The Economics of Green Growth

Green Economy Dialogue Meeting
OECD Conference Center, Paris
6 November 2012

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Green Growth

- "Green Growth" is Old Wine in a New Bottle
- Long history in economics recognizing market "externalities"
  - Pigou (1932), taxes; Coase's (1960)/Montgomery (1972)) on market based internalization of costs.
  - Expansion to macro-economy, sustainability (a la Weitzman,1976 and Solow (1992)
  - National Accounts w/integrated envir. accounting (e.g. NRC, 1999)

- Challenge is to
  1. Determine real market failures.
  2. Empirical evaluation—"optimal" level of pollution control
  3. Determine if it is possible to formulate a policy to efficiently correct the externality
  4. Choose and implement an efficient policy

See: Green Growth and the Efficient Use of Natural Resources, Reilly, J., Rpt 221 http://globalchange.mit.edu/research/publications/reports/all and, forthcoming in *Energy Economics*

Our National Accounting Systems: What missing, what's not?

- GDP not a good measure of green growth
  - Net National Product is a better measure because it includes changes in Assets
  - But only "Produced" capital? Actually changes in Natural Capital are often included indirectly...land, real estate prices, capitalization of firms that own natural resources, etc.
  - So revising the accounts often don't show much of a change in the bottom line.

- Is that the whole story?
  - Big missing element is Human Capital
    - Does this have anything to do with environment and natural resources—a bit but not the big story
  - The associated pollutant flows and their economic impact sector by sector are also missing.
    - Does not change the bottom line GDP/NNP accounting but provides the tools to evaluate how changes in the level of pollution, resource depletion, degradation will affect the economy.

A modified Social Accounting Matrix to account for air pollution health effects

		INTERMEDIATE USE						*HOUSEHOLD SERVICES*		FINAL USE				OUTPUT
		1	2	...	*j*	...	*n*	*Mitigation of Pollution Health Effects*	*Labor-Leisure Choice*	Consumption	Investment	Government Purchase	Net-export	
DOMESTIC PRODUCTION	1													
	2													
	:													
	i													
	:													
	Medical Services for Health Pollution							*Medical Services*		*Health Services*				
	n													
IMPORTS	1													
	2													
	:													
	i													
	:													
	n													
LEISURE									*Leisure*	*Leisure*				
VALUE-ADDED	Labor							*Labor*	*Labor*					
	Capital													
	Indirect Taxes													
	Resources													
INPUT														

Figure 1. Social Accounting Matrix for EPPA-HE. Source: Nam *et al*. (2010), p. 5016.

Use epidemiological studies on exposure response relationships

- Adopted from ExternE studies, an extensive review of existing epidemiological studies.
- ER functions quantify an increase in each health-end outcome given a unit change in a given pollutant's concentration level (measured as $\mu g/m^3$).

