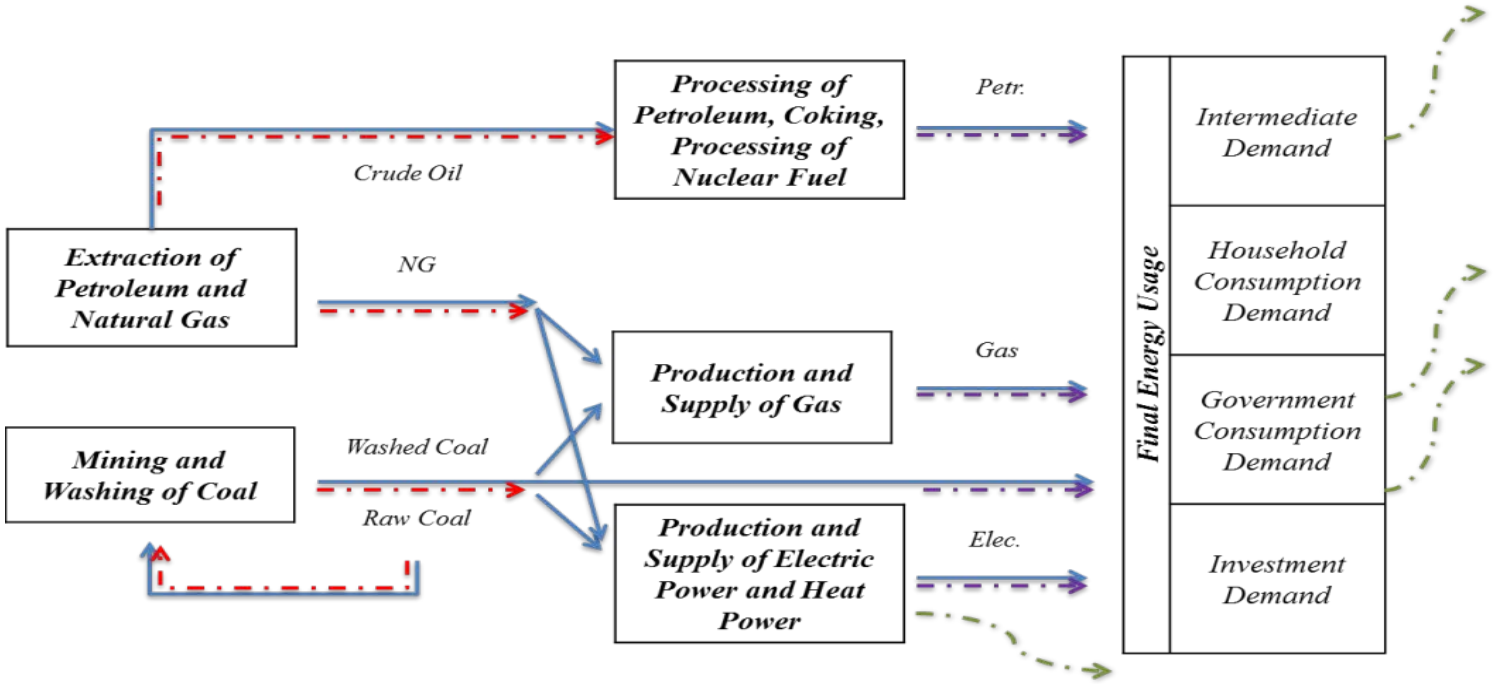




ENERGY & EMISSION MODULE

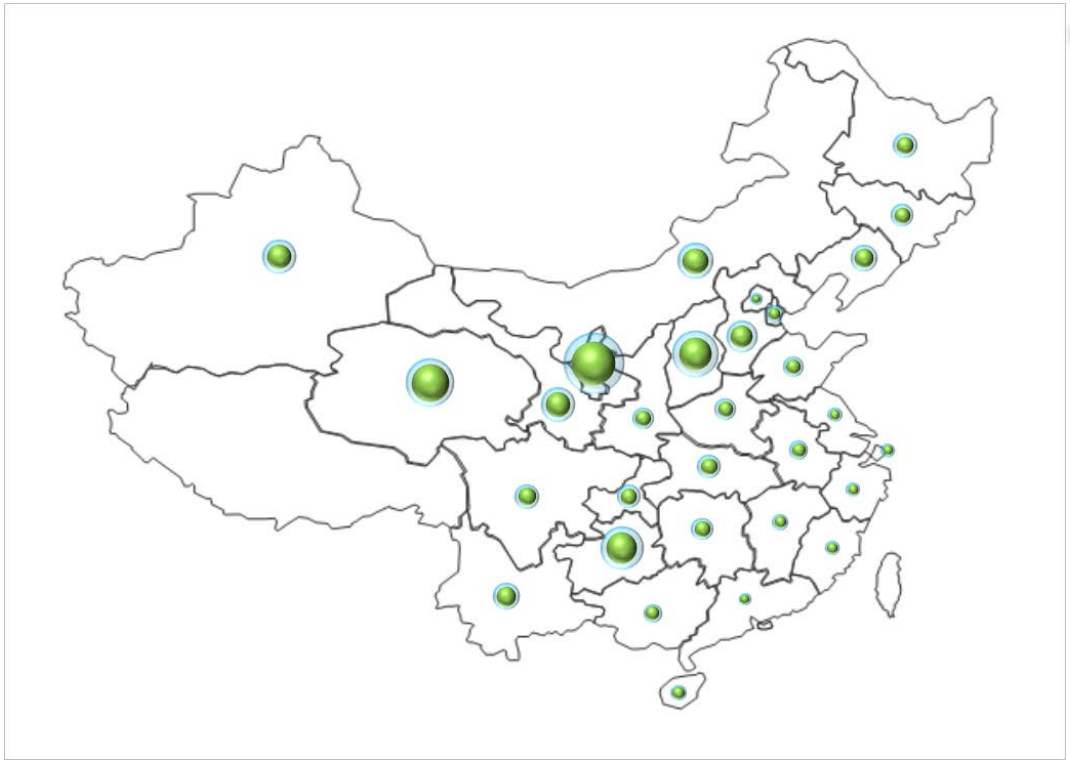
Link Carbon Flow with Energy Flow:

- Account and trace CO_2 flow in energy extraction, conversion and consumption;
- CO_2 geared with energy proportionally (Leontief);
- CO_2 emission permits introduced to model constraints on total emission;
- Gov. endowed with permits, can be auctioned and gave out for free.



