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China's Environmental Protection Tax and Its Reforms impact on Sectoral and Spatial Distribution of Air Pollution Emissions

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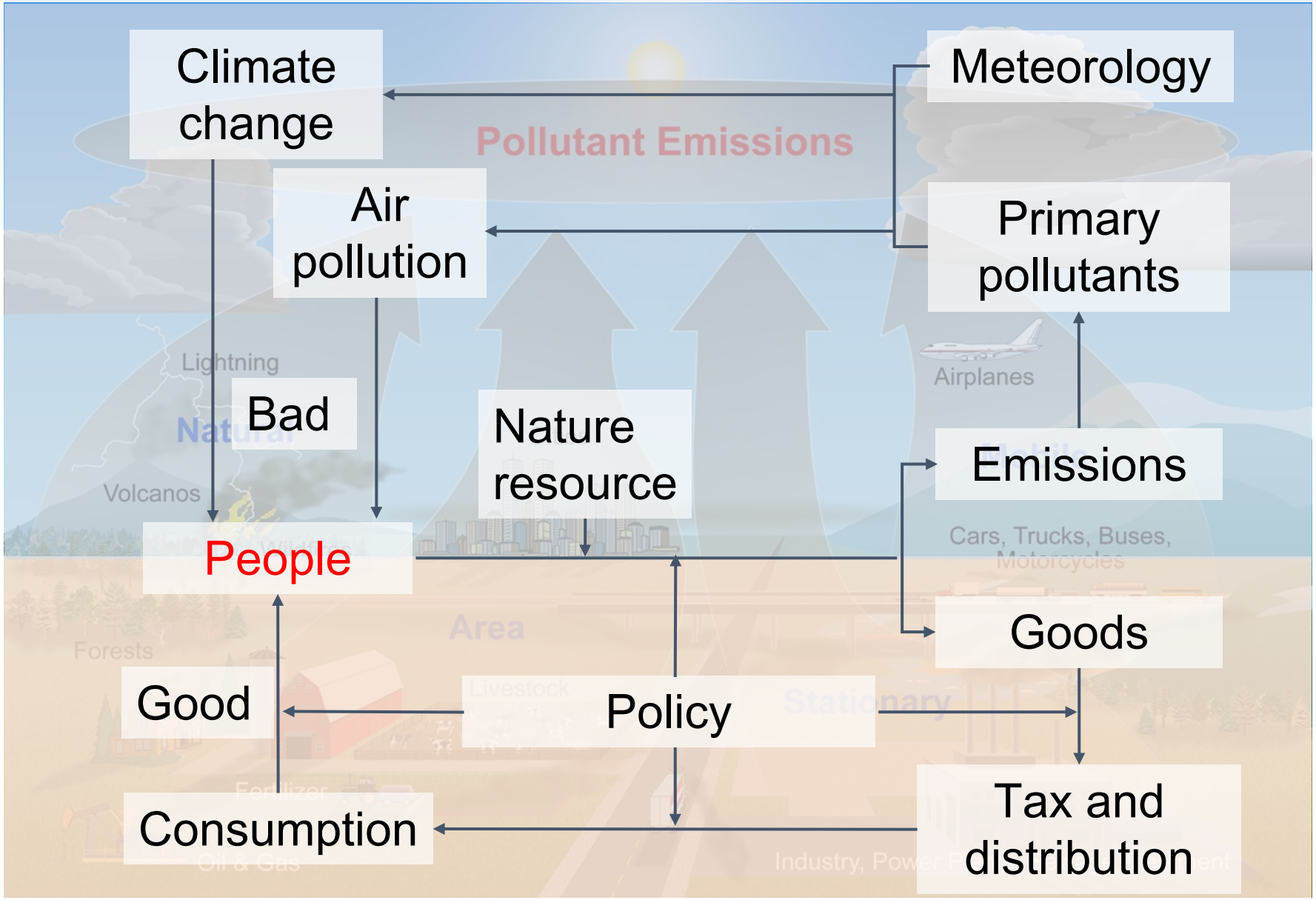
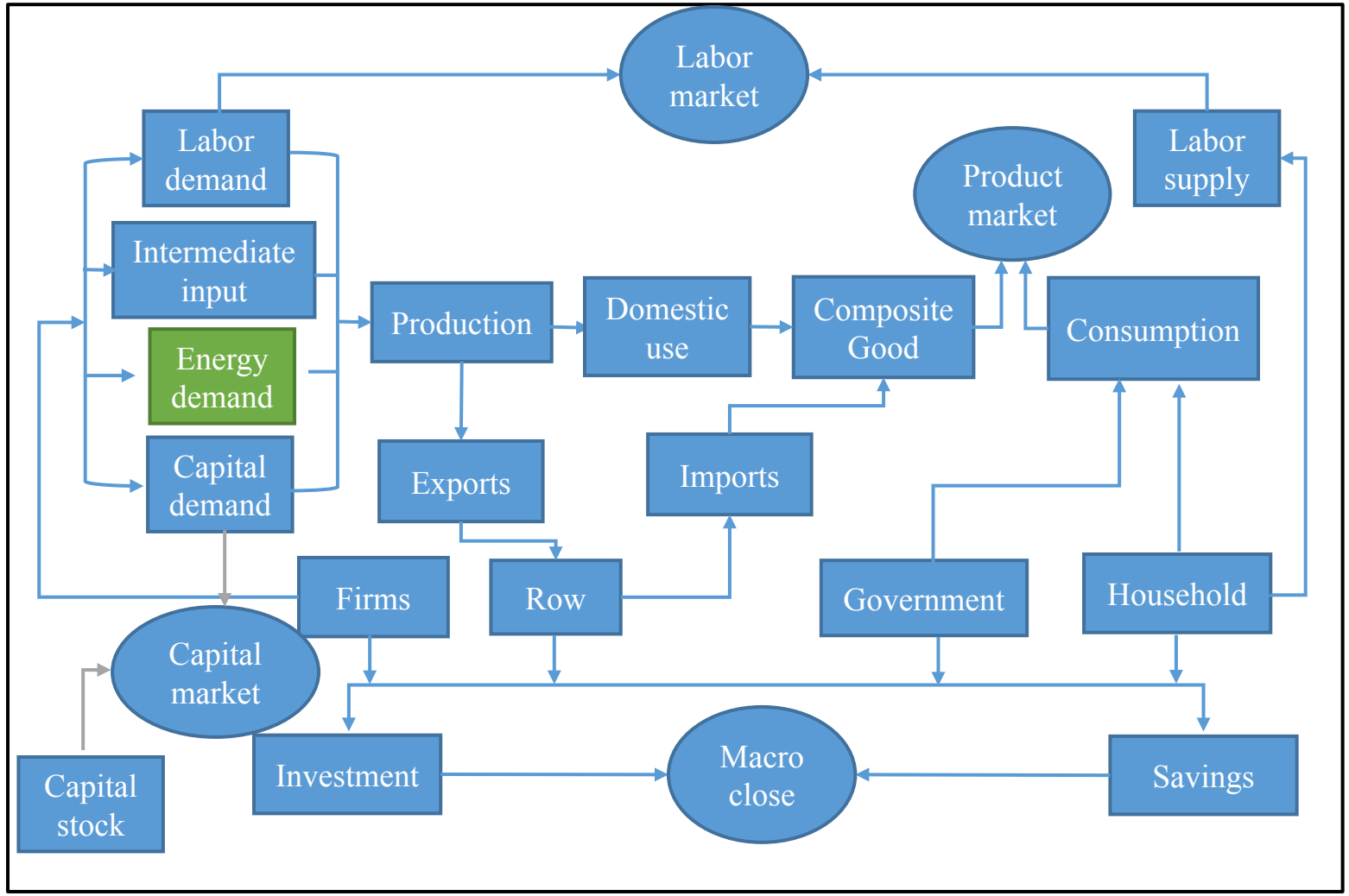
Contents