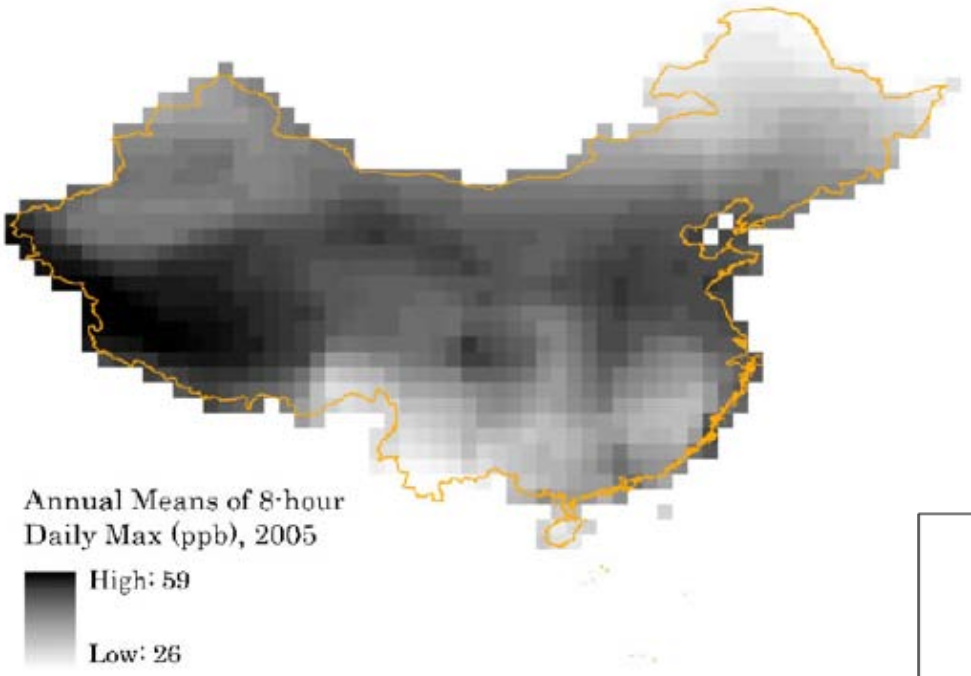
Receptor	Impact Category		ER function*	C. I. (95%) Low	C. I. (95%) High	Computed or Adapted from:**
Entire age groups	Respiratory hospital admissions	PM_{10}	7.03E-06	3.83E-06	1.03E-05	ExternE (2005)
		O_3	3.54E-06	6.12E-07	6.47E-06	ExternE (1999)
	Cerebrovascular hospital admissions	PM_{10}	5.04E-06	3.88E-07	9.69E-06	ExternE (2005)
	Cardiovascular hospital admissions	PM_{10}	4.34E-06	2.17E-06	6.51E-06	ExternE (2005)
	Respiratory symptoms days	O_3	3.30E-02	5.71E-03	6.03E-02	ExternE (1999)
	Asthma attacks	O_3	4.29E-03	3.30E-04	8.25E-03	ExternE (1999)
	Acute Mortality	O_3	0.03%	0.01%	0.04%	ExternE (2005)
		PM_{10}	0.06%	0.04%	0.08%	ExternE (2005)
	Chronic Mortality	PM_{10}	0.25%	0.02%	0.48%	Pope *et al.* (2002)
Children	Chronic Bronchitis	PM_{10}	1.61E-03	1.24E-04	3.10E-03	ExternE (1999)
	Chronic Cough	PM_{10}	2.07E-03	1.59E-04	3.98E-03	ExternE (1999)
	Respiratory symptoms days	PM_{10}	1.86E-01	9.20E-02	2.77E-01	ExternE (2005)
	Bronchodilator usage	PM_{10}	1.80E-02[a]	-6.90E-02	1.06E-01	ExternE (2005)
	Cough	O_3	9.30E-02[b]	-1.90E-02	2.22E-01	ExternE (2005)
	Lower respiratory symptoms (wheeze)	PM_{10}	1.86E-01[c]	9.20E-02	2.77E-01	ExternE (2005)
		O_3	1.60E-02[d]	-4.30E-02	8.10E-02	ExternE (2005)
Adults	Restricted activity day	PM_{10}	5.41E-02[e]	4.75E-02	6.08E-02	ExternE (2005)
	Minor restricted activity day	O_3	1.15E-02[f]	4.40E-03	1.86E-02	ExternE (2005)
		PM_{10}	3.46E-02[f]	2.81E-02	4.12E-02	ExternE (2005)
	Work loss day	PM_{10}	1.24E-02[f]	1.06E-02	1.42E-02	ExternE (2005)
	Respiratory symptoms days	PM_{10}	1.30E-01[g]	1.50E-02	2.43E-01	ExternE (2005)
	Chronic bronchitis	PM_{10}	2.65E-05	-1.90E-06	5.41E-05	ExternE (2005)
	Bronchodilator usage	PM_{10}	9.12E-02[h]	-9.12E-02	2.77E-01	ExternE (2005)
		O_3	7.30E-02[h]	-2.55E-02	1.57E-01	ExternE (2005)
	Lower respiratory symptoms (wheeze)	PM_{10}	1.30E-01[i]	1.50E-02	2.43E-01	ExternE (2005)
Elderly 65+	Respiratory hospital admissions	O_3	1.25E-05	-5.00E-06	3.00E-05	ExternE (2005)
	Congestive heart failure	PM_{10}	1.85E-05	1.42E-06	3.56E-05	ExternE (1999)