SCENARIOS -- BAU

	CODE	TARGETS	ALLOCATION	FLEXIBILITY
S1	NULL	Without any climate and energy policies		
S2	BAU	2005～2010: *Notice on the Completion of 11th FYP Regional Energy Conservation Targets* 2010～2015: *Work Program on GHG Controlling for 12th FYP* 2015～2020: Copenhagen Commitment of China. [1]		

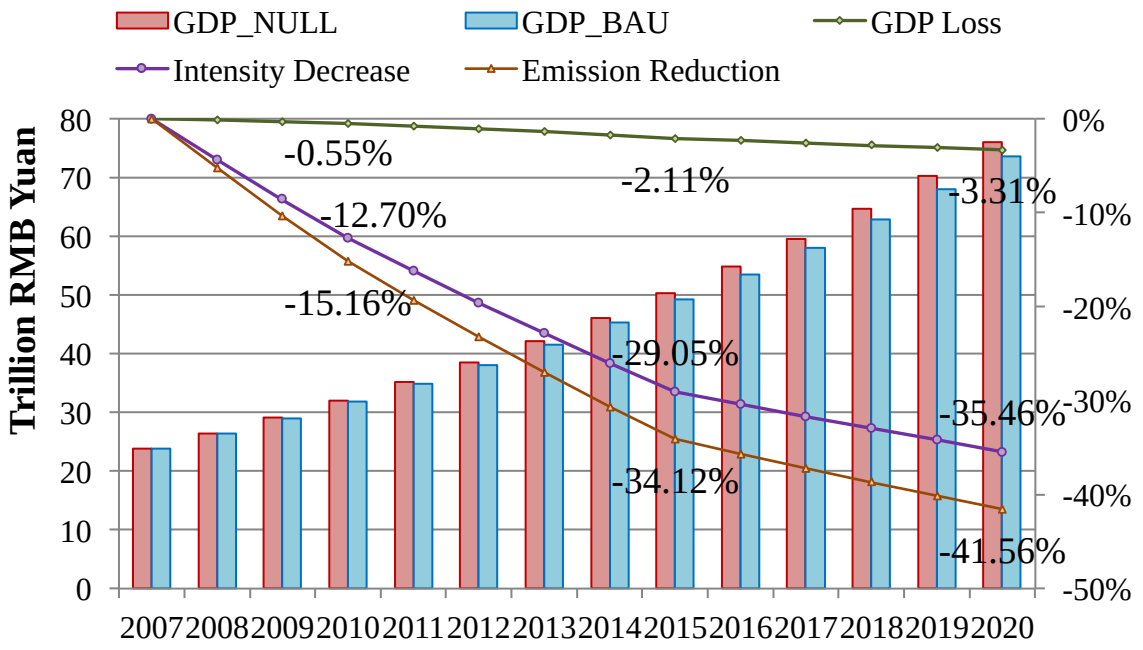


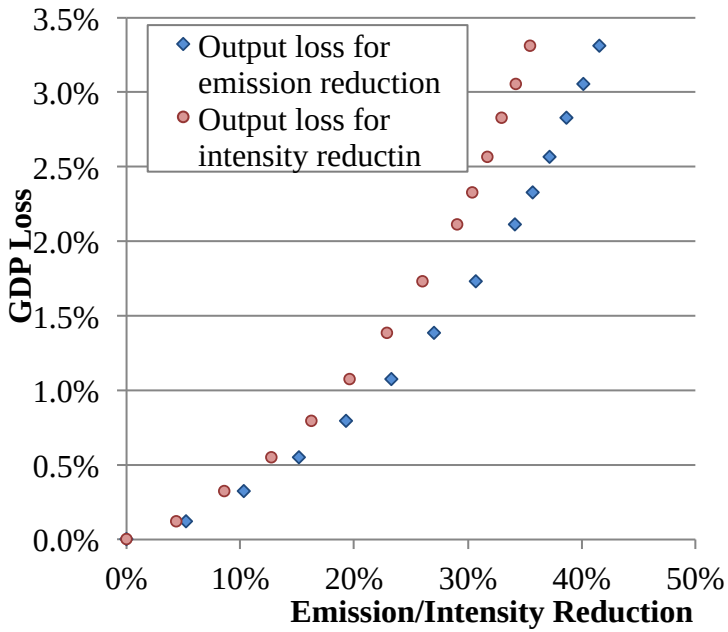
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020

SCENARIOS -- BAU

Economic Costs:

- yearly average GDP growth 8.26% in BAU, 8.54% in NULL;
- Nonlinear correlation between economic costs & emission/intensity reduction targets.