- Background
- Computable General Equilibrium model
- China's Environmental Protection Tax Analysis
  - — Analysis of Current Environmental Protection Tax
  - — Analysis of Environmental Protection Tax Reforms

Background


Climate change
Meteorology
Pollutant Emissions
Air pollution
Primary pollutants
Lightning
Airplanes
Bad
Nature resource
Emissions
Volcanos
Cars, Trucks, Buses, Motorcycles
People
Area
Goods
Forests
Livestock
Good
Policy
Stationary
Fertilizer
Consumption
Tax and distribution
Oil & Gas
Industry, Power

Computable General Equilibrium Model



Rational economic agents:

1) Minimizing production costs of firms
2) Maximizing welfare of consumers

Equilibrium conditions:

1) Product market clear
2) Labor market clear
3) Capital market clear
4) The investment decided by saving

Data

- Regional Input-output Tables
- Regional Social Accounting Matrix （SAM）
- Emission Inventory
- Regional Energy Balance Tables

Economic Data

		Intermediate demand			Total intermediate demand B	Total regional final demand F	International exports E	Exports G	International imports M	Imports H	Regional production (gross outputs) Y
		Sector 1	⋯	Sector k							
Intermediate input	Sector 1	x_{11}	⋯	x_{1k}	$\sum_{j=1}^{k} x_{1j}$	f_1	e_1	g_1	m_1	h_1	y_1
	⋮	⋮	⋱	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	Sector k	x_{k1}	⋯	x_{kk}	$\sum_{j=1}^{k} x_{kj}$	f_k	e_k	g_k	m_k	h_k	y_k
Total of intermediate sectors C		$\sum_{i=1}^{k} x_{i1}$	⋯	$\sum_{i=1}^{k} x_{ik}$	$\sum_{i=1}^{k}\sum_{j=1}^{k} x_{ij}$	$\sum_{i=1}^{k} f_i$	$\sum_{i=1}^{k} e_i$	$\sum_{i=1}^{k} g_i$	$\sum_{i=1}^{k} m_i$	$\sum_{i=1}^{k} h_i$	$\sum_{i=1}^{k} y_i$
Total of gross value added sectors V		v_1	⋯	v_k	$\sum_{j=1}^{k} v_j$	IV					
Regional production (gross inputs) Y		y_1	⋯	y_k	$\sum_{j=1}^{k} y_j$						

Input-Output Table

Social Accounting Matrix (SAM)

BASIC STRUCTURE OF A SAM

	Activities	Commodities	Factors	Private	Government	Capital	Rest of the World	Total
Activities		Gross Output					Exports	Total value production
Commodities	Intermediate Consumption			Private Consumption	Government Consumption	Private and Public Investment		Domestic Aggregate Demand
Factors	Salaries + capital earnings							Factors Remunera-tion
Private			Income, labor and capital		Transfers		Foreign Transfers	Private Income
Government	Indirect Taxes	Tariffs	Social Security Contribu-tions	Direct Taxes			Foreign Transfers	Gov. Income
Capital				Private Savings	Government Savings		Foreign Savings	Total Savings
Rest of the World		Imports		Payment Interest & Other	Payment Interest & Other			Income from RoW
Total	Total Value of Production	Aggregate Supply	Remune-ration Factors	Private Expenditure	Government Expenditure	Total Investment	Payments to RoW	