Valuating Outcomes

Outcome	Unit	Cost (1997 US$)
Hospital Admission*	per admission	284
Emergency Room Visits for respiratory illness*	per visit	23
General Practitioner visits:		
Asthma*	per consultation	4
Lower Respiratory Symptoms*	per consultation	13
Respiratory Symptoms in Asthmatics*	per event	0.60
Respiratory medication use	per day	0
Restricted Activity Day	per day	2.32
Cough day	per day	0.60
Symptom day	per day	0.60
Work loss day	per day	1.43
Minor Restricted Activity day	per day	0.60
Chronic Bronchitis*	per case	8,000
Acute Mortality	per case	662

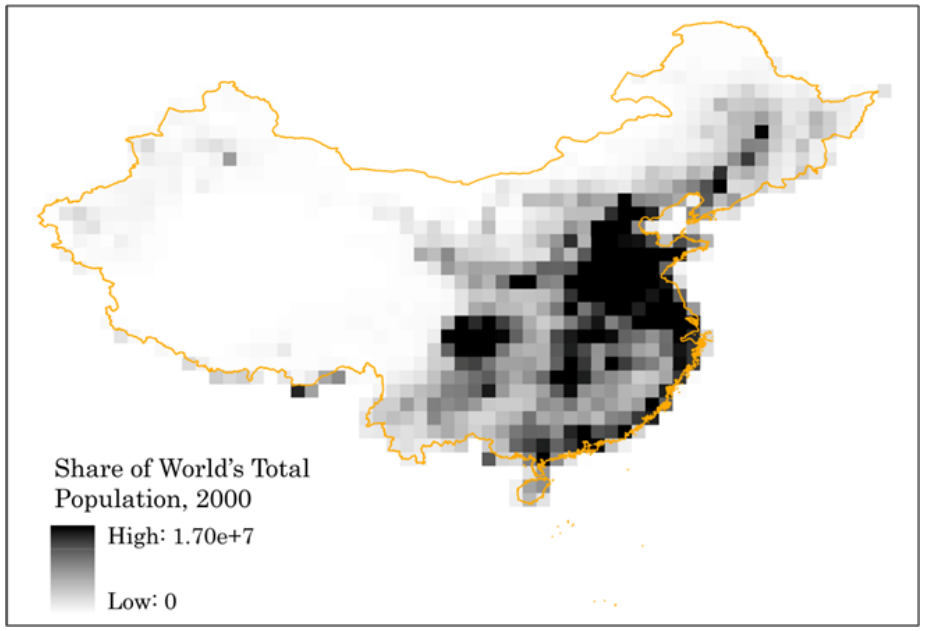
- Adopted from World Bank (1997) or scaled down from the European tables.
- Premature death based on lost labor...need to again get number of cases/people not dollars of labor input as productivity/wage changes over time.