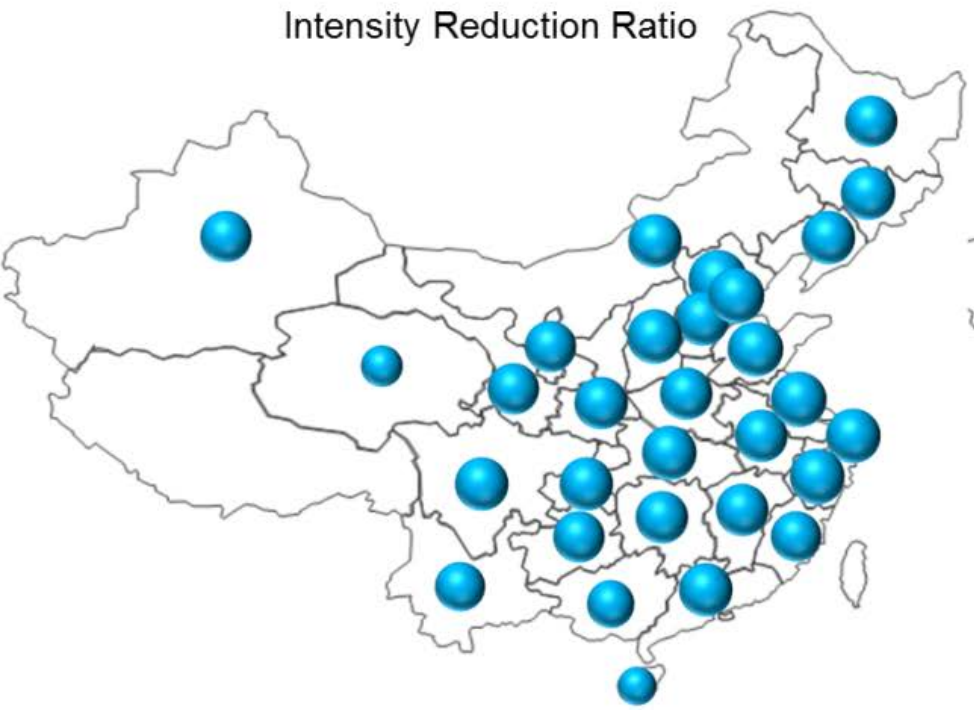


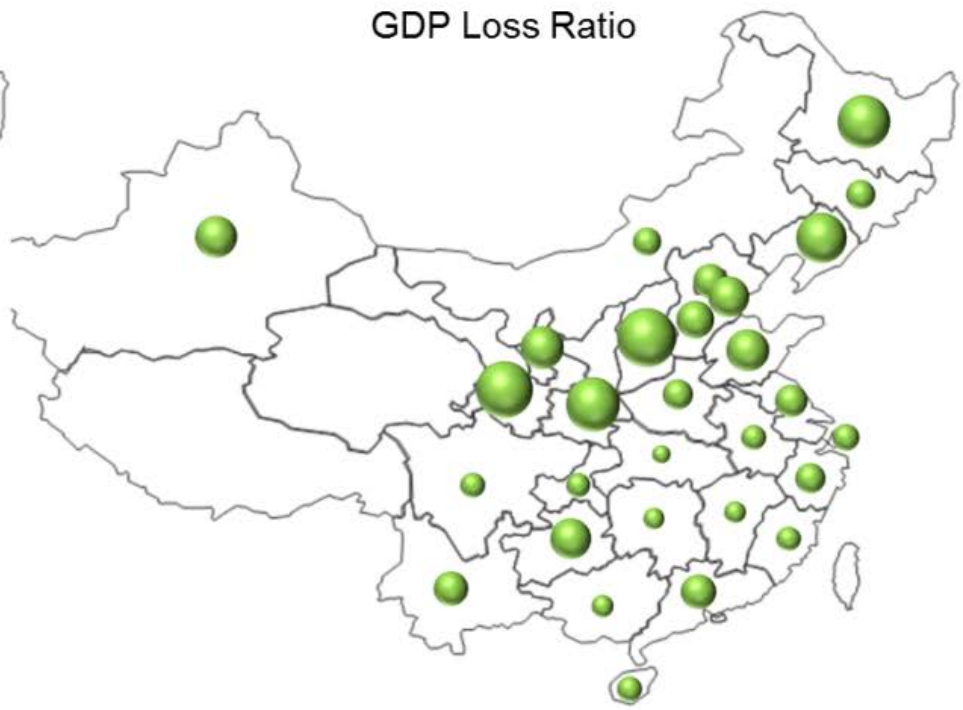


SCENARIOS -- BAU

Regional Effects:

- Energy intensive & industrializing regions (Mid/Northern) most affected;
- Energy exporting regions also affected;
- Less energy intensive regions (eastern coastal regions & southern regions) are less sensitive.