Energy and Emission Data

PKU-Inventory (2007): BC, CO, CO_2, NH_3, NO_X, PM_{10}, $PM_{2.5}$, TSP, OC, SO_2. VOC(Shaodong Xie, et al, 2016)

Table 2 Detailed source/fuel categories

No	Source category	Fuel/activity	Sector	Quality	CO_2	CO	PM	BC	OC	SO_2	NO_x	NH_3	PAH
1		anthracite	energy production	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
2		coking coal	energy production	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
3		bituminous coal	energy production	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
4		lignite	energy production	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
5		peat	energy production	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
21		anthracite	industry	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
22		coking coal	industry	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
23		bituminous coal	industry	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
24	Coal	lignite	industry	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
25		peat	industry	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
35		anthracite	residential/commercial	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
36		coking coal	residential/commercial	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
37		bituminous coal	residential/commercial	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
38		lignite	residential/commercial	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
39		peat	residential/commercial	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
81		patent fuel	residential/commercial	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
80		honeycomb/coal briquettes	residential/commercial	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
6		gas/diesel	energy production	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
7		residue fuel oil	energy production	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
13		natural gas liquid	energy production	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
19		gas/diesel	agriculture	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
20		gas/diesel	industry	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
26		residue fuel oil	industry	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
31		crude oil	industry	fuel consumption	✓			✓		✓			
33		natural gas liquid	industry	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
42		natural gas liquid	residential/commercial	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	
43		kerosene	residential/commercial	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
82		gas/diesel	residential/commercial	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
83	Oil	fuel oil	residential/commercial	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓
48		vehicle gasoline	transportation	fuel consumption	✓	✓	✓	✓	✓	✓	✓	✓	✓

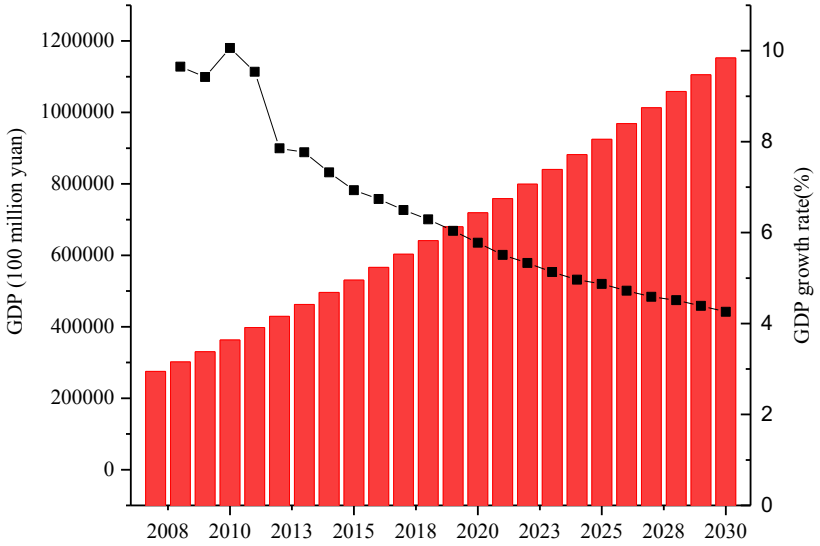
30 Regions' Energy Balanced Tables (2008)

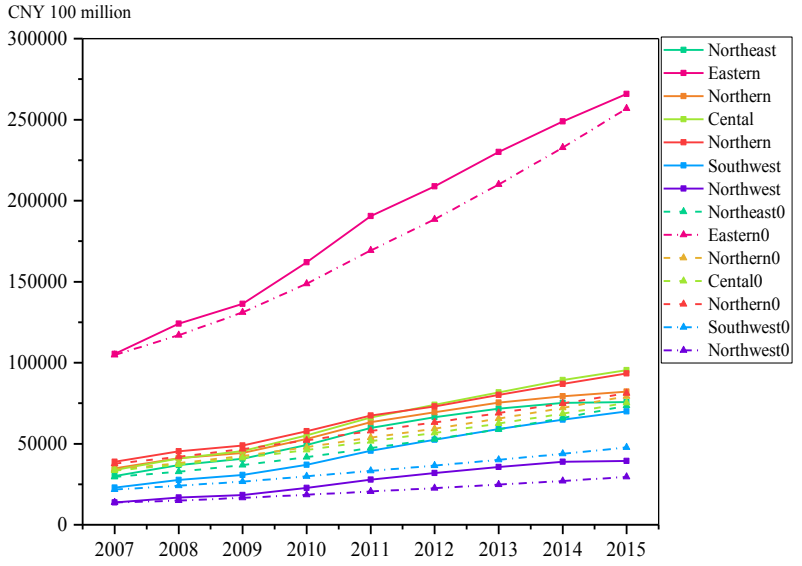
Energy Balanced Tables for Beijing (10^4ton)

	Coal	Coke	Gasoline	Kerosene	Diesel	Fuel oil	LPG	Nature gas
Agriculture, Forestry, etc	50.9	0.0	4.9	0.0	8.3	0.0	0.1	0.0
Mining and Washing	9.0	3.2	0.3	0.0	4.1	0.0	0.0	0.0
Light industry	116.1	0.0	5.7	0.0	3.4	0.9	0.5	0.5
Chemistry	145.1	0.0	2.6	0.1	2.5	16.8	7.2	2.8
Nonmetal manufacturing	248.0	4.7	1.3	0.0	11.4	7.4	0.3	0.8
Metal manufacturing	400.5	226.0	2.0	0.0	4.8	0.4	0.5	0.6
Machine manufacturing	27.5	3.8	2.3	0.0	1.5	0.1	0.1	0.2
Other industry	49.7	0.4	3.9	0.1	2.6	0.1	0.2	1.0
Electric Power, Heat, Gas and Water	1292.7	0.0	1.6	0.0	1.4	17.2	0.0	8.0
Construction	16.0	0.0	8.7	0.0	18.7	0.0	0.7	0.4
Traffic, Transport and Storage	51.2	0.0	82.1	276.6	110.4	0.0	2.3	6.2
Other Services	306.6	0.0	46.2	0.3	23.0	0.0	28.0	17.2