Relate pollution levels population exposed

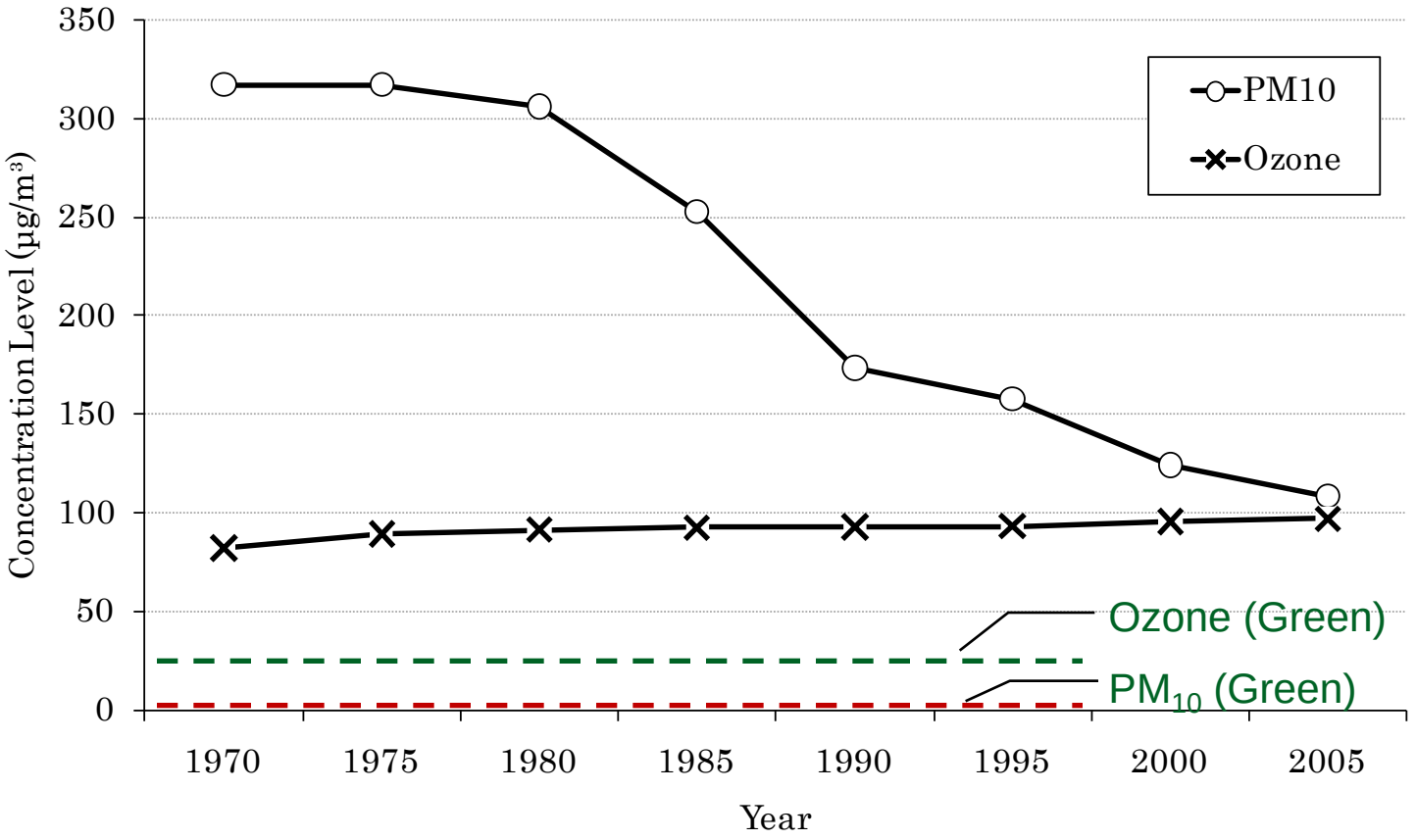


- 1° ×1° modeled data for 2005 from GEOS-Chem.
- Scaled by zonal means for 1970-2000 from the MIT IGSM.

- Population concentrated in eastern China.



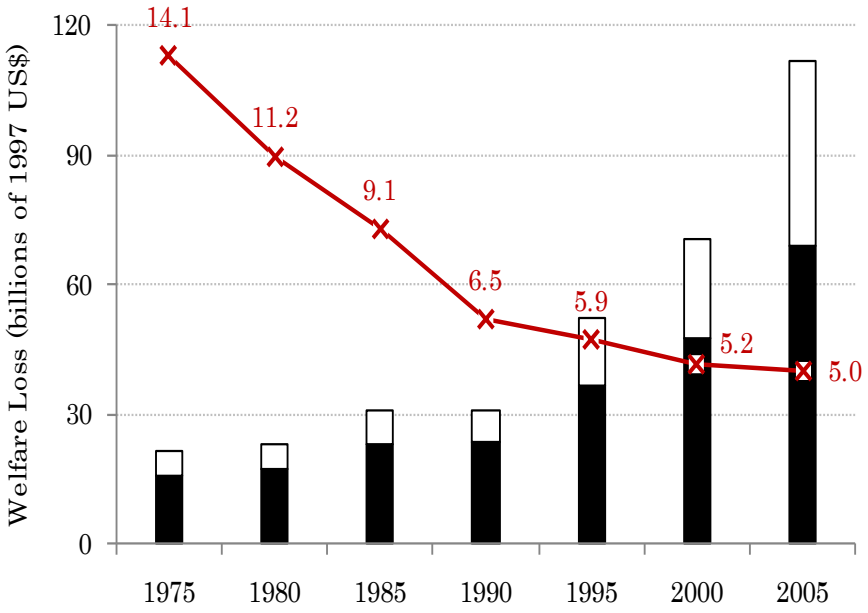
Air Quality Input: *Historical* vs. *Green*