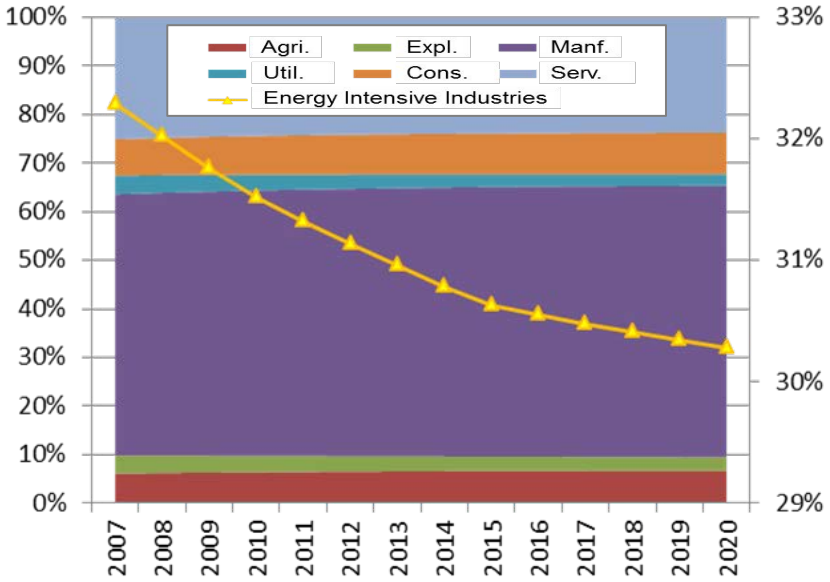


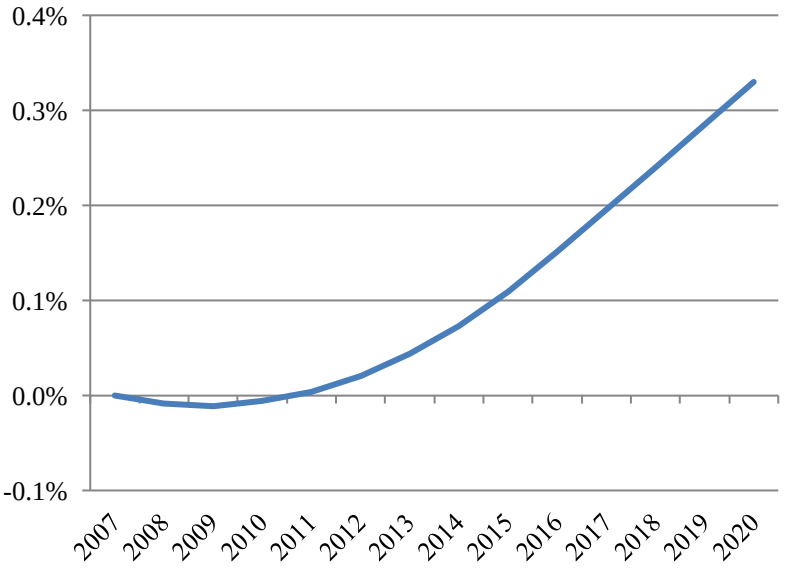


SCENARIOS -- BAU

Industrial Effects:

- General industrial structure is slightly changed, given the industrialization process in China;
- Share of energy intensive sectors[1] decreased observably;
- Industrial Structure change mitigates the impacts of policy shocks .





SCENARIOS -- Overview

Climate Policies:

	CODE	TARGETS	ALLOCATION	FLEXIBILITY
S3	EM_NT	Total Emission Constraint (Set According to BAU)	Regional Emission in Base-year	Non-tradable
S4	EM_T			Tradable
S5	OPT_NT		Regional Output in Base-year	Non-tradable
S6	OPT_T			Tradable
S7	WLF_NT		Regional Welfare in Base-year	Non-tradable
S8	WLF_T			Tradable

Allocation Criterions:

Criterion	Allocation
Emission	$EM_r \le \tau \cdot \overline{EM}_r$
Output	$EM_r \le \tau \cdot (\overline{OP}_r / \sum_r \overline{OP}_r) \cdot \sum_r \overline{EM}_r$
Welfare	$EM_r \le \tau \cdot (\overline{U}_r / \sum_r \overline{U}_r) \cdot \sum_r \overline{EM}_r$

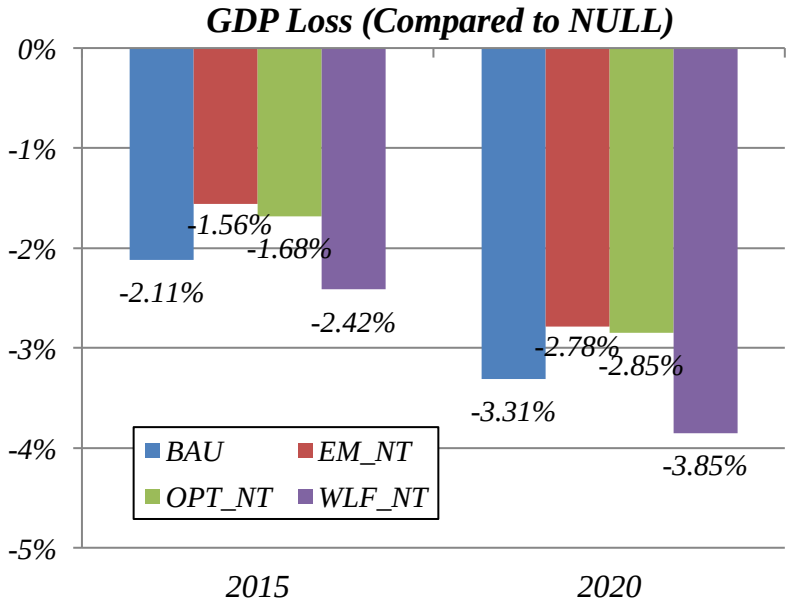
SIMULATION RESULTS -- Nontradable

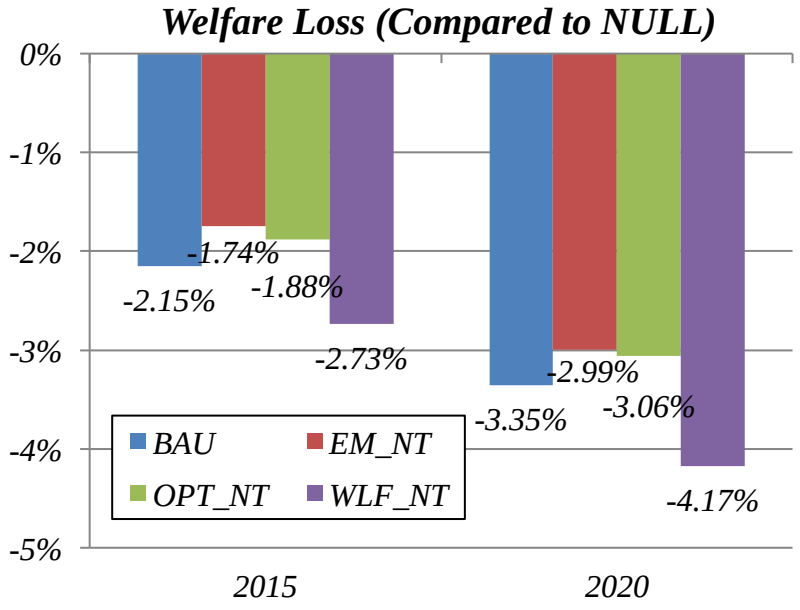
Conflicts between Efficiency & Equity:

- Allocation of permits determines regional MAC;
- Economic Efficiency: equalized MAC;
- Social Equity: equalized welfare/economic losses;

⇒ *No guarantee for the existence of a certain allocation satisfies both requirements;*