Validation

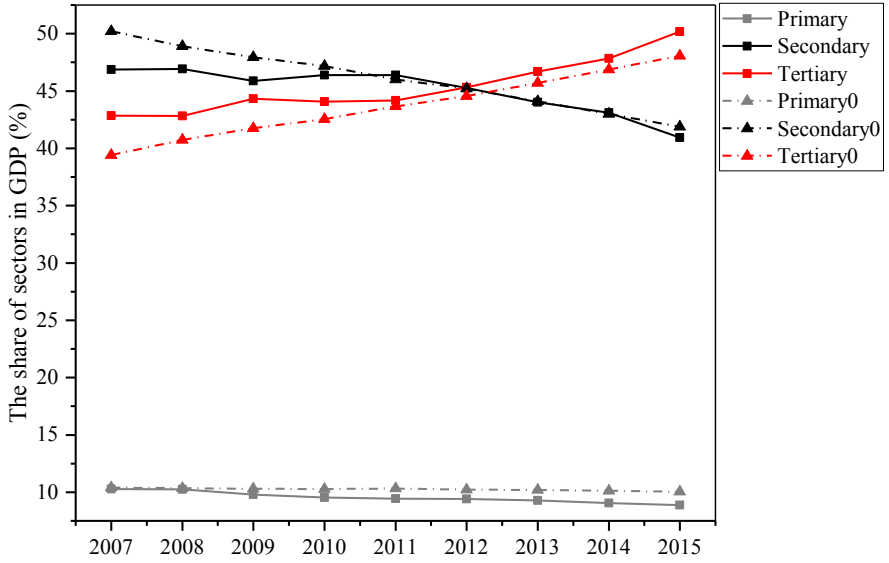
National GDP

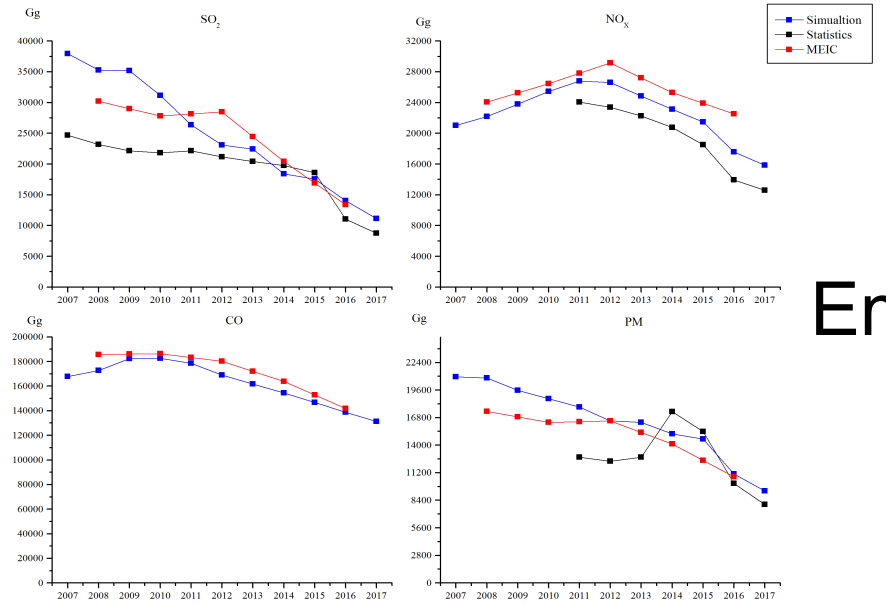




Regional GDP

Industry structure

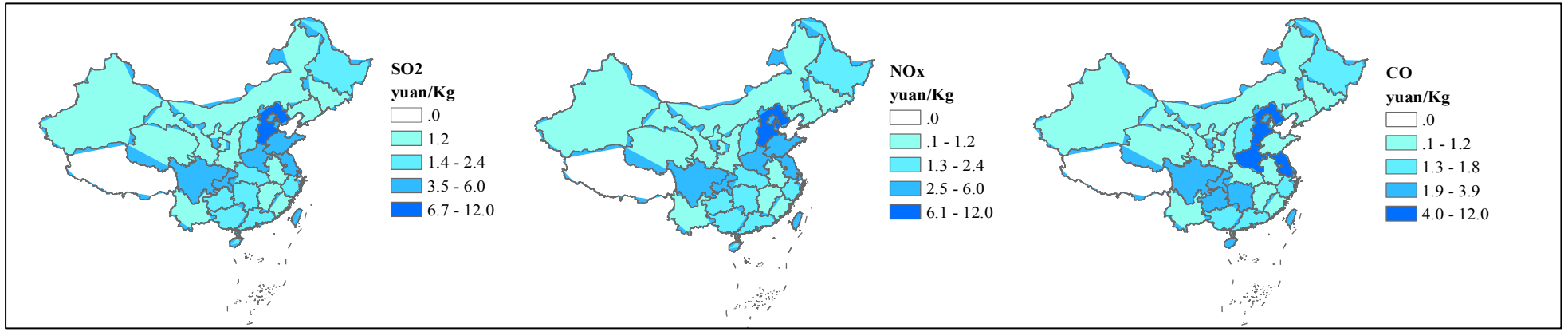




Emissions

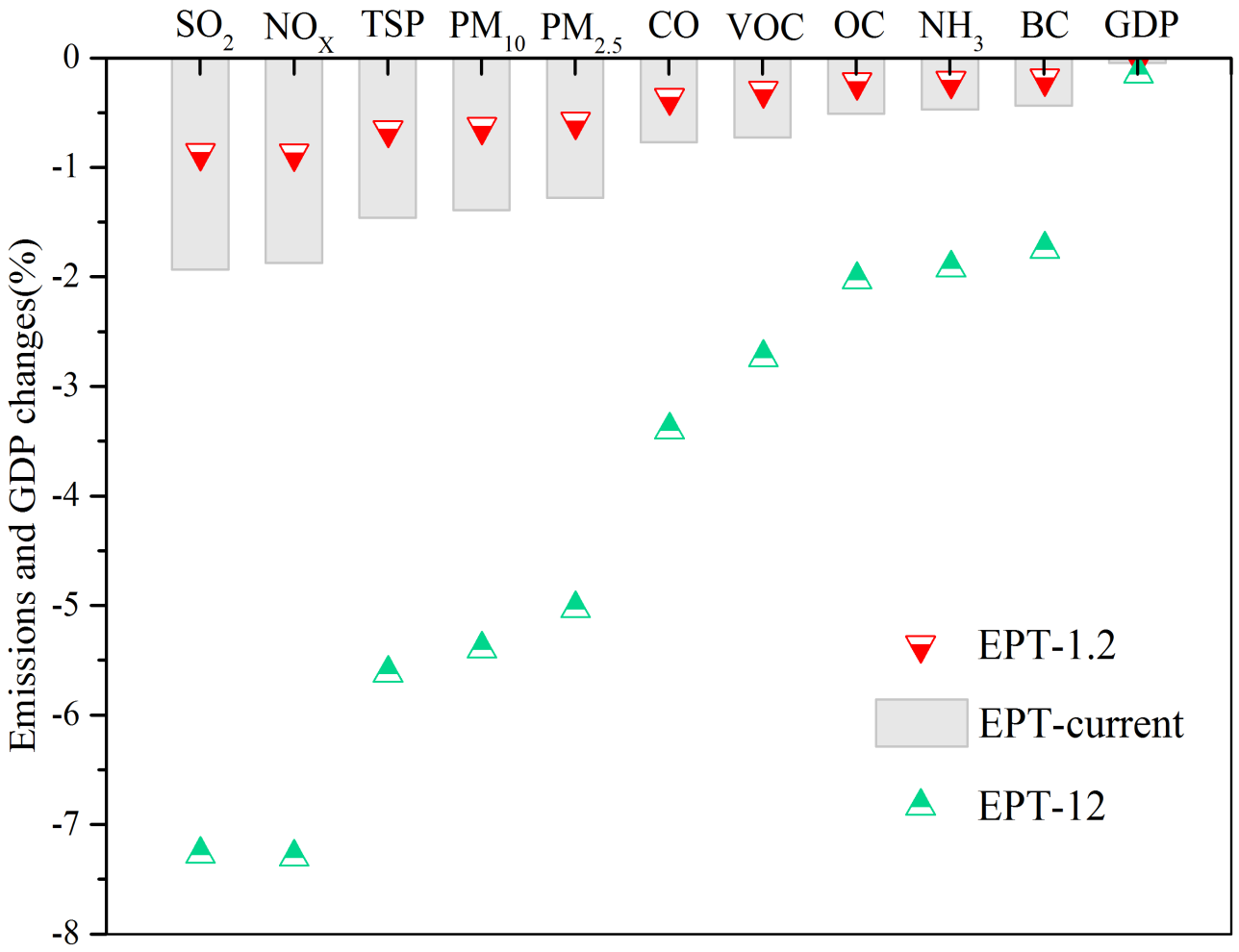
Environmental Protection Tax

	Environmental Protection Tax Law Description
Sectors	All enterprise except emissions from agriculture and moto vehicle/vessel/aircraft
Pollutants	The first three items of pollutants ranked in descending order of pollution equivalents. SO_2, NO_X and CO are considered in this paper.
Price	1.2 RMB to 12 RMB per pollutant equivalent value
Scenarios	S1: 1.2 RMB per pollution equivalent in all regions S2: The current EPT tax rates S3: 12 RMB per pollution equivalent in all regions