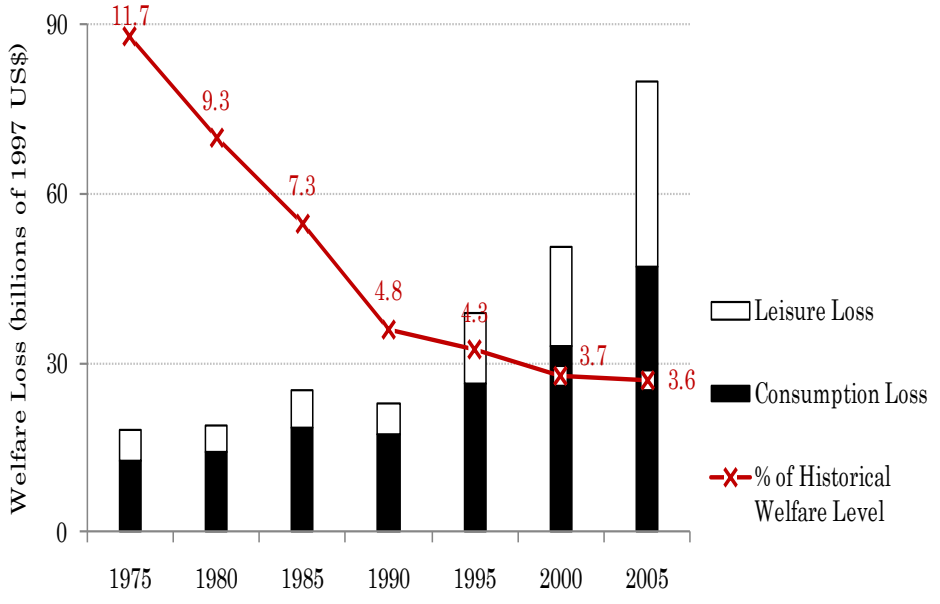
Pollution Health Costs

- Metrics of pollution-health costs
  - **Market economy effects measured by change in market consumption**
  - **Non-market effects are capture by change in leisure**
  - **Combined is total welfare loss**

Total Damages



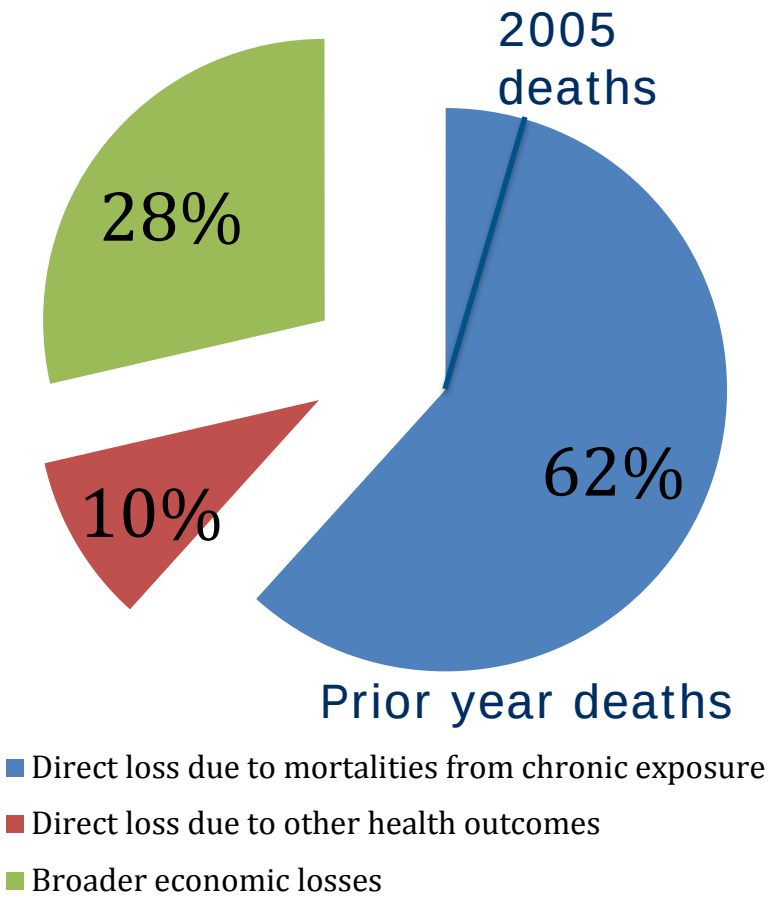
Benefits of meeting standard pollution targets



Sources of loss in 2005

- PM_{10} and O_3 account for **87%** and **13%** of the 2005 total pollution health costs, respectively.