⇒ *Reallocation of permits for income transfer leads to extra losses.*



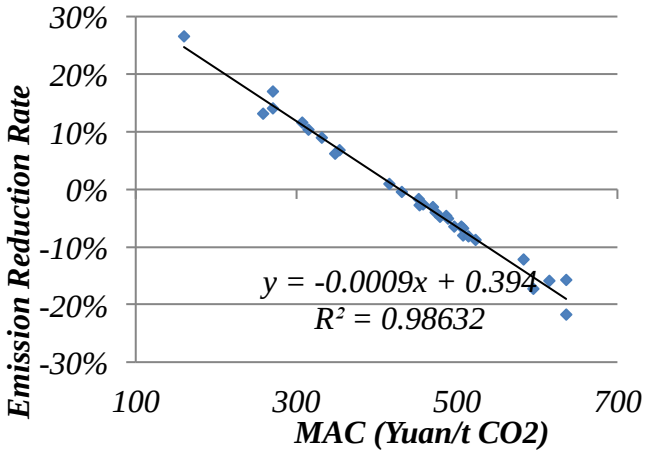


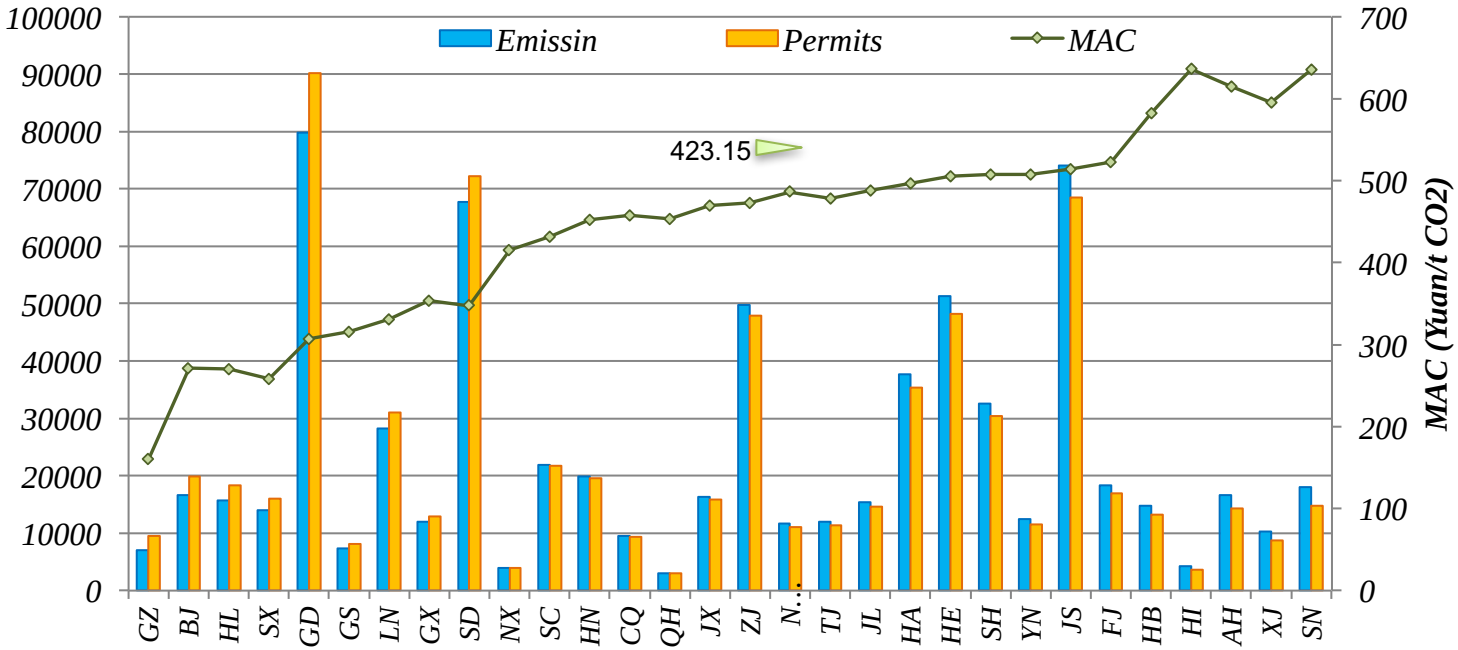
SIMULATION RESULTS – C&T

Decoupled Economic Efficiency with Initial Allocation:

- High MAC: Buy permits; Low MAC: Sell permits;
- Pareto optimization: equalized MAC.

⇒ *Emission reduction rate negatively related to MAC*





SIMULATION RESULTS – C&T

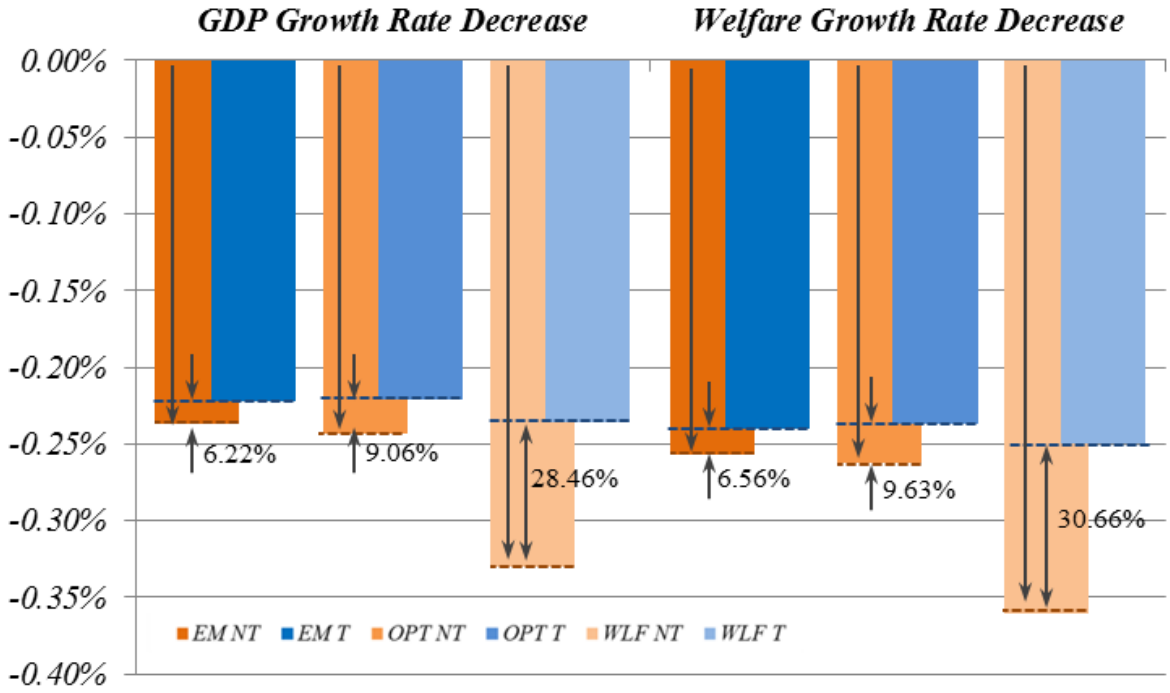
Effects of Emission Trading Scheme:

- Economic efficiency – by equalizing MAC across regions
- Policy flexibility – by narrowing economic/welfare losses across alternative allocation criterions

⇒ *Emission trading bridged concerns for efficiency & equity.*

⇒ *Emission trading provide permits with financial value;*

⇒ *Reallocation of permits would lead to income redistribution without significant losses in economic efficiency.*

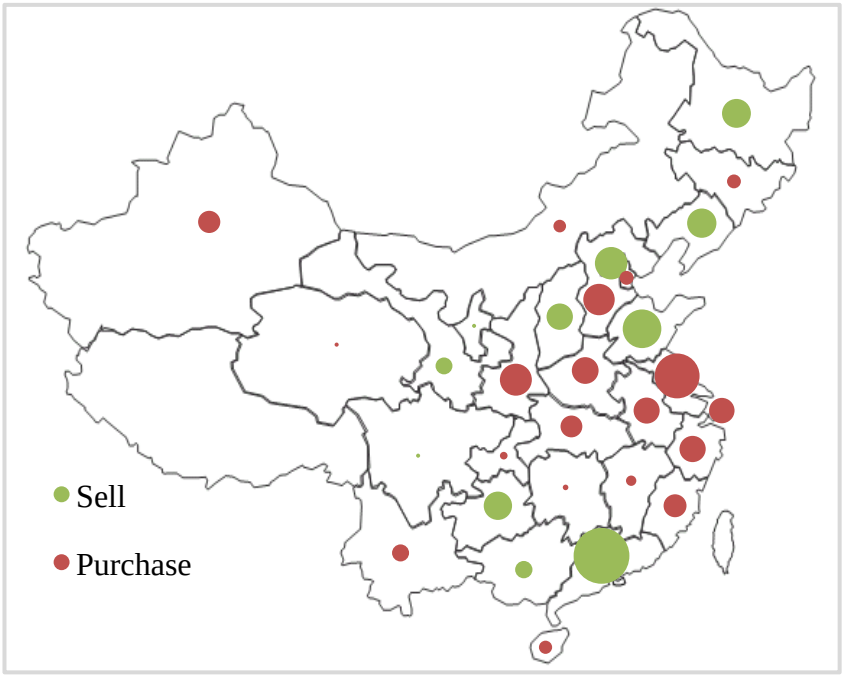


SIMULATION RESULTS – Reallocation

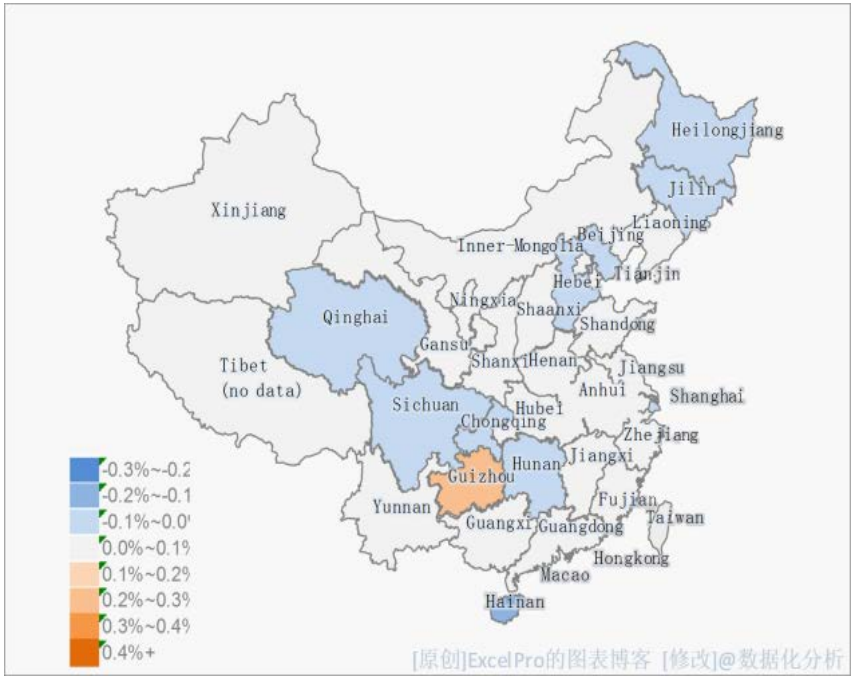
Base-Year Emission Criterion:

- Least distortion and lowest economic loss in non-trading scenario;
- Income transfer from industrialized to industrializing areas;
- Favorable to energy-intensive regions;