Regional pollutants price in current environmental protection tax

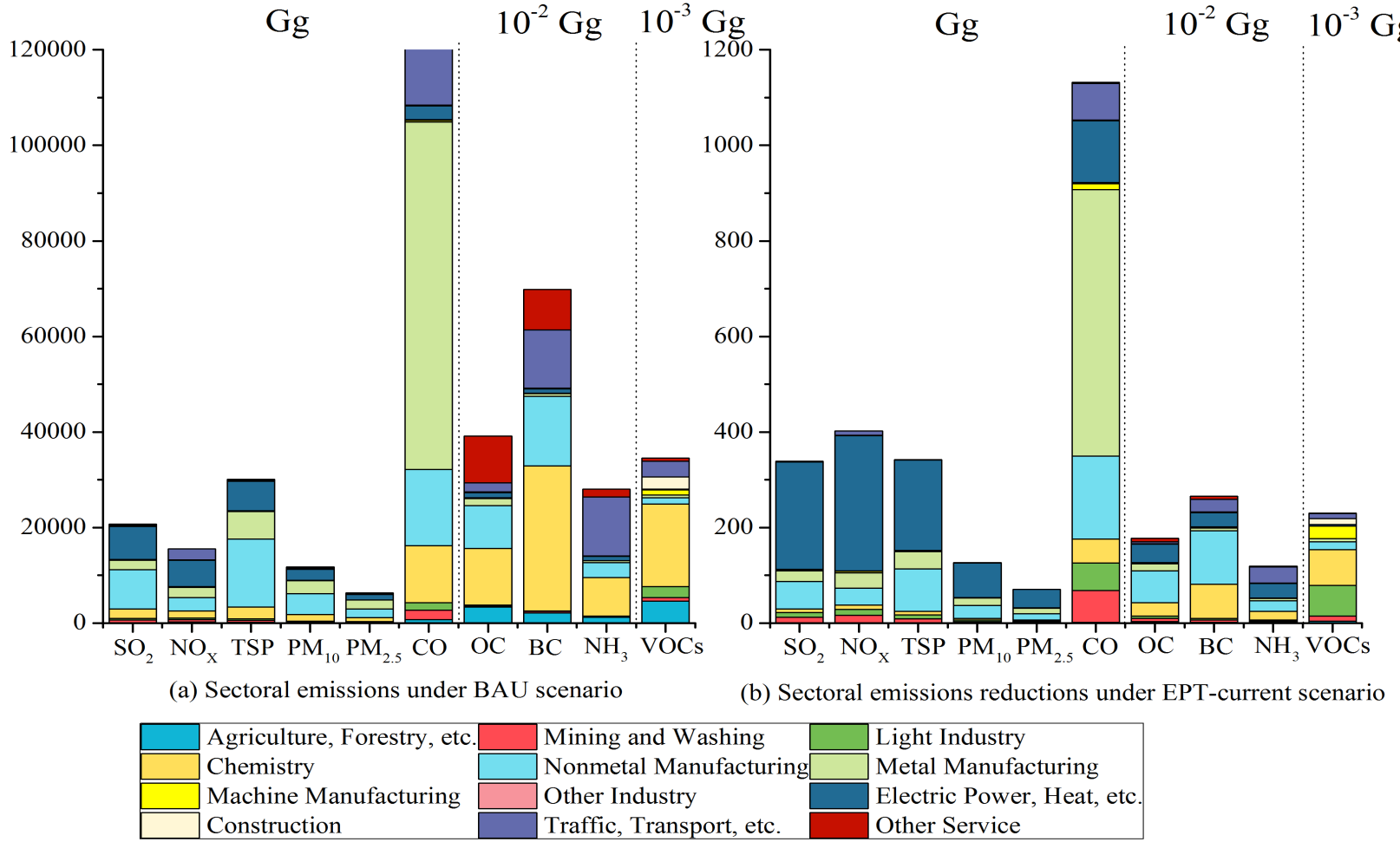
Impact of EPT on Emissions and GDP



- The tax leads to the largest declines in SO_2 and NO_X under all scenarios
- A more ambitious environmental policy is a necessary condition for air pollution mitigation in China
- This tax ultimately has a slightly negative effect on GDP