- **Chronic exposure to PM** as primary contributor (**62%**)
- **Broader Economic Losses** category account for **28%** of the total welfare loss in 2005.
  - This cumulative economic loss from less investment in previous periods and other broader interactions.
  - Much of the observed loss in 2005 is from actual damages that occurred in earlier years



What about pollution control costs?

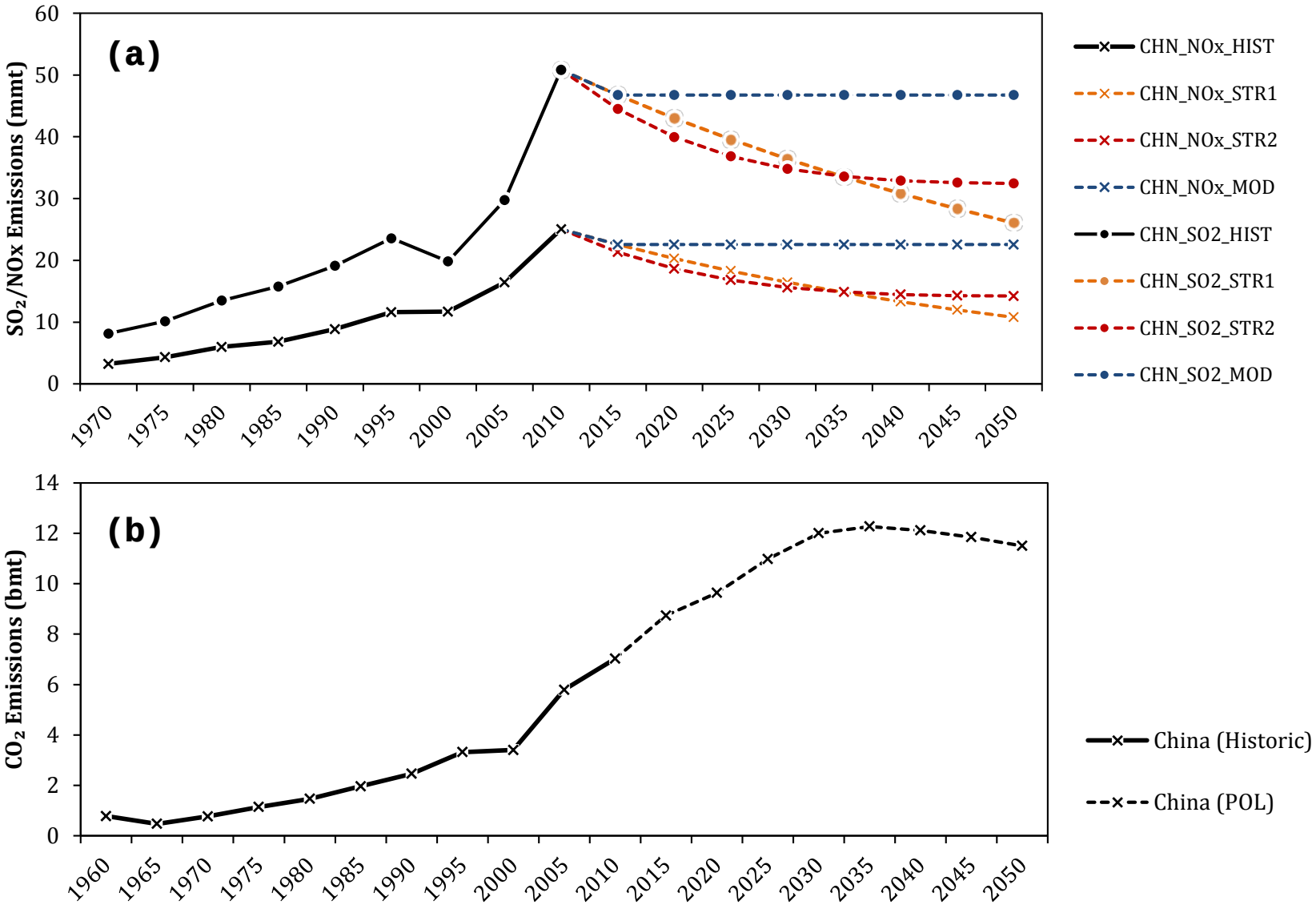
- In a separate recent study we look at Tighter NO_x and SO_2 Regulations in China ?