Emission Trading in EM_T Scenario



GDP Growth Rate Decrease in EM_T Scenario

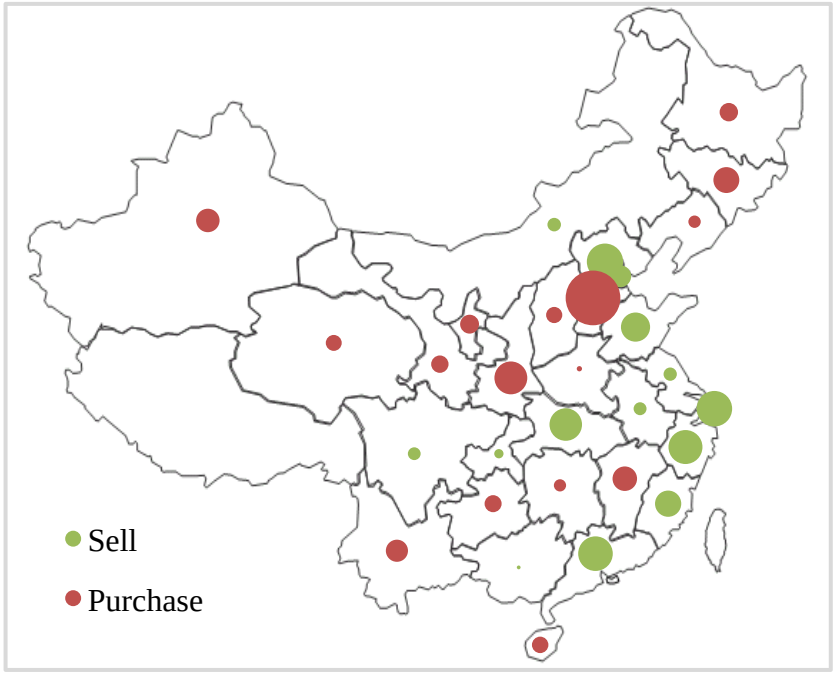


SIMULATION RESULTS – Reallocation

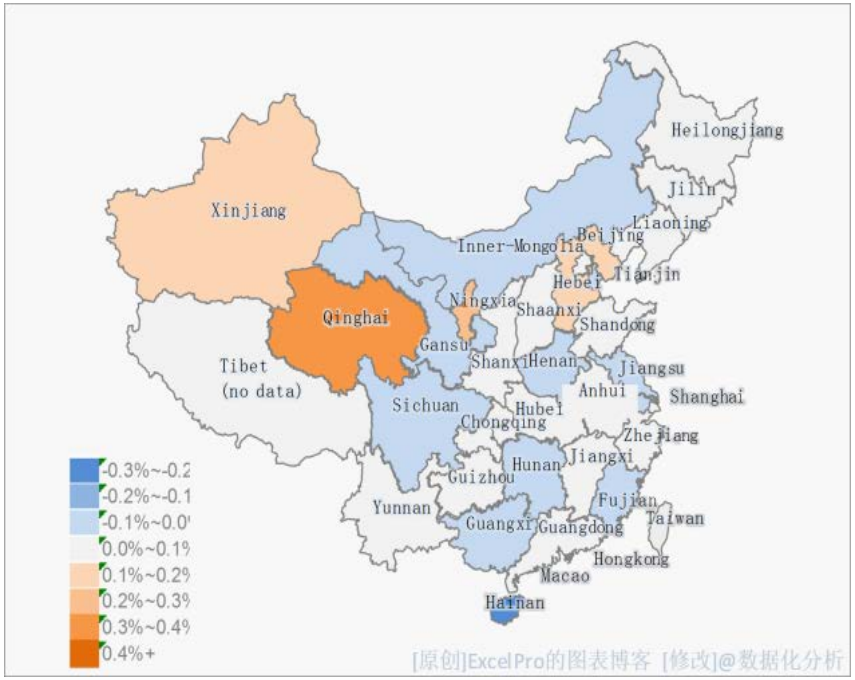
Base-Year Output Criterion:

- Income transfer opposite to EMT criterion;
- Low income western and middle areas and most affected;