Hu, et al., ERL,2019

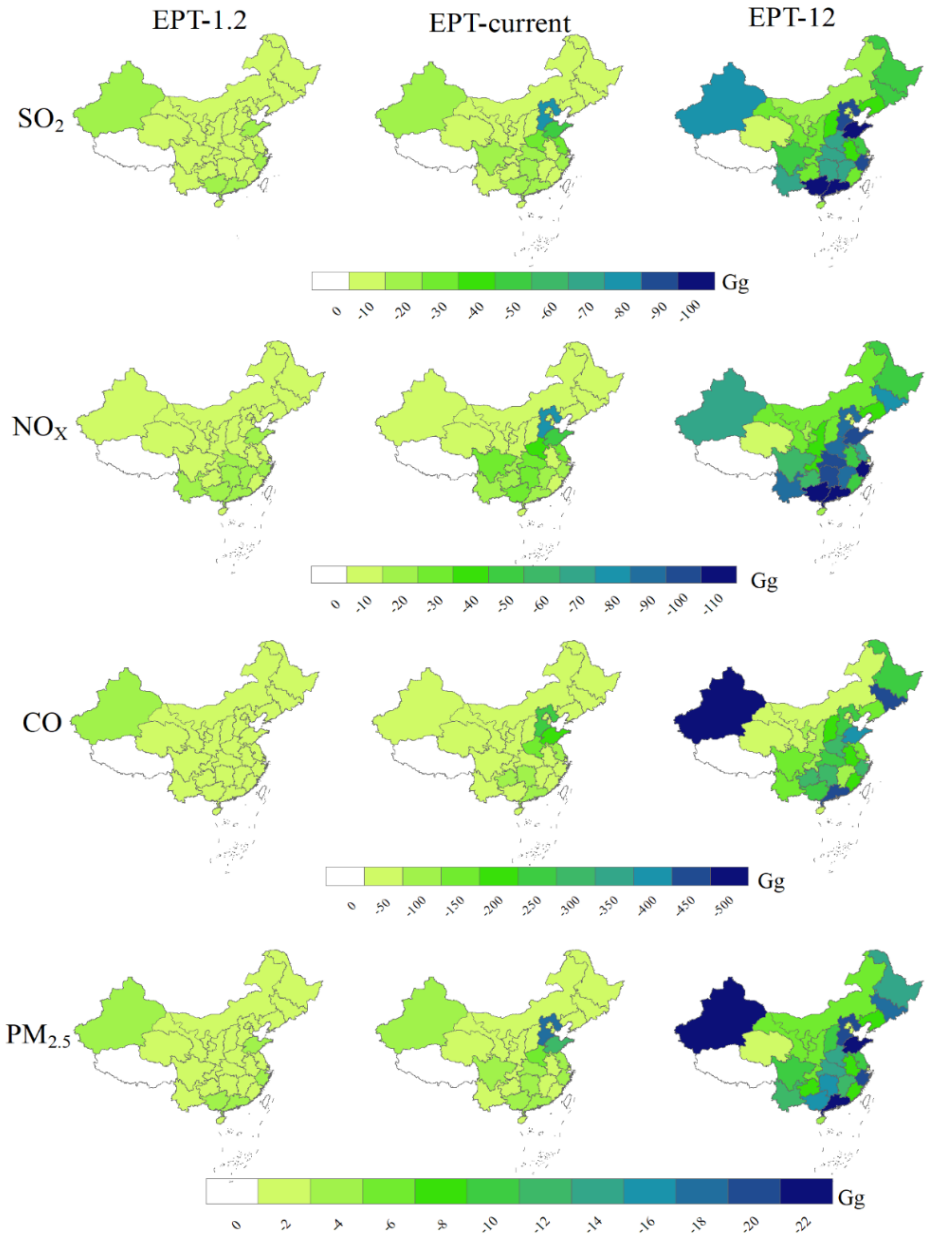
Impact of EPT on Sectoral Emissions



The significant effects only happen in sectors with high emission intensity (i.e., the electric power sector and nonmetal manufacturing sectors)

Hu, et al., ERL,2019

Impact of EPT on Regional Emissions



Substantial air pollutants reductions occur in:

(1) provinces with large economy scales(Guangdong, Shandong, Zhejiang and Hebei)

(2) provinces with SO_2-intensive and NO_X-intensive industry (Xinjiang, Guangxi, Jiangxi and Yunnan)

Hu, et al., ERL,2019

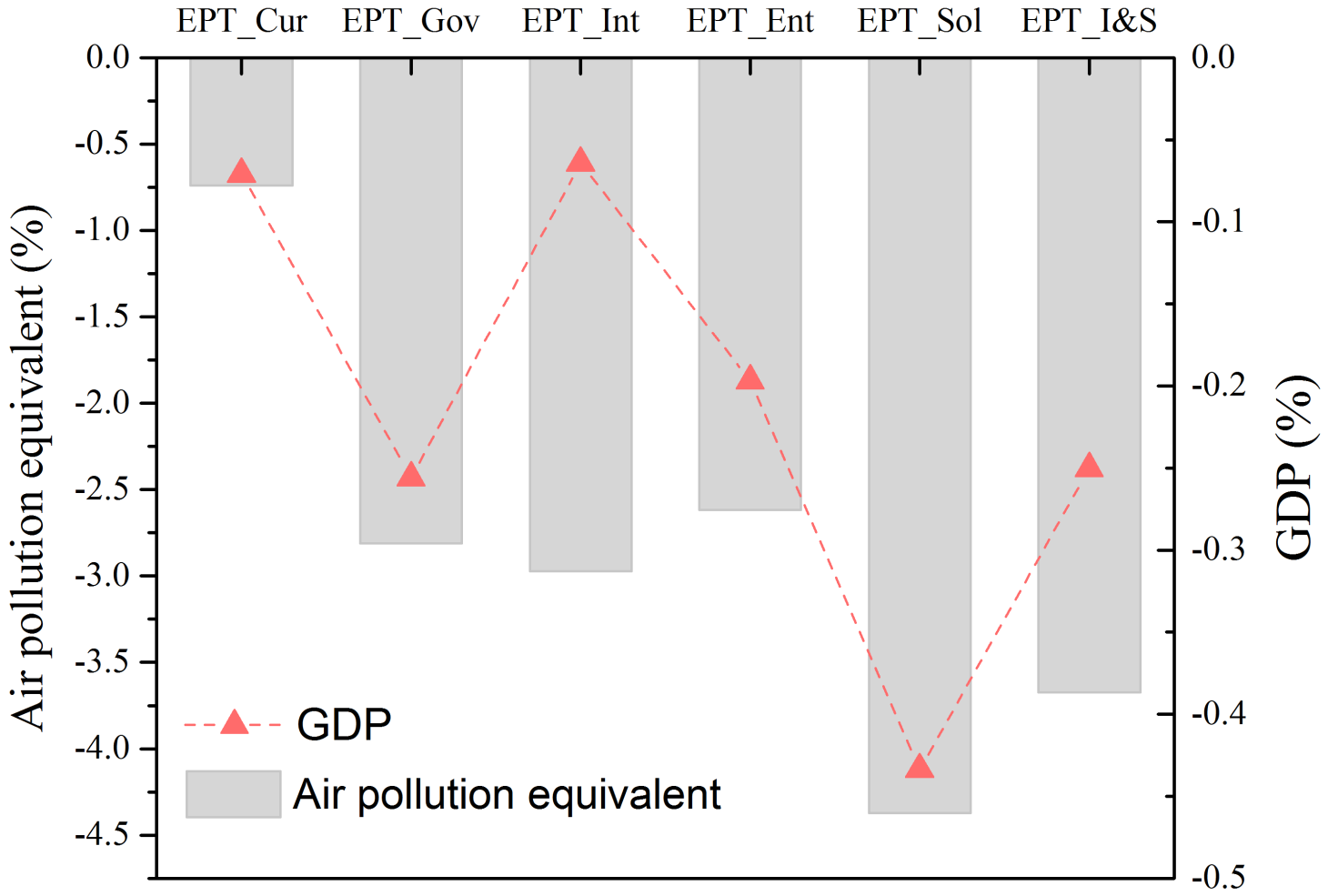
Environmental Protection Tax Reforms

- Tax Reform: recycling the tax revenues to reduce other distortionary taxes or transferring the revenues to other agents
- Double Dividend: tax benefits to both the environment and economy