- Specific questions?
  - How will China's pollution and climate policies interact with each other?
  - How will China's energy demand and supply structure change, if its proposed policy targets are attained?

7 policy scenarios varying pollution control levels, timing, and joint climate and pollution policies

Scenario	Brief Description
REFERENCE	• *Business-as-usual* scenario. • No policy constraints on SO_2, NO_x, and CO_2 emissions are imposed.
POLL_STR1	• *Pollution-control-only* scenario under the *STR1* reduction schedule. • SO_2 and NO_x meet the 12th FYP goals for 2015 and continue a linear decline by 8% and 10%, respectively, every five years through 2050.
POLL_STR2	• *Pollution-control-only* scenario under the *STR2* reduction schedule. • Ensures the same amount of accumulated SO_2 and NO_x emission reductions as POLL_STR1 does, but avoids early lock-in of investment in higher polluting technologies through pollution banking.
POLL_MOD	• *Pollution-control-only* scenario under the *MOD* reduction schedule. • SO_2 and NO_x meet the 12th FYP goals for 2015 and their emission caps are held constant through 2050.
CLIMATE	• *Climate-control-only* scenario. • Enforces a 17% reduction of CO_2 intensity every five years through 2050.
BOTH_STR1	• *Pollution-climate-control-together* scenario • Enforces POLL_STR1 and CLIMATE policy constraints at the same time.
BOTH_STR2	• *Pollution-climate-control-together* scenario. • Enforces POLL_STR2 and CLIMATE policy constraints at the same time.
BOTH_MOD	• *Pollution-climate-control-together* scenario. • Enforces POLL_MOD and CLIMATE policy constraints at the same time.

Various Emissions Targets

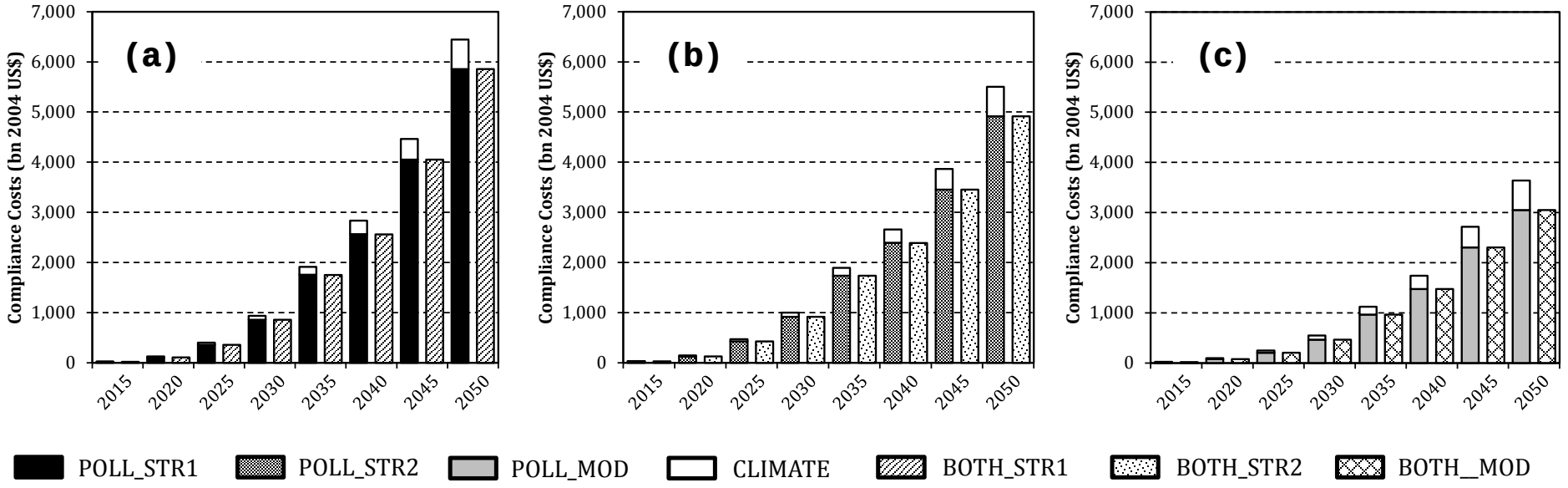


What about pollution control costs?