Emission Trading in OPT_T Scenario



GDP Growth Rate Decrease in OPT_T Scenario

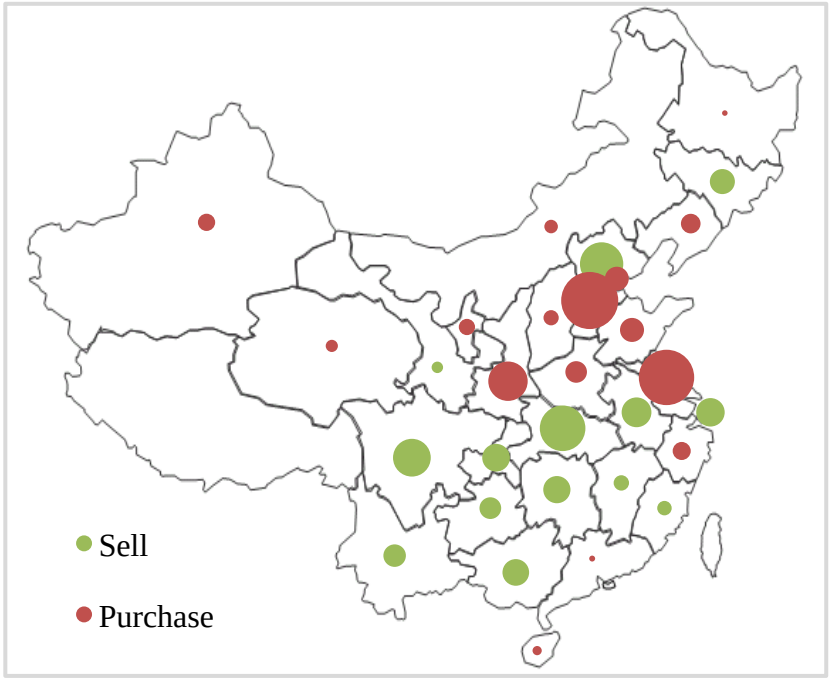


SIMULATION RESULTS – Reallocation

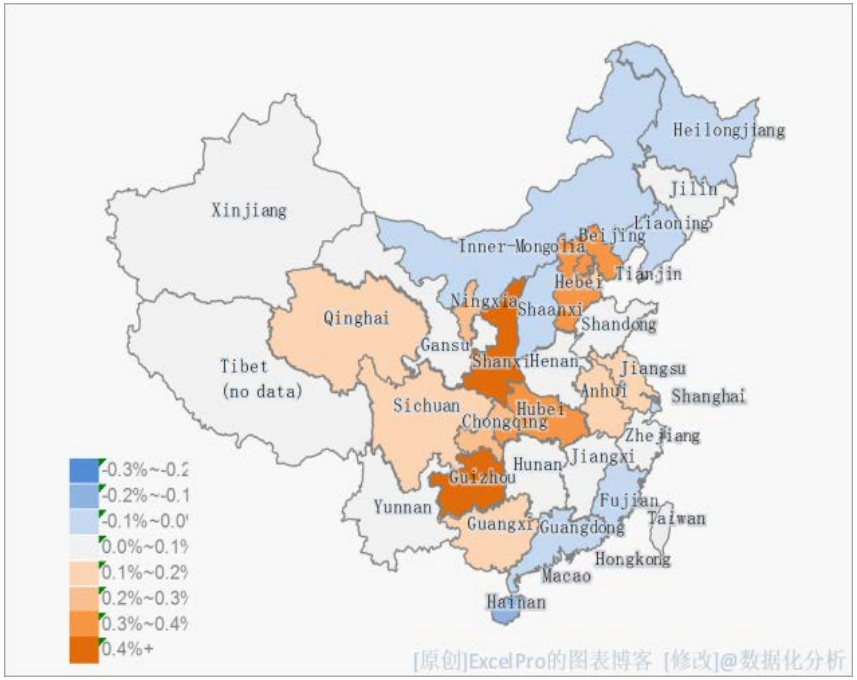
Base-Year Welfare Criterion:

- Highest distortion in non-tradable scenarios;
- Income transfer from Southern to Mid & Northern areas;
- Favorable to areas with higher consumption share.

Emission Trading in WLF_T Scenario



GDP Growth Rate Decrease in WLF_T Scenario

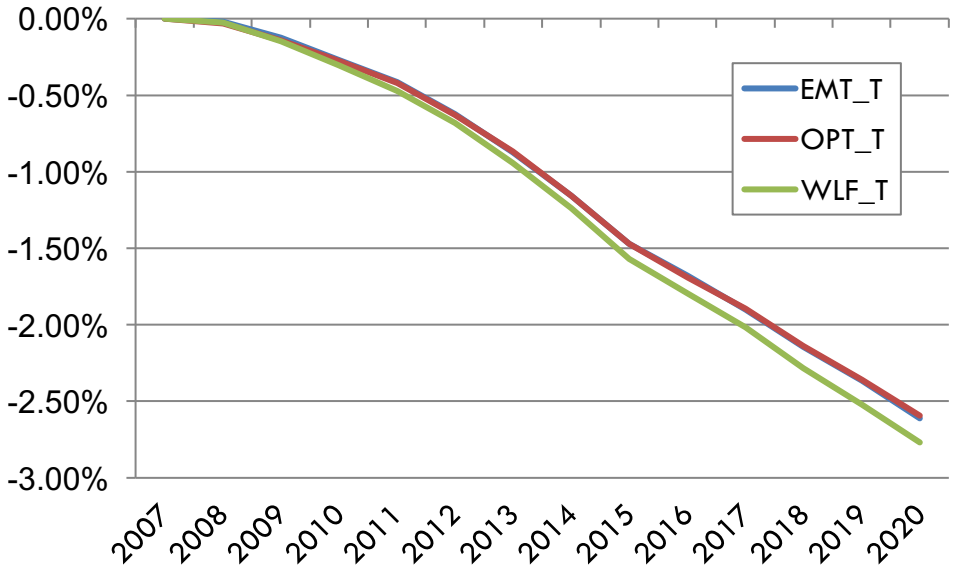


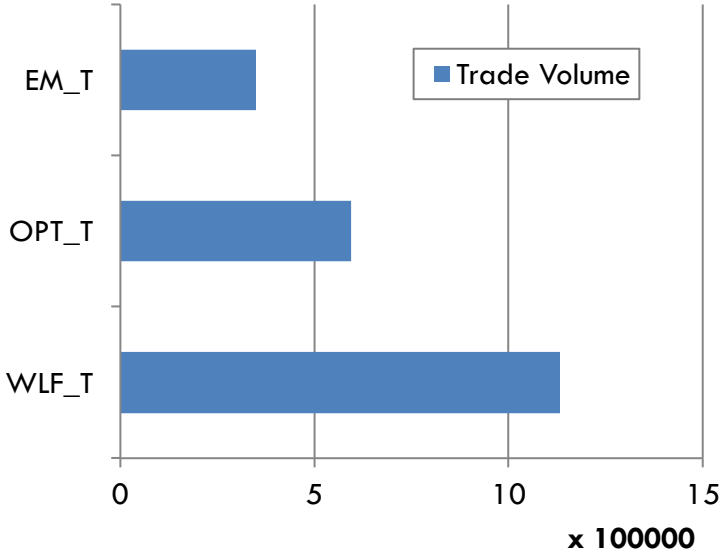
SIMULATION RESULTS – Reallocation

General Effects of Reallocation (i.e. the impact of income transfer):

- Production effect: MAC change – eliminated by trading system;
- Demand effect: demand structure change;
- Trade costs effect: change in trade flow;
- Growth effect: change in regional investment.

⇒ *Non-production effects are limited, does not affect flexibility of policies.*





CONCLUSIONS

Chinese Economy is Sensitive to Emission Reduction:

- Emission reduction will lead to 2.11% GDP loss in 2015 and 3.31% in 2020, in BAU scenario;
- Increasing marginal losses of emission reduction.

Effects of Emission Trading System:

- Improve economic efficiency of climate policies;
- Decouple economic efficiency with allocation of emission permits;
- Bridge concerns for efficiency and social equity

Effects of Emission Permits Allocation:

- Emission criterion: favorable to energy intensive regions;
- Output criterion: favorable to less-energy-intensive regions, may cause income transfer from developing regions to developed regions;
- Welfare criterion: largest distortion, favorable to southern areas.

欢迎批评指正！

Thank you for your attention