Scenario	Description
Baseline	No EPT tax
EPT_Cur	Current EPT without returning
EPT_Gov	All provinces apply the highest 12 RMB tax rate without returning
EPT_Int	The tax revenues from EPT_Gov are all used to reduce household income tax
EPT_Ent	The tax revenues from EPT_Gov are all used to reduce enterprise income tax
EPT_Sol	The tax revenues from EPT_Gov are all invested in solar PV installation
EPT_I&S	Half of the tax revenues from EPT_Gov are used to reduce household income tax and half are used to support solar PV installation

Hu, et al., Earth Future, 2020

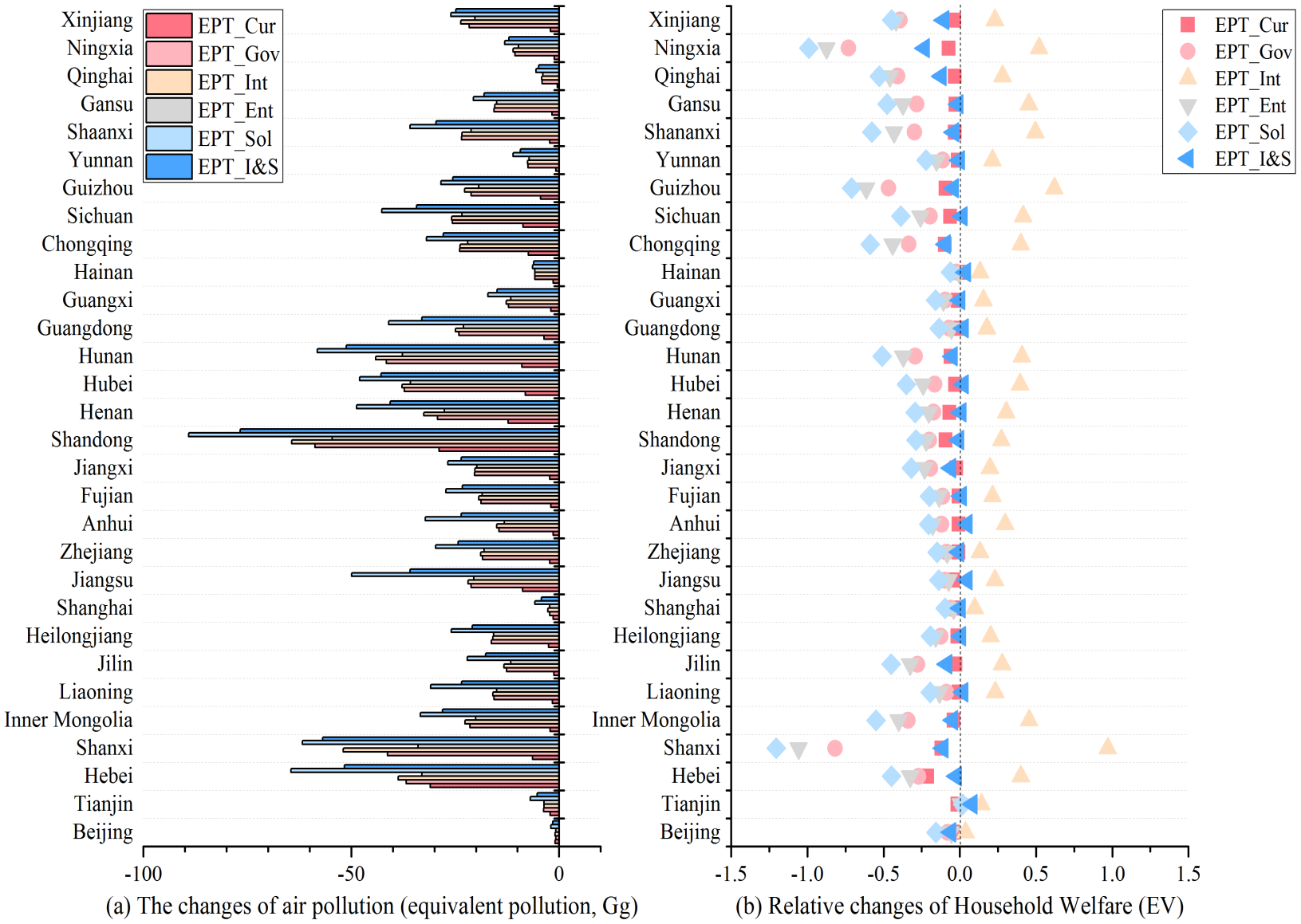
National Impacts of EPT Reforms



- EPT_Int is an efficient way to achieve the double dividend
- There is no double dividend under EPT_Ent or EPT_Sol scenario
- EPT_I&S could be a better approach to reduce more air pollution emissions

Hu, et al., Earth Future, 2020

Regional Impacts of EPT Reforms



(a) The changes of air pollution (equivalent pollution, Gg)

(b) Relative changes of Household Welfare (EV)

EPT_Int scenario could achieve the double dividend in all provinces, especially provinces with higher emission intensity, such as Shanxi, Hebei, Inner Mongolia and Guizhou Provinces.

Hu, et al., Earth Future, 2020

Conclusion

- At the national level, the overall effect of the current policy on air pollution mitigation is relatively small, less than 2% compared to a BAU scenario. A more ambitious environmental policy is a necessary condition for air pollution mitigation.

- Significant effects from EPT only happen in regions with large economic scale (i.e., Guangdong, Shandong and Zhejiang provinces) and in sectors with high emission intensity (i.e., the electric power and nonmetal manufacturing sectors).

- Strengthening the current EPT and returning tax revenues to reduce household income tax is the most efficient way to reduce air pollution from high emission intensity regions.

- To reduce more air pollutant emissions, returning half of the tax revenues to invest in solar power is the second best option, which substantially reduces both CO_2 and air pollution emissions with almost no impact on household welfare.

Thanks!