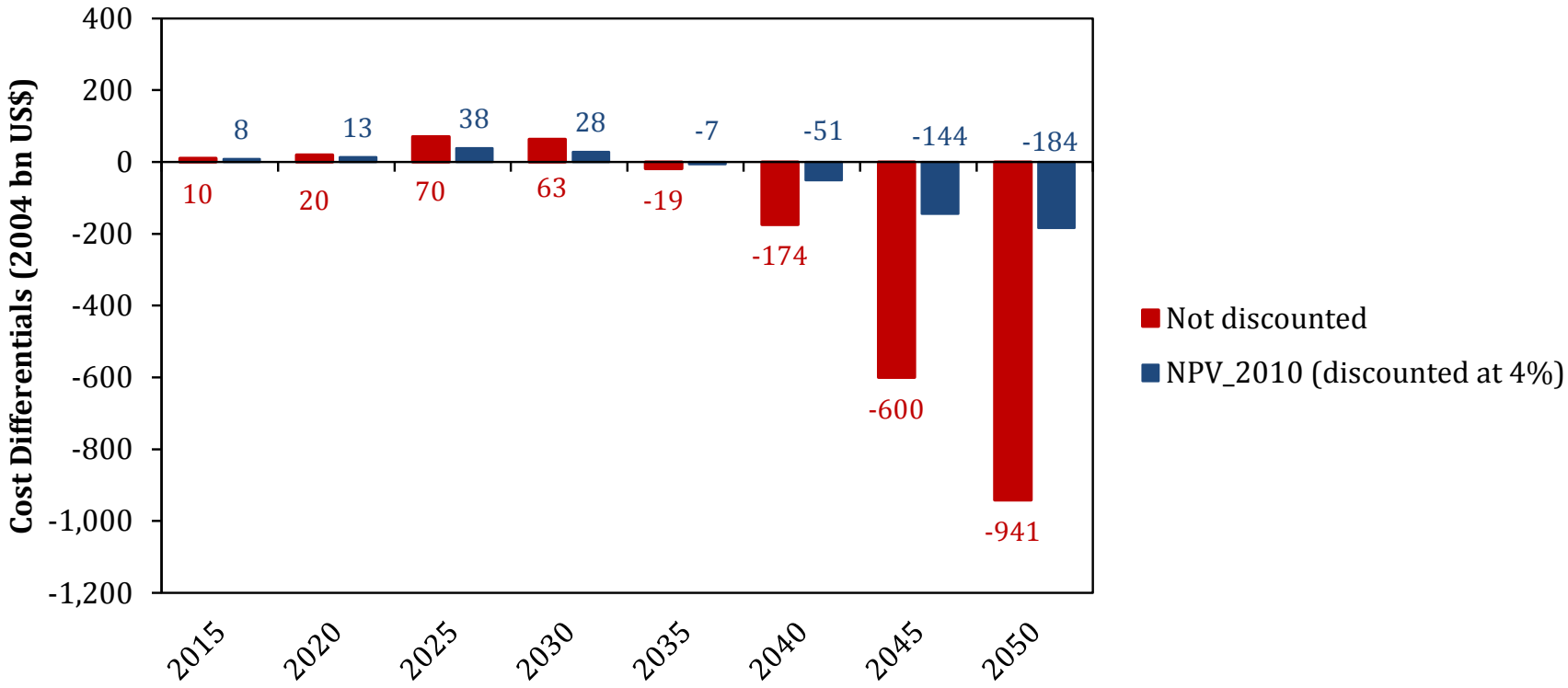
STR1 Targets: Meet Chinas's 12th FYP and continue declining

STR2 Targets: Same cumulative emissions reduction but forward looking behavior approximated to avoid lock-in

MOD Targets; FYP with no further decline



We get a lock-in effect, greatly raising costs if we implement the pollution policy gradually without looking ahead



General Conclusions

- Clearly there can be real economic benefit from pollution control.
- Here, potential dual benefit of reducing conventional pollutants and CO2.
- Costs of control can also be substantial.
- Challenge of incorporating a complex model of atmospheric chemistry and climate, and extending social accounts, valuing outcomes.
- Then how one implements the policy also matters.
- We know how to model “green growth” in principle, but the empirical aspects require much work.